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6th EUREGEO

Munich | Bavaria, Germany
june 9th | 12th 2009

EUropean Congress on REgional GEOscientific Cartography and Information Systems

Earth and Man

Proceedings
Revised Digital Edition

Volume I

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EUREGEO

Earth and Man

Proceedings Volume I

Revised Digital Edition

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Scientific Programme

Monday, June 8th

8:00 Pre-congress excursion to the Impact Crater Nördlinger Ries
Start at the congress site: Bavarian Agency for Surveying and Geographic Information (Landesamt für Vermessung und Geoinformationen Bayern) Alexandrastraße 4, 80538 München

Pre-congress excursion to Landslides in the Bavarian Alps
Start at the congress site: Bavarian Agency for Surveying and Geographic Information (Landesamt für Vermessung und Geoinformationen Bayern) Alexandrastraße 4, 80538 München

Tuesday, June 9th

12:00 Registration: Montgelas Saal at Congress site
Bavarian Agency for Surveying and Geographic Information (Landesamt für Vermessung und Geoinformation Bayern LVG, Alexandrastraße 4, 80538 München)

14:00 Official Opening by the Promoting Committee at Allerheiligenhofkirche of the Residenz München (entrance from Marstallplatz in front of Instituto Cervantes)

Melanie Huml, Staatssekretärin im Bayerischen Staatsministerium für Umwelt und Gesundheit

Marioluigi Bruschini, Assessore alla Sicurezza territoriale. Difesa del Suolo e della Costa. Protezione civile. Regione Emilia-Romagna

Oriol Nel·lo i Colom, Secretari per a la Planificació Territorial. Departament de Política Territorial i Obres Públiques. Generalitat de Catalunya

15:00 Welcome by the Scientific and Local Organizing Committee

Albert Göttle, President of the Bavarian Environment Agency

Keynote lectures

Ian Jackson, British Geological Survey: *174 years and you still haven't finished? – do geological surveys have a role in the 21st century knowledge economy?*

Guiseppe Bortone, Emilia-Romagna Region: *The contribution of the Emilia-Romagna Region to the 6th European Congress on Regional Geoscientific Cartography and Information Systems EUREGEO*

Oriol Nel·lo i Colom, Government of Catalonia: *Geology, landscape and spatial planning*

Luca Demicheli, EUREGEOSURVEYS: *Geology bridging Europe*

18:00 **Get-together party** at congress site Bavarian Agency for Surveying and Geographic Information

Wednesday, June 10th

8:45 Hall B 402 Soldner Saal (congress site)

Elmar Ahr, Bayerisches Landesamt für Vermessung und Geoinformation:

Welcome address at the Bavarian Office for Surveying and Geographic Information

9:00 Hall A 302 Reichenbach Saal session 10A1
Geohazards
Land instabilities

Hall B 402 Soldner Saal session 10B1
Application of maps, 3D-modelling and information systems for geoscientific analysis
Information systems

Hall C 500 Apian Saal session 10C1
Geothermal energy and other georesources

10:45 Coffee break and poster sessions corresponding to oral presentations

11:15 Hall A 302 Reichenbach Saal session 10A2
Geohazards
Seismic hazards

Hall B 402 Soldner Saal session 10B2
Application of maps, 3D-modelling and information systems for geoscientific analysis
Information systems *(cont'd)*

Hall C 500 Apian Saal session 10C2
Application of maps, 3D-modelling and information systems for geoscientific analysis
Digital mapping

13:00 Lunch break

14:30 Hall A 302 Reichenbach Saal session 10A3
Soil conservation

Hall B 402 Soldner Saal session 10B3
Geodata infrastructures
INSPIRE/One Geology

Hall C 500 Apian Saal session 10C3
Use of geophysical and remote sensing methods and technology

16:00 Coffee break and poster sessions corresponding to oral presentations

16:30 Hall A 302 Reichenbach Saal session 10A4
Soil conservation *(cont'd)*

Hall B 402 Soldner Saal session 10B4
Geodata infrastructures
INSPIRE/One Geology *(cont'd)*

Hall C 500 Apian Saal session 10C4
Former climate evolution at regional scale

20:00 Kaisersaal of the Residenz München (entrance from Kaiserhof and Hofgarten)
State reception by the Freistaat Bayern

Thursday, June 11th

9:00 Hall A 302 Reichenbach Saal session 11A1
Geodata infrastructures

Hall B 402 Soldner Saal session 11B1
Application of maps, 3D-modelling and information systems for geoscientific analysis
3D-Modelling

Hall C 500 Apian Saal session 11C1
Geological heritage and popularisation of geosciences

10:45 Coffee break and poster sessions corresponding to oral presentations

11:15 Hall A 302 Reichenbach Saal session 11A2
Geodata infrastructures *(cont'd)*

Hall B 402 Soldner Saal session 11B2
Application of maps, 3D-modelling and information systems for geoscientific analysis
3D-Modelling *(cont'd)*

Hall C 500 Apian Saal session 11C2
Geological heritage and popularisation of geosciences *(cont'd)*

13:00 Lunch break

14:30 Hall A 302 Reichenbach Saal session 11A3
Geothermal energy and other georesources
Mineral resources

Hall B 402 Soldner Saal session 11B3
Application of maps, 3D-modelling and information systems for geoscientific analysis
Geoscientific Cartography

Hall C 500 Apian Saal session 11C3
Geological heritage and popularisation of geosciences *(cont'd)*

16:00 Coffee break and poster sessions corresponding to oral presentations

16:30 Hall A 302 Reichenbach Saal session 11A4
Geothermal energy and other georesources
Mineral resources *(cont'd)*

Hall B 402 Soldner Saal session 11B4
Application of maps, 3D-modelling and information systems for geoscientific analysis
Coastal system management

Hall C 500 Apian Saal session 11C4
Geohazards – ***Floods***
Water resources

Friday, June 12th

9:00 Hall A 302 Reichenbach Saal session 12A1
Use of geophysical and remote sensing methods and technology

Hall B 402 Soldner Saal session 12B1
Geohazards
Land instabilities

Hall C 500 Apian Saal session 12C1
Coastal system management

10:45 Coffee break and poster sessions corresponding to oral presentations

11:15 Hall A 302 Reichenbach Saal session 12A2
Geothermal energy and other georesources
Water resources

Hall B 402 Soldner Saal session 12B2
Geohazards
Land instabilities *(cont'd)*

Hall C 500 Apian Saal session 12C2
Health aspects in Geology

13:00 Hall B 402 Soldner Saal
Closing ceremony

Saturday, June 13th

8:00 Post-congress excursion to Landslides in the Bavarian Alps
Start at the congress site: Bavarian Agency for Surveying and Geographic Information
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Statement of the Scientific Committee

Albert Göttle, Ulrich Lagally, Xavier Berástegui, Antoni Roca, Michela Grandi, Raffaele Pignone, Luca Montanarella and Luca Demicheli

After first informal operational contacts in 1992 the Geological Surveys of Emilia-Romagna, Catalonia and Bavaria organized the “1st Congress on Regional Geological Cartography and Information Systems”, which took place in Bologna in June 1994. The target of this congress was to present and discuss approaches, experiences and working results in the field of applied geosciences obtained by the geological surveys of the partner regions. At that time experts as well as users dealing with problems and solutions of geoscientific issues on a regional level started to exchange experiences

- *to present and identify the opportunities for geological research and analyses, which arise from local requests. They were able to compare the benefits from locally oriented approaches with the more nationwide or academically directed objectives, which tend to more general demands;*

- *to initiate the evaluation and application of these methodologies used in many regions of Europe and also the Mediterranean region.*

The series of congresses, carried out every three years since then, developed to an important meeting place for researchers, providers of geoscientific data and users. After the meetings in Bologna (1994), Barcelona (1997), Munich (2000), Bologna (2003) and Barcelona (2006) the sixth edition is now held in Munich again.

In 2000, the Secretary General of EuroGeoSurveys and the Head of the European Soil Bureau of the European Commission joined the Scientific and Organization Committee for the congresses. One objective of the co-operation of European and regional authorities is to complement the congress programme, focussing on issues of regional relevance, with important per-spectives on the European level.

The vivid dialogue, which started more than 15 years ago, shall continue in the future! It proved to be an active and lasting way to exchange experiences amongst numerous participants coming from all over Europe and even from Africa, Asia and America. The congress brings together those, who study the characteristics of a territory, work out solutions to environmental problems or focus on the application of geological know-how in their respective regional and national environment. In order to reach this target all efforts rely in an increasing way on information systems for the management of environmental data and the production of geothematic maps.

Like its precursors, the successful congress in Barcelona in 2006 ended with a joint document by the Scientific Committee as a conclusion and recommendation resulting from that meeting. The major topics of this document are presented as follows:

1. *Cooperation between European regions has demonstrated to be a very effective way in order to foster synergies and cost savings by facilitating exchange of experiences, methodologies and "best practices";*

2. *The construction of a "Europe of the Regions" can also be achieved by "bottom-up" initiatives by the Regional services;*

3. *Natural hazards, like landslides, earthquakes and floods, as a major topic, emphasizes the necessity to support hazard assessment for mitigation and prevention of risks;*

4. *Risk mitigation policy requires involvement of local experts in order to ensure that the information generated will be accepted and recognized by the local population;*

5. *Regional Geological Surveys have to take part in defining the regional and local development plans for urbanization and infrastructure;*

6. *For all these reasons we need geoscientific data acquisition based on field mapping and other complementary techniques, as well as digital interoperable information systems;*

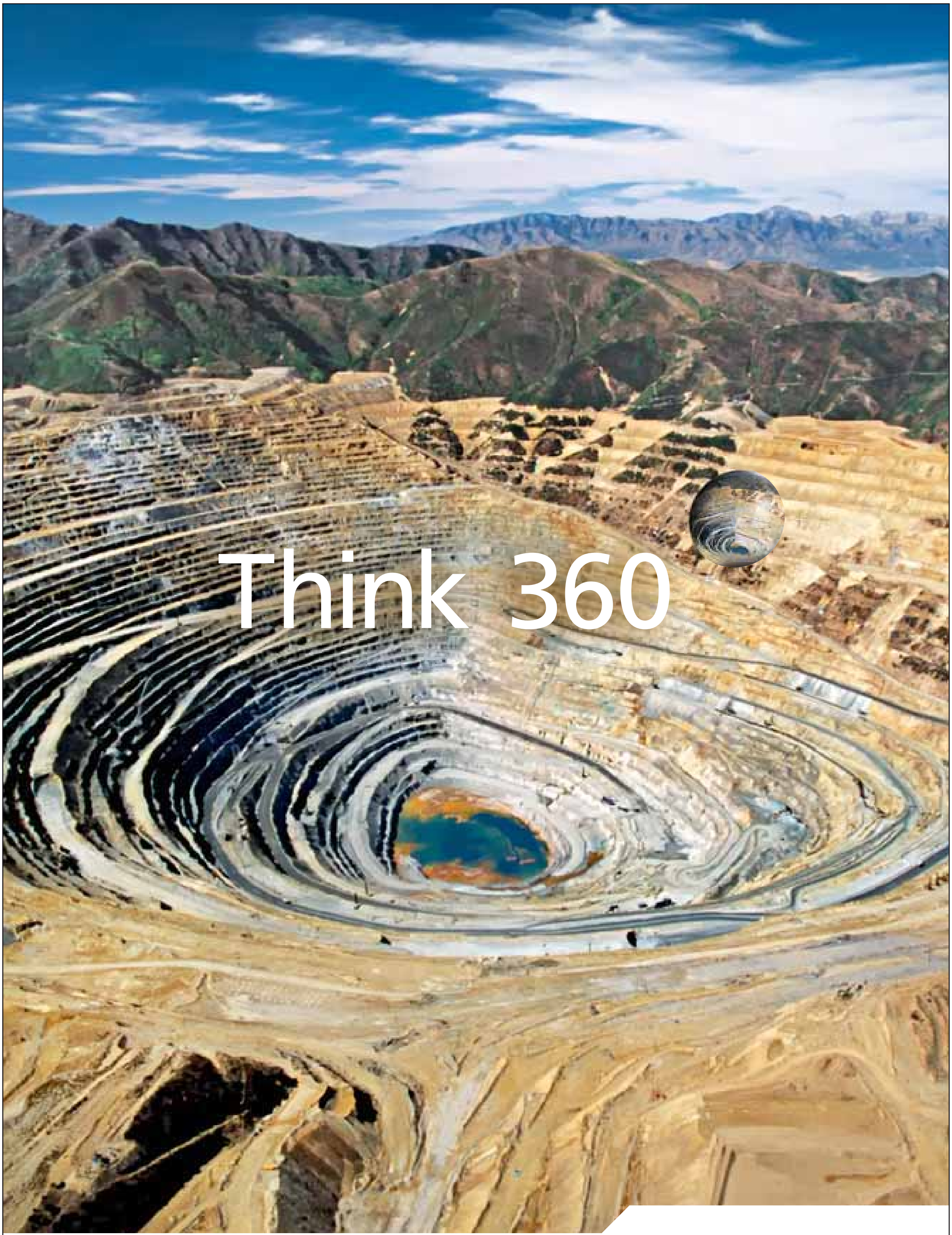
7. *Geo-scientific information has then to be translated by experts for a wide range of end-users with diversified social, economic and environmental concerns;*

8. *The next conference, to be organized in Munich in 2009, should be included in the International Year of the Planet Earth as one of the final events of this global initiative.*

The sixth **Eu**ropean Congress on **Re**gional **Geo**scientific Cartography and Information Systems (EUREGEO) in Munich focuses on the mandate and working results of geological, hydrological and soil surveys. More than 240 extended abstracts together with key note lectures, working group meetings and excursions will assure the success of this congress. With its subheading "Earth and Man" the discussion about the system Earth and mankind living on and from Earth shall be stimulated. In particular, the contribution to society needs and administration requirements will be analysed. Special emphasis will be put on the different operating levels in the quest for land planning and sustainable development, applying European, national, regional and local directives. The conclusions to be reached in this meeting should promote and encourage the integration of the geological and soil services into the society, which they serve.

The Scientific Committee, together with the Local Organising Committee, has the pleasure to welcome all participants to Munich. Have a fruitful conference and a pleasant stay in the capital of Bavaria!

Munich, June 9, 2009



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174 YEARS AND YOU STILL HAVEN'T FINISHED? – DO GEOLOGICAL SURVEYS HAVE A ROLE IN THE 21ST CENTURY KNOWLEDGE ECONOMY?

Ian Jackson (1)

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KEY WORDS: geological surveys, communication, mapping, modelling, strategy.

TOUGH QUESTIONS

Let me give my answer to the second question in the title: yes, but only if we change radically.

If the same question was to be put directly to wider society, who's taxes pay our salaries, and to whom geology and geological maps are at best a (colourful) mystery, I have no doubt they would respond – you've been doing this for more than a century, what more is there possibly left that we need to map? (a particularly pointed question for the old, small countries which make up Europe!). The fact is that there is a limit to how long we geological surveys can make a credible case for carrying on the sort of 2D geological mapping and map production (paper or digital) which belongs more to the 19th century than today.

These statements deserve explanation and continuing the provocative line, let me do that with some more questions. Why, in an age when the hardware, software, GPS and digital data exist, are the majority of geological surveys still doing field mapping on paper? And if most field geologists have a 3 dimensional model in their head when they are doing their mapping isn't their invaluable knowledge largely lost when they commit it to 2D maps and sections? Why should this be when there is a whole range of 3D modelling systems available?

We tell government and reviewers that geological surveys are unique centres of multidisciplinary geoscience – can we really put our hands on our hearts and say we really operate that way? We know that geology has no respect for political boundaries and that the environmental problems we face need an international approach, so why do we continue to operate in our own national silos, with little attention paid to the digital and taxonomic standards that would allow sharing of knowledge within and beyond geology?

We repeatedly assert how relevant geology is to society but do we really give enough priority and funding to communicating our science to the public and delivering products and services for them in a way that is meaningful and useful?

These and other points will be considered in more detail below.

INSULAR

We constantly tell government and those who review and audit us that geological surveys operate as unique centres of multidisciplinary geoscience. But do the geological, geophysical, geochemical, hydrogeological, and geotechnical "divisions" (the word is, literally, appropriate) of geological surveys truly regard integration as a priority? At another level, we know that geology has no respect for political boundaries and that the environmental problems we face need an international approach, so why do we continue to operate in our own national silos, with little priority given to the digital and taxonomic standards that would allow sharing of knowledge within and beyond our frontiers and the geological domain. Shouldn't we recognise the enormous strides that are being made in the "geography-led" spatial data infrastructure (SDI) arena and be an even stronger part of it. Shouldn't we borrow what we can from the other spatial and environmental sciences, some of which are much further advanced in taxonomy and semantics and mathematical modelling? Finally, having enjoyed a decade or more of the initial graphic and glitzy attraction of modelling and GIS, isn't it time we paid more attention to the mathematics that underpin it and our applications? How many of us include in our teams the oft-forgotten geostatisticians and mathematical modellers, people whose skills could enhance the scientific rigour of our work and open up the predictive dimension of time and thus new scientific discoveries?

WOW – BUT WHAT DOES IT ALL MEAN?

We are continually asserting how relevant geology is to society and government and yet we know that a very small proportion of the population can interpret a geological map or model (estimated at a lot less than 0.5%). Do we really give enough attention and funding to communicating this relevant science to the public in a way that is meaningful and useful to them? A 3/4D model may seem a far more superior way to convey understanding of the spatial and temporal arrangement of the subsurface *within* the geoscience community. Unfortunately, while a model should definitely improve the "wow factor", it may not always aid the comprehension of the issue by those *outside* our community. Complex and esoteric stratigraphy or physical properties remain complex and esoteric whether they are portrayed in 2 or 3 or 4 dimensions. We need to convey the messages in our models in a language the intended user will understand, be they a civil engineer, a government planner, or an insurance company. 3/4D modelling, together with virtualisation and visualisation, offer wonderful opportunities to make clear the societal implications of our work, but we lose a significant amount of their potential if we only communicate in the language of geoscience and forget the language of the client.

PRE-MATURITY

It's apparent, when you look at the parallel evolution of geological organisations across at least 3 continents, that 3/4D modelling has progressed by leaps and bounds in the last 5 years. It appears to have come of age. The sophistication and range of the modelling software is impressive, the array of applications in a variety of economic and environmental sectors is extensive and the visualisation techniques can be breathtaking. There is no doubt the geoscience community should look at the move, from what is, essentially, an anachronistic 19th century paradigm of 2 dimensional maps and sections, to the full 4 dimensions that geology occupies in the real world, with a sense of achievement. But should we be satisfied? Is that it? Is there anything left to solve?

Most would agree that we have hardly (and forgive the pun) scratched the surface. From the perspective of those of us who work in geological surveys there is still an awful long way to go, as the next section will describe.

ANYONE CAN PICK CHERRIES

3D modelling software is plentiful, varied and inexpensive and it's no longer too difficult to build a one-off 3D model for a particular research area. Without wishing to diminish these achievements and their individual innovative contribution, for a geological survey such projects are little more than pilot studies and demonstrations. To continue with such an approach alone is arguably no more than academic cherry picking. For organisations charged with a national, long term and strategic "mapping" remit, the serious and much more difficult challenge is to contemplate building, deploying and sustaining robust operational modelling systems and models across whole organisations and nations. The unique contribution of a geological survey to geoscience is not only first class underpinning research – it is excellent research *AND* deployment. If national geological surveys ignore the latter and simply regard 3D modelling as a series of localised research projects then they are forgetting their prime responsibility and are on a slippery slope to relative anonymity within the research and academic domain.

WHAT RUNS THROUGH THE PIPES IS MORE IMPORTANT THAN THE PLUMBING

The acceleration in the versatility of software and the speed and capacity of hardware (sometimes referred to as the "plumbing") cannot fail to impress. But what flows through the plumbing – the data content – is, arguably, more important. Regrettably, digital geoscience data content (its availability, quality and consistency) is far less mature than the plumbing. Digital content is the current limiter for geological surveys, not the sophistication of the hardware or applications. Lack of quality assured content severely restricts strategic and national initiatives. The burden of having to convert analogue data into digital form, then quality assure, condition and harmonise prior to a project, is a huge overhead for any venture, requiring a significant amount of often skilled human input. Yet with a more responsible approach in the past, an appreciation of the post-project value of data, respect for compliance with some basic rules and standards (as opposed to expedient and idiosyncratic wheel re-invention), we could all have been in a more favourable position today. Why hasn't the geoscience community devoted more time to agreeing basic data models and dictionaries? Why have we rushed on to the next project, without properly storing and describing the data and models we have spent so much time producing; reducing the sustainability, re-use and potential added value of our work at a stroke? This message is far from new, but how many of us can say that we/our organisations are not continuing to make the same mistake today and how many Surveys have (and are enforcing) data policies that would deal with the problem?

MODELLING IS A WAY OF LIFE NOT AN ISOLATED COMPONENT

Getting serious and professional about 3D modelling means embracing it throughout the geological data lifecycle. To achieve the synergies, efficiencies and benefits an organisation should be thinking 3/4D modelling at the inception of a project, building it into fieldwork/data acquisition - most field geologists have a 3 dimensional model in their head when they are doing their mapping, isn't that invaluable knowledge largely lost when they merely commit it to 2D maps and sections? The data processing and analysis stages should be designed with 3D in mind and we should ensure that dissemination and delivery take full advantage of the potential of the third and fourth dimensions. Last but certainly not least, integrating within this system a means of storing the models for subsequent re-use is paramount. To allow any of these stages to be restricted to the limitations of the 2D paradigm would be retrograde.

JUST HOW CONFIDENT ARE WE?

Delivering a model that people understand is a significant step, but we mustn't stop there. The next step is something that we never really tackled in 2 dimensional mapping – the step to assess and describe our confidence in the model, its geometry and attributes. Geology is an interpretive science; there are often few geological "facts" and a great deal of interpretation, usually proportionate to the distance below ground surface. Most people outside the profession (including many engineers and surveyors) do not appreciate or understand this aspect of our science. The fact is that geology is more akin to a detective with a set of clues than an observed and measured structure. How can we best evaluate and then show our estimate of error in a way that is both reliable and meaningful? How do we best communicate the certainty/uncertainty of our predictions?

THE WORLD DOESN'T OWE US A LIVING

If geological surveys want to survive then they need to stay fresh and agile and responsive. They cannot afford to be complacent. Just because some of us have been doing what we do for more than 170 years does not give us a divine right to do it in perpetuity. There is a limit to how often you can sell the geological re-mapping of a state or country. The move to systematic and operational modelling and delivering user-friendly digital products and services from these, provides a timely evolutionary opportunity for surveys; but even this is not an absolute guarantee of survival. The digital advances that have presented us with such wonderful opportunities also (at least from the standpoint of a geological survey) now present some threats. Analogue methods coupled with government policy that has been strongly protective of the public sector provision throughout most of the 19th and 20th centuries may have afforded us a very secure situation in the past. It does not take much imagination to see that novel computing solutions and ever-richer digital geoscience data, coupled with governments seeking to reduce public expenditure and place more work in the private sector, threatens this privileged position. As a senior Google person said recently, when addressing an audience of the directors of the National Mapping Organisations of the world, "we'd love to work with you guys ……. but please do bear in mind that we don't have to."

SO WHAT'S NEXT?

Having used a large slice of this paper to advocate what is essentially a policy of "implement and deploy", something that could be accused of being unambitious, let me be contrary. In a sense 3 and 4D modelling is yesterday's news. As scientists we can't live on this forever. Where is the next great step change in geoscience information? In the 1980's it was GIS, in the 1990's it was 3 and 4D modelling; what is the next leap going to be? In addition to developments in visualisation and virtualisation, which technologies will impact on our science? How will the advancement of ontologies and the semantic web, and in particular image and graphic semantics, change our approach? What are the implications of ambient computing and the sensor web? Will the collaborative web and social networking move into our scientific domain?

IN CONCLUSION

If geological surveys want to survive (and please don't get me wrong I think they should and have a vested interest in them doing so) then they have to consider the questions raised in this paper - and I would suggest tackle them collectively.

There are positive signs – the leading surveys appear to be agreeing that in order to survive they can no longer be idiosyncratic, introspective and amateur about their operations. They are reaching out and engaging with their user community - providing their customers with the products and services they need. They are exploiting technology to provide information in the form users need it, when they need it. They are meeting national and international legal requirements for data and information accessibility. They are improving the quality and consistency of their data and meeting standards. They are improving the interoperability of data, so it can be integrated with other, non-geological data – from climate measurements to financial and insurance information. And they are professionally managing their data and protecting their intellectual property rights, because they know without this, in this era of the knowledge economy, they will have few assets to exploit.

To go back to the questions in the title – the blunt truth is that for the geological surveys of the "old world" there is a limit to how many times you can say a map that few understand needs revising. In a world that is changing and innovating, and in a sense shrinking, at an accelerating rate, one thing seems obvious – it would not be a wise strategy for any geological survey to assume it can continue to operate unchanged and do so in isolation.

THE CONTRIBUTION OF THE EMILIA-ROMAGNA REGION TO THE 6TH EUROPEAN CONGRESS ON REGIONAL GEOSCIENTIFIC CARTOGRAPHY AND INFORMATION SYSTEMS (EUREGEO).

Giuseppe Bortone

General Director of Environment, Coast and Soil Department; Emilia-Romagna Region; Italy

INTRODUCTION

The Emilia-Region is honoured to contribute to the 6th European Congress on Regional Geoscientific Cartography and Information Systems (EUREGEO).

The objective of our regional strategy towards sustainable development fits well into the subtitle of this congress “Earth and man”. In Emilia-Romagna, we are undoubtedly living a historical period whereas it’s necessary to propose the central role of the environment, soil, landscape and natural resources in our political agenda. The challenge is to affirm environmental quality and territorial safety within a frame that imposes new and difficult objectives, while the system tends to a unsustainable growth. The priority is to work for a sustainable development, in the meaning that we need to put in all sectorial policies quality and sustainability concerns. A cross-cutting presence capable to drive all actions at local scale.

On this basis, knowledge is fundamental for supporting integrated policies and to allow public participation, which are the key issues for our new development model.

Indeed, the importance of the geoscience application is continually and rapidly increasing, with problems arising on local, regional and global levels, and exploitation and communication of geoscientific data and easy-to-use information systems are more and more necessary.

But another aspect that we whish to highlight, it’s the importance of this “three parties” regional cooperation: Bavaria, Catalonia and Emilia-Romagna for fostering the knowledge in geoscience as base for the sustainable development in all EU countries.

Some issues of our new development policies urge to be supported by common studies and research activities that we hope to develop in the framework of the next year cooperation programme with Bavaria and Catalonia. The main items, that we wish to put to the attention of this Congress, deal with: **renewable energy** and the targets of the Kyoto Protocol within 2020, **soil protection** with the very welcome soil directive, **water resources** and the objectives of water frame directive within the year 2015, and finally the **coastal zones** with its integrated coastal zone management strategies.

ENERGY (Geothermal and Carbon dioxide capture and geological storage)

An adequate energy supply has always been a fundamental prerequisite for economic development. In recent years, the safety of supplies and the reduction of pollution have also become the first priority. Hence the search for renewable and environmentally-friendly energy sources has become even more important. Recent technological progress, the variability of the cost and the difficult of supply of oil and gas, the need to reduce the use of fossil fuels in order to cut pollution and our reliance on supplies from foreign countries have made the exploitation of geothermal energy at any temperature one of the attractive and viable alternative.

Trying to contribute to these subjects, our geological, seismic and soil survey is carrying out study and research activities on geothermal energy as primary source of energy which, if properly harnessed, is renewable and environmentally-friendly.

Emilia-Romagna has no high enthalpy geothermal systems (i.e. T > 150°C) that can be used to produce electricity directly; nevertheless the presence of thermal springs and deep wells with positive heat anomalies point to low enthalpy systems which can be used for direct heat.

For example, in Ferrara and Bagno di Romagna, low enthalpy geothermal reservoirs have been tapped into and used for district heating and spa resorts. From preliminary analysis, it transpires that the areas of greatest interest for further in-depth analysis of potential geothermal reservoirs in Emilia-Romagna are those at the top of the structural highs.

Another field of interest it’s belonging to the safely Carbon dioxide capture and geological storage (CCS) from industrial installations and store it in geological formations. CCS is a bridging technology that will contribute to mitigating climate change. This technology should not serve as an incentive to increase the share of fossil fuel power plants. Its development should not lead to a reduction of efforts to support energy saving policies, renewable energies and other safe and sustainable low carbon technologies, both in research and financial terms, but it would

contribute to reduce EU CO2 emissions by 50% in 2050, while fossil fuel would be significantly replaced in the next decades.
We need to carry out studies and research on safe and long-term underground storage of CO_2 . This means through planning and geologic analysis of the storage site, safe operating during injection and continued monitoring systems.

SOIL PROTECTION

Soil, as affirmed by European Commission communication 179/2002, "performs a number of key environmental, social and economic functions vital for life" and is today threatened by phenomena and processes linked predominantly to human activity which can result in the loss of soil function and ultimately the loss of soil itself. The main threats facing soils in Europe are: erosion, contamination, loss or organic matter and sealing. In Emilia-Romagna approximately 35% of agricultural soils of the hill and mountain areas is affected by erosion. The gravest situations are due to the presence of erodible soils, intense precipitation with strong erosive capacity and crops offering poor cover. The risk of contamination affects the soils of the Emilia-Romagna plain above all, where the main industrial facilities and waste dumps are concentrated (local contamination). Moreover, the plain is at greater risk from contamination linked to excessive agricultural use of chemical substances (fertilizers and phyto-pharmaceuticals) and from disposal of wastewater sludge (diffuse soil contamination). This can cause toxicity and pollution with adverse repercussions on the food chain and the quality of surface and groundwaters. The soils present in some areas of the plain run the risk of decline in organic matter because of changed agronomic practices. Lastly urbanization, which affects large areas of the regional territory, is another threat, changing water flow patterns. This phenomenon, known as sealing, affects agricultural areas of the plain and the hill territory, and lead to a 70% increase in built-up areas between 1976 and 1994.
Integrated project together with the development of GIS tools for supporting spatial planning is indeed necessary for the next future.

WATER RESOURCES

The rich water resources of Emilia-Romagna, consisting of surface and groundwater, represent an irreplaceable heritage. Correct management of these resources is one of the region's top priorities. The geological data collected by Geological, seismic and soil survey has made possible the knowledge base pertaining to the distribution and classification of aquifers allowing to create a new 3-D model of the aquifers of the Emilia-Romagna plain.
As matter of the fact, we are facing drought and floods, with hydrological cycles seriously altered by climate change but also by human overexploitation.
The problem of supplying water in the necessary quantity and quality is therefore for us one of the major challenge of the coming years. Even in a country with abundant water resources, as the Northern Italy is. The amount of groundwater withdrawal is greater than the input from natural resources and as a consequence the ground water level is in average decreasing and surface water uses attempt the minimum ecological flow into the rivers. On the other hands, the risk of flooding due to uneven raining patterns and to much higher run-off, coming from ever increasing urbanised areas, is very high.
To reach the goal of sustainable development it is therefore necessary to revise actual resource use and pollution load pressure as well as we need to adopt new and more sustainable spatial planning strategies.
The change in frequency of occurrence of extreme events is changing the societal response to water management and we are convinced that there is no miracle cure to any region's water shortage or stress, but a package of solutions including: improved agricultural efficiency, better distribution to reduce losses, greater public awareness and participation, commitment to water equity and rights, information sharing, transparency, and the development of new water supplies even through re-use and recycling. The newly-released strategy reflects the demand for a more balanced approach in which better management of existing resources is complemented by investment in priority water infrastructure (twin track).
In other words, this means for us that the challenge for the future is the fully implementation of the European Waterframe Directive (WFD, 2000/60/EC), of the protection of groundwater against pollution and deterioration (Dir 2006/118/EC) and of the Directive on the assessment and management of flood risks (2007/60/EC).
Bench marking among our regions is that meaning strategical for the success of transposition of those directives into the regional laws and regulations.

COASTAL ZONES

The Emilia Romagna's coastal zone is of strategic importance to all regional territory. It is home to a large percentage of our citizens, a major source of food and raw materials, an important hub for transport and trade, the location of some of our most valuable habitats, and finally one of the

larger European tourist area, that represents a significant item of our regional income.
On the other hand, the coastal zone is facing serious problems:

- *widespread coastal erosion, often exacerbated by inappropriate human infrastructure and development too close to the shoreline.*
- *engineering works in some port areas and extraction of gas have contributed to coastal erosion and subsidence*
- *contamination of soil and water resources, pollution from marine or on-land sources, river borne pollution derived from agricultural runoff, demand of water quality and quantity that exceeds supply or wastewater treatment capacity;*
- *saltwater intrusion from overexploitation of coastal aquifers*

This situation of the coastal zone is leading to increasingly frequent conflict between uses.
For these reasons the Emilia Romagna Regional Government has approved the Guidelines on Integrated Coastal Zone Management (ICZM), on February 2005. The guidelines take into consideration many interrelated biological, physical, economical and social problems of the coastal areas and, in accordance to the EU recommendations on ICZM, an integrated and participative territorial approach has been adopted to ensure that the management of Adriatic coastal zones would be environmentally and economically sustainable, as well as socially equitable and cohesive.
In the frame of this activity, a Coastal Information System (SIC) has been implemented within EU CADSEALAND project, and it has been designed following the guidelines issued by European Commission within the EUROSION programme (EU commission, 2004). It provides information to develop a knowledge-base oriented to reduce coastal erosion and to foresee future trends and risks. SIC also contains data collected by different Institutions during the last 100 years, and several GIS products resulting from survey activities and from studies recently carried out by Geological Survey, and aimed to support planning strategies.
Also on this topics is fundamental for us to continue the exchange of expertise at european level and in particular in our regions.

CLOSURE

These and others are the issues that we wish to share with the participants to the 6th European Congress on Regional Geoscientific Cartography and Information Systems (EUREGEO).
We guess that each one of the recalled priority topics could become the reference for the next coming year of activities.
We are fully convinced that new challenges and ideas will rise up during the Congress works and discussions and this will contribute to the successful and bright continuation of the cooperation among our regions.
Together, we can try to answer to the ambitious challenge: “Earth and man”, or in other words to the new way of thinking for sustainable development, that, undoubtedly, needs to be more based on scientific knowledge and, at same time, on public participation. Therefore, let’s try to make geoscience, cartography and information systems in the middle of this project!

GEOLOGY BRIDGING EUROPE

Luca Demicheli

Secretary General of EuroGeoSurveys, the Association of the Geological Surveys of Europe

The need for more consistent geological data across Europe has been discussed by practitioners for many years. The current political situation strongly influenced by the on-going economic changes has contributed to recently bring this topic high also in the EU political agenda.

The price of minerals, metals and oil has grown dramatically over the past two years, up to a few months ago, creating huge difficulties to the economy of the EU, which depends on the import of such resources to satisfy internal demand. Then, all of a sudden the economic crisis invested Europe and the world, and the construction industry went across a huge crisis too, with direct consequences on the aggregates industry.

Is EU policy making aware of the importance of geology for facing economical, social or environmental challenges? One would probably reply that it is partially the case at least for environmental issues. Well, actually it is not really the case either. How many politicians know that 1 km of motorway requires 30,000 tons of aggregates, that will be transported from one place to another within Europe with huge energy consumption? And that at least 3 billion tons of aggregates are moved every year across the EU? It there is any sustainable land planning strategy behind? The question will not have an answer.

Even less is known by policy planners and legislators about the economic implications of resources supply or the health effects on populations exposed to certain radioactive or toxic minerals normally present in nature and located just close to the houses where people live.

Informing our politicians and the public at large is a huge challenge, that the International Year of Planet Earth has been addressing over the past three years.

Nevertheless a huge effort is still needed. Europe appears normally divided on issues for which it is supposed to have an agreed policy. What it is going to happen when it there is not even a EU policy or position? This is the case for geology. Even if important actions are being undertaken by the European Union, such as the Raw Materials Initiative, most of the actions at EU level are left to the Association of the Geological Surveys of Europe: EuroGeoSurveys, which is not a formal EU body. The Raw Materials Initiative itself advocates for a better networking among geological surveys. It is an important recognition and a huge step forward. However national geological surveys alone cannot bear the burden of shaping the European geological strategy without a clear mandate from the European Commission.

On the other hand the Commission in unlikely to express any position, since it there not exist any formal European body dealing with geological issues. Such a gap needs to be filled in.

This requires the cooperation and networking of all the parties involved. The role of regional geological surveys is crucial from this perspective. Regional surveys are the providers and owners of a huge amount of detailed local data. And we all know the geology is a ‘field work’ science. Only an in-depth knowledge of the local situation can ensure data reliability. Moreover, the local political situation can be better addressed only by local agencies. And each region has got its own needs and priorities.

It becomes clear that an efficient European geological infrastructure, in accordance with the ‘subsidiarity principle’ can be achieved only if every action is taken at the appropriate level: local, national and European.

In geological terms, ‘local’ stands for regional surveys, while ‘European’ still has no meaning.

Europe cannot afford the lack of a European body dealing with geology. Regional and national surveys need to strengthen their networking, as formally envisaged by the Raw Material Initiative, in all the geosciences fields. This first step is necessary in order to counteract the lack of a EU supranational body, and will perhaps help in making evident the need for creating one.

The regional surveys of Italy, Spain and Germany share a seat within the EuroGeoSurveys General Assembly, enabling the national geological survey to deliberate in a more transparent and democratic way and paving the way for a stronger position of geosciences into the EU policy arena. Further common actions are under consideration and will be implemented in the near future.

GEOSPATIAL CORE DATA – A PUBLIC SERVICE OF GENERAL INTEREST

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KEY WORDS: cadastre, aerial imagery, laserscanning, DTM, mapping, positioning, flood simulation, SDI.

The Land of Bavaria Agency for Surveying and Geographic Information (LVG) is pleased that EUREGEO has chosen its premises as the venue for the 6th EUREGEO congress.

Knowledge about reliable geographic information is crucial for many applications. The assumption that 80% of all data is linked with geospatial information does not seem to be too high an estimate.

The sixteen Länder of the Federal Republic of Germany act independently in the fields of official surveying and mapping and real estate cadastre. Covering 70.000 km², LVG is the largest mapping agency in Germany. It regards itself as a service administration with a long tradition and, in today's information society, as the supplier of up-to-date, precise and multi-purpose core geospatial information.

LVG's main products and services include:

- Real Estate Cadastral Services: The 51 Bavarian surveying offices (plus 22 branch offices) are in charge of more than 10 million parcels and 8 million buildings. They digitally store information about legal and physical borders, buildings and actual utilisation of parcels in the Digital Cadastral Map (DFK), through weekly updates.
- Aerial Imagery and Digital Orthophotos (DOP): Aerial flights are carried out continuously to cover the entire area of Bavaria within three years, using colour films and, increasingly, digital cameras. High resolution digital orthophotos are one of the results. LVG houses an increasing archive of more than 750,000 historic aerial images.
- Digital Terrain Models (DTM): DTMs are computed using airborne laserscanning techniques, thus providing information useful for flood simulations or monitoring landslides. DTMs are available in a grid spacing of a minimum 10 m, and already even closer for three quarters of Bavaria.
- Digital Landscape Models (DLM): The ATKIS-Basis-DLM is computed for the entire area of Bavaria. The updating of this data is partly realised by local topographers who detect and survey changes of features. An updating cycle of better than one year is achieved for the important feature classes such as roads, settlements and railway lines. Features like geocoded postal addresses are included.
- Digital Topographic Maps (DTK): Topographic maps at various scales are produced digitally. The maps are composed of several layers for manifold uses in applications. Combined data from topographical and cadastral sources (e.g. contours of buildings) are available on data carriers
- GNSS-Satellite Positioning Service: Within the Germany-wide positioning service SAPOS, LVG operates about 37 reference stations for various DGNSS services such as GPPS for post processing techniques or HEPS, which guarantees cm-accuracy in real-time, using mobile phone connections for broadcasting the data. Both GPS and GLONASS satellites are implemented. Galileo will be a future option.

Most of the products and services are offered via the Internet (www.geodaten.bayern.de), thus providing a fast and efficient means of dissemination.

GDI-By, the Bavarian Spatial Data Infastructure agency situated at LVG, promotes and coordinates activities to integrate core geospatial data with other special information via online services. Using the BayernViewer (ByV-) family many projects (e.g. ByV-denkmal or -aqua) have already been realised. ByV-plus combines the main products of LVG and allows various freely chosen Web Map Services (WMS) and prospectively Web Feature Services (WFS) to be added.

The possibility of integrating previously separated information provides new opportunities to extend our expertise about man-made and natural situations to shape future developments and manage disasters.

Topic – Application of maps, 3D-modelling and information systems for geoscientific analysis

MODERN GEOLOGICAL FIELDWORK AT THE BAVARIAN ENVIRONMENT AGENCY – AN ENTIRELY DIGITAL WORKFLOW WITH THE AID OF THE EXPERT MAPPING APPLICATION GEOKART

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KEY WORDS: GeoKart, digital field mapping, mobile data capture, geology.

INTRODUCTION

Since the 90s the working environment of field geologists at the Bavarian Geological Survey was getting more and more determined by digital technologies. There was a central database for storing data of geological point objects, supplements for digital maps were produced digitally and hand drawn manuscript maps were digitised in the cartography department for electronic publishing.

So it seemed an obvious question whether it was possible to convert the traditional and since more than 150 years well established methods of a field geologist, the use of analogue tools like field book, field map, pens & crayons, into a digital workflow in order to increase efficiency and quality of the mapping process.

Focussing on this question a research & development project entitled ***GeoKart*** was launched by the Bavarian Geological Survey in 1998. Meanwhile GeoKart is an application for digital field mapping and data capturing used productively at the geological department of the Geological Survey's successor authority Bavarian Environment Agency.

HARDWARE

To ensure the acceptance of a digital system for geological mapping by the users, the selection of the hardware to use in the field must focus mainly on a high degree of ergonomics, a pen driven input, sufficient computing power and long battery life.

Having used different mobile hardware concepts in the early years of the project, we now use modern tablet PCs that are as well lightweight (1,3 kg) as rugged and weather proof enough for geological field use. The tablet PCs come with a sunlight readable display of adequate size (SVGA resolution) and an internal GPS receiver.

Figure 1 – Hardware used for field work.

THE GEOKART SOFTWARE

On the tablet PCs the proprietarily developed software ***GeoKart*** is used for data capture and mapping. The user interface consists of several windows that can be arranged next to each other or displayed individually. The two main windows are the map window and the data window.

The map window can display georeferenced raster images like topographic maps, manuscript maps or aerial photographs. The raster images are stored in a catalogue and can be switched on and off individually or in sets. A cross lines symbol can be used to indicate the current position when the integrated GPS is in use.

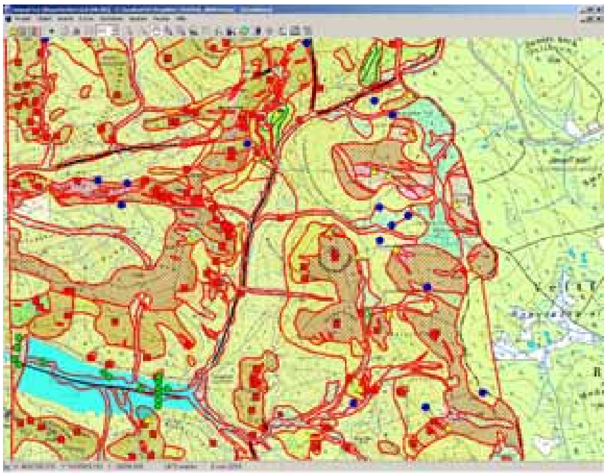

Figure 2 – GeoKart software with active map window.

On the map surface, geological objects are displayed in different ways depending on their types, geometries or attributes. New objects can be created by drawing with the pen on the touch screen or by using the GPS signal for positioning.

The data window is used for displaying and altering the data related to the geological objects. The forms of the data window provide common features known from database interfaces like tab sheets, data sensitive single field or table controls, key lists, data input assistants etc.

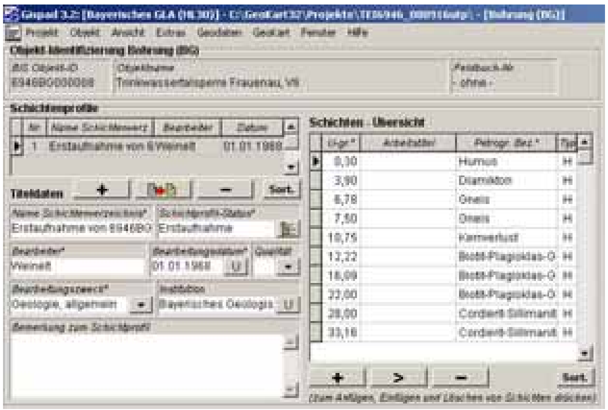

Figure 3 – GeoKart software with active data window.

A main feature of the GeoKart application is its class based object model. Contrary to most of the common GIS GeoKart has no layers, but only objects with predefined geometry types.

Furthermore, GeoKart has a topologic geometry engine, so any geometric elements (points, line segments, polylines, polygons) shared by different objects actually exist only once within the system. Editing geometric elements of an object that are also parts of other objects' geometries changes the geometries of all objects involved simultaneously (see Wölfl & Annau, this volume).

DIGITAL MAPPING WORKFLOW

GeoKart comprises two main thematic domains that have different purposes.

On the one side there is a domain related to the central database of the Bavarian Environment Agency, the so called ***BIS*** (Bavarian Soil Information System). GeoKart mirrors those parts of the BIS that are relevant for field geologists. It provides the same object classes, uses the same data model and key lists and implements a bi-directional interface for data exchange with the BIS. The data model of BIS objects is quite extensive.

In the field GeoKart acts like a mobile but offline client of the central database. It gives access to all information downloaded from the BIS before the field trip. All changes and additions to existing objects as well as newly captured objects can be uploaded to the BIS when returned to the office.

The other main domain of GeoKart, the so called ***Mapping Module***, is dedicated to support the actual geological mapping process from the first field observation until the completely accomplished geological map.

The GeoKart Mapping Module consists of three parts: a set of three object classes with distinct geometries and data models, the Map Unit Manager, and a set of additional tools and assistants.

Field observations are recorded by the creation of objects of the three classes *Mapping Point*, *Mapping Line* and *Mapping Area*. These objects of the Mapping Module, in contrast to the BIS objects, only have a limited set of attributes. They are designed to support the practical mapping process and are not intended to be transferred to the central database BIS.

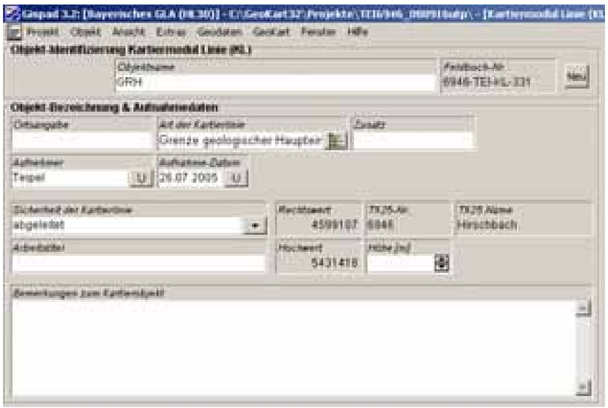

Figure 4 – GeoKart software with active data view of the class 'Mapping Line'

The objects of the Mapping Module are displayed with different colours according to the attributes they have been assigned to. Mapping Points and Mapping Areas can be attributed with a map unit defining their visualisation. Mapping Lines do not have this attribute as they usually border areas of different map units, they are displayed according to the attribute *type of line*.

Map units have a colour, a short and a long name, and they may be further described with comments. They can be freely created and edited by the user with the ***Map Unit Manager***. Map units are thus not fixed and determined like a database key list. On the contrary, they are individually developed by the geologist during the mapping process, thus allowing easy and quick response to changes in the mapping concept.

The GeoKart Mapping Module also provides additional tools and assistants to query, select and manipulate the Mapping Module objects. They can be used in various ways in order to optimize the results and the quality of the mapping process.

Figure 5 – The GeoKart Map Unit Manager.

After the completion of the mapping project, the geometrical data can be transferred via appropriate interfaces and export formats directly to the cartography department for further digital processing and publication.

BENEFITS OF THE SYSTEM

The actual mapping process itself, from the first point observation via lines and borders to the complete mosaic of areas, remains the same, no matter if it is done by traditional analogue or by new digital methods. But according to our experiences, the new digital system has some distinct benefits to offer:

- The import of all relevant objects from the central database BIS and all available digital maps into GeoKart before a field campaign provide the field geologist with an optimal data status for field work right from the beginning
- Only one single system supports the whole field work of the mapping geologist.
- Objects that already exist in the BIS can be altered or amended in the field. After the field campaign all changes can be easily and quickly updated in the central database by use of GeoKart's interface to the BIS.
- The users have complete access to all available and captured data at any time during project work.
- A standardized data transfer between cooperating geologists is possible, even while a project is in progress.
- When the mapping project is completed, all necessary spatial and attributive data are transferred digitally and without any media brakes to the cartography department for further processing, compared to the traditional handover of analogue manuscript maps a timesaving procedure.

As a conclusion, this compact system of hard- and software is characterized by a very high grade of efficiency.

STAND OF APPLICATION:

At the Bavarian Environment Agency the system GeoKart is meanwhile used by about 30 field geologists of the geological department as the standard tool for geological mapping and field data acquisition. Several geological maps have been produced solely by the aid of GeoKart. The functionality of GeoKart has also been extended to meet the requirements of further geoscientific departments like raw materials, hydrogeology or geological hazards. In these departments GeoKart is used by another 25 members of staff.

ACKNOWLEDGEMENT

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GEOLOGICAL 3D INFRASTRUCTURE FOR SWITZERLAND

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KEY WORDS:
Geology, 3D modelling, visualisation, data management, market analysis, methods, requirements, standards, consistency, software

WHY GEOLOGICAL 3D MODELLING?

Besides the fact that geology is a three dimensional science by definition, there are mainly three other reasons why geological 3D modelling is an important domain in the future:

- It is the key technology for a better understanding of geological settings and a comprehensive representation of geological data.
- It is of great importance for facing future challenges (e.g. land-use, radioactive waste deposits, natural hazards, etc.)
- It is the basis for more detailed modelling and analyses in domains closely related to geology (hydrogeology, geothermal energy, tectonics, engineering geology, hydrology, etc.)

TASKS AND AIMS OF THE SWISS GEOLOGICAL SURVEY

The reasons mentioned above are closely related to the main tasks of the Swiss Geological Survey (SGS), which are listed below:

- The professional production and preparation of geological data
- The adaptation and further development of new knowledge and technology derived from geological research and project management
- The coordination of international cooperation and technology transfer

In order to fulfil these tasks and to contribute actively to the geological 3D modelling community, the SGS has defined short-, mid- and long-term objectives (Figure 1)

Time horizon	Aim
Short-term	• Acquiring basic knowledge in the field of methodology, workflow, visualisation and data management
Mid-term	• Establishing a know-how transfer between science, industry, service providers (geologists, engineers, etc.) and the SGS. • Developing national, regional and local 3D models across the country at different resolutions and scales. • Providing basic data for decision making processes in economics, government and science.
Long-term	• Integrating geological 3D models into (3D) applications of federal institutions and partners.

Figure 1: Aims of the SGS for geological 3D modelling.

LEGAL FOUNDATIONS

Since its foundation in 1860, the SGS was performing its tasks without a federal legal basis. This deficit changed in 2008 with the introduction of the Swiss Federal Act on Geoinformation (GeoIG) (Schweizerische Eidgenossenschaft, 2008a). The GeoIG regulates the production, distribution, quality and pricing of geoinformation in Switzerland. Associated with this federal act is the Geology Ordinance (LGeolV) (Schweizerische Eidgenossenschaft, 2008b), which defines the mandate of the SGS:

Following these regulations, the SGS provides geological data and information of national interest in these domains:

- usage of the geological underground and trends of spatial planning
- occurrence and properties of groundwater
- geological conditions in the vicinity of existing and planned infrastructure of national interest
- occurrence and properties of geological formations suitable for the permanent storage of substances and waste
- deposits of mineralogical raw materials (e.g. non-metallic minerals as well as ores, oil and gas)
- basic principles of geothermal energy generation
- identification of dangers and risks to persons, objects, the environment and land-use through principles based on geological processes or the usage of the geological underground

In these acts 3D modelling is not mentioned explicitly. However, considering the strong evolution of this technology, it is a logical consequence that geological 3D modelling has to be taken into account for performing the respective tasks.

SETTING UP THE 3D INFRASTRUCTURE

In order to set-up an appropriate infrastructure for geological 3D modelling, the following steps based on the work of Baumberger (2008) have been performed or are envisaged:

- Pilot studies (completed)
- Definition of requirements (completed)
- Software-evaluation (in progress)
- Software-implementation (to be performed)
- 3D modelling (to be performed)

Pilot studies

One of the first steps in building up an IT-infrastructure is to identify the capabilities of the different technologies. To get a deeper insight into the capabilities of existing 3D modelling software, a number of pilot studies have been performed (Figure 2).

No.	Software-type	Model-type
1	3D visualisation and animation	Surface
2	3D visualisation and animation	Surface
3	Geological 3D modelling	Volume
4	Standard GIS	2.5D Surface

Figure 2: Overview of performed pilot studies

Almost every study was based on an individual software package and generated different types of output models. Two selected models (Nos. 2 and 3 in
Figure 2) are shown in
Figure 43 and 4.

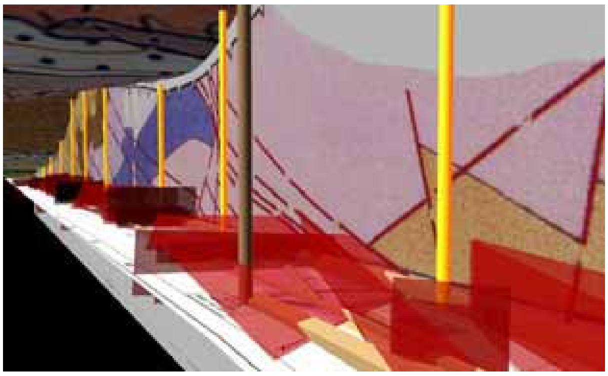

Figure 3: Insight into the Mont Terri anticline of the Jura Mountains (Jeannin et al., 2008; Oesterling et al., 2008), illustrating fault planes (transparent red) constructed from cross-sections and a highway gallery map; (cf. No. 2 in Figure 2)

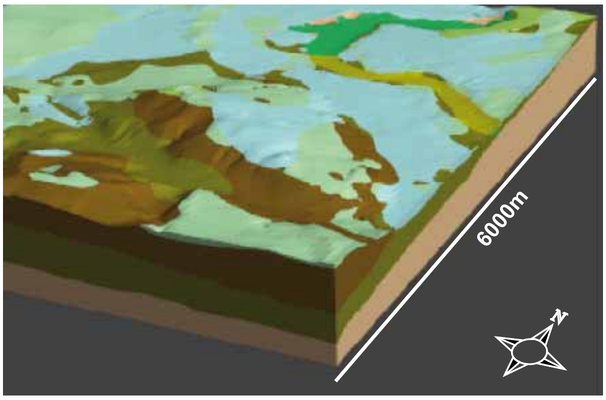

Figure 4: Detail of the geological 3D model of the greater Bern area, Swiss Midlands, 1:25'000; (cf. No. 3 in Figure 2)

Definition of Requirements

With the above-mentioned capabilities in mind, the next step is to define the requirements of the 3D modelling infrastructure.

Geological requirements

The geological setting of Switzerland is mainly characterised by three different tectonic units: Jura Mountains, Molasse basin and Alps. Each is dominated by a specific lithological regime (from sedimentary fill to crystalline basement) and has its own structural characteristics (undeformed to brittle or ductile tectonics). Geological 3D modelling of such contrasting regimes requires particular software capabilities, such as:

- Handling of thrusting, faulting and folding in all tectonic regimes.
- Handling of multiple z-values particularly in complex environments (e.g. overthrust folds).
- Handling of unconformities in heterogeneous and heterochroneous Quaternary deposits.
- Handling of artificial or secondary bodies (tunnels, caverns etc.) within the model and the possibility to cut them along with the geology and to project geological data onto them.

Technical requirements

Technical requirements are only related to the pre-existing internal IT-infrastructure. For instance, the IT-unit of the Federal Office of Topography swisstopo, which also includes the SGS, supports only particular operating- and database-systems.

Software evaluation

After these two initial steps it became clear that the needs and requirements of the SGS can be covered by standard software packages and that no software development is needed. In order to evaluate which software meets the aforementioned requirements best, a benchmarking of eight software packages has been performed.

Method of evaluation

A questionnaire containing 126 topics, divided into seven main categories, was developed. These categories and their covered topics and respective weighting are listed in Figure 5.

Category	topics	weight
Functionality and convenience	57	19%
Compatibility existing infrastructure	10	18%
Expandability	9	16%
Ergonomics	16	14%
Price / Quotation	10	14%
Documentation	8	10%
Manufacturer's portrait	16	9%
Total	*126*	*100%*

Figure 5: Overview of the weighted main categories of the market analysis and their related topics.

A priority was assigned to each topic, which was distributed unevenly in the main categories. To achieve balanced and consistent results, the main categories of the questionnaire were weighted using a paired comparison. As a result, a weighted ranking of the main categories could be derived, describing the importance of a category for this market analysis and balancing the uneven allocation of topics (
Figure 5).

Afterwards, the questionnaire was distributed to the particular manufacturers, who were asked to complete and return the questionnaire. The replies were then reviewed and benchmarked by the SGS. By multiplying the benchmarked answers with the assigned priority of each topic of the evaluation, a numerical and weighted ranking of the products could be produced.

Results of the evaluation

The majority of the products achieved a high level of performance. The completion of the key geological requirements mentioned above turned out to be the main challenge in distinguishing the products. Comparing the topics in the main category "Functionality and convenience" (data import and export options, workflow capabilities, handling of large datasets) shows that these criteria proved to be the most significant ones. Besides fulfilling the key facts, the main differences between the products are illustrated in Figure 6.

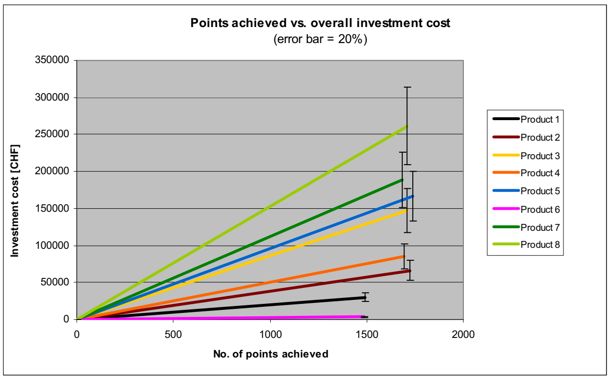

Figure 6: Diagram showing the overall investment cost vs. the number of points achieved. The flatter the curve is, the better the price/performance ratio.

Further steps

Based on the results of the software evaluation, detailed on-site product demonstrations are envisaged. This step will provide the basis for selecting and implementing the appropriate software for building up the 3D infrastructure.

OUTLOOK

The implementation of the geological 3D modelling software (including training) enables the SGS to face the future challenges related to geological investigations, such as:

#1 – Modelling methods and processes

Developing appropriate modelling methods and processes for different geological settings (e.g. local and temporal unconformities, overturned folds, etc.) and achieving high quality standards in methodological and practical workflows should be one of the principal aims of the SGS.

#2 – Visualisation of 3D models

Geological 3D models should serve the purpose of comprehensively presenting complex geological facts. Therefore, it is necessary to pay attention to topics regarding the quality of visualisation, the extraction of 2D images from 3D models and the level of detail. Additionally, by focusing on laymen, guidelines dealing with usability, visual habits, and visual reception should be developed in order to achieve a high level of acceptance.

#3 – Data management

The market analysis showed that a tight integration of available data is necessary in order to provide a well defined and well organized data base for 3D modelling. In the wide context of geological data management (acquisition, preparation, exchange and processing), especially the cross-linking of geological maps and boreholes should get attention in the pursuits of the SGS.

Therefore, besides gaining knowledge in the field of 3D modelling methodologies, parallel efforts should be made in establishing a powerful geological data network.

#4 – Consistency check of 2D data

Geology is an under-sampled science. In many cases, geological 3D models are based on a small number of “hard” data (e.g. observations in drill holes). Nevertheless, consistency checks of 2D data can be made easily using geological 3D models. Regarding the large number of underground data available (construction sites, drill holes, etc.) in Switzerland, the existing geological surface information (i.e. geological maps) can be checked for spatial consistency.

#5 – Swiss 3D modelling community

Despite the importance of geological 3D modelling and the existing models, the level of application, experience and knowledge is distributed rather heterogeneously throughout Switzerland. The existing geological 3D models (i) are local or regional, (ii) are bound to certain purposes or projects and (iii) are generally not known to other geologist, institutions or even the public. Therefore, there is a strong need to share information, knowledge, data, ideas, visions, etc. to achieve homogeneous and standardized geological 3D models.

The mission of the SGS as a governmental organisation should thus include (i) acting as an umbrella organization for geological 3D modelling, (ii) bringing together its various actors and (iii) checking national needs and requirements against international standards.

#6 – Map production

Geological 3D modelling is currently “only” an application and refinement of existing geological 2D data (maps, cross-sections) and not a tool for the production of new 2D data. However, it may be used for map production in the future.

The common production process of geological maps is based mainly on field observations. Subsurface data such as boreholes are integrated into the maps, its 3D-information, however, is only indirectly used. In long-term considerations, the current production process may be adopted in that way, that geological 3D-models constitute the data basis from which 2D geological maps and cross-sections may be derived.

#7 – General

The demand for and the use of geological 3D models will increase rapidly within the next years. The SGS possesses all the necessary skills, data and information in-house for developing meaningful and powerful geological 3D models.

Additionally, owing to the geological 3D modelling software that will be purchased, the SGS aims at an active role within the domain of geological 3D modelling in Switzerland. Based on this outlook, it becomes clear that only highly standardized, qualitatively excellent, meaningful and powerful geological 3D models can reach the acceptance they deserve among the public outside the expert groups.

ACKNOWLEDGEMENTS

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GEOLOGICAL MAPPING OF NATURAL AND ANTHROPOGENIC STRUCTURES IN THE CONTEXT OF A MUNICIPAL GIS – A CASE STUDY IN THE TOWN OF STRAUBING, GERMANY

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KEY WORDS: municipal GIS, urban geology, anthropogenic overprint, resource pits, landfill.

INTRODUCTION

In the context of a GIS offensive of the municipality of Straubing a systematic acquisition of data concerning the underground and mineral resources was conducted. The Lehrstuhl für Ingenieurgeologie of the TUM took over the geological part of the work in the context of two diploma theses.

Figure 1 – The Gothic city tower of Straubing, standing on a Pleistocene terrace is a typical building with a combined brick and natural stone construction.

The aim was to improve geological information from existing 1:50.000 scale to 1:5.000 even useable for town planning purposes. In addition to this also the abandoned resource-pits of the brickyard industry were regarded. Brick production is still one of the big industries in Straubing and major historic buildings as well as some modern ones are buildt with bricks.

GEOLOGICAL OVERVIEW

The town of Straubing is located in the district of Lower Bavaria in Southern Germany. The dominant geological structure is the wide Danube valley with its Quaternary fluvial sediments. Several gravel plain terraces can be distinguished in the town (Fig. 1, Fig. 2). These are covered widely by aeolian loess deposits. The Danube follows a tectonic depression along a NW-SE trending fault.

The underground of the alluvial sediments is formed by Tertiary and Mesozoic sediments and crystalline rocks of the Moldanubicum. Water from carst systems in the Jurassic limestones is used for geothermal purposes (UNGER et al. 1995).

North-East of the Danube valley the crystalline rocks build the gentle mountain range of the Bavarian Forest. To the south of the town lies the hilly landscape formed by Molasse sediments. Straubing is the centre of the so called “Gäuboden”, an agriculturally intensely used region, whose wealth is based on the occurrences of fertile loess loam.

EXISTING DATA AND GIS

For the work a multiplicity of data was used, which was mainly supplied by the responsible offices for the Straubing project. Among others the digital land register map of Straubing, the digital terrain model (raster 10 m), as well as a data record of the digital contours and several generations of aerial photographs from different decades formed the basis of the geological work. Important data on the locations of former brickearth pits and the history of the many brickworks and roof tile factories were gathered by interviews. Information was also recovered from archaeological and historical archives and from local historians and collectors of historical prints, postcards and photographs.

The processing of all data was conducted using ESRI ArcGIS 9.2 in the numerical laboratories of the Lehrstuhl für Ingenieurgeologie of the TUM.

RESULTS

Since there had only been a geological manuscript map for the topographic sheet Straubing (SCHELLMANN et al. 2006), there was a need for mapping the town geologically. The mapping in the scale of 1:5.000 was accomplished by a three months field work campaign. The acquisition of primary geological data was conducted by walking the whole town to experience even sophisticated morphological structures.

Also the manifold anthropogenic overprint was explored in detail. During mapping the following aspects played a central role:

- geomorphologic development of town area
- the Quaternary geology of the Danube valley
- structure of the pre-Quaternary underground
- brickearth, gravel and sand pits
- municipal waste landfill
- refill of World War II bomb impacts

Field mapping was the main method to collect primary geological data of an area of approx. 23 km². By this terrace edges and demarcations of gravel plains could be drawn more exactly than this was realized in the manuscript map. Then the "analogue" mapping was digitized in GIS (Fig. 3).

The localization of former brickearth and gravel extraction areas was strongly supported by a 3D-model generated on the basis of the digital terrain model (DTM). This was completed by the analysis of files in archives and municipal offices. For further interpretation different data from public services were loaded.

The most useful example is a set of military aerial photographs from the last years of World War II. They yielded important information about bomb impacts which allowed to locate impact craters and to delimit bombarded area as possible risks for civil construction works.

Results and stratigraphic profiles of drillings were integrated into the GIS, too. This makes the localisation of drilling points fast and access to geological information of the underground easily possible.

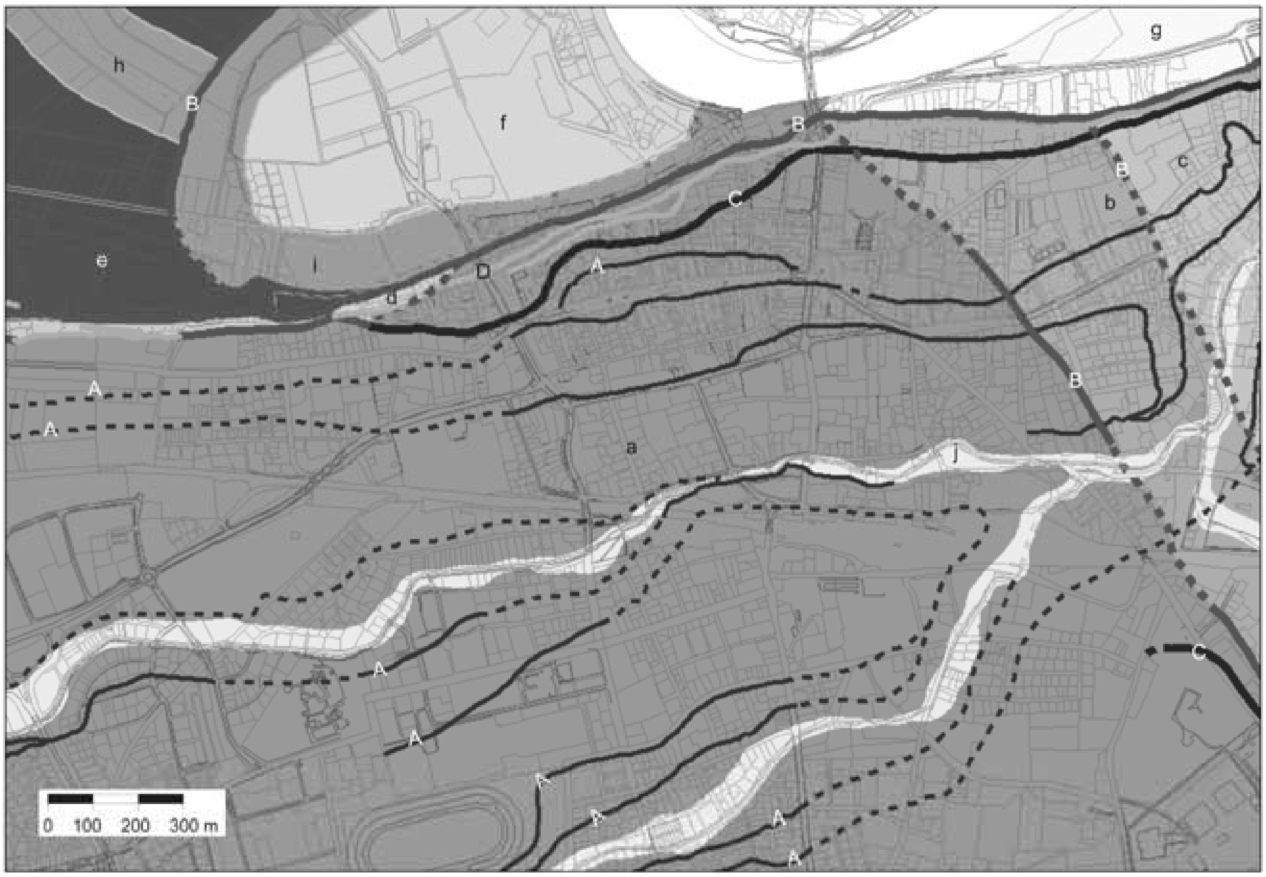

Figure 2 – Geological mapping of Straubing - detail from the geological map in GIS with brook terraces (A), geological borders (B), terrace upper edges (C) and anthropogenic terrace steps (D) and gravel plains: Pleistocene: older (a), middle (b) and younger (c) high terrace, lower terrace 1 (d) and 3 (e). Holocene: terrace 4 (f) and terrace 7 (g). Pleistocene lower terrace channel (h), Holocene paleo-meander (i) and valley filling of the Allach brook (j).

Figure 3 – Anthropogenic overprint in the form of open loam pits (a), completely filled loam pits (b), gravel pits (c), assumed gravel pits (d), land fills (e) and refilled bomb impacts of World War II (circles) in the centre of Straubing.

GIS BASED MAPPING OF DIMENSION STONES USED IN THE CENTRE OF STRAUBING

A further project was the setup of a GIS application for architectural objects with natural stone usage. This contribution to cultural geology was an absolute pilote project, since there is no preceeding work on this field.

The data acquisition started with a mapping of all sites, where natural stones were used as parts of private and public buildings, monuments, but also street pavements. The objects were then divided into different quality classes, depending on the contribution of natural stone elements to the appearance of the whole building.

Each stone object (ca. 1100) was then digitized and integrated in the maps of the municipal GIS. They are identified by charactistic symbols, connected to specific rock databases and there are links to fotographs of the objects (Fig. 4).

Special fields of mapping of stone objects were the St. Jakob basilica in the centre of Straubing, were numerous valuable epitaphs – mainly from Gothic times and altars consist of coloured limestones. Furtheron an inventory of the gravestones of the historic St. Peters cemetary was compiled. In this unique ensemble the most important types of monument stones from Bavaria are present. The rock determination of the gravestones were taken from GRIMM (1993) and NIEHAUS (1994).

All the natural stone objects are linked to a database with petrographic data and provenance information.

Figure 4 – Map of dimension stone objects in the centre of Straubing. The numbers refer to house numbers, the type of application is resembled by symbols .

The information drawn from cultural-geological investigations may not only be used by natural scientists, but also by architects, restorers, institutions involved in the protection of the cultural heritage and finally for touristic purposes. In Straubing guided “stone tours” are regularily offered (LEHRBERGER 2008). Further this information may be used for the interpretation of historical studies in the fields of the local and architectural history.

USE OF GEOLOGICAL DATA FOR THE MUNICIPAL AUTHORITIES

The case study of Straubing revealed a broad overview of the geological structure in the underground of the town. The data may be used for the urban planning activities as well as for special construction projects to yield information about possible contaminations, landfills, former brickearth and gravel pits (Fig. 5) or even the danger of blind bombs still present in the ground. The data can support activities in the field of preservation of cultural heritage, local history studies and even encourage teachers of the many different schools in Straubing to teach more “applied petrography” with examples easily accessible in the the town´s centre.

Figure 5 – The brick factory Jungmeier in the southern part of Straubing showing the extensive brickearth pits in the left background.

With its multiplicity of data, which extend historical and scientific up to economically important topics, it is also possible to establish a public information platform for the citizens of Straubing.

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“LEAVING THE UNIX-ICE FLOE”: THE MIGRATION OF GIS-BASED MAP PRODUCTION FROM ARCINFO™ WORKSTATION TO ARCGIS™ 9.x

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KEY WORDS: cartography, visualisation, fonts, styles, GIS, migration, geology, ArcGIS™.

INTRODUCTION

In 1990s, with the introduction of the UNIX-based geographical information system (GIS) ArcInfo™ Workstation at the Bavarian Geology Agency which is today the Bavarian Environment Agency (LfU), a high-quality workflow for map production had been established (For further information see the poster presentation “Visualizing geological data and managing quality in printed geological maps” by Toni Richtmann). Today, ArcInfo™ Workstation is considered an out-dated system. ESRI® has discontinued the further development of the system and consequently, related know-how at the Bavarian Environment Agency (LfU) is vanishing. Therefore, and for the purpose of an effective map production workflow, migration to the ArcGIS™ system – which has already been introduced in the LfU – has become inevitable.

Since 2007 the LfU cartography has been trying to leave the “melting UNIX-ice floe” and find its way to a forward-looking technological solution for its map production. This process leads to solutions as well as problems.

REQUIREMENTS AND RESTRICTIONS

The “Geological Map of Bavaria 1:25.000“ (GK25) represents the geological base-cartography of Bavaria (For further information see the poster presentation “Components of a geological map published by the Bavarian Environment Agency (LfU)" by Elke Grassmann). Thanks to its complexity it can be used as a reference for the old as well as the new production workflow. The complexity of the GK25 is the starting point to transfer map production into an ArcGIS™-workflow under consideration of the following requirements:

- No qualitative restrictions, compared to the old map production process
- Avoiding the need of data conversion during the process of data control and verification in cooperation with the geologists.
- PDF-Export of the produced data for process- and spot-colour offset printing
- Interconnectivity of GIS- and presentation data for as long as possible
- Simplification and partial automation of the workflow
- Working to the principle “What You See Is What You Get”

To realise the migration the following core tasks have been identified:

- Accomplishment of a pilot study on the preparation of high-quality printing data with ArcGIS™
- Transfer of ArcInfo™ symbols to ArcGIS™ symbol libraries
- Integration and test of the ArcGIS™ workflows in operational processes
- Successive partial automation of the workflow through in-house developments

Within the framework of the pilot study executed by ESRI®, the GK25 sheet “6741 Cham West” was prepared in an ArcGIS™-workflow right up to the production of a printable PDF. The conclusions drawn in the pilot study und the results of our own analysis are depicted in a possible workflow using ArcGIS™ and third party software (Figure 1). Some important results are described below.

THE DATA MODEL

In an ArcGIS™-Workflow the spatial data of the GK25 will be stored in ESRI®’s File Geodatabase. The Geodatabase (GDB) offers the possibility to formulate rules to check and preserve the topological integrity within and between point, line and polygon features. During the migration essential parts of the GK25 Data Model are transferred directly from the Coverage-Model to the GDB. In the GDB Data Model point, line and polygon features are separated.

Therefore it is necessary to store polygon borders twice. One version as a line feature class to represent the geological borders and their properties and a second version as a polygon feature class to represent the geological units. On the one hand there is still the problem to maintain the consistency between the two feature classes in a GDB during the process of digitisation.

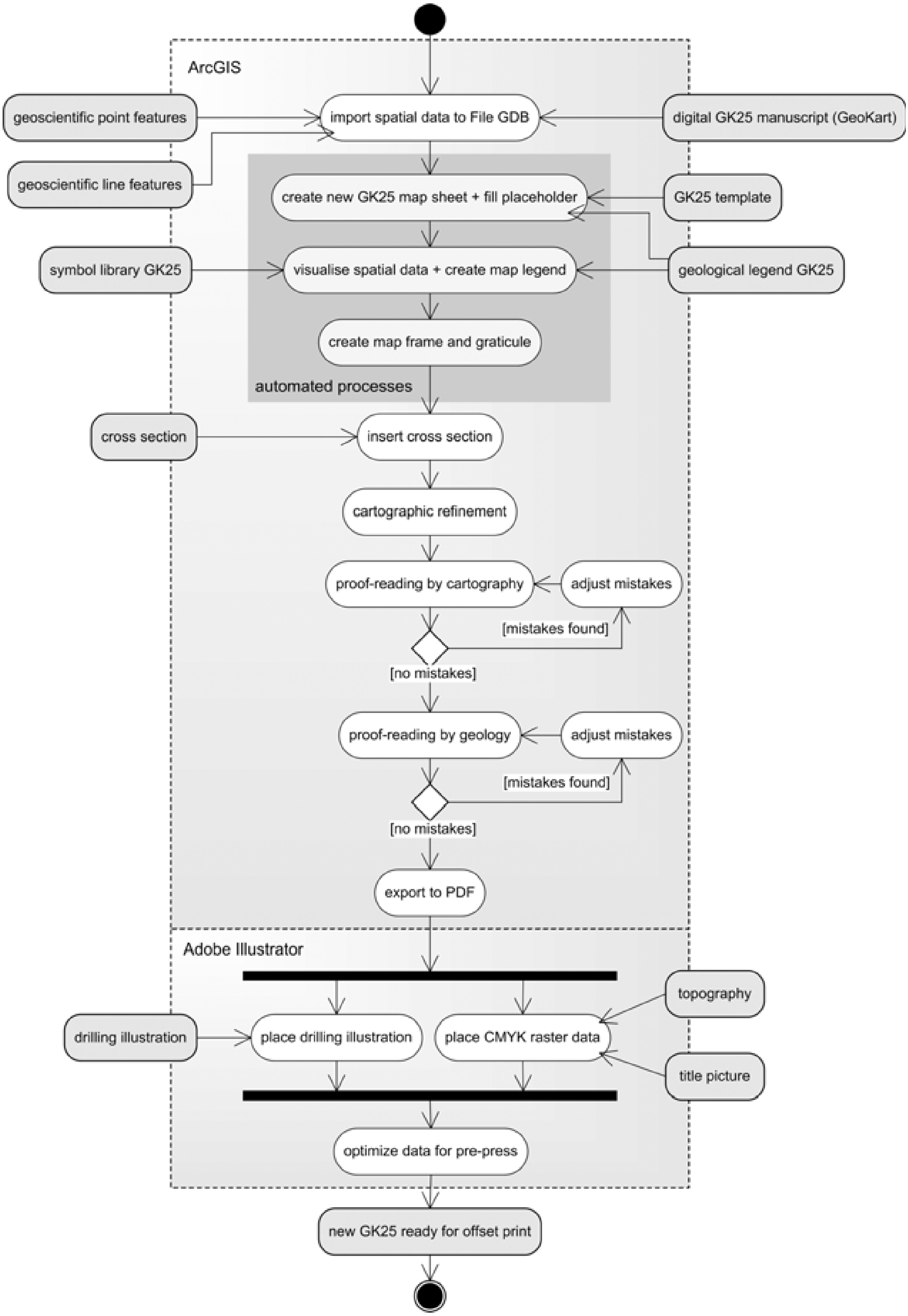

Figure 1 – ArcGIS™ based to-be-workflow with third party software Adobe Illustrator.

On the other hand further errors through external digitisation can be prevented by using domains and subtypes in the GDB. That means GDB has its advantages and disadvantages in comparison with ArcInfo™ Coverages.

CARTOGRAPHIC VISUALISATION

Symbol library GK25: To maintain the previous cartographic visualisation of the GK25 in an ArcGIS™- workflow it is necessary to transfer the complex symbol libraries from ArcInfo™ to ArcGIS™. Since the symbols in ArcInfo™ are based on an UNIX igl-font, a direct conversion into a format readable by ArcGIS™ is not possible.
Therefore, the system library must be reconstructed taking into account the existing symbol designs and dimensions. The pilot study has furthermore demonstrated that, besides cartographic restrictions, the use of multi-layer symbols entails performance problems. This problem can be solved by a combined use of own fonts and simple ArcGIS™-symbols.

Using the font editor "FontLab Studio 5", a workflow was developed which permitted to produce a True Type Font (TTF) for the visualisation of complex fill symbols (Figure 2). The symbol production and management is realised by using a central stored ArcGIS™ style-library.

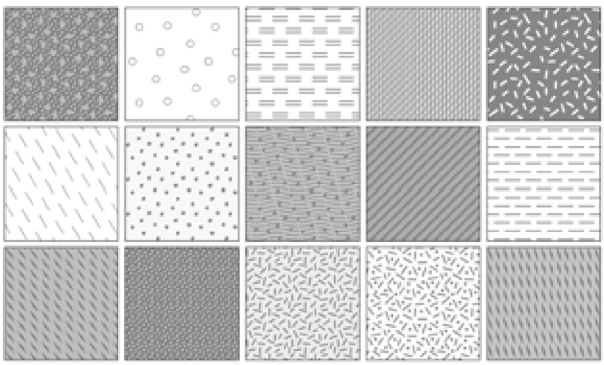

Figure 2 – complex font based fill symbols of the GK25 realised in ArcGIS™.

Cartographic optimisation: Since the release of ArcGIS™ 9.2 cartographic representation tools are available. With their help, legibility of maps can be optimised without changing the primary data. With respect to GK25-production the use of these tools would make sense for the optimisation of hash line symbols (e.g. tectonic faults), for the adjustment of fill symbols (e.g. small geological polygon features) or for keeping minimal distances (e.g. dip and strike strata symbol).

Legend generation: The standard tools of ArcGIS™ for legend generation fulfil some of the requirements of the GK25. However, practical application has shown that many settings must be adjusted manually. For GK25-production it would be preferable to connect the map legend with the GK25 geological legend. Thus the short and long description of geological units could be used directly in the map legend.

THE PRINTED MAP

In the course of migration the possibilities for process offset printing and spot coloured offset printing should be included. ArcGIS™ offers the possibility to define colours of vector data, bitmaps and grids in CMYK colour space and to export them as PDF. The definition and separation of spot-colours as well as essential features of pre-press, however, cannot be realised directly in ArcGIS™. Also, the integration of CMYK-raster data in map layout is problematic. Pre-press and the integration of raster data are therefore realised in Adobe® Illustrator®. This program offers all tools of classic DTP-production for preparing the data for printing. For spot colour printing the symbol colour of vector features can be defined as special CMYK-combinations. In Adobe® Illustrator® these features can be selected and transformed to spot-colours.

AUTOMATED PROCESSES

Some ArcGIS™ standard devices offer partial automations of certain work processes. Devices like the automated feature-labelling or the automated insertion of a map legend accelerate the cartographic production. This acceleration requires, however, the graphical revision of special cases. For the LfU cartography, the partial automation of the map layout, map frame, graticules as well as the map legend could be in the focus of future interest. The reason behind this is that during the process of corrections, it is very important that the geoscientists get a first draft of the map as close as possible to the final version. This can only be realized if the cartography has as little work as possible with such map elements. Due to the complexity of the map series manual reworks will be necessary to retain the quality and legibility of the GK25.

Many automated map production workflows show a decreasing cartographic quality. This can lead in the worst case, to spatial data being visualised while spatial information is lost. In other words, a high grade of automation will lead to a decreasing cartographic quality, if a reasonable cost-benefit ratio is to be maintained. Consequently, with the technical development of Geographic Information Systems a new challenge and chance to bridge the gap between automation and graphic quality arises for cartography. This should be kept in mind in the course of migration.

CONCLUSION AND FORECAST

The cartography of the Bavarian Environment Agency can currently produce simple map series and maps in an ArcGIS™-Workflow for digital print. The pilot study and internal analysis showed that a high quality map production including process- and spot-colour offset print is only possible in a combined workflow of ArcGIS™ and third party software.

Currently, different projects are running to substitute ArcInfo™ Workstation as the main tool of map production with ArcGIS™. The goal is to set up a workflow for high quality map production using standard tools of ArcGIS™ and third party software.

A long-term goal is to have a partially automated GK25-production and to transform the GK25 knowledge to other LfU map series. On the way to a partially automated GK25-workflow problems to solve include e.g. the design of a database-driven GK25 geological legend.

In summary, ArcGIS™ can be used to produce simple maps. To produce high quality maps like the GK25 for process or spot offset printing third party software like Adobe® Illustrator® is required.

APPLIED 3D GEOLOGICAL MODELLING IN THE MERSEY BASIN, NW ENGLAND

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KEY WORDS: 3D modelling, Mersey, NW England, Warrington.

Introduction

The River Mersey, NW England provided the focus for large scale industrial development principally during the 18th and 19th centuries. Rapid industrialisation associated with urban expansion and population growth has left a legacy of derelict and contaminated land and polluted groundwater.

The cities of Manchester, Salford and Liverpool on the banks of the Mersey are now the focus for major regeneration. Projects such as the Mersey Waterfront Development and the creation of the UK's first Media City in Salford will require up-to-date geoenvironmental information. The use and application of information about the properties of the sub-surface is critical to ensure that development takes place sustainably.

In NW England, the British Geological Survey (BGS) has developed 3D geological models of superficial deposits and bedrock units concentrated along a zone between Manchester in the east and Liverpool in the west, including Warrington in between (Lower Mersey Development Zone). This major urban development zone overlies the regionally important Sherwood Sandstone aquifer, which falls under Government legislation to control abstraction and pollution. 3D geological models have been developed to aid environmental decision-making to ensure that sustainable regeneration can be achieved.

Importantly, the 3D geological models also include artificial deposits. These deposits and excavations result from the activities of man and affect the physical properties of the shallow subsurface. Artificial deposits are often associated with highly variable ground conditions that may affect subsequent development. 3D geological modelling provides a powerful tool to enable the development of conceptual models to predict the variability of the shallow sub-surface and its properties prior to development. Potentially difficult ground conditions can therefore be anticipated and their presence incorporated into site investigation and development design.

This paper presents selected results of applied urban 3D geological modelling using Warrington, in the central part of the study area as a case study.

3D Geological Modelling of Superficial Deposits

3D geological models have been developed for superficial deposits and bedrock. This paper focuses on the development of models of natural and artificial superficial deposits overlying Permo-Triassic bedrock.

Seven main natural superficial deposits have been modelled using GSI3D™. Geological modelling of superficial deposits in the project area was carried out using GSI3D™ modelling software (Kessler et al., 2008). The software and its workflow allow the user to create 3D geological models by combining interpreted digital borehole data, Digital Terrain Models (DTMs) and digital geological maps to construct an intersecting grid of cross-sections. From the series of intersecting cross-sections, the surface and sub-surface distribution of each geological deposit is then defined and the geological model is calculated to derive the 3D distribution, geometry and elevation of each geological unit.

Over 850 borehole records within the National Geoscience Data centre at the BGS were interpreted geologically.

The results of 3D modelling in the Lower Mersey Development Zone have revealed a complex pattern of glacigenic, and post glacial sediments summarised in Table 1. An example of the completed 3D geological model for the Warrington area is shown in Figure 1.

3D Modelling of Artificial Deposits

Artificial deposits comprise deposits or excavations that result from man's modification of the landscape.

The Modelling artificial deposits in GSI3D™ uses a range of historic datasets including…

- Data are captured in GIS format, classified as Made, Worked, Landscaped, Infilled or Disturbed Ground (Powell et al., 1999; Ford et al.,

2006) and attributed with the source and age of data

- The data is then modelled in GSI3D™ using borehole information to define the base of Made and Worked Ground and subtracting them from the DTM, with the 2D artificial ground polygons delineating the areas.

	Geological Unit	Thickness (m)	Lithology	Environment (inferred)
Holocene	Artificial Deposits	0-5	Mixed	Anthropogenic (Artificial Deposits)
	Alluvium	0-3	Sand or peaty sand	Fluvial
	Peat	3-5	Peat	Organic
	Shirdley Hill Sand Formation	0-2	Sand	Aeolian
	Buried Peat	0-2	Peat	Organic
Pleistocene (Devensian)	Intra-till lenses	<1->10	Sand and gravel	Sub-glacial and supra-glacial drainage associated with glacial ice
	Till	<7	Gravelly clay with thin interbedded sands and silts	Sub-, supra- and intra-glacial
	Basal glaciofluvial deposits	<9	Sand and gravel	Sub-glacial drainage

Table 1. Summary of Superficial Deposits in Warrington.

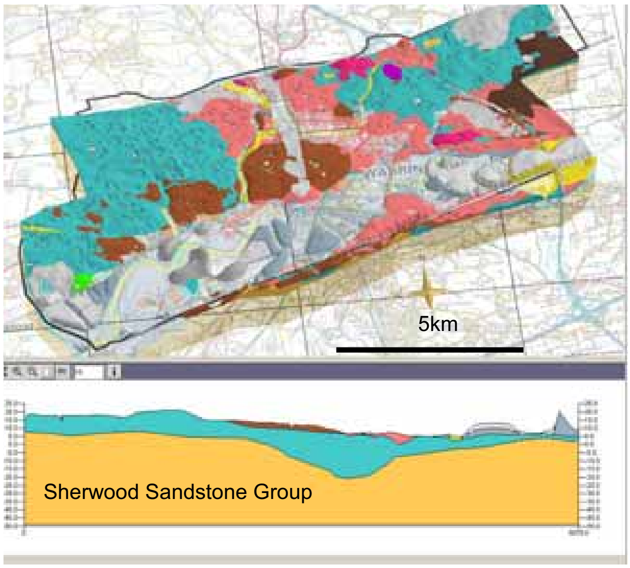

Figure 1 – 3D geological model and synthetic cross-section, Warrignton, UK. Blue – Till, Pink – Glaciofluvial Sand and Gravel, Dark Grey – Intertidal Deposits, Brown – Shirdley Hill Sand, Light Grey – Artificial Deposits. © Crown Copyright. All rights reserved. 100017897/2009.

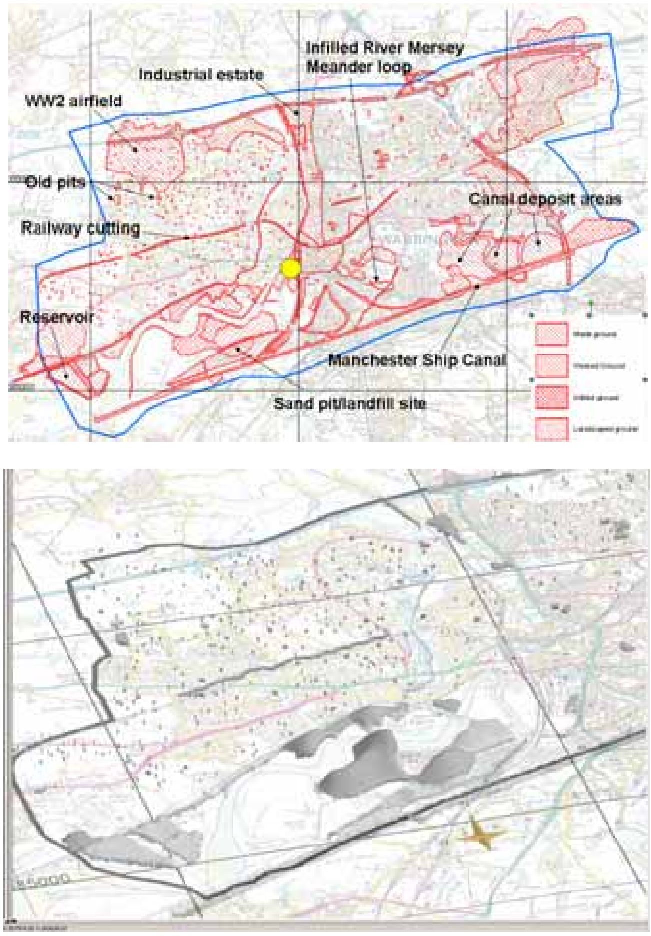

Figure 2 - Artificial Deposits modelling in 2D and 3D. © Crown Copyright. All rights reserved. 100017897/2009.

Conclusions

3D geological modelling using GSI3D™ provides a powerful tool to unravel the 3D geological and anthropogenic evolution of major UK urban areas.

It allows the 3D characterisation of the shallow sub-surface, including deposits and excavations relating to the activity of humans.

By applying 3D geological models of the shallow urban sub-surface, ground conditions and their properties can be used to support planning and sustainable development.

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AREAS SUBJECTED TO DEBRIS FLOW PHENOMENA IN FRIULI VENEZIA GIULIA ALPS.

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KEY WORDS: debris flow, Flo-2D, P.A.I. plan.

INTRODUCTION

Val Canale Valley is located in the Italian Julian Alps, in the North Eastern corner of Friuli Venezia Giulia Region. On 29th August 2003 the area has been invested by a strong intensity rainfall event (Pontebba's rain gauge station, recorded the highest rainfall depths: 389,6 mm in 12 hours, characterised by return periods in the 200 and 500 years for 12-h periods) that caused the death of two persons, 300 displaced and 260 damaged houses and substantial damages to infrastructures that were made unavailable for several days. The mobilization of more than a thousand of landslides occurred along the sides of the involved valley.

In collaboration with the Geological Service of Friuli Venezia Giulia Region and with the contribution, for the input data, of the Department of Territory and Sour-Forest Systems of the University of Padova, we investigated twelve river basins located in the studied valley with different geological-geomorphological and rheological characteristics. In order to better delineate the perimeter of the invested areas, to zone them according to the law D.L.L. 180/98 and to create new building zones (updating of the pre-existing Piano Stralcio per l'Assetto Idorgeologico, called P.A.I. plan) studies have been made over every single watershed.

The main objective of the paper has been to obtain, though a simulation model (that used Flo-2d software), a depositional map of every event occurred. After the simulation each area has been analyzed trough the Buwal method, obtaining a zonation of the investigated territory (P1, P2, P3, P4). All the data has been than imported into a GIS software and has been given to Local Authorities for further urban planning. Infact the use of simulations seems to be a useful tool. Its employ provides a qualitative global knowledge to support Authority decisions on intervention on the analyzed realty. Simulations represent only a first approach of study that has to be implemented in function of the single different user. The obtained output is an instrument as a DSS (Decision Support Systems) that gives the possibility to investigate the environment and the phenomena that characterize the reality and to promote a more aware use of the territory.

THE METEOROLOGICAL EVENT

The area of Val Canale as the whole northeastern part of Friuli Venezia Giulia Region, was invested by a high intensity rainfall on the 29th August 2003. The rainfall started at 12 a.m., firstly affecting the areas belonging to the upper sector of the mountains among Cucco, Malborghetto's huts and Ugovizza, then it gradually moved downwards with gradually increasing intensity.

A total value of 293 mm rainfall was recorded by the Pontebba pluviometric station from 2 to 6 p.m. This instrument is part of the network managed by the Regional Directorate of Civil Defence. Data are available at an interval time of 30 minutes. Maximum values of 50,8 mm in 30 minutes (between 5 and 5.30 p.m.), 88.6 mm per hour (from 3.30 to 4.30 p.m), 233.4 mm in three hours (between 2.30 and 5.30 p.m.) and 343.0 in six hours (from 12 a.m. to 6 p.m.) were observed. The total influx of meteoric event, which lasted about 12 hours, was equal to 389.6 mm.

The event has been thoroughly studied by Norbiato et al. (2007): radar and a raingauge observations are used to characterize the storm event.

Rainfall maxima from the Pontebba station, situated nearly the interested area, were characterized by return periods in the range 200-500 years for 1-h and 24 h, and in the range 500-100 years for 3-h, 6-h and 12-h durations (Norbiato et al., 2007).

METHODOLOGY

To simulate the debris flow events were adopted the commercial software Flo-2D, widely used worldwide. This code is used to simulate the path of a debris flow developed on alluvial Alpine fans and to outline the relative hazard expansion areas. Flo-2D is a 2-dimensional flood routing model of volume conservation that routes a flood hydrograph while predicting floodwave attenuation due to flood storage. Hyper concentrated sediment flow is simulated by the Flo-2D model using a quadratic rheological model that includes viscous stress, yield stress, turbulence and dispersive stress terms as a function of sediment concentration. The model uses the full dynamic wave momentum equation and a central finite difference routing scheme with eight potential flow directions to predict the progression of a flood hydrograph over a system of square grid elements. Wave propagation is fully controlled by topography and roughness or resistance to flow. The model is suitable to simulate flooding of rivers and can also be used to analyze problems of flood flows as unconventional not confined on alluvial fan with complex topography, mud flow and debris flow, and floods event affecting urban areas. Flo-2D model is an effective tool for the evaluation of hazard floods event and planning for mitigation measures. The fully developed debris flow can be modelled using rheological parameters defined by O'Brien & Julien in 1988.

In order to obtain good quality simulations, great importance should be given to the topographical input parameters. The initial development was done through the GIS Arcmap. Arcmap software was used to define the digital terrain model (DTM). Depending on the available data. In this case, DEM was generated from the data of the Technical Numerical Regional Chart at scale 1:5000 or, where available, by data from surveys realized with laser scanner technique. From these input data were created raster file (ascii format) with square cell of 5 m.

After importing data into the GDS input interface, it was chosen the input point for the hydrograph, and the outpoint that permitted the flow to come out from the computational domain. Typically those points coincide with a river, or with a road, or with a low morphologic place.

The choices of input parameters is very important. Every single basin has its own input hydrograph.

The great job that the Department of Land and Agroforest Environment of the University of Padova made, helped us a lot in recreating the storming conditions that characterized that day and the days before the event. With the given hydrograph we had the possibility to create the curve that branded the concentration by volume (C_v). Its range vary from 0.2 to 0.65 as maximum value.

The rheological parameters that have been used for the back analysis of the twelve studied basins, were obtained from literature. Eleven couple of rheological parameters (viscosity and yield stress) were used to recreate the scenario of the 29th of August. After simulating the phenomena, for each basin has been chosen the simulation that better fits the event occurred. The choice has been made keeping into account the thickness of the deposits measured on field just after the event and their dispersal along the depositional fans.

So, only one couple of rheological parameters is characteristic of a single event and usable for further simulations. These values have been used to simulate a new event with different characteristics (e.g. different hydrograph) on the new topography. New topography means that has been created a new DTM on the topography acquired by laser scanner technique after the stormy event. This new DTM has the debris deposits left on the plains and channels and the mitigation measures realized in every single studied basin. This permitted to have, for each basin, a new scenario of possible stormy events highlighting the hazard of each realty.

ANALYSES AND VALUTATION OF THE RESIDUAL HAZARD

The assessment procedure for hazard refers to what has been prepared by the Bundesamt für Umwelt, Wald und Landschaft (BUWAL) of the Swiss Confederation (ndr Swiss method) – (Raetzo, 2002). This methodology is similar to what provided by the Italian legislation in force on the hydrological risk assessment. Appropriate changes have been introduced in order to standardize these aspects and contextualize the method to the territorial jurisdiction. This method lets you choose to rely on simplified patterns that, while suffering from severe approximations, on the other hand constitute a common basis of reference on which all stakeholders can easily compare.

The Swiss method allows you to combine through a matrix of probability, values of occurrence and intensity of phenomena in order to obtain, with a good objective, the definition of dangerousness. The parameters assigned to these factors (1 to 3 for speed and geometric severity; 1 ÷ 9 for magnitude) as the input matrices in speed/frequency and probable magnitude/frequency likely to allow the allocation of the hazard class. (Autorità di Bacino dei fiumi Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione, 2007).

In this study we wanted to make a model which could simulate the possible different scenarios by providing a perimetration, the estimated detailed volume and a thickness of deposits. These data were processed with countouring operations, taking into account the defense works carried out in order to determine the magnitude of various phenomena, from which were subsequently obtained hazard classes (P1, P2, P3, P4).

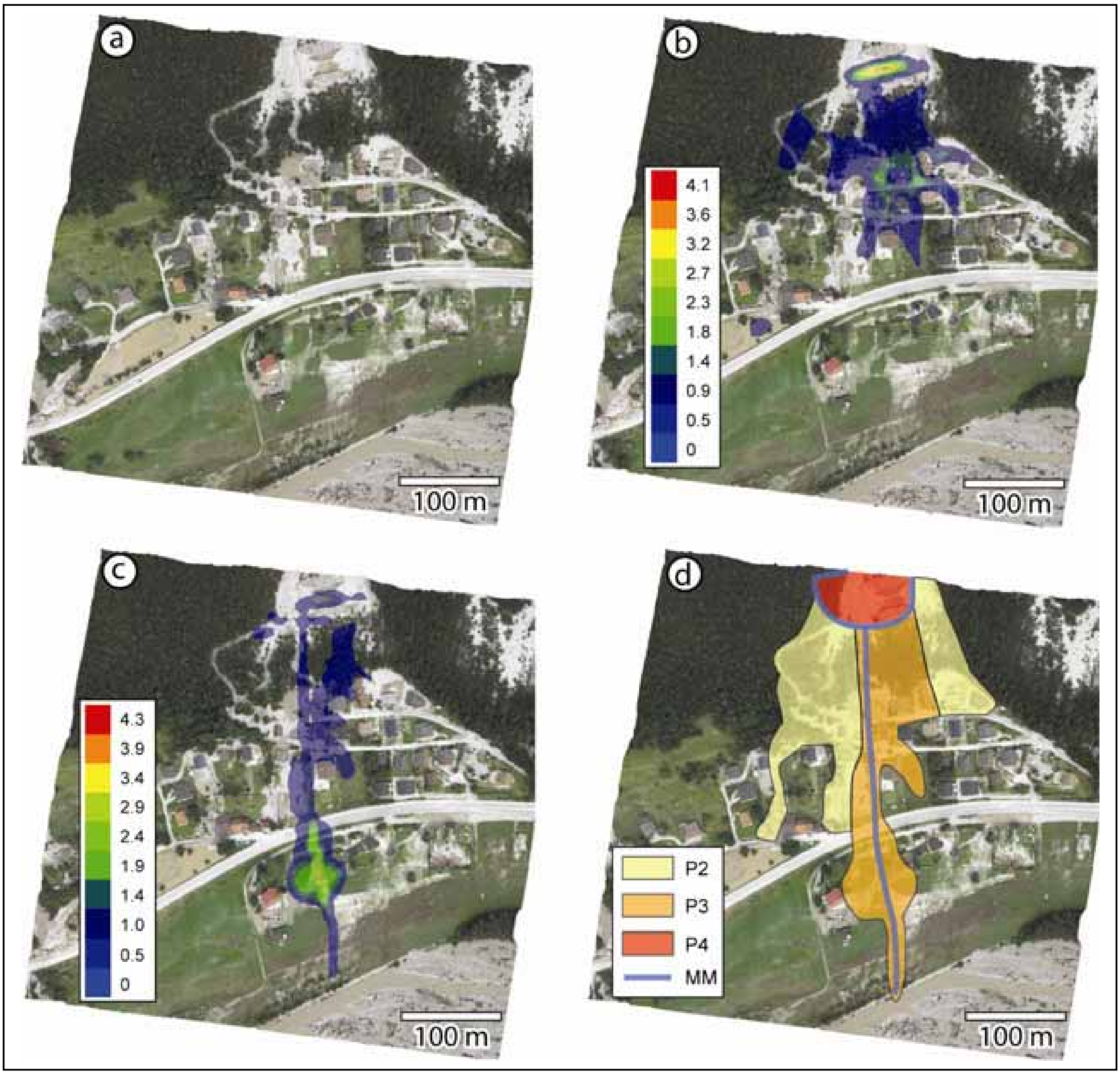

Figure 1 – a) Investigated area. b) Best back analysis simulation. c) Simulation with mitigation measures (MM). d) Hazard areas decided with Buwal method.

CONCLUSIONS

The use of simulations seems to be a useful tool. Their employ provide a qualitative global knowledge to support Authority decisions on intervention on the analyzed realty. Simulations represent only a first approach of study that has to be implemented in function of the single different user. The obtained output is an instrument as a DSS (Decision Support Systems) that gives the possibility to investigate the environment and the phenomena that characterize the reality and to promote a more aware use of the territory.

CREDITS

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3D ATTRIBUTED GEOSCIENCE MODELS AND RELATED GIS DATASETS TO ASSIST URBAN REGENERATION AND RESOLVE ENVIRONMENTAL PROBLEMS IN AND AROUND THE GLASGOW CONURBATION, UK

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KEY WORDS: Glasgow, Clyde, regeneration. 3D models, uncertainty, GIS, groundwater, leaching, engineering.

INTRODUCTION

Against the backdrop of global climate change and an increasing focus on sustainable development, there is a critical need to improve modelling, and especially time series modelling, of earth processes.

The British Geological Survey (BGS) is addressing this need by building on the platform of its existing spatial 3-dimensional modelling capability, to develop a UK-wide multidisciplinary, and potentially transdisciplinary, 'Environmental Impacts Modelling Platform'.

The BGS's existing 3D models are at a variety of resolutions, from national to regional and local. They focus on lithology, stratigraphy and structure, and are attributed with physical (e.g. engineering) and chemical properties, and can act as the platform for further modelling activities such as numerical modelling of groundwater. They are increasingly used in urban areas to solve geoscience problems and to improve the understanding of environmental processes; for example contaminant migration through soils, surface water and groundwater interaction, and mining hazards, within the 'Zone of Human Influence'. There is also a growing emphasis on the evaluation and communication of uncertainty in data and interpretations within the models.

These aims and aspirations fit closely to the strategic data needs and knowledge requirements of many large-scale and long-term urban regeneration projects being undertaken in areas of former industrial decline in parts of the UK.

The Clyde Corridor, which passes through the heart of the Glasgow conurbation, and which encompasses the areas covered by the Clyde Gateway and Clyde Waterfront initiatives, is the national regeneration priority for Scotland for the medium term (up to approximately 25 years). The regeneration is intended to stimulate economic growth on a national scale, drive smaller community regeneration projects, and tackle concentrated deprivation in key areas of Scotland (Scottish Executive, 2006), which has stemmed from industrial decline.

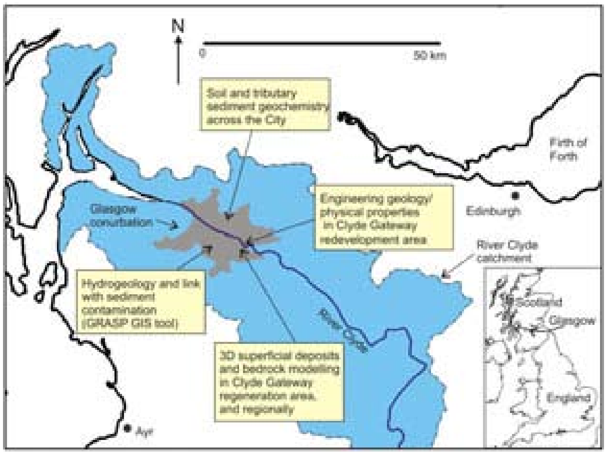

Figure 1 – Location of the Clyde catchment and Glasgow conurbation with some of the available multidisciplinary datasets. .OS topography © Crown Copyright. All rights reserved. 100017897/2009.

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The Scottish Government (Scottish Executive, 2006) has emphasised that successful regeneration requires the public and private sectors to work together at all levels, and with the communities themselves, to create real change (economic and social), with local authorities being the key strategic player on the ground. This ties in with a key component of the British Geological

Survey's strategy (British Geological Survey, 2009) which emphasises the need for effective partnerships with its stakeholders (government, their agencies, universities, commerce and the public) so that it can continue to acquire, collate and provide comprehensive and authoritative geoscience data and knowledge as the basis for the research and modelling that it and others carry out.

Consequently, the BGS with local authority partners including Glasgow City Council, is developing integrated and attributed Dynamic Shallow Earth 3D Models and comprehensive geoscientific databases of the Glasgow conurbation and the surrounding catchment of the River Clyde. This is being achieved through a major multidisciplinary project (the Clyde Urban Super-Project (CUSP)), and more specifically, through the development of the Clyde Gateway 3D pilot geological model. The latter covers key sites such as the Clyde Gateway regeneration area, major new road and motorway extension projects, and the venues and related infrastructure for a major sporting event, the Commonwealth Games, in 2014.

The models and datasets under development will provide planners and developers in the Glasgow area with up-to-date, accessible environmental and engineering geoscience data and knowledge for regeneration areas. They will enable improved understanding of: the "Zone of Human Interaction", impacts of urban land use on ecosystem services; and environmental change at local to regional scales.

SUPERFICIAL DEPOSITS AND BEDROCK MODELS

The Glasgow models synthesise available digital data from boreholes, geological maps, mine plans (related to the extensive 19th and 20th century coal and ironstone mining) and terrain models. Local to regional scale (1:10,000 to 1 50,000) detailed models, which focus on characterising the near-surface superficial (including anthropogenic) deposits and shallow bedrock (less than 200m depth) (Kessler *et al*. 2005), are generally considered to be of most use in urban planning and development.

BGS uses GSI3D (©Insight GmbH) software to build the models of the superficial deposits and artificial ground in the Glasgow area. The superficial deposit sequences are relatively complex. They reflect successive advance and retreat of ice sheets, several marine inundations during and since the last glaciation, the development of terraces, the deposition of estuarine sediments, and local lakes, the latter commonly infilled partly by peat deposits. As a result, therefore, within the Clyde Gateway Pilot 3D geological model (Figure 2), 15 units have been identified and modelled. Some are only of very local distribution or of very variable thickness, whereas others are widespread.

The GSI3D method utilises a digital terrain model, geological surface outcrops and down-hole coded borehole data to enable the geologist to correlate between boreholes and the outcrops, or subcrops, of geological units, and to construct intersecting cross-sections (fence diagrams). The cross-sections and geological envelopes (limits of the geological surfaces) are then used to build a surface in the GSI3D model (calculation by the triangulation method). Models can additionally be attributed with geotechnical, hydrogeological and other properties and are then published in the Subsurface Viewer. This is an easy-to-use, intuitive, and interactive model-viewing tool which can create:

- Models displaying the geology or other pre-selected applied themes (e.g. hydrogeological properties)
- Geological maps (at surface and uncovered)
- User defined synthetic borehole logs
- User defined synthetic horizontal and vertical sections
- Visualisation of the geometry of single and combined units
- Model and map exports to ArcGIS© and hardcopy

These can be used in linear route assessment, in planning and refining development footprints, and in planning site investigations. With the addition of new site investigation data and revision of the model, a ground model of the site can be created.

The 3D geological model is, therefore, a powerful predictive tool and time saving asset that assimilates large amounts of urban geodata into one easy-to-use package. However, it must not be regarded as a substitute for detailed site investigation.

The Carboniferous bedrock which underlies the Glasgow area comprises simply folded and complexly faulted strata. The strata comprise mainly cyclic sandstones and mudstones with limestones, coals, ironstones and seatrocks. The coal seams and other stratigraphic boundaries included in the bedrock model (six layers in total) were recognised and modelled from sub-surface data (boreholes and mine plans) of varying data densities. The surfaces and faults were modelled using GoCAD™ software (Figure 3), a commercial 3D modelling package used widely in the hydrocarbon industry. The surfaces were then exported to GSI3D and embedded in the Subsurface Viewer.

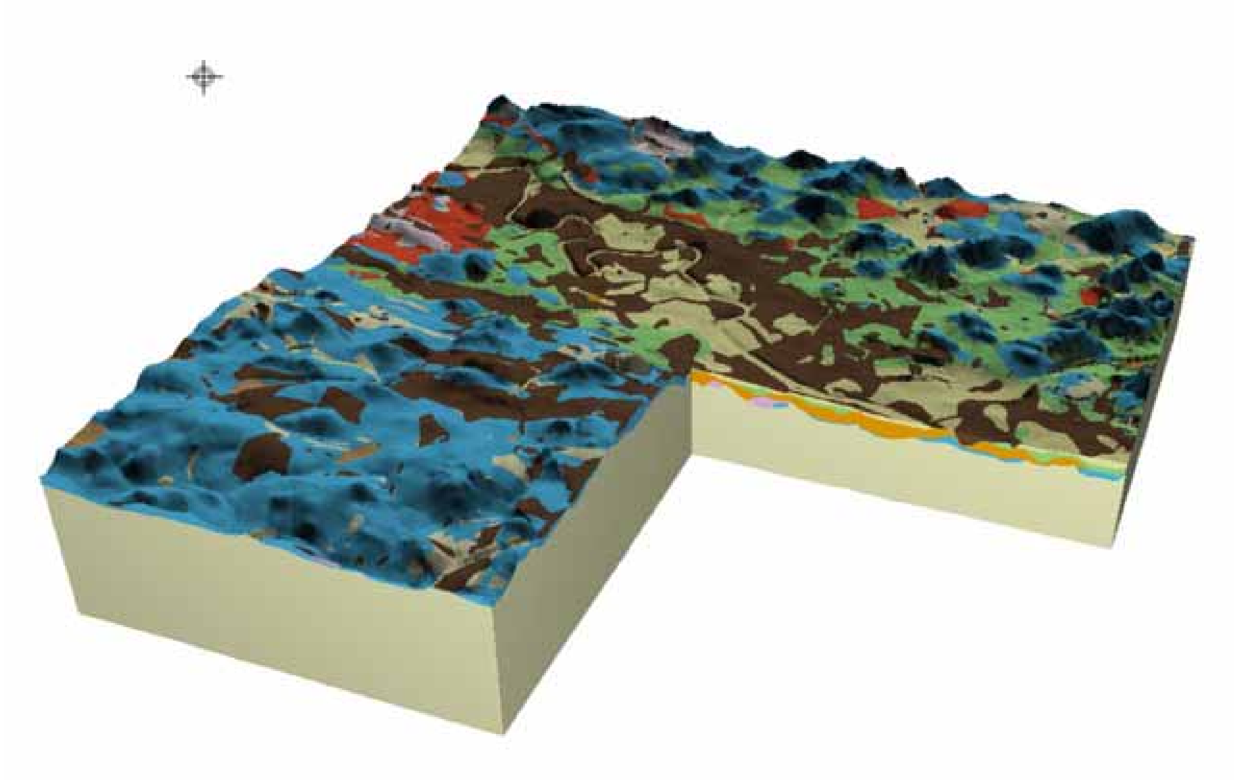

Figure 2 – Clyde Gateway Pilot 3D superficial deposits model, looking southeast (area 10km x 10km, vertical exaggeration x5)

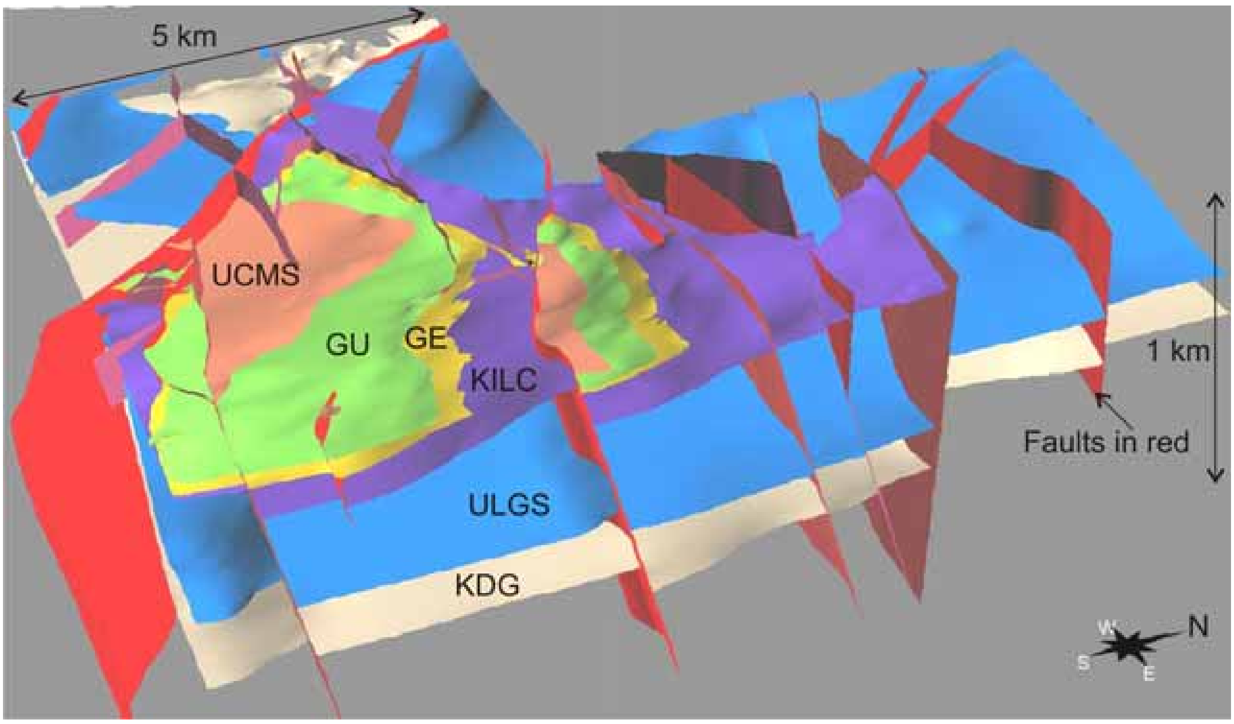

Figure 3 – Clyde Gateway Pilot 3D Bedrock model, looking west (vertical exaggeration x3).

As shallow mineworkings are often an issue for planning and redevelopment, the faulted coal seam surface models, combined with areas of known and probable areas of mineworkings, provide an improved digital dataset to determine the extent and depth of this potential hazard.

The models provide a framework for further modelling, for example of groundwater conditions. However, while bulk attributions of these 3D geological models are useful for portraying general properties, such as engineering geological (Merritt *et al*., 2006) or hydrogeological (Kessler *et al*., 2005) characteristics of the area, they do not portray the inherent variability of each unit needed for more site-specific considerations. Insufficient data are available on the variability of units for more detailed, cellular (voxel) attribution. Therefore, a range of GIS methods has also been developed to present and interrogate the geodata (Entwisle *et al*., 2008).

MODEL UNCERTAINTY

Uncertainty of each modelled layer is calculated using the BGS confidence calculator v1.2. This combines measurements of data density and geological complexity from an input Microsoft Excel® data file and ASCII modelled horizon grid. The superficial uncertainty layers are supplied as ArcGIS© 9.2 raster grid format and in the GSI3D subsurface viewer.

The data density factor for the model includes assessments of the distribution of borehole, mining and map data. An influence distance of 200 m and a scale of 0.5 -100 were used to calculate the data density uncertainty. A grid of 100 by 100 with 500 iterations was used to calculate the geological complexity uncertainty. Together with the geological complexity weighting, the model uncertainty is greatest where there is little data and where the surface dip changes rapidly. The output is a grid file ranked from *relative* low to *relative* high uncertainty.

The relative, combined uncertainty scale must be translated by the user into uncertainty categories, with the lowest number representing the lowest uncertainty and the highest number the highest uncertainty. For example, for models in the Glasgow conurbation, 5 categories could be considered. In ArcGIS© this would be easy to achieve on the uncertainty raster grid by symbolising using 5 classes.

Lowest uncertainty (highest confidence) areas (=1) would be those that are well constrained by geological data and where the geology is relatively simple. In these areas, the error on the bedrock model might be considered to be of the order of ± 10m in XYZ. For example, those areas of the Wilderness Till Formation (WITI) uncertainty surface on Figure 4 that are blue.

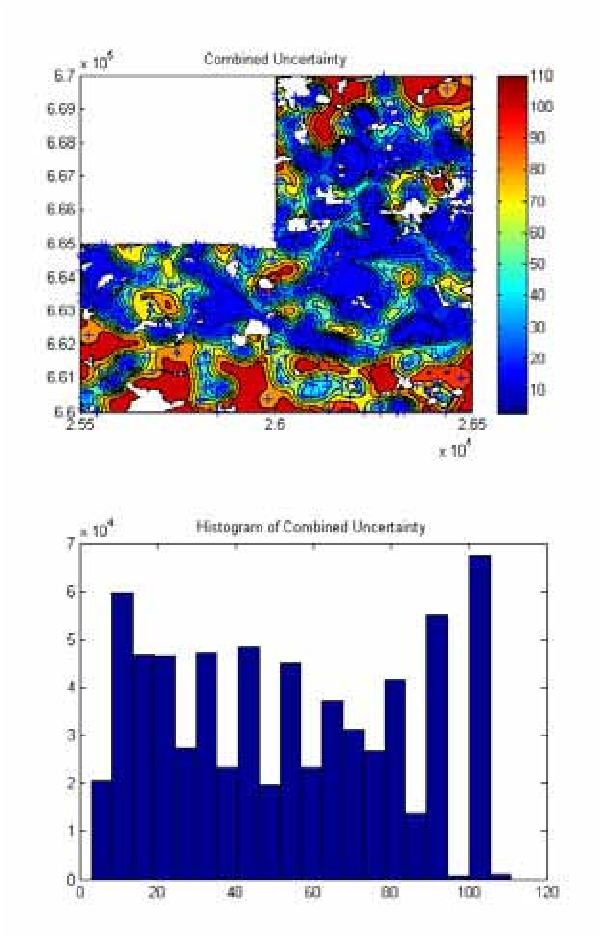

Figure 4 – Clyde Gateway Pilot 3D Geological Model; combined model uncertainty for the Wilderness Till Formation (WITI); area as in Figure 2.

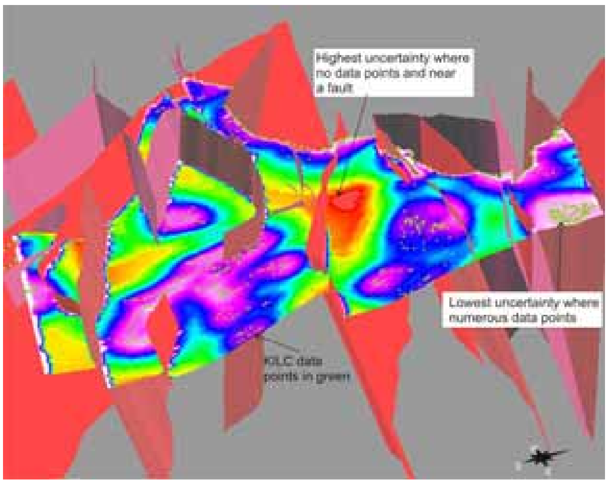

Figure 5 – Clyde Gateway Pilot 3D Geological Model; combined model uncertainty for Kiltongue Coal seam draped on the geological surface in GOCAD™.

Average uncertainty (average confidence) areas (= 3) would be those constrained by some geological data and where the bedrock geology is moderately complex i.e. faulted or folded (or variable thickness with superficial deposits). In these areas, the error on the model might be considered to be of the order of ± 30m in XYZ.

Highest uncertainty (lowest confidence) areas (= 5) would be areas not constrained by any geological data and where the geology is complex i.e. faulted or folded. In these, the error on the bedrock model might be c..± 70m in XYZ. For example those areas of the WITI uncertainty surface on Figure 5 that are red to orange.

GROUNDWATER

Preliminary groundwater modelling in the Glasgow area is concentrating on the hydrogeology of the superficial deposits aquifer(s), in the Clyde Gateway area. The modelling is based on the Pilot 3D (GSI3D) Geological Model of the project area. This has been greatly rationalised in view of the limited availability of groundwater level data for superficial deposits aquifers, and particularly time-series data.

A conceptual model has been built based on 3D aquifer geology prepared using the GSI3D model. The groundwater flow model ZOOMQ3D is used to simulate the groundwater heads. A purpose-written tool is used to convert data from GSI3D to ZOOMQ3D. The ZOOM family of numerical groundwater models consists of the saturated groundwater flow model ZOOMQ3D (Jackson and Spink 2004), an advective transport particle tracking code ZOOPT (Jackson 2004) and a distributed recharge model ZOODRM (Mansour and Hughes 2004). All these models are created using a pre-processor called ZETUP and spatial input files from a GIS (Jackson and Spink 2004). ZOOM was developed using object-oriented techniques, a programming approach commonly applied in commercial software development but only relatively recently adopted in numerical modelling for scientific analysis. The main feature of the ZOOM models is that of grid refinement, so that any number of linked finite-difference grids can be used to zoom in on a particular part of the groundwater system.

Groundwater recharge is calculated using the ZOODRM model. This model uses distributed rainfall, evaporation and land-use data to calculate recharge using the soil moisture deficit method (Penman, 1948; Grindley, 1967). The recharge model also incorporates overland water routing to rivers, leakages from pressurised water mains, and has been updated to account for recharge processes in urban areas. Recharge values are passed as one of the inputs to the flow model. Other inputs include hydrogeological, geological and hydrological data including river/stream flows, groundwater levels, and soil, artificial ground, superficial deposits and bedrock properties including permeability. A preliminary, unvalidated steady state run is obtained from the groundwater flow model to predict groundwater levels in the superficial deposits. Where groundwater level data are available, these have been used to constrain the model. The steady state model can then be used to undertake predictions of the impact of particular scenarios, such as the impact of Sustainable Urban Drainage Schemes (SUDS), or an increased number of soakaways for storm water discharge, climatic variations, or groundwater abstraction.

Some results of the groundwater modelling, including modelled groundwater levels under the various scenarios, are exported from ZOOM and displayed within GSI3D. Other outputs including predicted groundwater discharges to surface waters are displayed as appropriate, in ArcGIS®.

At this stage, only an unvalidated groundwater model has been developed. Such a model should be viewed as a 'type' model, illustrative of the type of groundwater system that is believed to exist in the Clyde Gateway area. As more data become available subsequently, they will be used to validate the model and to develop it further.

A PRELIMINARY GIS-TOOL TO ASSESS THREATS TO SHALLOW GROUNDWATER QUALITY FROM SOIL POLLUTANTS (GRASP)

A GIS-based prioritisation tool known as GRASP (GRoundwater And Soil Pollutants) has also been developed and trialled in and around the Glasgow conurbation (O'Dochartaigh *et al.*, 2009). It is intended to aid urban planning and sustainable development by providing a broad-scale assessment of threats to groundwater quality across the conurbation. Hence, it can assist in the protection of groundwater as required by the European Union Water Framework Directive (2000/60/EC) and the Groundwater Daughter Directive (2006/118/EC).

GRASP identifies areas where shallow groundwater quality is at greatest threat from the leaching and downward movement of potentially harmful metals in the soil. Metal contamination is a known problem in Glasgow, and this is especially so with respect to Chromium.

GRASP is a development of an existing British Standard – International Standards Organisation methodology to determine the leaching potential of metals from soils, and which has been validated for 11 metals: Al, Fe, Cd, Co, Cr, Cu, Hg, Ni, Mn, Pb and Zn (BS-ISO 15175:2004). The GRASP tool combines in addition assessments of soil leaching potential with soil metal content data to highlight threats to shallow groundwater quality.

The input parameters for GRASP (soil pH, clay content, organic matter, sesquioxide and metal content) are based on the systematic geochemical dataset of 1600 soils (4 per km^2) collected across Glasgow as part of the BGS Geochemical Baseline Survey of the Environment (G-BASE) project. These parameters are combined with assessments of climate, groundwater levels and the leaching potential of unsaturated Quaternary (including Anthropogenic) deposits to produce maps that prioritise likely threats to shallow groundwater quality. Data processing for the GRASP methodology is carried out in five steps in Microsoft Excel®, using Visual Basic® programming language, and ArcGIS® software.

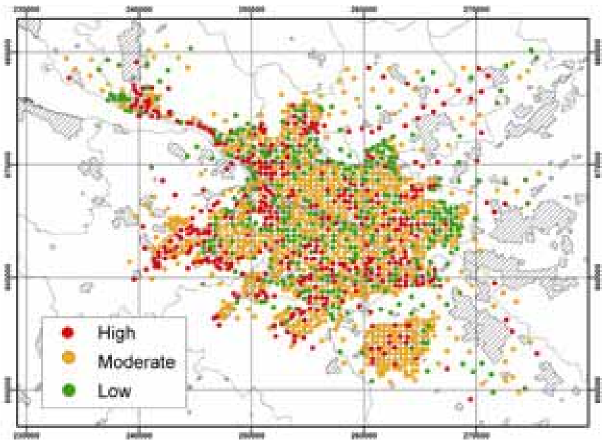

Figure 6 – GRASP prioritisation rankings for the Glasgow conurbation. OS topography © Crown Copyright. All rights reserved. 100017897/2009.

CONCLUSIONS

The attributed 3D geological model and GIS tools and outputs allow visualization of the geology and a wide range of geodata as cross-sections, plots, and graphs which characterize modelled unit variability. These can be used to communicate to both specialists and non-specialists alike a broad range of geological information.

The integration of information from the 3D model with GIS provides a powerful desk study tool to aid planning in general, and the planning of ground investigations in particular, and so can be an important aid to achieving sustainable urban development.

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FROM THE CARG PROJECT – GEOLOGICAL MAP OF ITALY, 1:50,000 SCALE – TO 3D GEOLOGICAL MODELLING

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KEY WORDS: CARG Project, geological map, geological database, three-dimensional geological modelling.

NATIONAL GEOLOGICAL MAP AT 1:50,000 SCALE - CARG PROJECT

The Geological Survey of Italy (Servizio Geologico d'Italia – SGI) realizes the national geological map at 1:50,000 scale - CARG Project, in cooperation with territorial organizations, research institutions and universities.

The CARG Project involves about 60 structures including territorial organizations (Regions and Autonomous Provinces), CNR (National Research Council), University Departments and Institutes. 1200 operators work at the project: project managers, scientific coordinators, surveying directors, field geologists, analysts, cartographers and administrators.

The rules and the financial frame arranged, since the end of the 80s, by means of many bills (fig. 1), provided altogether approximately 81,259,000 Euro outlaid for: production and informatization of 255 geological maps at 1:50,000 scale; 14 geothematical maps at 1:50,000 scale; 7 marine geology maps at 1:250,000 scale of the Adriatic coastal areas; 1 morphobathymetric map of the Tyrrhenian Sea; part of the Deep Crust Project (CROP 11); management of the geological database, its integration, methodological and prescriptive testing (LETTIERI et al., 2008).

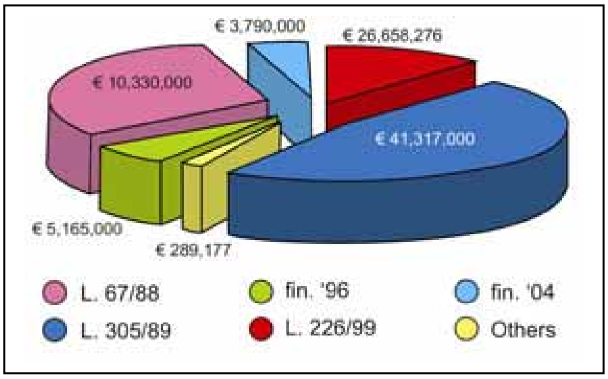

Figure 1 – CARG Project: funding distribution.

In order to attain a homogeneous and organised project, the SGI, with the effective collaboration of CNR and Universities experts, published the guides to the survey.

CARG guide lines can be consulted at the ISPRA web site: www.apat.gov.it.

Of about the 255 geological maps financed 148 have been completed so far (both printed and in press) and 107 are still in progress (Fig.2); these maps can be consulted at the APAT web site address: www.apat.gov.it/Media/carg/index.html.

The CARG Project has introduced some important innovations compared with the previous national geological map project (at 1:100,000 scale); first of all the realization of a geological database (1:25,000 scale) where both surface and subsurface data collected for the realization of each geological sheet are stored and organized in accordance with the logical scheme defined in specific guide lines. Moreover, in the frame of the CARG Project, survey of lacustrine areas and of marine areas falling within the borders of the geological sheets at 1:50,000 scale is planned and Unconformity bounded stratigraphic units (UBSU) have been applied.

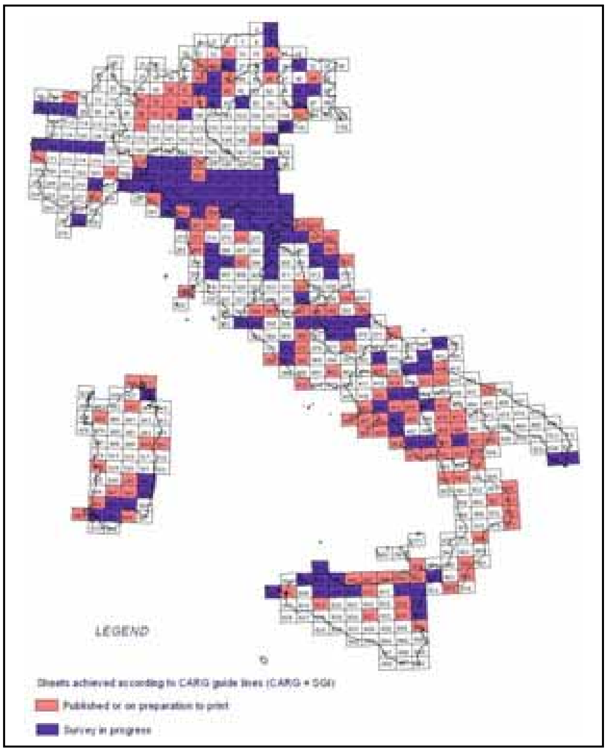

Figure 2 – CARG Project: state of the art.

Extensive geological survey and mapping of the Quaternary deposits have been introduced in the CARG Project. Lithologies and depositional systems are differentiated and mapped into the geological sheet, UBSU are used both for continental and volcanic deposits, a subsoil sheet is carried out in some plain areas.

CARG DATABASE

One of the main achievements of the CARG Project is the realization of a geological database at 1:25,000 scale that pairs the carrying out of the geological mapping. To define the database logical model (fig. 3) and ensure uniformity of data supplies, guide lines (AA.VV. 1997) were established.

The database structure distinguishes two main categories of entity: the first with geometric and descriptive properties and the second characterized uniquely by description properties. Both are organized into different information layers where connection between graphics and descriptive elements is guaranteed in a system of relational data managed in the form of tables. The geometric properties are represented not only by geometric primitive elements (points, lines and polygons), but also by the type of spatial relationships between data (relations of inclusion, of adjacency, etc..).

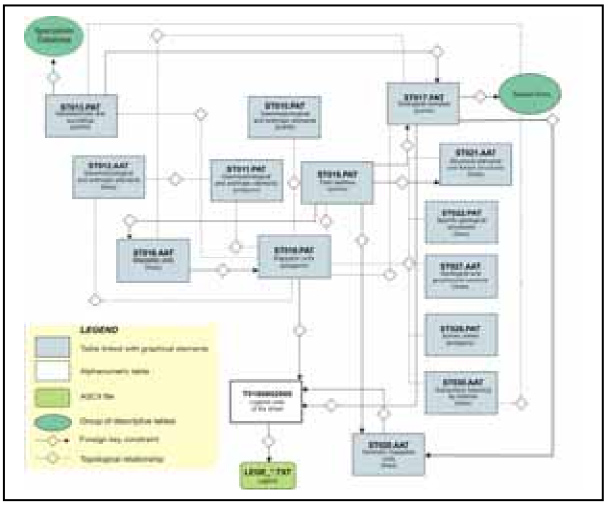

Figure 3 – CARG database: logical scheme.

The information layers that make up the CARG database are organized as follows: punctual, linear and polygonal geomorphological and anthropogenic elements; resources and prospecting; geological samples; geological mapping units; points of geological observations; plicative structures and structural elements; geological processes details; geological and geophysical paths.

The digitalization of a geological sheet follows the logical scheme of the CARG database; the original author map reported at the 1:10,000 or 1:25,000 scale is acquired in a digital format and georeferenced using ESRI ArcGIS software version 9.

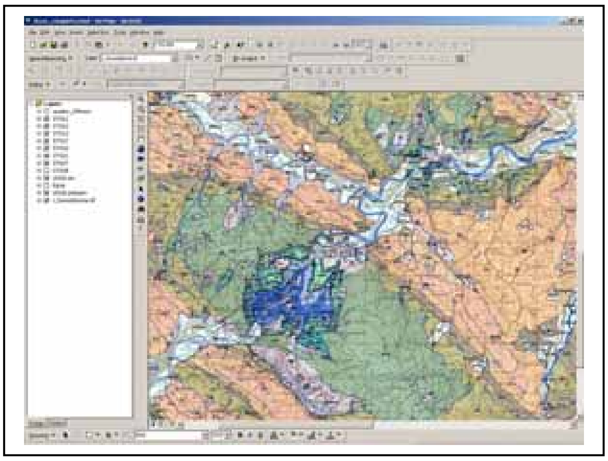

Figure 4 – Geological sheet geodatabase (e.g. Fossombrone sheet).

These rasters are used as a reference for the video acquisition by a vector-based representation of the geometric primitives; alphanumeric content associated with geometries are also included.

The geodatabase (Fig.4), set using ArcMap application, allowed for the editing of data in feature class representing classes of objects with the same geometric primitive (points, lines or polygons) pertaining to the single information layer provided by the CARG database. The arcs related to geological mappable Units (mainly sedimentary and tectonic limits) are video acquired, fixed in ArcInfo and topologically built to obtain polygonal entities to which information about geological units are assigned. Punctual items referring to structural elements show measures of the inclination and direction relative to North.

Digital data of each geological sheet are processed and collected into central SGI Geodatabase in order to obtain an homogeneous product within the whole territory.

Some information from the CARG database are shared through the Geological Survey Portal of Italy (http://serviziogeologico.apat.it/Portal/), created in 2006 according to the INSPIRE standards. The Portal allows to search metadata and its related information belonging to remote databases owned by Geological Survey of Italy (e.g. Geological Map of the Italy at scale 1:500,000; Geological Map of the Italy at scale 1:100,000; Geological Map of the Italy at scale 1: 50,000 (CARG Project); IFFI Project on landslides; Database of Drilling (L. 464/84); Geophysical Database).

3D MODELLING

Since 2000, the SGI has promoted projects devoted to test the full applicability of the CARG database for the creation of three-dimensional geologically coherent structures.

The first achievement of these projects is the full integration, in a 3D environment, of digital primary geological observations from field survey (CARG database) addressing several of the existing limitations that are inherent in traditional methods of map production and publishing.

To define a general workflow for 3D reconstruction, several 3D models (tab. 1), corresponding to a whole geological sheet (600 km^2) or part of it, have been built; they represent different geological domains, ranging from the Apenninic fold and thrust belt to the alluvial plains, from the deep structures of the Southern Alps to volcanic area (ARANEO et al., 2004; D'AMBROGI & DOGLIONI, 2008; D'AMBROGI et al., 2004; MARINO et al., 2005).

3D Models	Geological domain	Area (km2) / Depth (m)	Data input: surface	Data input: subsurface
Fossombrone	Northern Apennines	600 / 3500	Field data (1:10,000) Bedding attitude measurements	Cross-sections Well stratigraphies Seismic profiles
Firenze	Alluvial plain	25 / 100		Cross-sections Well stratigraphies Bedrock isobaths map
Polino	Central Apennines	18 / 400	Field data (1:10,000)	Cross-sections
Cimini	Volcanic area	250 / 3000	Field data (1:10,000)	Well stratigraphies Bedrock isobaths map
Fiumicino	Alluvial plain	80 / 100	Field data (1:10,000)	Well stratigraphies
Vette Feltrine	Southern Alps	300 / 2500	Field data (1:10,000) Bedding attitude measurements	Cross-sections

Table 1- Characteristics of 3D geological models.

Move software package, by Midland Valley Exploration Ltd., is used to manage and integrate the full suite of complex multi-scale geological data. The software allows to honour all the selected datasets, or part of them, to obtain well constrained and geometrically coherent 3D models.

The defined workflow (fig. 5) optimizes the use of field data (boundaries, azimuth and dip, tectonics), both surface and subsurface (tab. 1); these data, providing essential constraints to obtain 3D models, are integrated with geological cross-sections and seismic reflection profiles, when availables.

Actually, the test area is the Sheet 386 Fiumicino (Geological Map of Italy 1:50,000 scale) corresponding to the fluvio-deltaic sector of the Tevere River (Central Italy), an highly urbanized area, typically characterized by poor outcrop data; on the other hand, very large borehole statigraphies data for the onshore area and good quantities of seismic data for the offshore area are available.

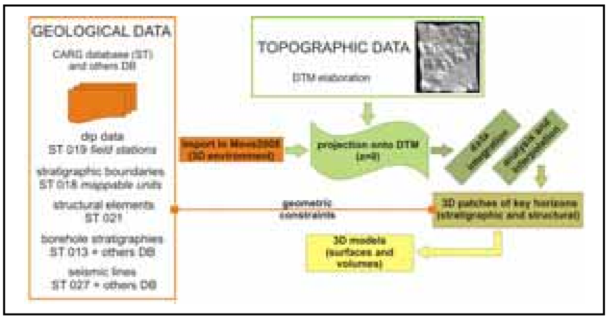

Figure 5 – Workflow for the construction of 3D models.

The onshore subsurface data (144 boreholes over an area of 80 km^2) allow to define detailed lithostratigraphic and paleoenvironmental 3D model of the fluvio-deltaic area; the integration between onshore model and offshore data will be accomplished in the future. The borehole stratigraphies have been collected and codified in accordance with a standard lithological description; some geological cross-sections, along preferred directions, have been used to identify the more continuous lithological units (D'AMBROGI & RICCI, 2008).

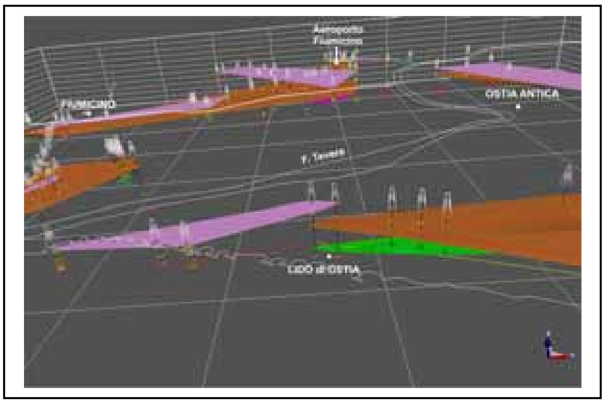

Figure 6 – Surface boundaries between the main lithological units.

Visualizing and managing in 3D both borehole data and interpreted cross-sections allows to built well constrained geological surfaces (fig. 6); the 3D model could be updated real time if other constraints (e.g.: more borehole stratigraphies, geophysical data) will be acquired, allowing up-to-date volume assessment.

A similar workflow have been applied to geological datasets available for the entire Italian territory (e.g. isobaths map of base of Pliocene deposits, isobaths map of Moho discontinuity, litosphere thickness map, seismic lines from Deep Crust – CROP Project, Italian Seismicity Catalogue CSI-INGV, Heat flow map, Gravity map) to generate geological surfaces providing an overview of the deep structure in the Italian region (fig. 7) (D'AMBROGI et al., 2007).

The opportunity to manage, model and display, also via the Web (http://serviziogeologico.apat.it/modelli3d/index/3d_web.htm), multi-scale complex geological data is the main goal of 3D geological modelling projects, performed by SGI.

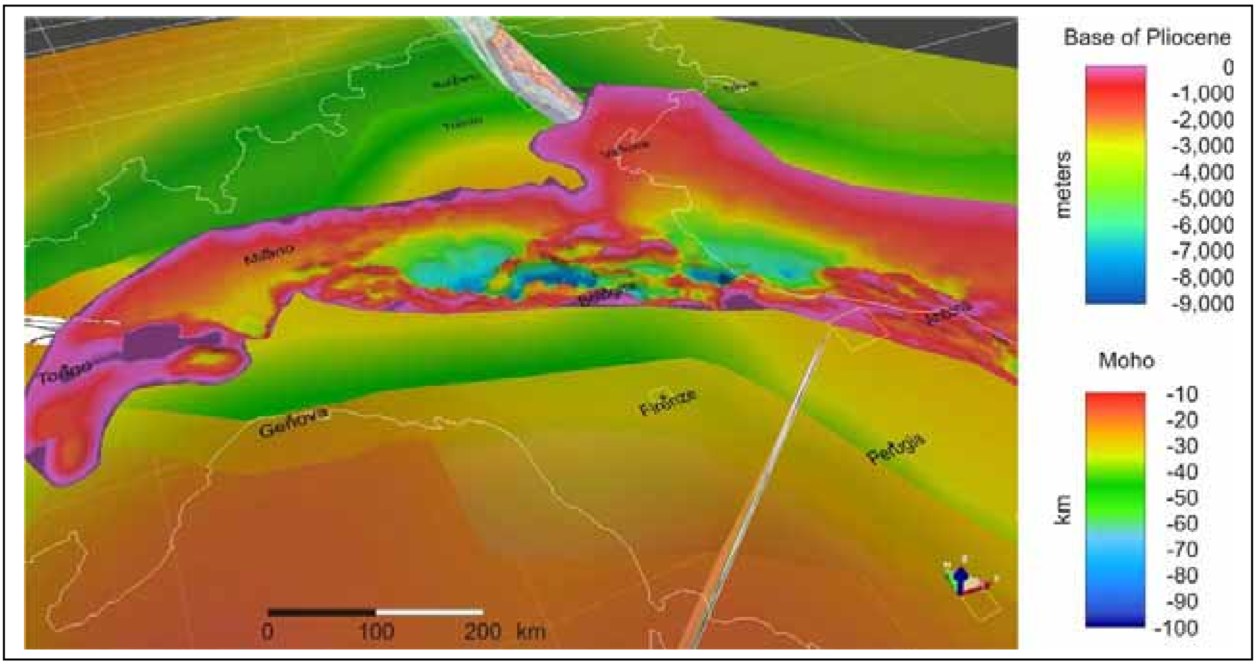

Figure 7 – The irregular surface, from pink to blue, is the base of Pliocene deposits; the yellow to green surfaces are the Adriatic Moho and Tyrrhenian-European Moho. Images of interpreted seismic profiles are partially visible.

CONCLUSIONS

The policy of CARG Project is to provide an efficient framework to collect, manage, and disseminate geological data.

In order to increase the processing of geodata, addressing the limitations that are inherent in traditional methods of data representation, map production and publishing, SGI developed an integrated structure, from the field survey towards the production of 3D geological models.

The full applicability of the CARG database for the creation of geologically coherent 3D structures at multi-resolution levels, from detailed outcrops to regional scale, have been tested.

The 3D geological models, collected in a 3D environment, point out the opportunity to maximize the integration and accessibility to the whole informative content of geological databases.

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GIS-TECHNOLOGIES FOR ENVIRONMENTAL MONITORING AND NATURE-USE PROBLEMS

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Abstracts

In the report we discuss the main issues of information and analytical supporting of environmental monitoring tasks, such as:

- storage, systematization and operative analysis of the vast volumes of monitoring data,
- geological and ecological researching (such as forecast of mineral deposits, estimation of ecological state of a mining region, etc.),
- decisions acceptance for situational management.

We would like to present our techniques and home-brewed software packages providing technological solution of these problems. The approach is based on integrated analysis of data about geological or ecological situation/object/process from different sensing levels of the Earth. Presented technologies obtain all steps of data processing and presentation: from data acquisition, georeferencing, data integrity and quality assurance, through multi-level analysis to pre-print of hard-copies of published maps or decision-making support systems for mineral exploitation and environmental protection management – and combine all tools of information technologies: Relational Database Management System (RDBMS), Internet-based distributed computing framework, analytical procedures including mathematical and heuristic algorithms and, of course, Geographical Information Systems (GIS).

Strategy of the sustainable development includes providing efficient nature-friendly policy of exploitation of resources meeting social standards and maintaining ecological balance. So, one of the main factors of it's realization is environmental monitoring of exploration and exploitation of mineral, energy and other natural resources.

The primary tasks of environmental monitoring is data gathering, storage and processing for estimation of current ecological situation, forecast of possible negative changes in it and operative information support of decision-making processes. Character features of environmental monitoring are heterogeneity of forms and digital formats of the source data, large volumes of the processing information, lack of mathematics describing studied natural and technogenic processes. Successful solution of these problems can be obtained only by combination of all tools of information technologies: Relational Database Management System (RDBMS), Geographical Information Systems (GIS), Internet-based distributed computing framework, analytical procedures including mathematical and heuristic algorithms.

Laboratory of Geoinformatics, VNIIgeosystem, has accumulated wide experience in development of methods, techniques, and solutions for information and analytical support of the geological, ecological and nature-use studies. Our studies are focused on elaboration of methodology and original algorithms of integrated analysis of the data about studied processes of objects. and development of intellectual user interfaces providing the each stages of the process - from data acquisition, georeferencing, data integrity and quality assurance, through multi-level analysis to pre-print of hard-copies of published maps or decision-making support systems for mineral exploitation and environmental protection management. Our home-brewed software package GIS INTEGRO is successful used for geological studies: forecast of mineral deposits, 3D modeling and economical evaluation of reserves, processing and interpretation of geophysical data, problems geological cartography. Main results of our works include digital ecological maps and atlases of the main mining territories of Russia and other countries, applied information and analytical support systems based on data bases, cadastres, and GIS-projects for different fields of the nature-use and environmental management.

Vast volumes of source information used for solving of environmental tasks requires of development of the tools for storage, systematization and operative analysis of the monitoring data. At the framework of this problem we developed original software platform allowing for quick and effective construction of multi-tier computer information and analytical systems (IAS). The presented platform provides full visual design of client applications without any coding and powers of modern relational databases. Such approach allows to minimize time, financial and professional resources during developing the programme systems.

The platform was successful used for development of applied information and analytical systems in different fields of nature-use management, such as:

- monitoring of the groundwater state and account of resources and reserves for federal and territorial levels;
- monitoring of licensing of mineral deposits exploration and mining;
- monitoring of oil and gas fields exploration and exploitation.

At the frameworks of the problem of analytical support of environmental studies we developed the computer technology of complex estimation of ecological situation based on integrated analysis of natural characteristics of the area under studies and technogenic impacts to it from the geological exploration and mining. Foundation of the techniques bases on conversion the real situation to the environmental model of the studied area defined by criterion function and set of factors identifying properties of the geoenvironment and level of technogenic impacts to it. The technological implementation of our techniques is based on original software applications and is easily adapted to popular geographical information systems (so, an expert can use all traditional function of the spatial analysis which are contained in GIS). The special procedures of analytical processing and model compilation are join in the special modulus (and it allows to use other GIS-share if it is need). The processing algorithms implemented the software are adopted to ecological data structures. The friendly user interface allows a subjective specialist to use this system. The presented technology and software were tested within several project in collaboration with major research organizations in the field of the ecology of exploitation of the mineral resources. Our technological solutions was used for realization of such projects as follows:

- GIS-version of Annual Governmental Report «Environmental situation in Russia»,
- Information and analytical support of the Situation Center of the Ministry of Natural Resources of Russia,
- Digital atlas of geo-ecological maps of Russia, scale 1:5,000,000 «Assessment of ecological implications of mineral exploitation»,
- Environmental monitoring system of the oil and gas bearing regions of Western Siberia.

The most important component of information support of decision-making in nature-use tasks is developing of systems of situational management representing a complex of specially organized workplaces for personal and collective analytical work of the head or group of heads. The primary goal of such system is support of decisions acceptance on the basis of visualization and the profound analytical processing of the information about studied object. Because most of the nature use processes and activities are spatially located, the geographical information systems become the important part of the situation management. The GIS provides not only visualisation of geographically registered data and related spatial analysis functions, but also acts as the command envelope controlling operation and interaction of other subsystems. Such a GIS centred system was recently developed at VNIIgeosystem and runs the operations map of the Situation Centre of Ministry of Natural Resources of Russian Federation.

BEEGIS: THE OPEN SOURCE MOBILE GIS FOR FIELD MAPPING

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KEY WORDS: BeeGIS, digital field mapping, open source, GIS, geology.

INTRODUCTION

BeeGIS is a new open source GIS software for field mapping conceived for pen computer working with any operating systems (Windows XP and Vista, Mac OS, Linux).

This software was born with the idea to create a tool to be efficiently and friendly used in the field by professionals (mainly geologists and engineers) who may have a limited knowledge of GIS and who want to minimize the learning time for new technologies.

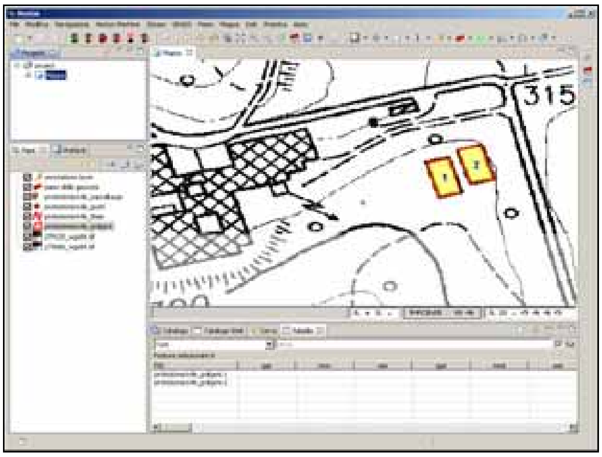

Figure 1 – The BeeGIS interface.

After an unsatisfactory previous experience with a commercial software house (CLEGG et al. 2006; DE DONATIS & BRUCIATELLI, 2006) our lab (LINEE - Laboratory of Information Technology for Earth and Environmental Sciences) decided to focus on open source world. From the collaboration between the lab and HydroloGIS, an environmental engineering company with big experience in development of GIS in Java, a new open-source system for geological mapping was developed.

BeeGIS has its roots in Udig and JGrass GIS framework (open-source) which were integrated with several new tools designed *ad hoc* for field work, tools for:

- data acquisition from any NMEA compliant GPS receiver for capturing points, lines and polygons in both automatic and manual mode;
- drawing and writing annotations directly on the map with the digital pen that allows you to draw and paint;
- "Geonoting": tool conceived to draw sketches, write text notes and attach any kind of file, with the ease of drag & drop. Digital pictures, once embedded, can be enriched with on-image annotations.

These tools have been thought and developed for field usage in order to preserve the traditional methods for mapping, while replacing the pencil and the paper (map and field book) with a digital stylus on special touch-screen. BeeGIS is not only thought to help the user to fully support his data acquisition (CARVER ET AL., 1995; WALKER & BALCK, 200; AKCIZ ET AL., 2002), as he would do with traditional tools. BeeGIS also wants to drastically reduce the loss of information and time by immediately gathering and storing informations just on site and keeping data immediately sharable.

MAIN FEATURES

GPS tools - The GPS Tool allows the user to make BeeGIS interact with any GPS unit supporting NMEA protocol, via serial connection and have his current position drawn ot the map.
By "serial connection" we mean any physical or virtual serial port, like those creted by Bluetooth enabled GPS or by older wired USB GPS units. The GPS Tool is capable of accessing these COM ports using rxtx (www.rxtx.org) serial I/O libraries. Since also integrated GPS exploit this functionality, BeeGIS can also connect to them.

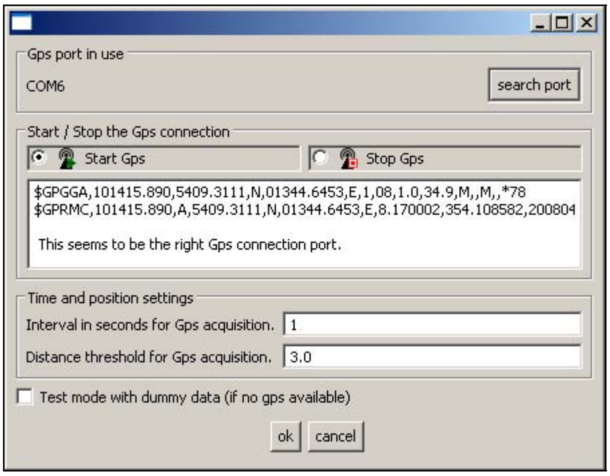

Figure 2 – The GPS tool.

Once a GPS connection is established, BeeGIS offers a set of functionalities:

- logging can be enabled, and a pulsing cursor will appear on top of the map layers showing current position updated in real time (1 sec.).

- the user will be able to draw points, line or polygons in two ways:

1. Manual node acquisition: the user will ask the GPS tool to add a node from the current GPS coordinates to the active layer. Points are placed as single units into the current layer. Lines/polygon are created adding as nodes the submitted GPS positions, into lines/polygon layers. These are different only for the fact that in polygons the last node is always linked to the first one, to close the drawn geometry.
2. Automatic node acquisition: the user will ask the GPS tool to create new nodes at specified time/distance intervals from coordinates acquired in real time by the GPS unit. In this way the user will be free, for example, to follow a path while BeeGIS is drawing a polyline on its "paths" layer or to delimitate larger areas.

Geonote **-** Geonote is a tool which gives the possibility to put on a map notes containing drawings, text or any known and unknown file.
Geonote, at first glance, looks like one of those software used to create desktop digital yellow notes. It is made of an upper part containing a title label, few small buttons through which the background colour of the note can be changed, and two buttons used to save&close the note or discard it.
The lower main-part is completely dedicated to the taking of notes. It is separated in three different tabs, each of which with a different purpose.
1- *drawing tab:* The first tab enables a drawing area dedicated to sketches. This tab is conceived to take fast notes with the tablet's digital stylus and reminds us that BeeGIS is mainly dedicated to tablet pc usage on field.
2- *text tab:* On this tab text can be type with the keyboard (virtual on-screen keyboard on tablet Pc).
3- *media tab:* This tab is a very useful one. In this tab you can drag'n-drop any file that will be stored with your note. These files can be either digital camera shoots, spreadsheets or any kind of document the user wants to associate with the subject. All these data will be stored together in an H2 database (embedded in BeeGIS) and will be at hand in any moment. By double clicking on an inserted file, this is opened with the default system application for that particular media type. This applies for all media types, except for image files, for which BeeGIS provides an extra editor. This special picture viewer gives the user the possibility to draw notes on the image with the digital stylus.

Once you push the save button, the note closes and a red pin remains on the map. The note is saved with its coordinates and the used reference system. That is important because the position is reprojected on the fly for every needed projection system and can be used in every case.

For now geonotes are kept totally in the H2 database, so by passing to someone else the folder containing the notes, nothing else is needed for him to see your notes.

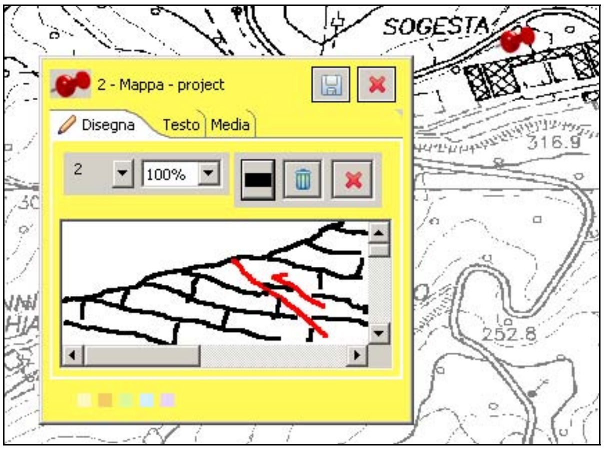

Figure 3 – The Geonote tool.

Fieldbook - When we designed and developed the geonotes for the BeeGIS extentions, the major problem was how to organise them properly, access them quickly and save them somehow. This is how the fieldbook (BRINER ET AL., 1999) came to life.

The field book wants to be an easy accessible collection of the geonotes created in our project. Browsing the field book, geonotes can be selected and highlighted: by text in the title, by color, by creation date or as GPS output.

Annotation - In order to keep the traditional way of field mapping using coloured pencils on the paper map, BeeGIS offers an annotation tool that allows to draw lines, fill areas with colour or delete wrong annotations.

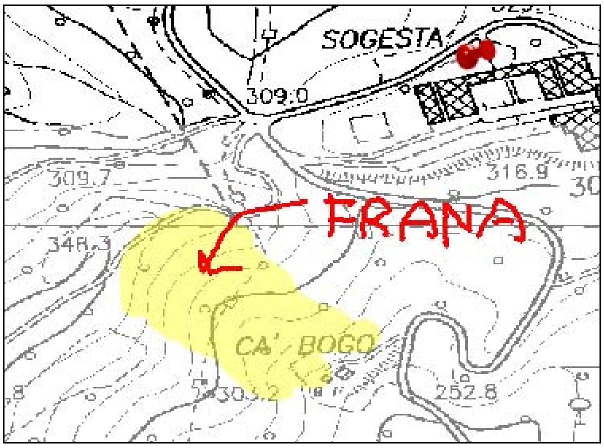

Figure 4 – The Annotation tool.

The annotation toolbar does not have any topological control. Some annotation properties can be chosen as colours, whereas width and transparency can be chosen from drop-down menus or dialog windows. The properties panel gives the possibility to quickly remove the last inserted stroke, without the need to change the tool. The annotation tool can be used very easily in the field where the environmental conditions are not the same of the "armchair work" in the lab.

To remove a stroke inserted earlier the annotation remove tool has to be selected.
Since we are supposed to be on the field with a tablet where is not so easy to pick exactly the stroke we want to remove, the annotation remove tool becomes a line tool. A red draw line is dragged on the map and all the intersecting annotations (in that layer) will be removed.

Updating - BeeGIS can be easily updated on line any time new packages are developed or new fixes are released: from the help menu>software updates > find and install. Here you can find an up-to-date list of available packages.

In order to download the last version of the software and to join the community of users and developers, you can visit http://www.beegis.org .

Figure 5 – BeeGIS Website: www.beegis.org

FUTURE DEVELOPMENTS

Next forecast step is the development of a Form editor. This tool is conceived to create customized forms which can be used for data entry during field work. This tool will be very helpful especially when a surveyor must work within the simplified bounds of the interface prepared by the manager for the quick insertion of information (HOWARD, 2002; BRODARIC, 2004). Each time that a cartographic element is added in a theme, the appropriate form appears for the insertion of the data that must be gathered for the associated layer.

AKNOLEDGEMENT

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3D EXPLORATION MAPPER – EASY VISUALIZATION OF THREE-DIMENSIONAL GEODATA

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KEY WORDS: Real Time 3D Rendering, ESRI ArcGIS Extension, Geophysical Data Visualisation

INTRODUCTION

The paper is dealing with a new technique of 3D-visualisation that has been developed mainly for the interpretation of geophysical datasets used in the oil and gas exploration. The viewer is not only capable of fastly modelling surfaces and subsurfaces of a working area but in addition is giving the user the possibility to integrate seismic profiles, log-files and other geophysical 2D-data, while interactively moving around in an 3D environment.

CONCEPT

The concept of the 3D Exploration mapper is based on the experience of GAF AG in various projects for the oil and gas industry. In this sector it is normal to work with a huge amount of variable data sets, not only restricted to geophysics. Due to the fact that most companies in the oil and gas sector are working nowadays with very complex 3D software packages it seemed to be helpful to develop a tool that can be used very easily by field geologists themselves or the GIS department. That thought led to the decision to produce the software in an ArcGIS environment which is by now well known and distributed in these sectors.

SOFTWARE ARCHITECTURE AND FEATURES

The 3D Exploration Mapper software is an ESRI ArcGIS 9.x extension integrated into ArcMap using all the advantages of ESRI's two dimensional mapping tool. It uses Microsoft DirectX technologies for the rendering and is built with Microsoft's .Net Framework as well as ESRI's ArcObjects for spatial data processing. This ensures that the software can handle all the well-known GIS data formats and a future-proof support for new developments of the underlying base components.
DirectX can take advantage of the newest graphics card hardware power, which, with its multiple separate processing units (over 200 compared to the 4 of a Quad Core CPU), can enormously speed up time consuming calculations like real time shading.
As a result, the amount of data that can be simultaneously rendered in real-time rises to a stage, where interpreting GIS data and its relations in three dimensions is practicable.
A rendered high resolution digital elevation model with adjustable exaggeration, real time lighting und colour gradient for the different elevations can provide much more information than a two dimensional visualisation (Fig.1). If you go one step further by combining it with remote sensing and geophysical data, e.g. satellite images and seismic profiles and geological subsurface models you open complete new ways of intuitive interpretation for the GIS user.

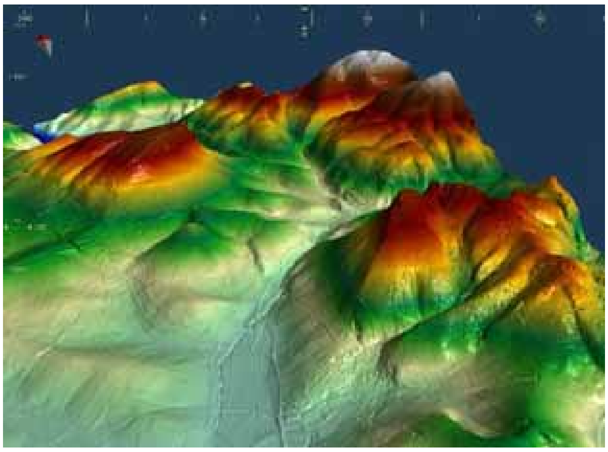

Figure 1 – High resolution laser scanned elevation model.

Designed originally for the needs of exploration tasks, many features were developed regarding the special data types and formats of the hydrocarbon industries. There are special displaying options for seismic profiles that allow easy histogram stretching visualisations with different colour gradients (Fig.2). Even unprocessed data can be loaded and fitted on-the-fly to the scene. Simultaneously displaying different measuring methods directly in the geospatial context can help discovering new relations and prove assumptions.

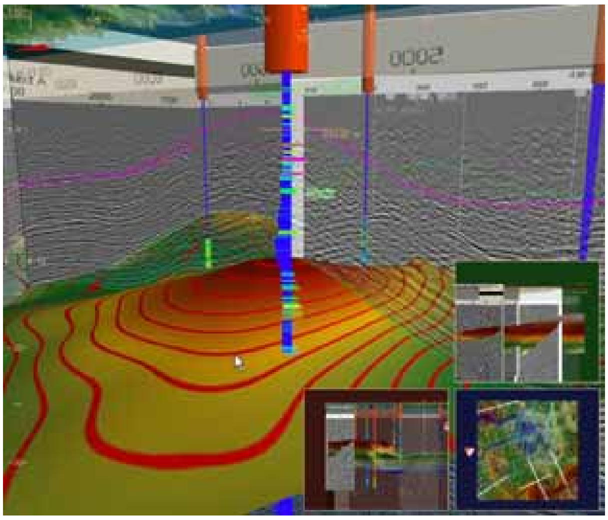

Figure 2 – Borehole log with three parameter view in front of seismic data.

Tested in different pilot projects, the tool helped understanding and visualization the relations between all kinds of GIS data whenever a z-coordinate is present.

Some easy to use raster processing features help filling voids in elevation models and interpolating airborne geophysical scan line data. Those geophysical layers can be moved and stretched freely in vertical direction for better fitting in the scene's vertical coordinate system.

The user interface provides besides the main perspective view three embedded orthographic viewports along the x, y and z axis, which helps digitizing in the 3D environment (Fig.3), while a heads up display with compass and artificial horizon helps orientating.

Some other features are:

- Common database compatibility
- Special exploration data formats like SEGY and LAS
- Volume calculations
- Transparency rendering methods
- Free moveable clipping plane generates cross sections
- On-the-fly isoline rendering
- High resolution screenshot export
- Drainage line visualisation
- Google maps popup window

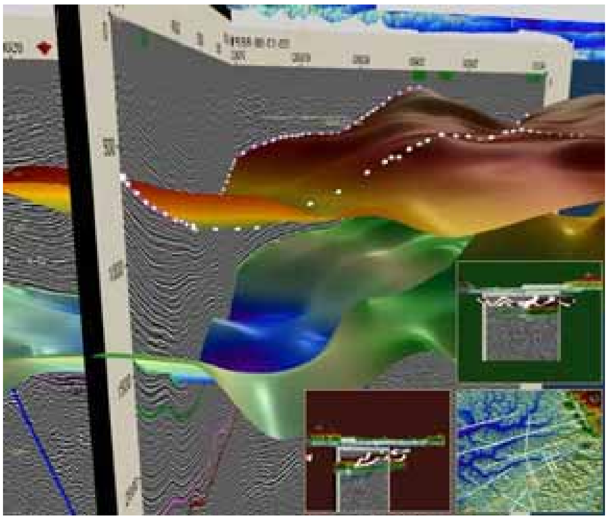

Figure 3 - 3D-digitizing seismic horizons.

CONCLUSION

The 3D exploration mapper was initially developed for the oil and gas industry but showed to be very useful in all areas that have to deal with the quick visualisation of three-dimensional data. It is used now in other geological mapping projects as an interpretation tool and proved its value in the image interpretation and enhancement workflow as a whole. Due to its easy adaption to different work tasks it has a big potential in helping to achieve many scientific and commercial goals.

ACKNOWLEDGMENT

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THE PRODUCTION OF PRINTED GEOSCIENTIFIC MAPS AT THE BAVARIAN ENVIRONMENT AGENCY

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KEY WORDS: printed maps, interactive maps, web-map services, geographic information systems (GIS)

A look back …

The official geoscientific surveying in Bavaria has a long tradition. It starts in the year 1850 with the foundation of the geological state service ("Geologischer Staatsdienst") by King Max II. and it has been continued until today by the department 10 "Geological Survey, Economic Geology, Soil Protection" of the Bavarian Environment Agency (LfU).

The findings of the basic geoscientific groundwork are published mainly in maps, in periodicals or books. More recently they are also published on the internet. Since over 150 years of its existence the geological survey has published a huge amount of geoscientific maps in the subject area of geology, hydrogeology, soil science and natural resources in scales between 1:25.000 up to 1:4 million, which allows to fit the entire area of Bavaria on a postcard.

The role of maps within geoscientific publications

You can get a good overview of the variety of geoscientific publications of the LfU if you either take a look at the printed list of publications (GLA, 2005) or at the online store of the LfU (www.lfu.bayern.de/publikationen).

The maps and the associated explanatory notes make up by far the biggest share of the publications. This indicates the dominating role of the printed map as an important medium for the information transfer within geosciences. The poster presentation dealing with the status of geoscientific map works in the Bavarian Environment Agency (GRASSMANN & SCHRÖDER, 2009) in these proceedings gives an overview about the availability of geoscientific maps in the subject areas geology, hydrogeology, soil and natural resources.

The techniques of the map-making process

The technique of the map-making process at the LfU has changed fundamentally in course of time. Up to the early 1990th the field maps manually created by the geologist had been manually transferred to printing film by the cartographers - each color separately. Nowadays the geological field maps are scanned, georeferenced and finally digitized. The derived geological data are stored in a Geographic Information System (GIS) which has all kinds of tools to analyze and visualize the data together with other spatial data. At the LfU the creation of the map layout, the symbolization and the annotation of the printed geological maps take place in a GIS called ArcInfo Workstation of ESRI. Only the last step of the pre-press, in which the title column and the map-document are put together and the color separation in CMYK- and spot colors takes place, is been done outside the GIS using a DTP-program (Adobe Illustrator).

The poster presentations of GRASSMANN (2009) and RICHTMANN (2009), which are published as well in these proceedings, give a good idea about how printed geoscientific maps are produced at the LfU.

Because of two reasons the LfU is on the way to switch its technological basis for the production of printed geoscientific maps from ArcInfo Workstation to ArcGIS which is offered by ESRI as well:

Firstly the development of the GIS ArcInfo Workstation has been discontinued by the software manufacturer ESRI since quite some time. At the moment it can still be used but it is only a matter of time, when the support will also be discontinued. Secondly the collection of data and the geoscientific analysis at the LfU is also done mainly within ArcGIS.

Although ArcInfo Workstation and ArcGIS are offered by the same software manufacturer the data formats and the software interfaces of both systems are very different from another. The problems which are encountered by the cartographers while they try to switch from one software system to another are described in another article in this proceedings (BOEDECKER, 2009). One problem e.g. in ArcGIS is faced, when one is trying to use spot colors, which are crucial for improving the readability of geological maps especially in areas with complex bedding of the geological units.

Although the GIS-technology has made substantial progress in the field of cartography, it is still not possible to produce a high quality printed geological map by only using ArcGIS (Version 9.3) and without reducing quality demands.

Geoscientific maps at the LfU

Until 10 years ago, the printed map was the only way to publish geospatial cartographic data. Since the user of geoscientific information increasingly works with GIS, the demand for geodata has been growing. To meet the demand and also because a GIS is used for data storage and map production, the printed maps are also published respectively distributed in the following formats:

- georeferenced image data
- PDF-files
- Multimedia CD
- georeferenced vector data

<u>Georeferenced image data</u>

The georeferenced image data and the PDF-files are created at the LfU on the basis of the printed maps. The data are a scanned version of the printed map with map frame und legend. To create georeferenced images out auf regular raster images the internal image coordinates are converted in "real world coordinates" according to the map projection. After this transformation the image will fit together with other georeferenced topographical data within the GIS. This process of georeferencing leads to the impression that the georeferenced map compared to the printed map is slightly rotated. Therefore the LfU will offer besides the georeferenced image data the map in PDF format, which will make it easy to reproduce the printed map without distortion.

<u>PDF-files</u>

More and more geoscientific maps are published exclusively in PDF on the internet. Because of the low demand in these cases the production of a printed version of the map is not reasonable from the economical point of view. Basically the amount of time and effort for the cartographic creation of this type of maps is almost the same as for printed maps. Because these maps are also optimized for a certain map scale, name placement conflicts have to be resolved or a readable and therefore elaborate map legend has to be set up as well. Only if the amount of map themes presented and the requirements in the cartographic quality of the maps are reduced, it is possible to speed up the map making process substantially. Examples for the group of PDF-maps are the map series „Shallow Geothermal Energy 1:200.000“ and the „Soil Map 1:25.000" (ÜBK 25). The geo data which are used to produce this map sheets are also available to GIS-user and are presented in some of the web map services of the LfU.

<u>Multimedia-CD</u>

In addition to the classic map poducts multimedia CD-ROM for selected topics have been created at the LfU. The user of these CDs is guided by an intuitive user interface to make it easier to access the data even when there is no GIS available. Because the effort to create this type of multimedia CD is very high, this type of media has only be developed for selected topics which are of potentially high interest for the public:

- Overview map of the geology of Bavaria 1:500.000 ("Geologie von Bayern")
- Meteorite Crater ("Das Ries")
- Mineral Resources of Bavaria ("Bodenschätze in Bayern")
- Soils of Bavaria („Die Böden Bayerns“)

<u>Georeferenced vector data</u>

The vector data (e. g. in coverage or shape format) are derived from the geo data, which are the basis for the printed geoscientifc maps. They can be used for analysis and visualization purposes within a GIS. Nevertheless the user of the data is not able with the exclusive use of this data to reconstruct the printed geological map. The reasons are that the map legend, the symbol library and the topographical base map are missing. Therefore the user of this type of data does not want to recreate the original geological map. He instead will prefer to work with the geological attribute data behind the geometry. For this purpose data which are coded with a standardized legend are suited the most. This type of data however is up to now not available for all the published geological maps in Bavaria.

Interactive maps

Since the introduction of the soil information system (Bodeninformationssystem (BIS)) in the year 2003 the public is able to access many geo data for free using the interactive web map services of the so-called "Geofachdatenatlas" (www.bis.bayern.de).

The interactive maps offer the possibility to chose the map extent randomly - independent of the map sheet lines of the selected map topic.

The user is able to zoom in or out in order to view the whole content of the underlying geodatabase. Besides to move around on the map the user has the opportunity to access the attribute data behind the area, point and line features on the maps. He also can select or deselect certain map themes in order to compose his own thematic map, which meets exactly his needs of information.

Since some of the map themes offered in the Geofachdatenatlas are also available as standardized web map services, the same map graphics can be easily embedded in other web based interactive mapping applications.

Unfortunately the cartographic quality and readability of interactive maps is not as elaborate as the quality of printed maps. Because of this the user of interactive maps is often forced to zoom back and forth to find a map extent and scale which is suitable to decode the map content. This makes it more difficult to get a grasp of the spatial connections and to maintain an overview as well as a detailed perspective. One reason for this limitation of interactive maps is the fact that the creation of interactive maps are mostly left to GIS specialists rather than to refer to the know-how of cartographers in this field.

As the importance of topic oriented internet portals is increasing in the future the need for multimedia CDs is decreasing. Right now there is an internet portal covering the topic of geothermal energy (Information System of shallow, near-surface geothermal energy) under way at the LfU. It will provide access to detailed geospatial data dealing with geothermal energy via an interactive map service.

The future of printed geoscientific maps at the LfU

Because of the growing competition of GIS and Internet the printed map has lost its central position as source of information within the geoscience. In the future, the LfU will mainly offer printed maps in these fields of geoscience, where either a strong interest of the public is assumed, a (legal) obligation to continue an existing map series exists or where there is a special project in which it appears reasonable to present the results on a printed map which is furthermore financed by project resources.

The following map series are belonging to the described group of maps:

- Geological Map 1:25.000 (GK25)
- Geological Survey Map 1:200.000 (GÜK200)
- Soil Survey Map 1:200.000 (BÜK200)
- Geoscientific Survey Maps of Bavaria in the scale of 1:500.000 and smaller
- Geoscientific Maps of selected Regions of Bavaria („Sonderkarten“)

The GÜK200 and the BÜK200 take on a special position in this list because these map series are covering the whole national territory of the Federal Republic of Germany. The thematic content of the maps is delivered by the geological surveys of all 16 states of Germany separately to the Federal Institute for Geosciences and Natural Resources (BGR), where the layout of the above-named map series is done and where the map sheets are finally published.

The GK25 is **the** basic geological map series of Bavaria. The fields of application range from regional and local planning, building ground survey, exploration of natural resources to the point of use by “spare time” geologists or paleontologists, who look for good collection sites. Since the end of the early 1950s up to now almost 300 out of 546 map sheets, which are in the scope of the administrative responsibility of the state of Bavaria, have been completed. Considering this the completion of this map series still belongs to the indisputable core tasks of the geological survey of Bavaria.

The Geological Survey Map of Bavaria 1:500.000 (GK500) is the best known map out of the group of Survey maps. Since the publication of the 4th edition in 1996 it belongs together with the explanatory report to the most demanded geoscientific maps in Bavaria.
In the current year the hydro geological map series is planned to be published as printed maps. It consists of four thematic maps, which will cover the most important aspects of hydrogeology of Bavaria in a scale of 1:500.000 (BOEDECKER & BALG, 2009).

Compared to the number of small scale survey maps the amount of special maps is much more comprehensive. The big choice of special maps reflects the fact, that the state of Bavaria has an abundance of geological specialties. One widely known example is the “Nördlinger Ries” which is the best preserved big meteorite crater of the world. The area of the meteorite crater is covered on two maps in the scale from 1:50.000 to 1:100.000, which are a good example for maps out of the group of special maps.
Right now a map of the Inn-Salzach area, a landscape which was significantly coined by the glacial period, in the scale of 1:75.000 is under way. Besides a geological map of the „Upper Palatinate Forest” in the scale of 1:150.000 will be published during the EUREGEO 2009. This map will have a trilingual legend (languages: German, English, Czech) as well as the geological map of the “Bavarian Forest”, which was published last year. Both maps are aimed at the interested layperson, who wants to get to know about the geologic history behind the scenery of beautiful natural landscapes. Therefore the sites of geological beauty and distinctiveness (geotop) of the program „Bayerns schönste Geotope“ are printed on the maps to emphasize the geo-touristic orientation of the maps.

The demand for printed geoscientific maps

The above-named map series are on top of the ranking of sales figures of geoscientific maps at the LfU. Even 13 years after the release of the geological map of Bavaria 1:500.000 the map is still the best selling individual geoscientific map. It is followed by the two geological maps of the Nördlinger Ries and of the Bavarian Forest.

From the nearly 300 map sheets of the map series of the geological map 1:25.000 (GK25) on averages 1000 copies altogether are sold every year. This shows, that even in the days of internet and mobile mapping devices there is still a small but important market for printed geoscientific maps.

Advantage of printed maps over interactive maps

In recent years the printed map as media to present spatial geoscientific data has fallen under the pressure of competition by interactive maps on internet or CD. The following table compares the two kinds of presentation of spatial data. Thus the assets and drawbacks of printed maps as opposed to interactive maps become more evident. The grey colored cells show the strength of the respective presentation format.

property	**printed map**	**interactive map**
information at a glance	many	not many
readability (e.g. no labeling conflicts)	manually optimized	not manually optimized
density of information	high	low
quality of symbols	high	limited
standardized (comparable) colors	possible	limited
suited for outdoor use	good	limited
up-to-dateness	low	high
cost of production	high	low
map extent arbitrary	no	yes
free choice of map topics	no	yes
address based navigation	no	yes
costs for the customer	low	free

Printed maps are advantageous if complex issues with high density of information have to be presented in standardized form for a - compared to the map scale - large spatial extent. Thus the maps of a map series become matchable among each other. Because of the high resolution - up to 2500 dpi - which can be achieved using the techniques of offset printing it is possible to display by far more information on a printed paper map as on the same unit of area of an regular PC-screen which only has an maximal resolution of 150 dpi. As a matter of fact one can easily prove this assertion by holding a printed GK25 next to the PC-screen while displaying the same map extent on the screen.

Conclusions

In the past printed geoscientific maps have been the most important media to propagate the results of the geoscientific research of the LfU. Recently this presentation format has been displaced increasingly through PDF-maps on the one hand and through interactive maps on the other hand. This results in a significantly bigger choice of media with geoscientific information. The geoscientist or the professional user prefers to analyze and visualize geo data within a GIS. They will work with printed maps less and less frequent.

Nevertheless there are still good reasons to produce printed map sheets for selected map series. The geoscientific survey maps (GK500, HK500 etc.) and the map series of the geological map of Bavaria 1:25.000 (GK25) are the most important examples.

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GEOSCIENCES AND THE INTRINSIC LOGIC ("EIGENLOGIK") OF CITIES

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KEY WORDS: Eigenlogik, cities, urban planning, GIS.

During the last decades, globalization seems to have made many cities more uniform. However, people in different cities – e.g. in Munich, Barcelona or Bologna – feel the differences between them and are able to describe these differences to a certain degree. In addition, there may be a common feeling about the specific characteristics of a city supported by the local office of tourism to brand "a global city with a heart", "a city that spreads from the sea to the mountains" or "the red and literary city".

Cities are the places where more and more people concentrate. Actually, more than three billion people are living in cities and in densely populated areas, and for the first time in human history, more than 50 % of the global population are living in urban settlements (Worldwatch Institute 2007).

Astonishingly, differences between cities have not been in the focus of social sciences during the last decades. Sociologists have developed methods of empirical investigation of social structures and processes on a micro- or macro-level where cities only served as possible containers in which these problems were studied without any further interest in the cities as such.

Other disciplines like geology tried to circumvent cities because knowledge about the subsoil is difficult to get in an area covered by buildings and infrastructure. On the other hand, a geologist with some knowledge of the regional geology of Central Europe would know why the city of Stuttgart gets its water from the distant Lake of Constance (Stuttgart is surrounded by mainly fine-grained siliciclastic rocks and karstic limestone), why Essen is a centre of the German heavy industry (Variscan foreland with its coal deposits), and why Frankfurt am Main is a privileged place for trade and commerce as it lies at the northern edge of the Upper Rhine Graben, the structure of which seems predetermined to serve as a favourite traffic route from south to north in Central Europe. Cities also have a metabolism (Fischer-Kowalski et al. 1997). For instance, they need water and mass resources for their reproduction while emitting used materials like wastes and polluted water into the environment. So, both activities, provision and discharge, need a thorough and – if possible – 3D investigation of the local geology comprehensible for decision makers who are not normally geologists (cf. Hoppe et al. 2006).

During the last few years an interdisciplinary research cluster at Technische Universitaet Darmstadt initiated by sociologists developed a different approach towards bringing the differences between cities into focus. The principal contention of this group rests on the hypothesis, that cities can be analyzed by identifying their inherent logic which is based on historical development as well as current social interaction, but also on its material properties, be they natural or technical. So, the Darmstadt group tries to decipher the Intrinsic Logic ("Eigenlogik") of Cities (Berking & Löw 2007, Löw 2008) concentrating on theoretical background as well as governance of cities and transfer of knowledge from science to decision makers.

Here, we report about a sub-group group consisting of scholars from Environmental History and History of Technology, Economics, Engineering, Land Use Planning and Geology which will focus on the natural conditions, land use, energy consumption and water culture under the perspective of sustainable development ("Urban Environments - Highways and Detours to Sustainability"). The project starts by comparing the trajectories of the two cities Mainz and Wiesbaden towards sustainability. They are neighbouring cities, both situated on the River Rhine. Similar in population size they are both capital cities of the Bundeslaender Rhineland-Palatinate and Hesse respectively. Notwithstanding these outward parallels they are radically different in terms of historical development and display a markedly diverse sense of identity.

Since the different scientific disciplines have developed divergent and sometimes incompatible theories and methods for their research, we plan to use GIS as a tool for unification and integration of research findings as well as heuristic processes. This GIS will unite and aggregate the spatial data of all disciplines of this group (geology, soils, rivers and creeks, types of land use, urbanization, water infrastructure, house prices, election results etc.). The aim is to tease out patterns and structures by producing thematic maps and thus stimulate further and new questions to identify the operation modes and effects of the intrinsic logic of cities. The expectation is that this will enable the research group to find out similarities and differences between the cities as well as methods to generalize the results. A further step may be the test of these results in other cities as well as in metropolitan areas in a later stage.

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FROM 2D GEOLOGICAL MAPS TO MULTI-DIMENSIONAL MODELS OF ENVIRONMENTAL CHANGE IMPACTS – CHALLENGES AND ASPIRATIONS FOR NATIONAL GEOLOGICAL SURVEYS

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KEY WORDS: Geological maps, GIS, 3D geological models, environmental impacts, uncertainty

GEOLOGICAL MAPS AS NATIONAL GEOSCIENCE KNOWLEDGE BASES

Geological Survey Organisations (GSOs) provide regional and national geoscience knowledge bases for effective decision-making on mitigating the impacts of natural hazards and environmental change, and on sustainable management of mineral, energy, water and land resources. Traditional geological maps have been the principal medium used to synthesise and communicate explicit knowledge on the stratigraphy, structure and composition of the Earth's surface and shallow subsurface. In the UK, the highly varied geology, high degree of urbanisation, long legacy of industrial development and a complex regulatory and planning framework created a requirement for high-resolution geological mapping at 1:10,000 scale. From the mid-1970s onwards, demand increased to produce thematic environmental geology maps and reports, aimed specifically at planners, regulators and developers (Smith and Ellison, 1999). The objective of these more sophisticated products was to unlock and communicate some of the additional, implicit knowledge on resources, hazards and constraints that are 'hidden' on a standard geological map. In the 1990s, GIS and decision-support systems began to replace these products (Culshaw, 2005). This drove the development of digital cartographic production systems to capture information from pre-existing paper geological maps (Jackson and Green, 2003), and the development by some surveys (including the British Geological Survey) of digital field data recording systems to facilitate a fully digital workflow from field observation to map, GIS and 3D model delivery (Howard et al, 2009).

FROM MAPS TO 3 DIMENSIONAL MODELS

Although geological and thematic maps have served the geoscience user community effectively for nearly 200 years, they have some basic deficiencies as a communication medium for explicit, spatially located 3D geological information (Loudon, 2000). In particular, the knowledge they convey is explicit in 2D, but largely implicit in 3 and 4D. The most serious knowledge gaps are in shallow superficial deposits, and at depth below major unconformities. These gaps coincide with those parts of the subsurface where information is in greatest demand from the modern user community. Shallow (less than 20 metre depth) 3D geological knowledge is required for a diverse range of applications, including engineering, waste management, environmental assessment, planning and environmental regulation and aggregate mineral exploration and exploitation (Culshaw, 2005). Deeper, spatially accurate geological information, once mainly required for exploration and management of hydrocarbon, coal, groundwater and metalliferous mineral resources, is now in increasing demand for newer technologies such as clean coal, underground gas storage, nuclear waste containment, and storage of carbon dioxide.

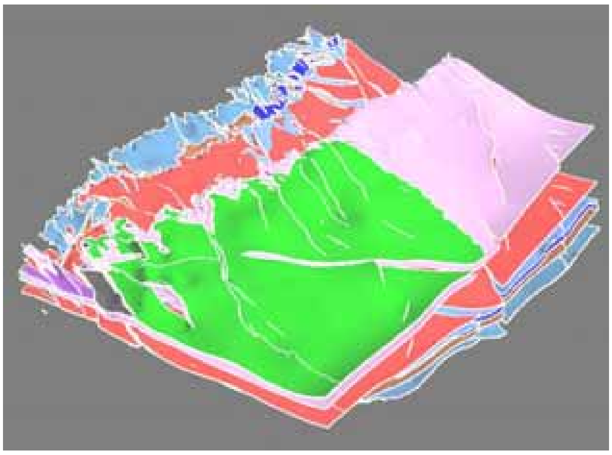

Figure 1. 3D geological model of part of central England. Approximate model dimensions 75km. x 30 km. x 0.4 km. The model was constructed to identify pathways for contamination of the underground public water supply by mine waters and by lower quality groundwater from minor aquifers. The model was essential to identify pathways but outputs were presented to the users as a simple 2D GIS.

In the geosciences, combination of spatial and process models has been pioneered by the hydrocarbons, groundwater, nuclear waste management and contaminated land remediation industries, principally to model multi-phase fluid movement through reservoirs, repositories, artificial seals and containment rocks. Although many GSOs are now developing 3D geological models to communicate spatial geological knowledge, few users currently have the 3D information technology to utilise or query the models (Figure 1). Integration of spatial and process models remains in its infancy. Moreover, it is becoming increasingly apparent that, to meet future demands for understanding, modelling and predicting the impacts of environmental change, geoscience knowledge will need to be incorporated into more holistic environmental change impact models. These will be constructs of inter-operable, spatial environmental datasets and dynamic process models, and will cut across the interfaces between the geosphere, hydrosphere, biosphere and atmosphere. Their development will require unprecedented levels of interdisciplinary collaboration across the environmental sciences.

ENVIRONMENTAL CHANGE IMPACTS MODELS – CHALLENGES AND ASPIRATIONS

In the past, national geological mapping programmes in most countries have proceeded systematically, with the aims of completing map coverage to common standards and steadily improving accuracy and consistency. Uncertainties in interpretation have been concealed from users behind the aim to present, on a map, a single, defendable scientific interpretation. For spatial geological models the approach and prioritisation of effort is likely to be driven by new imperatives, in particular:

- The needs for interoperability and integration with other environmental datasets;
- The need for information on uncertainty in data and interpretations and on confidence and probability of predictions and scenarios, to enable risk-based decision-making by users;
- An understanding of the key sensitivities in environmental systems and the models that represent them, so that geoscience data collection and modelling can address the most important data variables and gaps in knowledge.

But, most importantly, future priorities will be driven by the pressing, trans-national and cross-disciplinary requirements for solutions to environmental change and future resource security. The geological models of the future will hang on consistent but low resolution trans-national 3D frameworks, and will employ interoperable spatial data models and standards. Compared to geological maps, their resolution, content and attributes will far more heterogeneous, confidence will be communicated and a range of alternative models and downstream predictive scenarios will be presented. To achieve these goals, the scientific, technical and cultural challenges will be considerable but rewarding.

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THE ORGANIZATION OF A GIS DATABASE ON NATURAL HAZARDS AND STRUCTURAL VULNERABILITY FOR THE HISTORICAL CENTER OF THE CITY OF VALPARAISO (CHILE).

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Keywords: *natural and anthropic hazards, risk assessment, GIS.*

THE MAR VASTO PROJECT : AN IMPORTANT COOPERATION ITALY - CHILE

The Project "MAR VASTO" ("Risk Management in Valparaiso/Manejo de Riesgos en Valparaíso", MAR VASTO 2007, Indirli et al. 2008) started in March 2007, with coordination of ENEA (Italian Agency for New Technologies, Energy and Environment), participation of several partners (Italy: University of Ferrara, University of Padua, Abdus Salam International Centre for Theoretical Physics - ICTP/University of Trieste; Chile: Valparaiso Technical University Federico Santa Maria, Santiago University of Chile), and support of local stakeholders. Being Valparaiso included since 2003 in the UNESCO Word Heritage List of protected sites, the project main goals have been the following: to collect, analyze and elaborate the existing information; to develop a GIS digital archive, well organized, user-friendly and easy to be implemented in the future, with hazard maps and scenarios; to provide a vulnerability analysis for three historical churches (La Matriz, San Francisco del Baron, Las Hermanitas de la Providencia, made by various materials - masonry, concrete, wood and adobe – and located in different city sites) and for a building stock in the Cerro Cordillera (partially inside the UNESCO area), analyzing more than 200 constructions; to suggest guidelines for future urban planning and strengthening interventions.
Valparaiso represents a distinctive case of growth, inside a remarkable landscape, of an important Pacific Ocean seaport (over the 19th and 20th centuries), up to reaching a strategic importance in shipping trade, declined after the Panama Canal opening (1914). Thus, Valparaiso tells the neverending story of a tight interaction between society and environment, stratifying different urban andarchitectonic layers, sometimes struck by disasters and always in danger. Certainly, the city is subjected to various natural hazards (seismic events, but also tsunamis, landslides, etc.) and anthropic calamities (mainly wild and human-induced fires). These features make Valparaiso a paradigmatic study case about hazard mitigation, and risk factors must be very well evaluated during the restoration phases to be planned in the future.

THE GIS DATABASE

The work on the GIS geo-referenced database elaborated materials purchased both in Chile and Italy. It has been indispensable to build at ENEA a detailed DEM (Digital Elevation Model) of the Valparaiso area, by generating ortho-photos from the very helpful aerial photos provided by SHOA ("Servicio Hidrográfico y Oceanográfico de la Armada de Chile").
Digital cartography (streets, buildings, quoted points, and other information) provided by the Valparaiso Municipality Heritage Office ("Oficina de Gestion Patrimonial, OGP) was often not very accurate and didn't match the above said aerial photo of the Valparaiso area. Therefore, a field survey using DGPS (Differential Global Positioning System) has been carried out in situ, in order to check aerial photos and cartography provided by Chilean partners and verify the GIS database from the topographic point of view. The DGPS survey provided a pattern of points enabling to remove uncertainties, and clarifying univocally the real geographic position.
The GIS database platform organized in clear and user-friendly maps a huge amount of data (aerial

and satellital photos, cartography, batimetry, GIS urban layers, geo-referenced historic maps, etc.) of general interest, but also information targeted on specific hazards and building inventory of the Cerro Cordillera investigation. The latter can be considered a robust step ahead**,** having focused, even if for a limited area, architectonic/urban planning analyses, evaluation of structural vulnerability and definition of some intervention proposals. Thus, the GIS modules implemented for the selected sector and heritage buildings could be easily extended in the future to all the historical city, in the framework of further research stages.

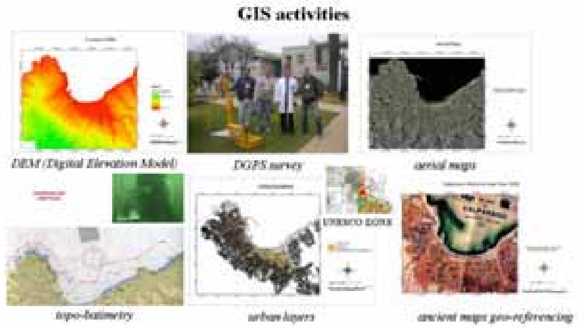

Figure 1 – The "MAR VASTO" project: GIS activities for Valparaiso.

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HAZARD MAPS

Hazard maps have been developed for natural (earthquake, tsunami, landslide) and anthropic (fire) disasters and then stored in the GIS database (MAR VASTO 2007).

Seismic hazard

Chile is one of the most seismic country in the world, interested by major earthquakes during its history, including the City of Valparaiso. "State-of-the-art" information has been provided by Chilean partners (mainly University of Chile, Santiago) and stakeholders; specific studies on seismic hazard have been carried out by Italian partners (mainly ICTP). It is worth noting that the deterministic approach has been followed in the "MAR VASTO" project, in order to evaluate the seismic input in the Valparaiso area for certain earthquake scenarios (in general), and in some sections underneath the churches locations (in particular). In fact, case studies indicate the limits of the PSHA (Probabilistic Seismic Hazard Analysis) currently used methodologies, deeply rooted in engineering practice, supplying indications that can be useful but not sufficiently reliable (Indirli et al. 2006), as shown by recent examples (Kobe 1995, Bhuj 2001, Boumerdes 2003 and Bam 2003 events).

The following four scenarios, taking into account two fault rupture typologies (unilateral and bilateral), have been considered for the urban Valparaiso area:

-Magnitude 7.5 Occasional (Occurrence Period ≈ 120-140 years, Strong),
-Magnitude 7.8 (1985) Sporadic (Occurrence Period ≈ 200-250 years, Very Strong),
-Magnitude 8.3 (1906) Rare (Occurrence Period ≈ 500 years, Disastrous),
-Magnitude 8.5 Exceptional (Occurrence Period ≈ 1000 years, Catastrophic).

The deterministic model has been firstly checked on the 1985 seismic event available recordings, and then extended to the other scenarios, obtaining synthetic time-histories (Displacement, Velocity and Accelerations) for the two horizontal ground motion components (N-S e E-W) and a dense grid for the Valparaiso urban area, storing different 96 maps in the GIS database. Specific seismic inputs have been elaborated for the sites of the three churches, in order to evaluate structural
vulnerability and effectiveness of strengthening interventions.

In conclusion, seismic hazard is very high in the Valparaiso urban area, not only concentrated in the flat zone along the coast (because of local amplification effects due to soft soil), but also widespread in the hills, for geologic/topographic configuration and structural vulnerability. Of course, secondary effects should also be foreseen (tsunami, landslide, fire, etc.).

Tsunami hazard

Inundations happened several times in the past; starting from source models and simulations (1985 and 1906) studied by SHOA, other Valparaiso tsunami scenarios have been considered:

- Magnitude 7.0 Frequent (Occurrence Period ≈ 70-80 years),
- Magnitude 7.5 Occasional (Occurrence Period ≈120-140 years, Strong),
- Magnitude 7.8 (1985) Sporadic (from SHOA) (Occurrence Period ≈ 200-250 years, Very Strong),
- Magnitude 8.3 (1906) Rare (from SHOA) (Occurrence Period ≈ 500 years, Disastrous),
- Magnitude 8.5 Exceptional (Occurrence Period ≈1000 years, Catastrophic).

Then, inundation maps have been implemented, defining a relationship between the sea wave maximum height and the amplification in comparison with the reference earthquake event.

It is clear that all the coastal line in the Valparaiso harbour zone must be considered at high risk of flooding.

Landslide hazard

Thanks to the indispensable support of SHOA, OGP and local universities, landslide hazard and susceptibility maps have been implemented through in-field campaign, reconstruction of past landslide events from historical archives, pluviometric analysis and digital/analogical aerial photos elaboration. Landslide hazard is very high in all the Valparaiso amphitheatre. The upstream hill side is characterized mainly by mud-debris flow events, in the interior of the eluvium covering, triggered a couple of times in the year, concentrated in the summer season. The intensity of those phenomena can vary widely, but the presence of densely populated urban settlements in ravine beds, escarpment sides and valley heads (often artificially terraced) makes the associated risk very high. The coastal flat is reached by moved materials only when the event is intense or when several activated areas merge and flow together in the same bed. Fall events are punctual and characterized by local effects, but often destructive, at the basis of the sub-vertical sides. Certainly, seismic ground shaking as starting point of landslide phenomena should be carefully investigated.

Fire hazard

Fires certainly are the most frequent and dangerous disaster in Valparaiso. The “state-of-the-art” information has been provided by the Firemen Corp and OGP, with particular regard to the Calle Serrano tragedy. In fact, on February 3rd, 2007 a violent explosion due to a gas leak killed four people, destroyed some heritage buildings and damaged others in Calle Serrano, in the core of the UNESCO zone of Valparaiso. Despite the good expertise of local Firemen, fires occur in the urban area (due to bad maintenance of electric systems and gas pipelines, building materials, lack of education and vandalism), but also in the surroundings forests and bushes (mainly human-made events). Furthermore, the risk is worsened by usual windy weather, narrow and tortuous hill roads, presence of wooden houses and sometimes insufficient water pressure in the hydrants. Also the presence of the close harbor facilities represents a further risk factor. Moreover, important monuments were burned during the 1906 earthquake, but also damaged by recent fires (as the Church of “San Francisco del Baron” in 1983).

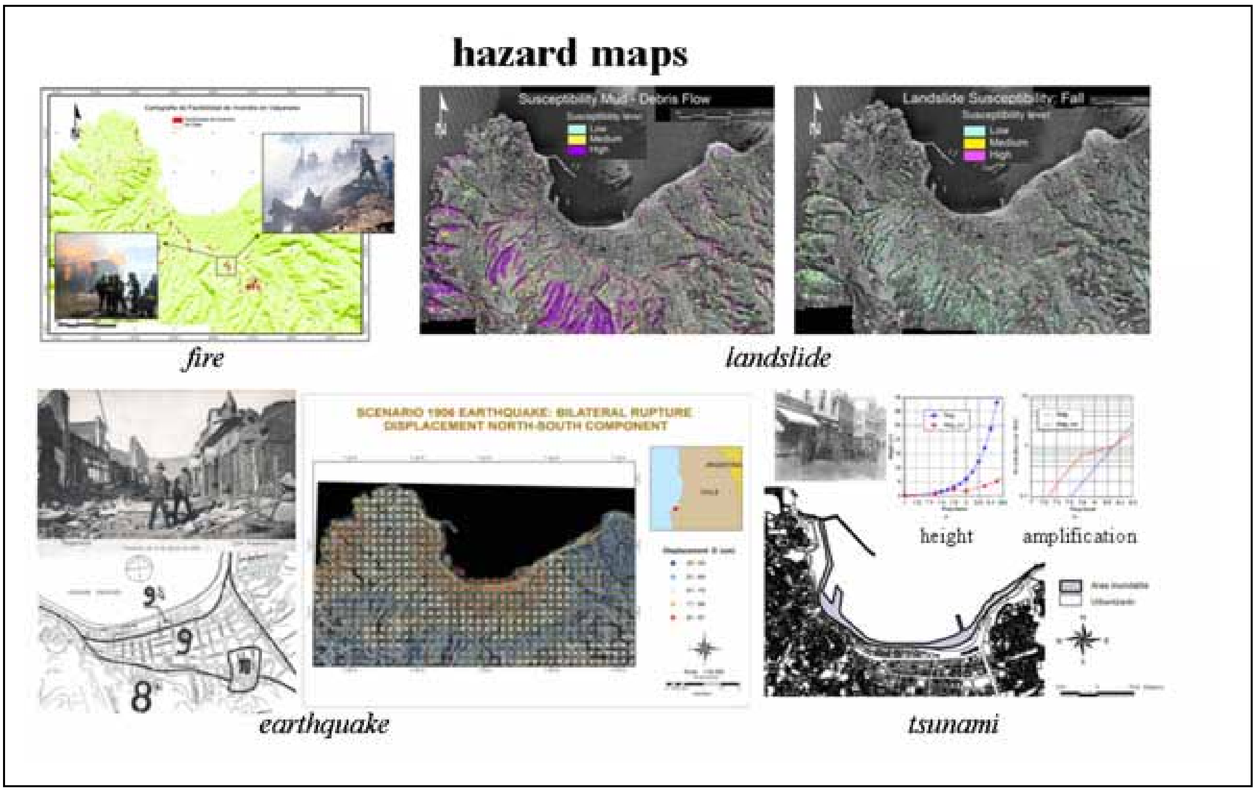

Figure 2 – The “MAR VASTO” project: hazard maps for Valparaiso.

CONCLUSIONS

"MAR VASTO" project (MAR VASTO 2007) showes importance and effectiveness of a GIS database, in order to merge together different approaches (hazard mapping; building inventory; architectonic, urban planning and structural vulnerability analyses; intervention proposals, etc.) to study historical centers, important for their patrimonial value, prone to natural/anthropic disasters.
In fact, Risk Assessment can be managed by using innovative and integrated tools (like GIS-based software and standard loss estimation methodologies), provided by huge digitized archives and interactive import-export capabilities.
Specific categories can be defined for cultural heritage assets and historical centers, together with the definition of vulnerability functions for masonry buildings, by including specific algorithms already developed by the scientific community. In addition, some studies can provide accurate procedures (earthquake deterministic models and scenarios) for the protection of strategic structures, cultural heritage, and urban environment, already applied in the framework of important international projects.
The identification of a global risk factor for a given area (or a building), is another crucial step to carry out in the future, because the definition of combination methods needs deeper analyses. Thecomparison of codes and standards regarding the natural hazards mitigation, inside and outside the European Community, is another fundamental step of the work, in order to get a common and updated set of rules.
Moreover, the risk assessment databases should be flexible, freely available for use by any country and organization through Internet access, open-source, capable to be multi-hazard and international in scope, encouraging the worldwide community to participate to their development and validation.
Finally, the purpose of this article is to provide some elements for a step ahead, hoping in new studies and researches for further developments.

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DIGITAL GEOLOGICAL MAPPING – A NEW APPROACH

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KEY WORDS: mobile Geological Information System, PDA-based digital field book

INTRODUCTION

In recent years a rush for mineral resources and raw materials together with strong growth in the mining industry was observed. New interest of the growing mining industry combined with the potential of newly available datasets has triggered numerous geological mapping projects during recent years. Not only new geophysical airborne surveys, but also technical improvement in satellite earth observation technology and analytical laboratory work made it easier to accelerate and generally improve the mapping process. Given these new tools and rapid evolution in computer technology – especially for Geographical Information Systems (GIS) – not only is new mapping work enhanced, but also the review and reinterpretation of former geological models is required.

These developments consequently lead to new, high standards in all fields of geo-science and geo-science related projects. The desired scientific output is no longer restricted to hardcopy maps and written reports, but now includes digital data formats and databases interlinked with each other and integrated into a GIS environment.

While these improvements in technology are highly welcome, they nevertheless pose a challenge to mapping techniques in the field and the office, after data collection. The general need within industry and various countries, to cope with these challenges, leads to an increasing number of tendered projects, especially in Africa.

GEOLOGICAL MAPPING

Taking a closer look at classical geological mapping techniques, it is obvious that they are not efficient in the use of modern data and the technical achievements mentioned above. To name just the main problems:

- There is no standardisation of field book entries of geologists, which leads to a varied structure of the observation data.
- Only a single dataset at a time can be used as a hardcopy information layer in the field.
- Orientation accuracy in the field and on the map depends strongly on the landmarks of the area and is not only time-consuming, but can lead to serious misinterpretation.
- The creation of map products normally starts after the field work is complete and is not done by the mapping geologist. The iterative interpretation process of the geologist (data collection – visualisation – interpretation) directly in the field is not effective.
- A gap exists between the fieldwork, digitalization and GIS integration.

All these factors lead to ineffective use of valuable field work time - the most cost-intensive part of geological mapping – and an inefficient interpretation-creation process, from beginning to end.

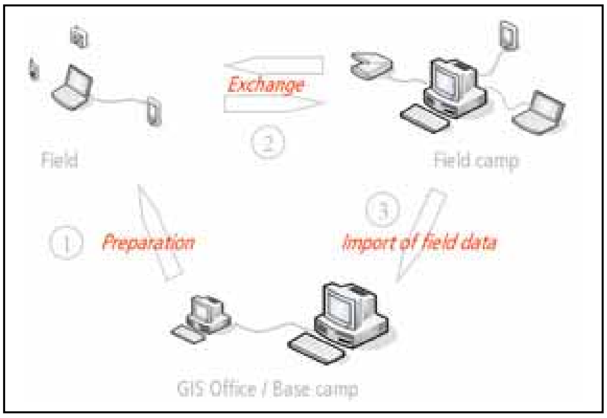

Figure 1 – Workflow of Digital Geological Mapping.

DIGITAL GEOLOGICAL MAPPING APPROACH

Since early 2003, GAF AG introduced a new method to geological field work with the launch of the GeoRover™ Software as part of a modern digital geological mapping approach. Gaining experience in different geological mapping projects for the hydrocarbon industry, the company set up a system for the mapping geologist in the field. In this concept of new mapping techniques, strong emphasis was placed on communication between the GIS experts and the geologists, right from the beginning. Easy transfer between data acquired in the field and the GIS work involved in final map production was - and remains - the main aim of the concept.

With this aim as a precondition, a tool was established that is easy-to-use and still highly accurate and compatible to other software packages. It is tailored to the geologist without profound GIS skills. This tool formed the backbone of different mapping projects carried out by GAF AG from 2003 onwards. It is based on a relational database and the use of a combined mobile laptop-PDA (GPS-connected Personal Digital Assistant) system. Using this technique, each field geologist is supported with a data display in the field and can immediately enter attributes to each observation point via standardized ‘pick lists’ and free text fields. The collected data is then integrated in a main database and easily shared and visualised. In short, the mapping geologist is equipped with a digital field book which is constantly updated and the interpretation of the data is enhanced by visualisation in no time.

- Observation data is standardized and comparable by a tailored relational database.
- All observation points are directly attributed, stored, and visualised in the field.
- Direct access in the field to different datasets is possible using a GPS-connected viewer.
- The easy-to-use functionality of the system lets the mapping geologist do the digital mapping by creating shapefile-formats in the GeoRover™-GIS already during the field work, leading to facilitation of the iterative mapping process in a “growing GIS”.
- In the end, the cartography expert gets interpreted digital data from the field to be directly integrated into the GIS environment.

GAF AG has used this digital geological mapping approach successfully in different types of projects:

- A very intensive and successful test for the setup followed from 2004-2008 in a World Bank financed geological mapping project for the Republic of Madagascar. In a consortium with the Federal Institute for Geosciences and Natural Resources (BGR), over 7000 observation- and data-points were captured, interpreted and stored, while mapping an area of approximately 150.000 km2. This resulted in the production of over 100 different maps dealing with the fields of geology, geochemistry and hydrogeology and especially mineral potential, in different scales from 1:100 000 to 1:500 000.
- In 2008 the company supported the Republic of Ghana in their “Ghana National Geological Map Project” carried out by BGR. After implementation of the approach into their own system and training of local staff, the Geological Survey of Ghana continues to use these techniques very satisfactorily.
- In Oman and Romania (2003-2005), the approach was used for hydrocarbon exploration by interpreting salt-tectonic related uplifts. This was done by on-the-spot interpretation of remote sensing data and seismic profiles throughout whole of Oman and most of the Transylvanian basin in Romania.

CONCLUSION

In conclusion, this new mapping approach is significantly speeding up the geological mapping process while increasing the quality of end products. New developments in computer and earth observation technology are efficiently integrated into a system coordinating the processes from the compilation phase to the production of final products.

At the moment the system is successfully in use in ongoing geological mapping projects in Uganda and Morocco.

ACKNOWLEDGMENT

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GIS-BASED DETECTION OF RECENT SURFACE DEFORMATION PROCESSES AND DIFFERENTIATION BETWEEN THEIR CAUSES

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KEY WORDS: GIS, surface deformation, faults, CO_2-injection, deep geothermal energy

INTRODUCTION

Beside the centuries old exploitation of resources through mankind nowadays the Earth´s crust additionally is the target of modern production of energy, i.e. deep geothermal energy and CO2-injection. Both methods are most successful in geologically complex areas, e.g. Upper Rhine Graben, North German Basin. At the same time such areas often show recent geodynamic processes (Lehné & Sirocko 2005, 2007, Rósza et al. 2005, Hoppe & Lang 2007). In order to differentiate between natural and anthropogenic induced vertical crustal movements complex GIS-based data analysis with respect to all site specific influencing factors are needed. Our approach is a GIS-based 4D-query tool for quantification and differentiation of movements.

METHODS

For differentiation between the causes for surface deformation all site-specific influencing factors must be quantified and interpreted. In this context the availability of seismic data is important in order to connect detected surface deformation to geological structures, i.e. salt structures and faults. Additionally near surface faults which might be recent active can be analyzed for their possible function as CO2-paths.

To allow differentiation between geodynamic causes and anthropogenic or periodic causes for the recorded surface deformation all site-specific influencing factors (groundwater, soil, tide, rainfall, watering, dewatering, etc.) need to be addressed and quantified on the basis of all available data as well as fieldwork.

Due to the high number of influencing factors the differentiation of causes for detected surface deformation is best done by the use of powerful GIS-based queries. To support such queries it is intended to program a 4D-query routine on the basis of .net. The query routine enables third parties to independent long term differentiation between causes for detected surface deformation.

ECONOMIC BENEFIT

In particular the possibility to differentiate between several causes for surface deformation is economical auspicious. The use of the upper 5000 m of the earth´s crust is increasing (e.g. CO2-injection, deep geothermal energy, oil and gas). For such projects it is important to define the zero state of the surface in the target area to allow both an interpretation of the geodynamic processes and an accurate monitoring. In consideration of all site-specific parameters the information, achieved by the query routine, can be used e.g. by insurances (estimation of damage potential), the operator (monitoring, estimation of success) or the supervisory body.

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A REGIONAL 1:250.000 SCALE GEOLOGICAL MAP OF SICILY AS A TOOL FOR A NEOTECTONIC MODEL OF CENTRAL MEDITERRANEAN

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KEY WORDS: Structural geology, neotectonics, geothematic cartography, Sicily (Italy), Calabria Peloritani Arc, Apenninic-Maghrebian Chain, Pelagian-Sicilian Thrust Belt, Tyrrhenian Basin.

A regional 1:250.000 scale geological map of Sicily has been realized, using data obtained from decades of field studies and analyses, integrated with volcanological as well as geophysical data. A wider knowledge of the southern Apennines geological features and of the surrounding seas (Tyrrhenian and Ionian basins), detected thanks to the seismic lines of the CROP-Mare project, permit to propose an updated structural model of this area of the Mediterranean Sea (Finetti et alii, 2005; Lentini et alii, 2006).

Sicily, located in the central Mediterranean, plays a fundamental role for the comprehension of the complicate geodynamic evolution. In the geological map some orogenic domains and the foreland-foredeep systems are represented. Moreover the structural features are well evident.

In the whole of the southern Apennines – Sicily – Tyrrhenian system some structural domains can be distinguished: the foreland domains are represented by two continental blocks, the Apulian Block to the north and the Pelagian Block to the south, respectively belonging to the Adria and to the Africa plates. They are separated since Permo-Triassic times by the oceanic crust of the Ionian Sea.

In Sicily the Foreland Domain is represented onland by the Hyblean Plateau and the Sciacca area (Fig. 1*).* It extends offshore in the Sicily Channel and the Sahel. The western boundary is represented by the N-S Axis (Tunisia) and eastwards the Malta-Hyblean Escarpment delimits the continental crust with the oceanic Ionian crust.

The Apenninic-Maghrebian Orogen is located between two oceanic crusts: the old Ionian crust, at present time subducting beneath the Calabrian Arc, and the new crust of the opening Tyrrhenian Sea. The orogenic belt is represented by a multilayer allochthonous edifice, composed of the Calabride Chain (CC) tectonically overlying the Apenninic-Maghrebian Chain (AMC), which in turn overthrust onto the Upper Miocene and Pliocene top-levels of a deep seated thrust system, originating by the deformation of the innermost carbonates of the Pelagian block (External Thrust System: ETS).

The AMC tectonic units derive from the orogenic transport during Oligo-Miocene times of sedimentary sequences deposited in palaeogeographical domains located between the Europe and the Afro-Adriatic plates. These units are composed of Meso-Cenozoic shallow-water carbonate platforms detached from the Panormide/Apenninic continental Block, recognizable by means of seismic lines shot in the Tyrrhenian offshore of Southern Apennines and Northern Sicily. The Meso-Cenozoic basinal units, that compose the AMC, belong to two main groups of sequences, originally located on oceanic crusts separated by the Panormide/Apenninic Block: the external ones (Ionides) related to an original basin, belonging to branches of the Ionian Palaeobasin involved in the orogenesis, and the internal ones ascribed to the Alpine Tethys (Sicilide Units).

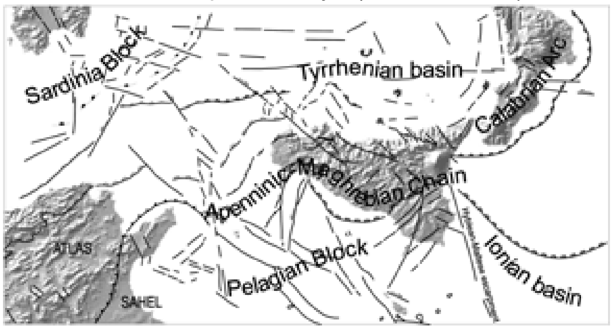

Figure 1 – Tectonic sketch Map of the Central Mediterranean Sea with the main structural domains.

The terrigenous deposits of the basinal sequences belonging to the Ionides are represented by Tertiary foreland/foredeep deposits, whose relationships with the substratum are occasionally preserved, although large detachments occurred with further forward transport, which generated repeated slices with an apparent increase to the original thickness.

In the geological map of Sicily the allochthonous units of the Oligo-Miocene Numidian Flysch have been distinguished from the authocthonous ones. That permits an easier lecture of the general structural features, because the uppermost nappes occupy the structural depressions. Moreover the different flysch-type tectonic units present different density of slides and that is important for a regional planning.

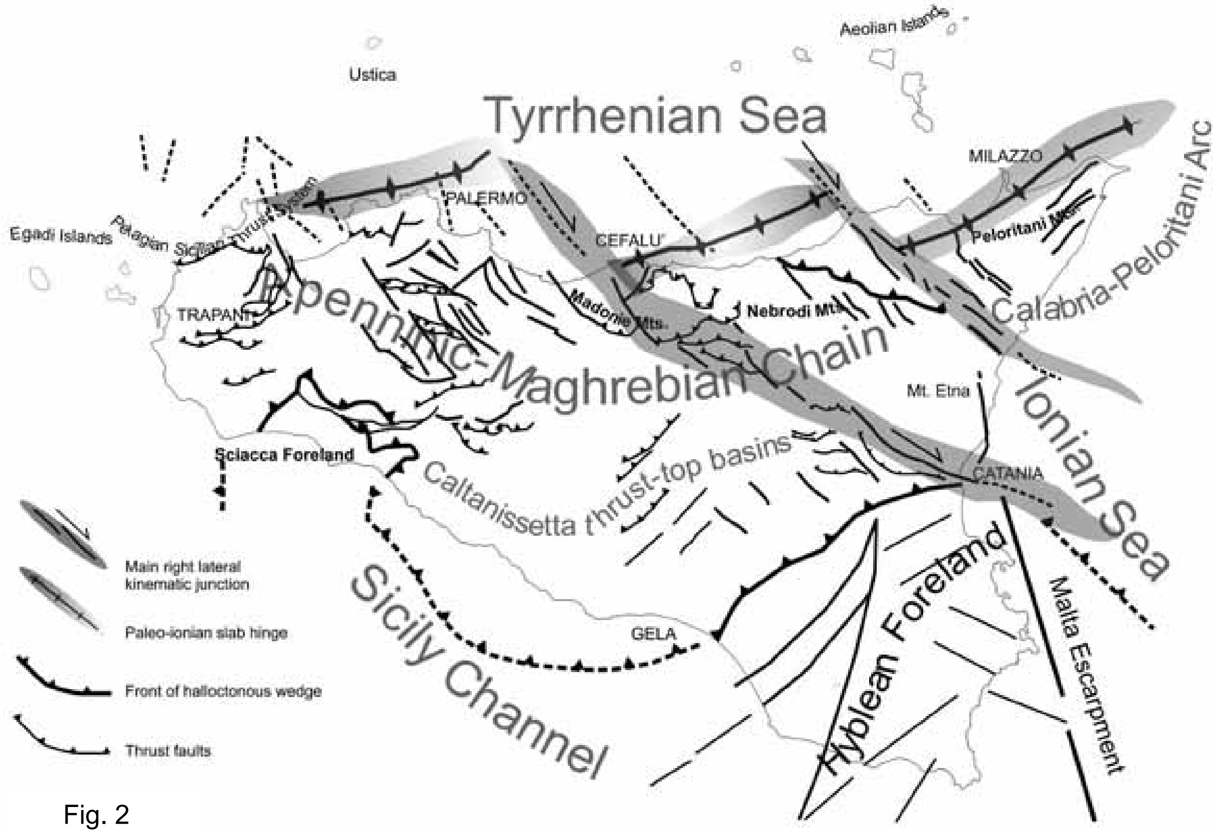

Fig. 2

The Calabride Chain characterizes the Calabria-Peloritani Arc and originated by the delamination of the European margin. This roof thrust system includes nappes of Hercynian basement with remains of the original Meso-Cenozoic covers deformed during the Paleogene and sutured by the Late Oligocene-Early Burdigalian Capo d'Orlando Flysch (Lentini et alii., 2000).

The Tyrrhenian Sea is a triangular-shaped basin with a maximum depth of more than 3600 m. It has developed since Middle Miocene times by means of extensional processes. The southern sector of the basin is connected with the current tectonics of the Apenninic-Maghrebian Orogen. It is characterized by two abissal basins (Marsili and Vavilov) floored by oceanic crust of different ages.

The Aeolian volcanic arc is composed of seven islands and at least six volcanic seamounts. It is thought to be the product of subduction-related calc-alkaline arc volcanism, and demonstrates the subduction of the Ionian oceanic crust beneath the Calabria-Peloritani Arc.

The CROP-Mare crustal sections allow to distinguish thickness and distribution of the different crusts in this area of the Mediterranean Sea, and that there is a strong relationship with the geodynamic evolution of the orogen.

The geophysical data, integrated by the geological and volcanological ones mainly collected in Sicily during the compilation of the regional map, allow to restore the palaeogeography and the geodynamic evolution. Between Europe and the Afro-Adriatic margins the Alpine Tethys, characterized by an oceanic or thinned crust, was located. The Palaeoionian Sea was a basin intervening since Permo-Triassic times between the Apulian and the Pelagian Blocks, and branches of the Palaeoionian basin were floored by the Ionides.

The geological data allow to recognize three orogenic stages: the Eo-Alpine (Cretaceous-Eocene), that is recorded in northern Calabria, Corsica, and in the Tyrrhenian sea; the Balearic stage (Late Oligocene-Early Miocene), in which the Corsica-Sardinia block collided with the Adria-Africa margins with thrusting of the Alpine Tethydes over Panormide Units; and the Tyrrhenian stage (Middle Miocene to Present), when the onset of the Tyrrhenian back-arc basin occurred and the geodynamic evolution of the orogenic belt was influenced by the Ionian slab retreat, closing the interposed basin with tectonic transport of the Ionian ocean cover (Ionides) over the foreland blocks.

Both the foreland blocks extend below the orogenic belt, reaching the Tyrrhenian margins, with a gradual thinning and a transition to a Palaeo-Ionian slab, probably not active at present time, from which the Ionides detached and overrode the ETS.

The seismogeological data indicate that at the present time the Panormide continental crust is colliding with the Pelagian Block. The geological evidence of this collisional stage is manifested in the NW-SE oriented South Tyrrhenian System (STS), characterized by dextral faults, affecting both the offshore and the onshore of Sicily.

A specular structural setting has been recognized along the perityrrhenian sea in front of the southern Apennines (Cilento). There a sinistral fault system is developed both offshore and onshore.

Thus at present time two collisional settings have been recognized in western Sicily and in southern Apennines. The trascurrent fault systems drive the Calabria-Peloritani Arc toward SE. The distribution of the hypocenters of the earthquakes and the clear images of the CROP project showing the Ionian slab indicate that Southern Calabria and north-east Sicily represent the only segment of the arc still subducting.

The collisional stage, recognized along the Tyrrhenian coast of Sicily, runs from the offshore of Palermo town to Patti area, where the Vulcano line separates the contemporaneous active subduction processes below the Calabria-Peloritani Arc. The STS drives the transfer of the orogenic belt towards the Arc, characterized by the still subducting Ionian oceanic crust. Geological mapping, integrated with stratigraphic and structural analysis, widely carried out in Sicily, show that this area is dominated by a strike-slip tectonics, connected with the geodynamic evolution of the Tyrrhenian stage. Beside to the NW-SE oriented right lateral faults, antithetical NE-SW system, associated with N-S normal faults and south-verging thrusts, occur. All these structures are compatible with an unique kinematic picture.

The regional geological map of Sicily emphasizes the structural features of this area. It is evident that the South Tyrrhenian System, well developed in the southern sector of the Tyrrhenian Sea, dominates also the onshore areas of the Island. Some examples can be observed in western Sicily. There, the east-west oriented carbonate ridges, belonging to the Pelagian-Sicilian thrust system (M.Kumeta, Rocca Busambra), are bounded by reverse faults and controlled by NW-SE oriented trascurrent faults with dextral component. The sigmoidal characters of the ridges, as well as those of the fold axis, indicate a dextral movement.

The Patti area (NE Sicily) is characterized by a set of dextral faults belonging to the STS, NE-SW sinistral faults and N-S oriented normal faults. These latter belong to the Vulcano line, a NNW-SSE oriented fault, that represents a boundary between the collisional setting to the west and the still subducting Ionian slab to the east. It crosses the Eolian Islands and separates the areas with volcanic activity to the east (Vulcano, Panarea, Stromboli) from the western islands (Alicudi, Filicudi), where active volcanic phenomena seem to have stopped at the present time.

The structural data observed on the regional geological map suggest that the complicate set of faults could be interprete as the surficial espression of main NW-SE crustal elements, which drive the orogenic belt toward SE. In the Fig.2 two main shear zones are drawn, based on the mesostructural mesurements carried out in the field work. They could affect the slab hinge detected by the seismic lines of the CROP-Mare project and progressively displaced toward SE, until to join to the active slab in front of the Calabria-Peloritani Arc.

The M.Etna volcano (Lentini, 1982) is located close to the boundary between the collisional area and the still subducting Ionian slab, and it is bounded by two major strike-slip shear zones. Between them some sigmoidal N-S oriented normal faults are recognizable. This picture can provide a convincing hypothesis about the origin of the volcano.

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3D GEOLOGICAL MODELLING AT THE BRITISH GEOLOGICAL SURVEY USING THE GSI3D SOFTWARE AND METHODOLOGY

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KEYWORDS: Geological Modelling, GSI3D software, Geological Survey Organisations.

BACKGROUND

As a national geological survey organisation the British Geological Survey (BGS) has produced paper maps of Britain's geology at a series of scales for the past 175 years. Over time these have become more detailed with the one-inch (1:63 360) scale being the standard output in the mid 19th Century whereas today 1:10 000 is considered appropriate for modern needs over most of Britain's landscape.

In 1815, twenty years before the establishment of BGS, William Smith was already addressing the need to present the third dimension of the geology as well as the surface arrangement of units on 2D paper maps. Over time, cross-section drawing became more refined, resulting in outputs such as fence, ribbon and block diagrams to reveal the 3D structure, while contoured surfaces or thicknesses (isopachs) were used to show the spatial position of individual units such as major unconformities or sequences. Geological maps often require another geologist to understand them fully; the surveyors' spatial ideas, models and concepts can never be properly represented in a 2D map output, and so, until recently, much knowledge has been lost to the science and to the users.

In 2000 BGS began the translation of their traditional 2D geological map outputs into fully interactive 3D geological models of the subsurface. This was possible because, by 2000, the Survey had digital geological maps at scales effective for modelling (Jackson & Green, 2003), licensed, nationwide high-resolution Digital Terrain Model (DTM) coverage, and databases of both, borehole index and downhole data supported by corporate dictionaries for lithological and stratigraphical terminology.

MODELLING SOFTWARE & METHODOLOGY

The Geological Surveying and Investigation in 3 Dimensions (GSI3D) software tool and methodology has been developed over the last 15 years. The initial software was developed by H-G Sobisch as a tool for modelling shallow superficial-Quaternary sequences using a cross-section-based approach. From 2001-05 BGS became involved in the accelerated development of the GSI3D software and methodology, initially through the Digital Geoscience Spatial Model (DGSM) project (see Smith *et al*. 2005). The advantage of GSI3D is that it has been designed to use all common types of digital BGS data, and combine these with the wealth of knowledge otherwise trapped within the scientists' brain, to produce 3D geological models (Kessler & Mathers 2004).

BGS now builds its general deep regional models at 1:1 Million, and 1:250 000, resolution using GOCAD, a software tool particularly favoured by the oil industry, whilst GSI3D is mainly used to produce 1:50 000 and 1: 10 000 resolution models of the near-surface terrains characterised by artificial ground, superficial deposits and straightforward bedrock geology. As the two modelling packages can also exchange files they have been used together successfully in the construction, validation and delivery of some models.

GSI3D MODELS

To-date detailed GSI3D models have been constructed for areas such as Greater London and the Thames Gateway Development Zone, parts of southern East Anglia, Manchester, Merseyside and Glasgow. (Figures 1 & 2 below).

GSI3D is also frequently used in building 3D models as commercial contracts for clients such as the Environment Agency of England and Wales (EA), the UK Water Sector and Local Government (Figure 1). These are usually constructed to the clients' specifications and have been mainly utilized for groundwater management, recharge, aquifer protection, groundwater flooding, archaeological assessment and planning (see Mathers, 2008 for further examples). Many of these models have focussed on important aquifers such as the Chalk and Sherwood Sandstone. Currently released versions of GSI3D are limited to modelling in areas of simple bedrock with normal faulting corresponding roughly in Britain to Triassic and younger strata (Figure 1) and Quaternary deposits.

CONTINUOUS DEVELOPMENT

In 2007 BGS embarked on a 3-year R&D project to extend the use of the GSI3D software and methodology to most styles of bedrock geology, notably faulting (normal, reverse, strike-slip, scissor, thrusts-nappes), folding, intrusive and cross-cutting bodies and overturned - overfolded strata. Initial results from this development are encouraging and are focussed on testbed models of faulted Palaeogene and Mesozoic strata beneath London and folded and faulted Lower Palaeozoic rocks in Plynlimon, Central Wales. BGS hope to roll out a beta version of the new GSI3D bedrock software early in 2009.

MODEL DELIVERY

Customers can obtain BGS models in several ways. Geological models can be served via the web in form of Flash animations and 3D PDFs giving the users a pre-view of the model and some interactive functionality. BGS also uses a Java based 3D viewer that forms a sub-set of the GSI3D software called the Sub-surface Viewer. In these viewer applications the user can create synthetic boreholes and sections, change the theme properties of the model, create contour maps as well as explode the model for detailed analysis These calculations are performed on the user's PC so only the data has to be transmitted via the web or CD-ROM. Data can also be delivered to customers in many other requested formats such as scattered x,y,z points, ASCII grids, ESRI shapes and grids and VRML surfaces (Kessler, Mathers & Sobisch, 2008).

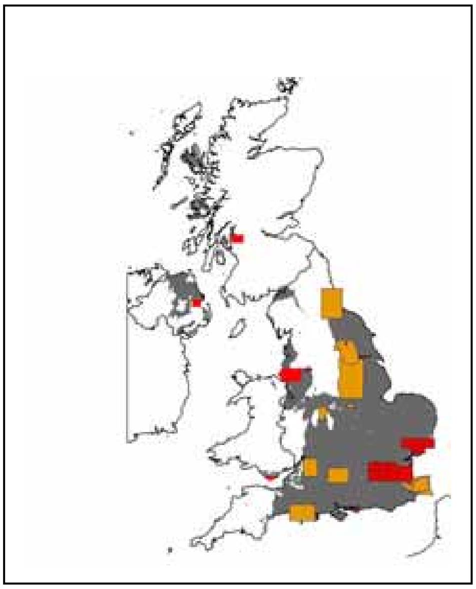

Figure 1 – Availability of 1:50 000 and 1: 10 000 resolution BGS models, standard models are shown in red and commercially built models in amber. Triassic and younger rocks are depicted in grey.

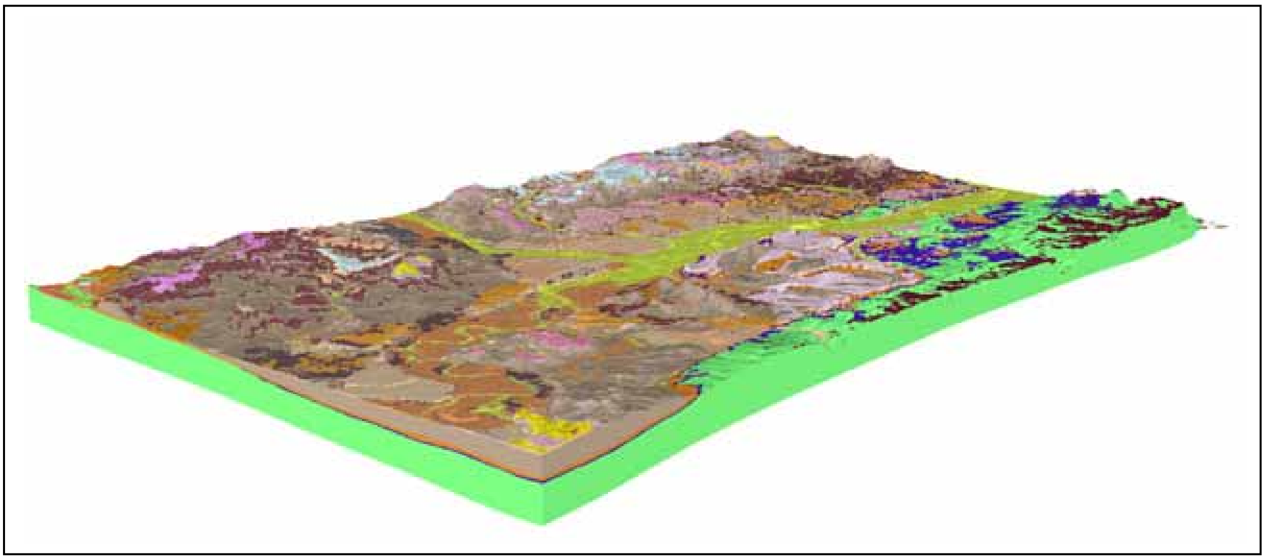

Figure 2 – 1:50 000 scale geological model of Greater London viewed from the southwest. The Chalk bedrock is shown in green. The area covers 60 x 40 km to a depth of up to 300m..

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KRIGING ASSISTANT: AN INNOVATIVE AND AUTOMATIC PROCEDURE FOR GEOSTATISTICAL ANALYSIS OF ENVIRONMENTAL DATA

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KEY WORDS: geostatistics, kriging, environmental data treatment, automatic kriging procedure.

ABSTRACT

Experimental data analysis and treatment are very important in order to understand and reconstruct spatial and temporal unknowns' parameters of several environmental "phenomenons" (for example, geochemical ones). For this reason our research team is working since 1983 in order to develop new techniques on which build up a system to help any researcher in geostatistical evaluation of environmental projects, avoiding the mistakes made in Sardinian mines.

The target of this work is to introduce the first version of new software named "Kriging Assistant" (KA). This software is able to support the user during the geostatistical estimation of a geo-resource because it is able to determine the model of experimental semivariogram with its parameters (range, nugget effect and sill) and to proceed independently to data kriging (point or block), in an innovative and automatic assisted path. Calculating procedures of KA are quite different from those of many other similar programs, because it does not use any type of default parameters, but each one is calculated directly on the real experimental dataset.

INTRODUCTION

The procedure, reported in this paper, represents the last step of the research of our department team, which is working since 1983. Given the bad results in several Sardinian mines (for example Masua and Funtana Raminosa), the beginning efforts were especially in utilising in different way the geostatistics (Mazzella A. et Al., 1983, Mazzella A., 1984). In particular we studied the characteristics of the semivariogram in order to deepen the real meaning of model curves and of each experimental semivariogram parameter. Subsequently we focused in development of new techniques and procedures for interpolating any kind of data and determining characteristic parameters of environmental "phenomenons". During these years we produced several works presented in national and international meetings (Mazzella A., 1985, Mazzella A. et Al, 1985, Mazzella A., 1998). The goal was to produce procedures to integrate in a future global project to help the user in evaluation of any environmental "phenomenon" and now we are here to present the first version of the global project. The name of this first system is "Kriging Assistant" (KA).

KA, which gathers all research results obtained all over the years, is aimed to help the researcher in geostatistical evaluation of environmental data (for example, geochemical ones). The main feature of KA regards its ability to solve the problem of semivariogram modelling; in fact, this feature is absent in all others geostatistic programs. This characteristic, in our opinion, is very important to reduce the evaluation errors. In fact considering the modelling of semivariogram as a non problem causes serious effects in the final results. In any case, from the classical geostatistics point of view, the modelling of semivariogram is not a problem or, worse, a procedure that could be solve by the personal feeling and experience.

KA is based on the experiences of Carr and Mela (Carr J.R. et Al.,1998) who developed two applications to calculate the experimental semivariogram and krige the original dataset, on GSLIB library (Deutsch C., 1992) by which we write optimized subroutines and, finally, on an innovative interpolation technique we used to create a new automatic procedure for semivariogram modelling (Mazzella A., 2008).

This procedure, obviously, represents one of the most important steps during the entire evaluation process of a dataset.

The semivariogram modelling, undervalued by classical geostatistics, is, in our opinion, the cause of errors in many evaluation processes, because the evaluation resulting from an improper semivariogram model is different from that deriving from a well calculated model.

PROCEDURE DESCRIPTION

KA was written in Microsoft Visual Basic 6, this programming language has been chosen because it is perfectly integrated with the Microsoft Windows libraries and it is easier than other language (C++ or JAVA) to manage the windows and the calls to system libraries. This fact makes KA a user friendly program for all the operations, in particular for reading data file K.A. uses Windows standard windows and buttons.

Once KA boots, its main window is shown with the splash screen, Figure 1.

Figure 1 – KA main window.

Because KA theoretically is able to complete the entire evaluation process (from data reading to contouring map production) without any user intervention, a warning message informs the user on the default experimental semivariogram calculation conditions, Figure 2.

Figure 2 – KA alert window.

Default calculus is done by KA with 0° of direction and 90° of regularization angle. The user can customize both these default parameters of KA, Figure 3.

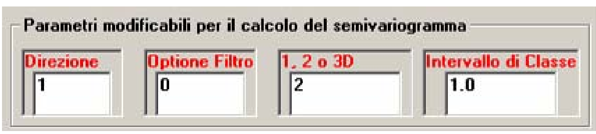

Figure 3 – KA panel to modify the parameters for the calculus of the experimental semivariogram.

In every case, to evaluate experimental dataset, KA needs to know the datafile format (actually supported only "geoeas" or "comma delimited" formats) and the column sequence information (X, Y, experimental value positions).

The first datafile ("geoeas" type), Figure 4a, is particular because the first rows are used to describe the columns of the datafile and the variables are separate by one or many spaces; the other datafile (comma delimited, Figure 4b) is a simple text file where the experimental data are written one for row with the variables separated by commas.

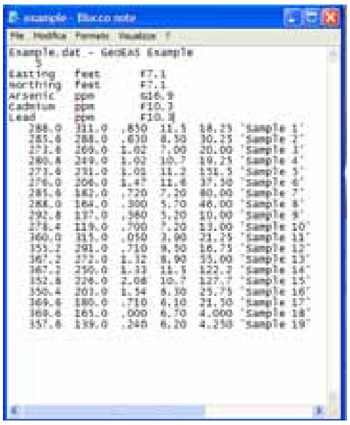

Figure 4a – Example of datafile according to Geoeas standard.

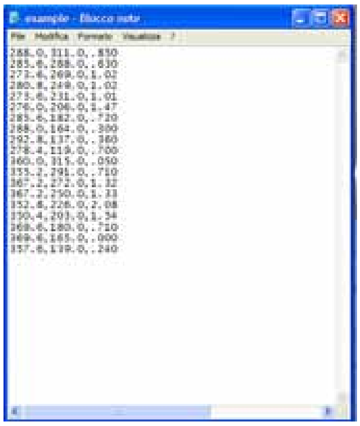

Figure 4b – Example of datafile according to comma-delimited standard.

Selected datafile and its standard, KA shows the map of experimental samples position and value, Figure 5.

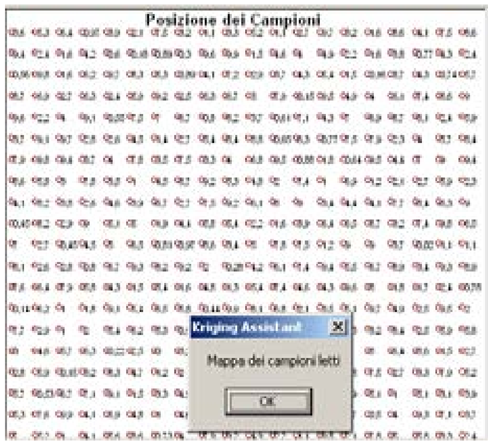

Figure 5 – Sample map.

Then KA proceeds automatically to experimental semivariogram calculus, Figure 6. In Figure 6, KA needs to know which technique is to use for modelling the experimental semivariogram curve.

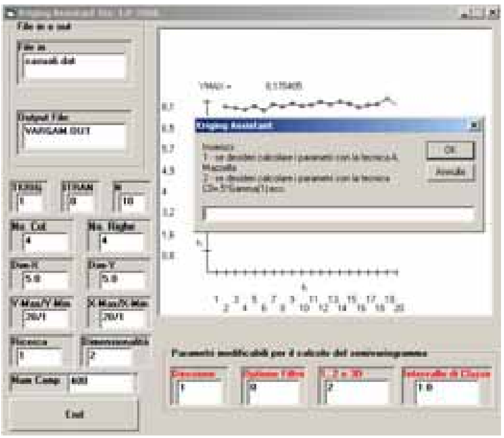

Figure 6 – KA panel to select the modellig technique.

This job can be done according to three different techniques:

- with Mazzella (Mazzella A., 1985) technique, Figure 7.

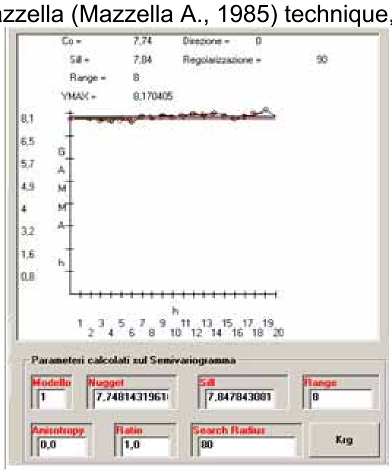

Figure 7 – Mazzella modelling technique (Mazzella A., 1985).

- with the Carr-Mela (Carr J.R. et alii, 1998) technique, Figure 8.

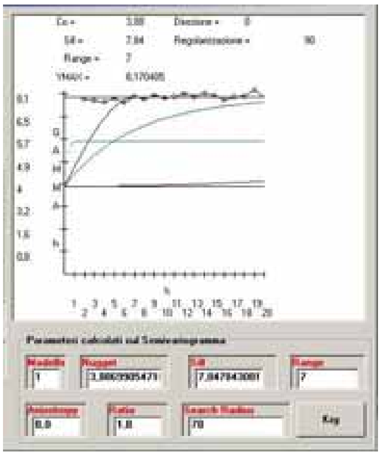

Figure 8 – Carr-Mela modelling technique (Carr J.R. et Al., 1998).

- with one of previous techniques and user customization of calculated parameters (for expert users only).

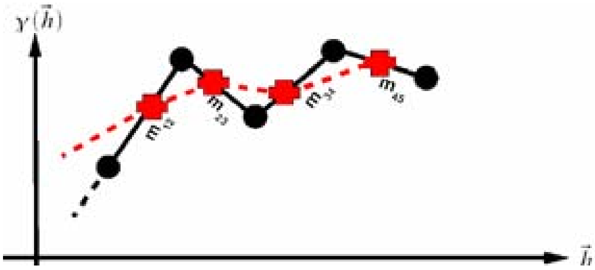

Figure 9 – Schematic representation of Mazzella modelling technique (Mazzella A., 1985): black line is the experimental semivariogram, red line is obtained weighing the experimental values with the number of pairs of experimental semivariogram.

Mazzella modelling technique (Mazzella A., 1985) calculates nugget effect, sill value and range directly from experimental data (Figure 9). In this way a new curve is obtained weighing the experimental values with the number of pairs of experimental semivariogram and extending this new curve to intercept the gamma-axis.

Instead Carr-Mela technique (Carr J.R. et Al., 1998) calculates only the nugget effect dividing by 2 the first point of the experimental semivariogram while the other interpolated points are the experimental values.

The comparison between these two technique, Figures 7 and 8, shows that Mazzella technique (Mazzella A., 1985) gives the best fitting results.

Then, according to model selected and any possible user customization, KA starts the kriging procedure. Estimation results' can be displayed by a coloured-blocks map or line-level map, Figures 10 and 11.

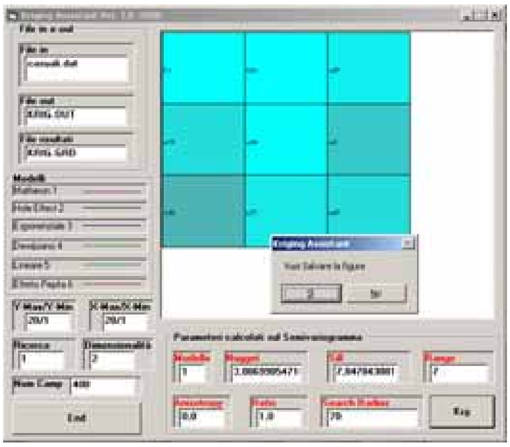

Figure 10 – Coloured-Block map.

CONCLUSIONS

During our simulations, Kriging Assistant was always stable, quick and powerful.

We are still working on this project in order increase the amount of readable datafile. In fact, actually KA can read only two type of datafile ("geoeas" and "comma delimited"), we think it will be better to implement at least one other type of datafile the Excel file (*.xls), in recent years become a "de facto" standard for many people.

Then we are working to automate all the evaluation process without any user contribution through automatic selection based on minimal errors in critical pass (for example modelling semivariogram).

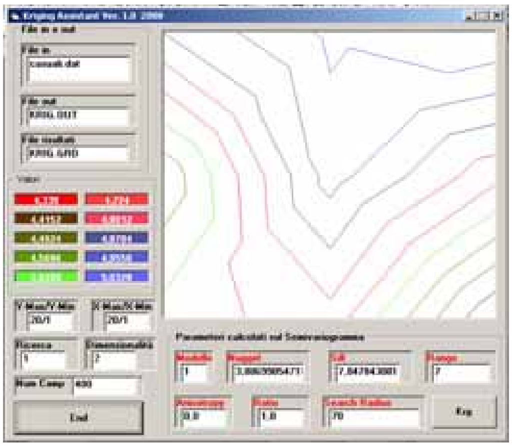

Figure 11 – Line-Level map.

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COMBINING GIS WITH 3D FOR GEOLOGICAL SUBSURFACE MODELLING ON THE BASIS OF SPARSE DATA SETS

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KEY WORDS: 3D-modelling, GIS, data-management, GOCAD

OBJECTIVE

The Geological Survey of Bavaria as part of the Bavarian Environment Agency (LfU) has been implementing 3D-modelling as a major part of geological data management, analysis and decision support for several years already. Having realized that current software is designed almost exclusively for the rather specific needs of the exploration industry (e.g. De Kemp, 2000; Wu, 2005) many technical and logistic obstacles had to be overcome for the usage at the survey.

Geological surveys in general put their main focus at the shallower subsurface level with data coming from conventional geological maps, wells and field-observation. In contrast to the petroleum-industry that can make use of extensive seismic surveys and does not have to deal with often inconsistent and complicated outcrop situations. However, with the combined adaption of several software and specific modelling approaches (some examples see De Kemp, 2000; Görne and Krentz, 2007; Tonini *et al.,* 2009) 3D-technology is now becoming more and more a pretty quick and strategical tool for ensuring data consistency and for building subsurface models also from sparse input data.

Results from modelling are used for revising input data (esp. well stratigraphy) and attribute modelling for hydrogeological and geothermal issues.

USING GIS FOR 3D-DATA MANAGEMENT

To do so, workflows are now implemented and techniques are developed for a fast and iterative data-conversion between the conventional GIS-world with its potential of high-level accuracy with extensive data accessibility and the 3D modelling packages that have to produce and test a variety of equally possible hypothetical models in an iterative and rapid way in order to build a so-called “common earth model” (McGaughey and Morrison, 2000). Normally, the main gateway is via the construction of geological cross-sections, calculation of (true) thickness maps from boreholes, and a rapid fault-network construction in 2,5D. These are all done mainly in GIS since processing time, data storage, accessibility and consistency can be easily managed at professional level. Unfortunately, 3D-packages still are not designed for performing exact spatial queries by maintaining topology. In most cases, queries are based only on point/line/surface/voxet nodes and not on their intersection in 3D (Martin *et al.***,** 2007). Spatial queries that take into account these object intersections are very complex and need huge processing time, therefore GIS still is the better way for data selection based on combined alphanumeric(!) attributes and topological queries.

Modelling at a regional scale in combination with only few data at depth puts a need to face some specific challenges:

- Additional constraints have to be calculated and constructed either in the form of new additional points or minimum/maximum constraints for some model attributes like thickness, slope, topology since geological data is often heterogeneous in space and quality and is often of rather soft value (e.g. geophysical data in the context of structural modelling).
- Normally, modelling does not look for a unique and unambiguous solution rather it has to deal with probabilities and various equally probable solutions that might serve as thresholds for risk assessment.
- Data have to be pre-processed in order to give direct access to all its information (e.g. well data is better treated as well objects instead of a set of individual points as topological information may be lost).
- Modelling has to be reproducible which implies the usage of as many geological constraints as possible to guide the mathematical interpolation as deliberately as possible and to minimize manual adjustments.
- Modelling has to be technically fast, simple and in a semi-automatic way. Otherwise one might end up in a never ending cycle of model trimming. Often modelling starts during data acquisition which urges constant data update and model modifications.
- Main sources of information are wells and geological maps. Bearing in mind that a geological map is a mapper’s 3D-model reduced to 2D, many topological constraints can be potentially extracted: Minimum/ maximum thickness, fault displacement, basic configuration of fault network, the units’ relative position in 3D-space and so on. A handicap is most 3D-software’s incapability of directly importing true polygons and of performing topological constraints based on them.

Therefore, four modules of software extensions have been tested as prototypes and are currently under development:

1) An ArcGIS-extension for easy data transfer and construction of geological cross-sections in 2D and 3D. Data is converted between geological maps, arbitrary (kinked) cross-sections, 3D-space and vice-versa (Schetselaar, 1995; Kus *et al.,* 2006). Construction of cross-sections is done in ArcGIS after data projection onto profil-lines and can be compared to cross-sections from 3D-modelling (figure 1).

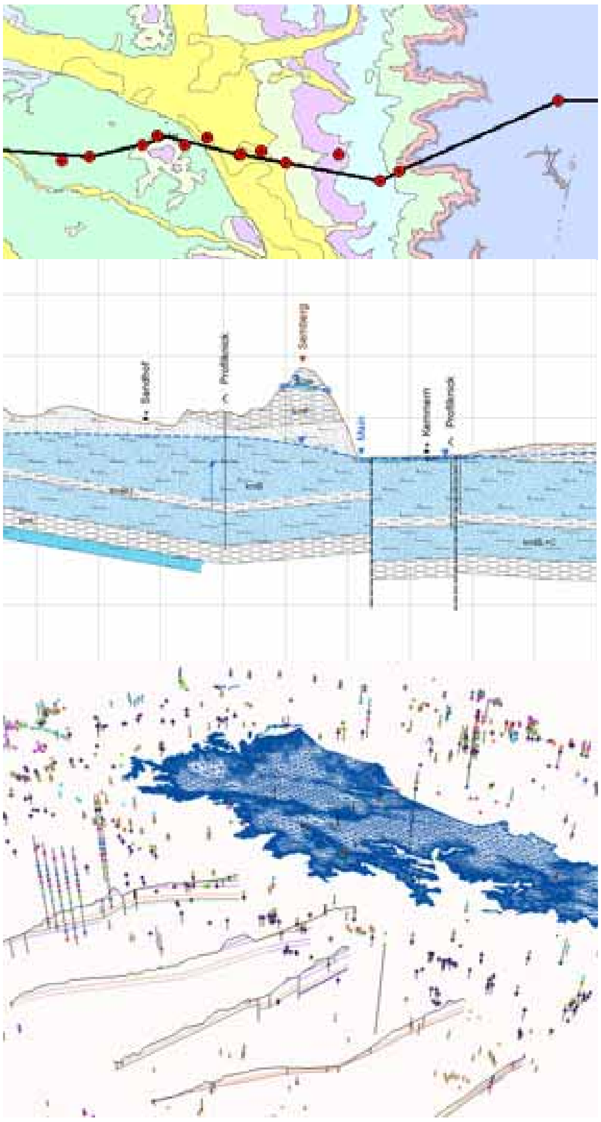

Figure 1 – Top: Arbitrary cross-section in map-view (ArcGIS) and data to be intersected and projected respectively. Middle: Cross-section view in ArcGIS ready to publish. Bottom: Perspective view (ArcScene) of cross-sections together with boreholes and interpolated surface (from GOCAD).

2) An ArcGIS-extension for easy construction of 3D-fault networks based on geological maps allowing also the analysis of a set of different network configurations. Based on assumptions derived from geological map interpretation, a 3D-fault network is created automatically (figure 2). Various network configurations can be analysed and tested without starting the whole modelling process in GOCAD.

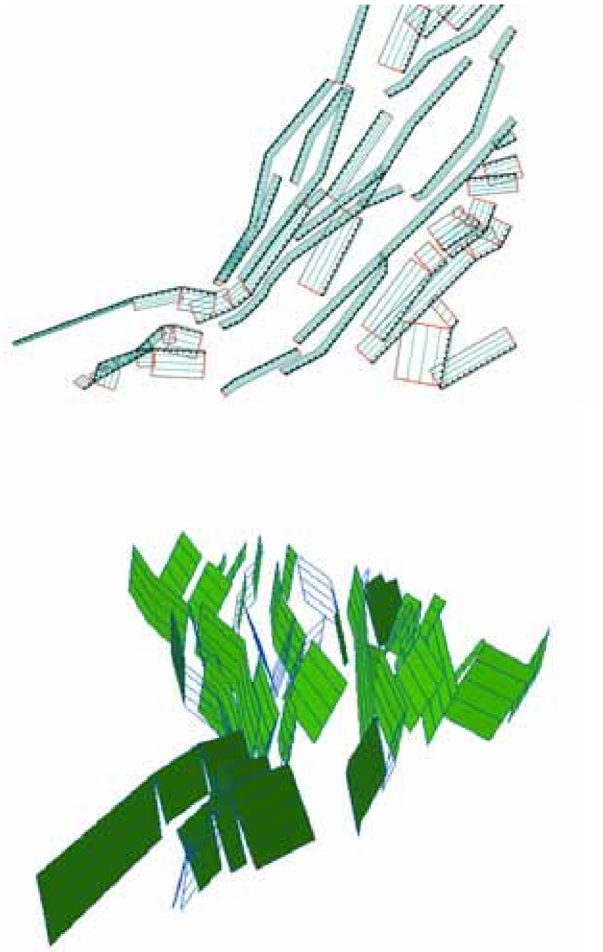

Figure 2 – Map view of 3D fault-outlines, outcrop lines and plunge lines. Data is Z-aware (top). Same fault-data in perspective view. Data is generated from dip attributes and tectonic map (bottom).

3) An ArcGIS-extension for the routinely extraction of all sorts of topological and stratigraphic information from digital geological maps: Outcrop and plunge lines, areas of a unit's non occurrence at the topographic level (older units outcropping), areas of its possible occurrence (potentially covered by younger strata), outcrop-areas, areas of erosion, areas with a unit's same relative position with respect to the DEM and minimum/maximum thickness areas can be derived from the geological map by semi-automatic extraction based on the stratigraphic column (De Kemp, 2000; Groshong, 2006).
4) A stand-alone module for the conversion of stratigraphic well data. Like in many databases at geological surveys, stratigraphy is stored in the survey's database as unit information. Interpolation on these data does not account for erosion and complicated sedimentary patterns (Lemon and Jones, 2003). However, in order to calculate thickness 3D-modelling assumes stratigraphy as

horizon-specific (figure 3). The difference is that the latter is an isochronous information. Conversion is done based on a stratigraphic column including the units to be modelled and the corresponding well-markers in the database. This effectively means a re-coding of all well markers.

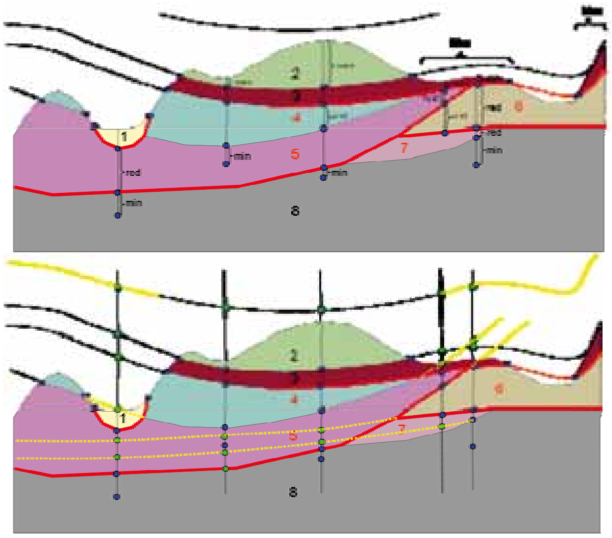

Figure 3 – Top: Well data and outcrop maps provide depth information which can be differentiated only in conjunction with a stratigraphic succession and information about type of boundaries ("stratigraphic column"). Bottom: Interpolation of true depth information with minimum/maximum depth constraints leads to consistent geological restoration with respect to surface intersections. Ideally, virtual constraints are calculated at all data points for all units. Dots: Points of observation. Thick (red) lines: erosional surfaces. Dotted lines: Boundaries interpolated by depth calculations on all observation points. Numbers refer to stratigraphic layering.

Modelling is done afterwards within the GOCAD-system and in the future results are to be saved in the subsurface information system for Bavaria (BIS) as the survey's common spatial database that already holds all the well and GIS-data. For this, simple 3D data-models still have to be designed. It is not intended to reproduce a model's internal topology within the database neither to offer any tools for model update/ modification (Breunig *et al.*, 2000). These highly specialised tasks will stay part of the specific modelling packages. Only data regarding geometry and volume based attributes will be exported into BIS for the long-term storage (Smith, 2005; Kessler *et al.*, 2008).

RECENT AND ONGOING 3D-MODELLING IN BAVARIA

Up to now three regional models have been built at the Bavarian Geological Survey, each covering roughly 10.000 km^2 (Ringseis *et al.*, 2002, Kus *et al.*, 2007, Kainzmaier *et al.*, 2007). Due to software-limitation and the complicated process of model update these models are so called 2.5D-models represented by surfaces only (figure 4). Currently, three models in the same regional context are under development.

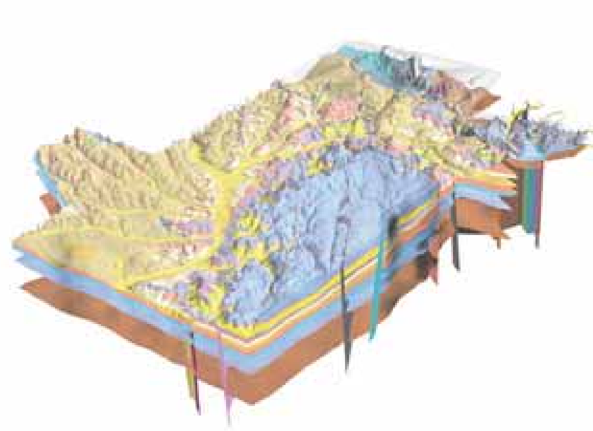

Figure 4 – Perspective view of a regional model consisting of top-surfaces and faults.

The most recent usage of 3D is the re-interpretation of old 2D-seismic data that is currently only accessible as paper-plots. 3D-georeferencing of these scanned images in combination with velocity-analysis, borehole data and new digital 2D- as well as 3D-seismic opens a promising way for a new tectonic interpretation of the south German molasse basin at a regional scale.

LESSONS LEARNED BY MODELLING AT A REGIONAL SCALE

Though 3D-software is already performing at a very high level, some few, but crucial functionalities are still not available due to its focus on seismic data. This includes the interpretation of geological maps. A viable workaround is by using GIS as a main data pre-processor that generates additional constraints. Modifying the overall geological structure of a regional model is way easier in the 2(.5)-GIS than in a true 3D-suite due to its reduced dimensionality and topological as well as geometric precision. GIS serves fine for deriving data for several hypothetical geological settings and easy batch programming (esp. Geomodeller in ArcGIS, Python). Using the combination of GIS with the interpolation in 3D leads to faster model building.

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SWISS NATIONAL MAPPING AGENCY ESTABLISHES HIGH PERFORMANCE MAP PRODUCTION WORKFLOW

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KEY WORDS: swisstopo, National Mapping Agency, Topographic Landscape Model, ESRI, Map Production Workflow.

TOP-FACTS

- The base for the new map production workflow is a 3D Topographic Landscape Model (TLM) with better than one meter accuracy of primary geometry in x, y, and z.
- TLM data are transferred to DCMs (Digital Cartographic Models) where they are managed and edited using a high performance cartographic production system.
- This cartographic production system efficiently handles incremental updates by leveraging geodatabase technology, automated GIS processes, and user-friendly editing tools.

swisstopo

The Swiss Federal Office of Topography (www.swisstopo.ch) is the national agency responsible for creating and maintaining the basic geodetic, topographical and geological data for the whole of Switzerland. swisstopo also publishes and updates the internationally recognized Swiss national topographical map series at a variety of scales.

New workflow

swisstopo is completely changing how they produce geographical data and maps. The new workflow offers several key advantages:

- A Topographic Landscape Model (TLM) is the basis for Digital Cartographic Models (DCMs) from which swisstopo's maps are derived.

- The TLM and DCMs are both stored in ArcGIS. Updates from TLM are transferred to the DCMs.

- The timeframe between collection of aerial images (the basis for the TLM) and finished map products is shortened considerably from over two years down to about nine months.

swisstopo's new workflow is mainly being implemented through two core projects: TOPGIS and Genius-DB.

TOPGIS

The TLM is swisstopo's vector landsacpe model consisting of basic topographical data like land cover, waterbodies, streets, and buildings. The TLM is very up-to-date across all of Switzerland and parts of the neighboring countries, is seamless across this area, in 3D, and very accurate with better than one meter accuracy in all three dimensions.
The TLM is accompanied by a new Digital Terrain Model (DTM-TLM) which is designed to be consistent at all times with the TLM. The DTM-TLM is derived principally from LIDAR data, and both the TLM and the DTM-TLM are photogrammetrically updated based on ADS40 imagery.
For the capture and administration of the TLM and DTM-TLM, a high performance infrastructure is used – called TOPographic Geographic Information System (TOPGIS).

Figure 1: This image is a screenshot from TOPGIS showing TLM data captured on top of an orthophoto. (© 2009 swisstopo)

Based on ArcGIS, TOPGIS is the central production infrastructure for the TLM, and uses a database-centered system for data capture, editing, management and storage. TOPGIS is a fusion of photogrammetry and 3D GIS. It allows up to 50 operators to simultaneously edit 3D data in

one single system. As a core component in swisstopo's geodata infrastructure, TOPGIS provides GIS data to a large number of current and future products.
TOPGIS is in full-scale production since summer 2008.

Genius-DB

Genius-DB is swisstopo's future, GIS-based cartographic map production system also built on ArcGIS. Genius-DB will support the management and editing of swisstopo's Digital Cartographic Models (DCMs). Data are input to the Genius-DB system from the Topographic Landscape Model (TLM), passing first through a cartographic generalization system which is the responsibility of a third party. Figure 2 shows that a series of DCMs are built, corresponding to the various map scales of the Swiss national map series. DKM25 (corresponding to a map scale of 1:25.000) and DKM50 (1:50.000 map scale) are directly derived from the TLM, whereas DKM100 is derived from DKM50. To support the cartographers' work, especially in handling future changes (so-called incremental updates), relationship links are maintained between TLM and DCM features.
Like the TLM, DCMs are seamless over the whole of Switzerland. However, DCM data are 2D and cartographically enhanced. Several map products are created from DCM data, the most important being the national topographical map series.
A major goal of Genius-DB is to improve the efficiency of handling incremental data updates. This will be achieved by leveraging the relational geodatabase technology and the automation processes available in ArcGIS. Moreover, it is paramount for swisstopo to have efficient cartographic editing, while maintaining their world-renowned standard for map quality. The cartographic representation and editing features in ArcGIS are seen as key to maintaining this high quality standard.
Genius-DB is planned to enter into production at the end of 2009.

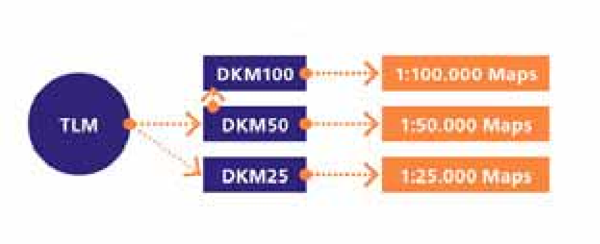

Figure 2: Derivation of DKMs and national map series from the TLM.

NEW INSIGHTS INTO THE GEOLOGY UNDER LONDON THROUGH THE ANALYSIS OF 3D MODELS

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KEY WORDS: 3D geological model, London Basin, Faulting, Chalk.

ABSTRACT

This paper will describe firstly the combined cognitive and geostatistical modelling methodology that was developed in order to produce a structural model of the Chalk under London and secondly how the resultant model has improved our understanding of how the London Basin evolved during the Cretaceous period.

A major difficultly in elucidating the structure of the Chalk in the London Basin is that the Chalk is largely unexposed. By using a combined cognitive and geostatistical approach, the resultant 3D model for the London Basin was more consistent with current geological observations and understanding. In essence, the methodology proposed here decreased the disparity between the digital geological model and the geological reality.

Previously, the geological structure of the London Basin was thought to be 'relatively' simple, being dominated by a broad north-east trending syncline. However, 3D modelling suggests that, in detail, the London Basin is a far more complex structure, being a collection of at least 5 fault-bounded basins. The model also indicates that the structural style of the basin changes moving north to south. This corresponds to the boundary between two structural provinces observed within the basement strata in the region (London Platform, part of the Midlands Microcraton in the north and the Variscan fold-thrust belt in the south).

INTRODUCTION

Since 3D geological modelling became an economic and technical reality in the late 1980s (Rosenbaum and Turner 2003), there has been a remarkable growth in computer modelling applications able to proffer 3D modelling solutions (Gibbs, 1993; Perrin et al., 2005; Sobisch, 2000). It is now possible not only to view and manipulate 3D models on a standard desk top computer but also to integrate disparate digital datasets (De Donatis et al., 2008; Kessler et al., 2008). This has enabled 3D geological models to become a standard geological tool (Rosenbaum and Turner, 2003; Xue et al., 2004).

One of the key developments within the UK has been the increased availability of digital geological data. This increased accessibility of digital data has resulted in 3D models moving from the conceptual model of Fookes (1997) towards the 'real' geological model of Culshaw (2005).

The production of detailed 3D geological models for London is providing new insights into the geological evolution of the London Basin. In this paper we will discuss the development of these models and how they are being used to better understand and communicate the subsurface geology of London.

GEOGRAPHICAL AND GEOLOGICAL CONTEXT

The model of the Chalk encompasses an area within the catchment of the River Thames (Fig.1). Geologically, the London Basin is a broad, gentle syncline, whose axis can be traced from Chertsey through to Chelmford (Fig.1). The London Basin formed in the Oligocene to mid-Miocene times during the main Alpine compressional event (Ellison et al., 2004). Formations in this region range from Cretaceous (144 to 65 Ma) to Quaternary (2 Ma to present day) in age. The Cretaceous Chalk is present at subcrop throughout the London basin and comes to the surface along the southern margin (the North Downs) and along the northwest margin Chiltern Hills) and is locally at or close to the surface e.g. along the Greenwich and Purfleet anticlines in East London.

The Cretaceous Chalk is typically a fine grained white limestone. It has a total thickness of between 175 and 200 m and generally thins from west to east. Overlying the Chalk is the Palaeogene deposits of the Thanet Sand Formation, the Lambeth Group, and the Thames Group, which consist of the Harwich and London Clay Formations. Quaternary deposits are encountered throughout the London Basin. These include evidence of ancient river systems and the development of the present-day River Thames valley.

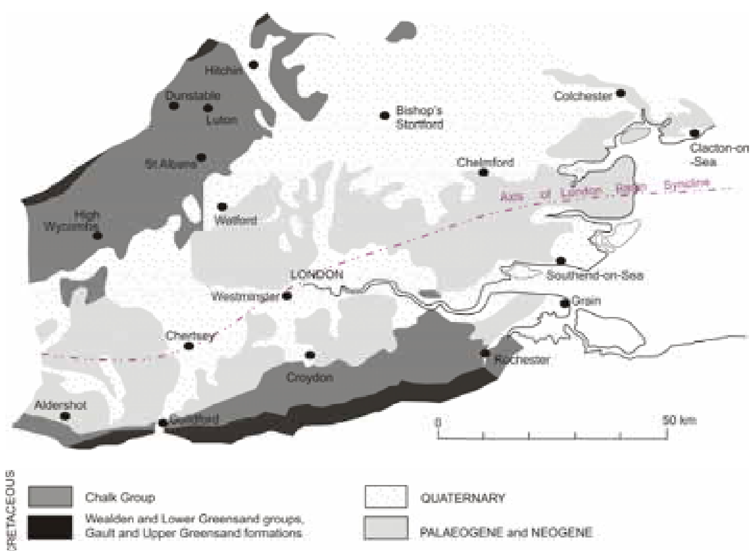

Figure 1 - *Geological sketch map of the project area. Adapted from Sumbler (1996)*

GEOLOGICAL MODELLING

Modelling was carried out to ascertain not only the distribution of the six Chalk Formations found within the London Basin but also the Chalk's structure (Fig 2). One of the major difficulties in ascertaining the structure of the Chalk within the London Basin is that the Chalk is largely unexposed, either covered by superficial deposits (drift) or obscured from view due to urban development. Therefore the project had to rely to a large extent on the interpretation of archival subsurface data.

Although few faults are indicated on the current published geological maps, there is a growing body of data, particularly from recent deeper engineering projects such as the Channel Tunnel Rail link (CTRL), CROSSRAIL and the Docklands light railway, that suggests that faults are far more numerous.

A methodology was needed to enable the modeller to pick out areas of possible faulting and to achieve a geologically reasonable solution even in areas where the data were sparse or uncertain (Lemon and Jones, 2003; Kaufmann and Martin, 2008). Therefore a methodology was developed that combined a cognitive and geostatistical approach using the combined functionality of GSI3D (version 2.5) and GoCad (version 2.1.3).

The GSI3D modelling methodology (Sobisch, 2000) was used as it allows the modeller to model the distribution and geometry of geological units by using a knowledge driven approach (Wycisk et al., 2009). This functionality provides the modeller with the ability to connect areas where there is either only partial data coverage or where the geometry of the geological units is poorly understood. The London Chalk Model was constructed by correlating outcrop data with boreholes that were linked together in a network of intersecting cross-sections.

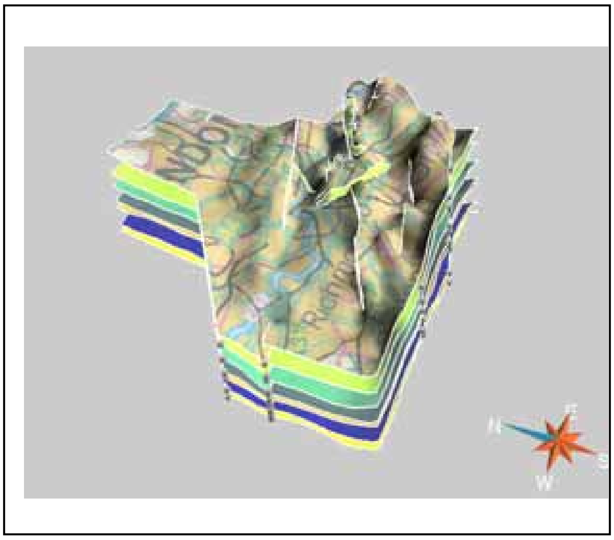

Figure 2 - 3D model of the 6 Chalk Formations under London (coloured yellow, blue and green in diagram). OS data ©Crown Copyright. All rights reserved. BGS 100017897 / 2009.

In order to determine the presence or absence of faulting within the Chalk of the London Basin, a set of criteria was devised. These included the following:

Dip of units: where the dip is greater than 5 degrees, then the Chalk strata were considered to be faulted.

Where boreholes show a change in depth of a unit progressively across a section, then the strata were considered to be folded.
Where boreholes show a sharp change in depth, then the strata are considered to be faulted.
Shape and style of folding: where folds are monoclinal with steep limbs dipping greater than 5 degrees, then the limb was considered to be faulted. Monoclinal folds were considered to be likely candidates for faulting.
Geological information on faults gathered from maps, memoirs and papers was digitised and used to aid decision making.
Linear zones of displacement were interpreted as faults, rather than regarding them as the consequence of folding. This preference is justified by: the general style of the linear zones; by their association with truncated and offset landforms; and by displacements determined from borehole data during the modelling process.

Once these steps were completed, the data was exported into a geostatistical modelling package; in this case GoCad. Using scripts within GoCad, triangulated surfaces were generated for each formation and fault plane. The surfaces were constructed using a discrete smooth interpolation (DSI) algorithm (Mallett, 1997). This algorithm produces a geometry which is smooth, but also takes account of a set of constraints, in this case the borehole and cross-section data (Galera et al., 2003). A series of steps were then followed which removed cross-over errors between the surfaces. Once these stages were completed, the resultant model could be visualised and assessed (Fig 2).

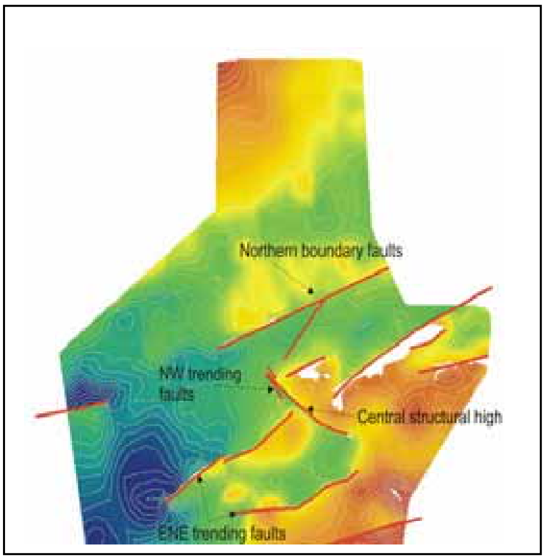

Figure 3 - Structure contour plot of the top of the Chalk, showing major fault groups and location of structural high (red- high, blue-low).

THE STRUCTURE OF THE CHALK UNDER LONDON AS DERIVED FROM THE 3D MODEL

The 3D geological model of the Chalk under London indicates that, in detail, the London Basin is a much more complex structure than previously thought, being a collection of at least 5 fault-bounded sub-basins (Fig. 3).The model also suggests that the project area can be split into two sections or regions, which have behaved differently during the evolution of the basin. This split can be related to the two structural provinces observed within the basement strata in the region (Ellison et al., 2004): the northern portion being underlain by the London Platform (part of the Midlands Microcraton) and the southern portion by a zone of transition between the London Platform and the Variscan fold-thrust belt (Fig. 4).

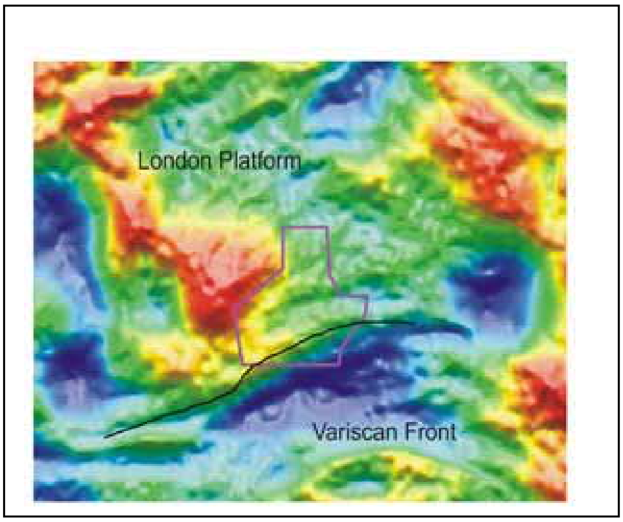

Figure 4 - Colour-shaded bouguer gravity relief map (red–high, blue–low) showing the location of the boundary between the two structural provinces (black line) dissecting the project area (outlined in purple).

This change in basement material across the Basin has determined, to a large extent, the type and intensity of geological features found in each region. For example, folding within the project area can be divided into two groups: the first group found south of the London Basin Axis (Fig.1) and coincidently South of the River Thames, consists of east-north-east trending periclinal folds, including the Greenwich and Streatham anticlines. These features are generally high amplitude and short wavelength folds, many of which are asymmetric, usually with steeper north-facing limbs. The second group is confined to the northern part of the project area and these are in the main low amplitude, long wavelength folds.

Faulting is predominantly confined to the south-eastern portion of the project area; its distribution within the London Basin again appears to have been controlled by the properties of the basement which underlies it. The faults, broadly speaking, can be divided into 3 groups (Fig. 3): ENE-trending faults, which downthrow to the north (the majority of faulting within the south-eastern sector); ENE-trending faults, which downthrow to the south (northern boundary faults); and northwest trending faults, which downthrow to the west (located between Lambeth and Catford). Displacements range between 10 to 50 m. The modelled Chalk surfaces also suggest the presence of a central structural high near Deptford, located between the Streatham and Greenwich faults. The central structural high is bound to the west by the NW-trending faults and to the north by an ENE-trending fault near Bermondsey.

CONCLUSION

To conclude, the 3D geological model of the Chalk under London represents a significant advance in the understanding of the evolution of the London Basin. The application of innovative procedures and software for the assessment of disparate spatial data has resulted in an improved understanding of the development of the London Basin.

ACKNOWLEDGEMENTS

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TOOLMAP – 'SION' METHOD: DEVELOPMENT OF A NEW GIS FRAMEWORK FOR DIGITAL GEOLOGICAL MAPPING

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KEY WORDS: geology, geological maps, digital mapping, GIS tool, Open source software.

INTRODUCTION

With the constant development and the spreading of use of information systems as well as modelling, analysing and visualisation tools, the need for digital data is increasingly growing. During the last few years, this trend was strongly marked in geosciences especially in fields such as engineering geology and geological mapping.

Classically, a geological map gives a 2-D modelling of a complex 3-D environment. Mapped entities are defined by:

- A collection of geologic features which carry a geometry (point, line, polygon) in association with numerous descriptive attributes (e.g. lithological, chronological, structural, morphological ones)
- The relationships between these objects.

Handling information required to build digital geological maps implies of first analysing and extracting semantic content of the geologic objects and of identifying their spatial relationships.

THE 'SION' METHOD

Since a few years, CREALP has developed, in close collaboration with the Swiss Geological Survey (SGS), the 'SION' method, an innovative approach for implementing geological maps in digital format using GIS technology. This methodology aims at providing a consistent geological GIS fulfilling a number of strong requirements like:

- Storing and modelling geological objects in an exhaustive and accurate way through a robust data model
- Distributing the geologic features in relevant layers according to their geological meaning
- Developing an efficient method for geometrical construction of the digital map solving issues related to superposition of objects associated with multiple layers.
- Implementing a data model offering powerful capabilities of analysis (spatial and non-spatial).

TOOLMAP

As a natural extension of this technique, CREALP launched in 2006 the development of TOOLMAP a standalone software program that fully implements the principles that underlie the method (fig. 1). TOOLMAP provides tools that abstract, organize and transform field data to the relevant digital datasets used to generate the digital geological map and derived geothematic maps. This is achieved through the integration in TOOLMAP of:

- A versatile relational database that allows the handling of geospatial data (geometry and attributes) with various levels of complexity
- A GIS engine with the associated tools for editing, geoprocessing and validating data (topological and semantic rules).

This open-source and cross-platform (Windows, Linux, Mac) software is actually developed in coordination with the SGS in the framework of the production of maps of the Geological Atlas of Switzerland at 1:25 000 scale (GA25). The Beta version was recently tested for successfully implementing the new geological data model that underlies the geological information system of Switzerland being developed by the SGS. The first public release candidate of TOOLMAP is planned for April 2009.

Although initially dedicated to digital geological mapping, TOOLMAP is very suitable for handling other types of data because of its open design and its comprehensive functionalities.

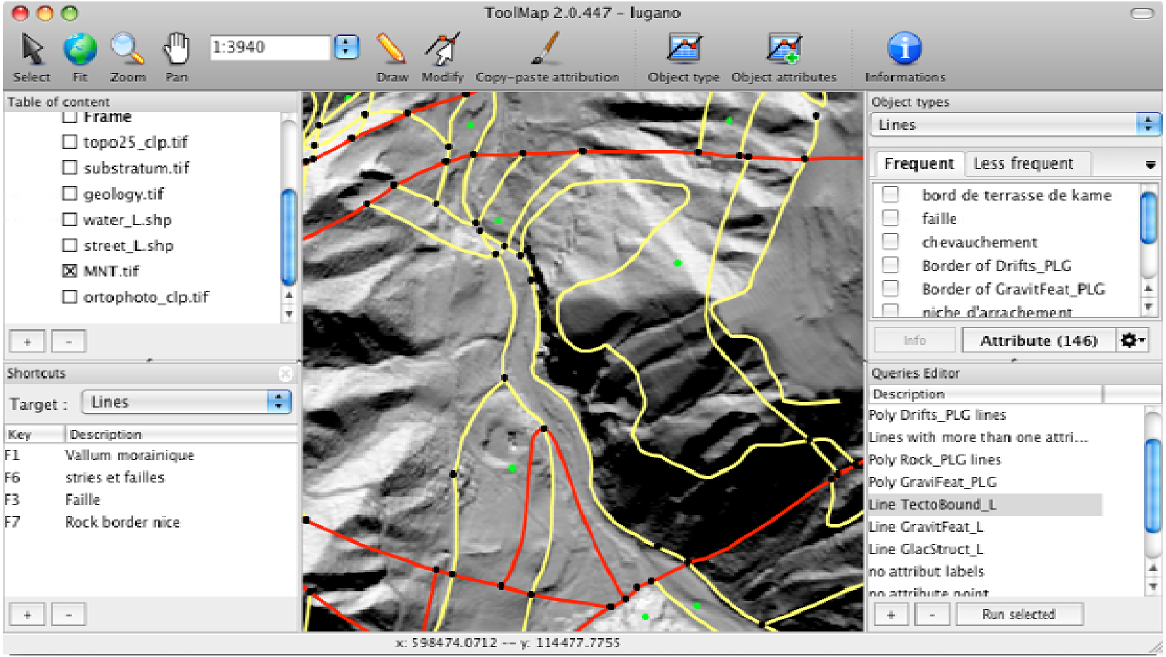

Figure 1 – An overview of the ToolMap User Interface.

CONCLUSION

TOOLMAP and its built-in concept offer a new technical framework for a full integration of GIS technology into the geological map production cycle (fig. 2). The close combination of a step-by-step process and dedicated tools is a pledge for ensuring constant quality and consistency in the production of digital geological maps. This GIS-centred approach offers the ability for the geologist to enhance field data acquisition and map accuracy by combining, at each stage of geological mapping, geological data with other geo-spatial datasets such as DEM, digital orthophotos, multi-scale topographic maps.

This way, geological surveys and geoscientists can increase use and usability of their data by providing more powerful digital cartographic products especially in terms of spatial analysis and geological data management.

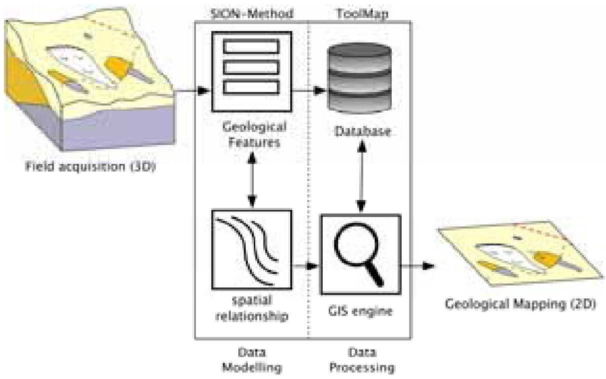

Figure 2 – GIS Framework for digital geological mapping consisting of two components: the SION-Method and TOOLMAP software

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GEOTHERMAL INFORMATION SYSTEM (IOG) FOR BAVARIA

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KEY WORDS: shallow geothermal energy, heat exchanger, groundwater, site condition, geothermal potential, map service, geothermal information system.

INTRODUCTION

The current situation with a dramatic increase of shallow geothermal plant installations in Bavaria has increased the need for fundamental geothermal data. In the design of plants for the use of shallow geothermal energy it is absolutely necessary to get reliable information considering the geothermal conditions at the plant location. In the case of borehole heat exchangers, an under-dimensioning can have consequences during full load operation in the form of very low heat source temperatures. Furthermore under-dimensioning can lead to a longterm decrease of heat source temperatures, if no adequate thermal regeneration is provided.

Another aspect is the necessary information about the site conditions at the plant location. Especially the requirements of the water right regulations, such as the term of water Management Act (WHG) in connection with the Bavaria Water Acts (BayWG) and the resulting administrative regulations have to be taken into account. The fundamental water management and groundwater protection objectives as well as the selection of environmentally friendly material for the installations in the underground are given in the "Guideline for Ground Heat Exchangers in Bavaria" (BWP, 2006).

SHALLOW GEOTHERMAL MAPS

The knowledge of the specific underground conditions at a planned location are essential for the appropriate design of a shallow geothermal plant. Many construction offices and the majority of company engineers use assumptions and estimates for the design with respect to thermal conductivity and specific heat capacity of the ground. Information about the shallow geothermal potential, the geological and hydrogeological conditions, drilling risks and many other important parameters can be obtained from the responsible geological services.

The Bavarian Environmental Agency is occupied with the development of a Geothermal Outline Map (scale 1:200.000) and the Geothermal General Condition Map (scale 1:50.000) based on the geological map 1:25.000. Layers of these geothermal maps are:

- Propagation of drinking water and spa water protection zones
- Position of borehole heat exchanger wells, boreholes with sensible groundwater usage, groundwater wells, domestic wells, etc.
- Geological and hydrogeological sensitive areas
- Geological structures
- Limitations of drilling depths
- Groundwater conditions (groundwater contour maps, groundwater chemistry, etc.)
- Site conditions for borehole heat exchangers or groundwater heat exchanger (classification: critical, uncritical for the installation of a borehole exchanger / groundwater heat exchanger or single case decision areas)
- Depth depdendent heat extraction capacity of a typical ground heat exchanger

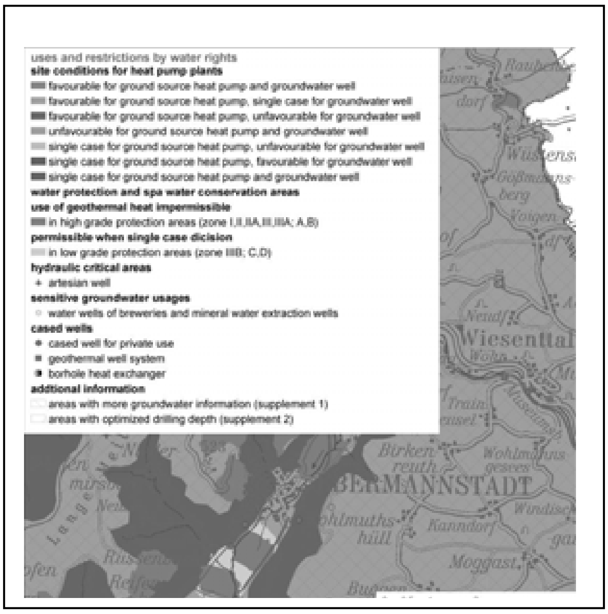


Figure 1 – Legend and map of basic conditions for shallow geothermal plants.

Based on these maps the house builder, construction office or boring contractor can get first or detailed information about the site conditions. In the near future the maps will be accessible for the public through a web map service.

GEOTHERMAL INFORMATION SYSTEM (IOG)

The realisation of the Geothermal Information System (IOG) is nearly completed. The System combines a map server function and an information tool about the site conditions for ground heat exchangers.

Today geological or hydrogeological maps are more and more presented in digital format. Many authorities use web map server applications to present the digital data in the internet. The Bavarian Environment Agency developed an information system that comprehends different layers on topics such as noise cadastre, alpine nature risks or the European Water Framework Directive. All these layers are contained in one information system. For this reason it is very easy to insert additional thematic layers in this system.

Furthermore the current version of the Geothermal Information System (IOG) includes site information concerning the requirements and restrictions of ground heat exchanger systems. For this reason every interested user can input his township and the system automatically moves the map to the extent of this town. After poointong to the site of interest, it is possible to get information about the geological, hydrogeological, shallow geothermal conditions, the geothermal potential, etc. The result is directed into a text document, that can be downloaded and printed..

The advantage of the presentation of the information in text form rather than in a number of maps is, that the information is thus usable for the broad public and not only for experts in the field.

A broader access to the potentials of shallow geothermal energy will optimize design of the plants and thus increase the use of this technology. Additionally the sensibility of the potential user with respect to potential risks of the technology will be increased.

Another advantage is, that through the information system necessary consultation time of personnel at authorities will be reduced.

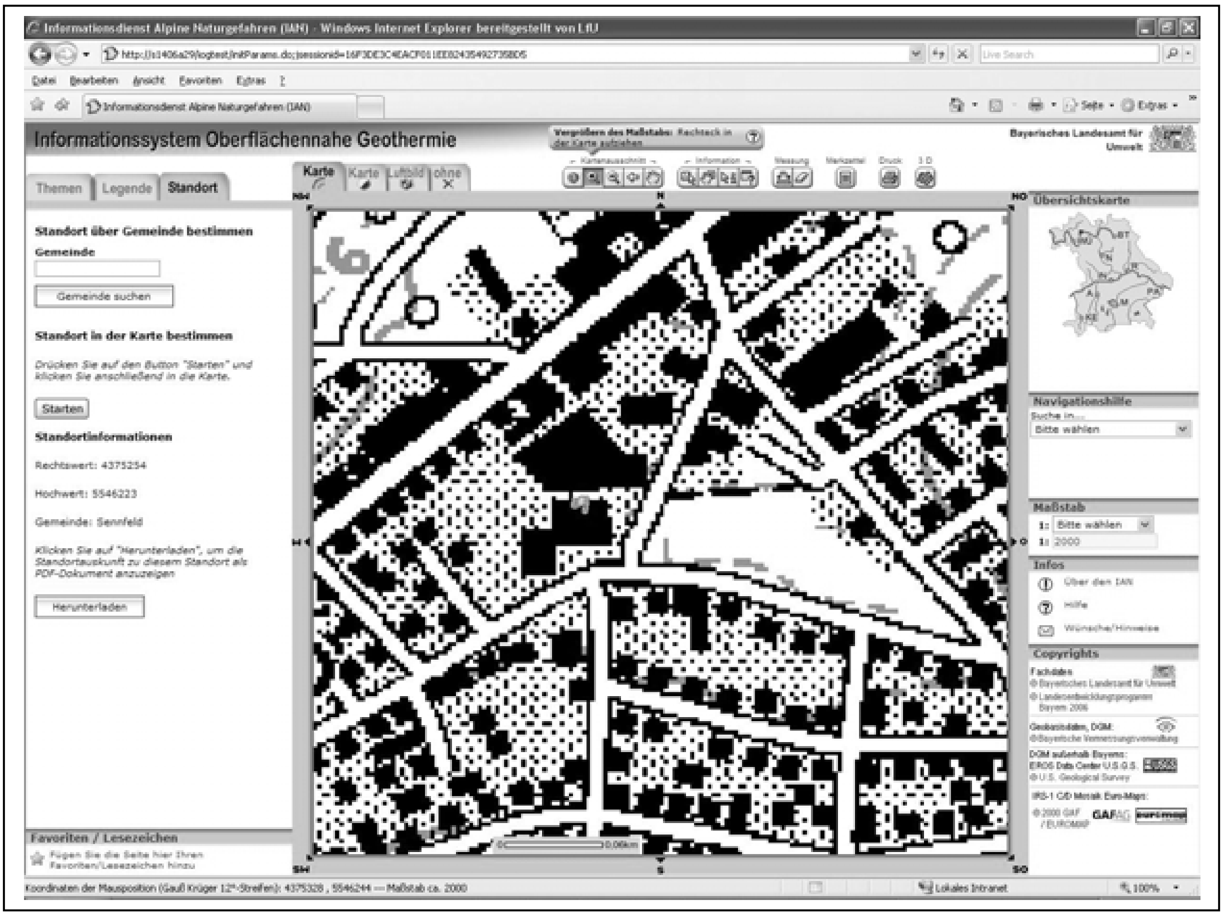
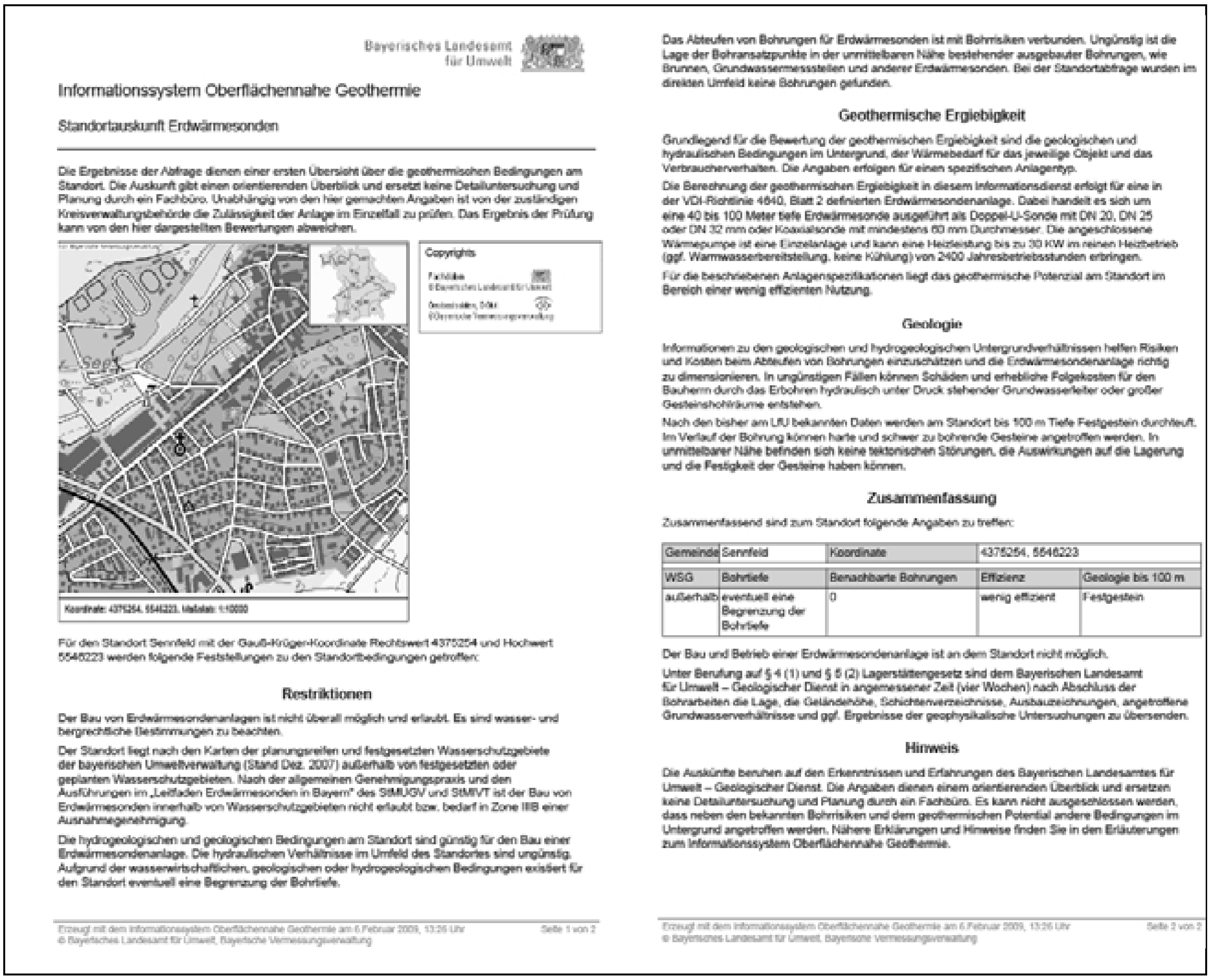


Figure 2 – Zoom and pan-function to a site of interest in the Geothermal Information System (IOG).



Bayerisches Landesamt für Umwelt

Informationssystem Oberflächennahe Geothermie

Standortauskunft Erdwärmesonden

Die Ergebnisse der Abfrage dienen einer ersten Übersicht über die geothermischen Bedingungen am Standort. Die Auskunft gibt einen orientierenden Überblick und ersetzt keine Detailuntersuchung und Planung durch ein Fachbüro. Unabhängig von den hier gemachten Angaben ist von der zuständigen Kreisverwaltungsbehörde die Zulässigkeit der Anlage im Einzelfall zu prüfen. Das Ergebnis der Prüfung kann von den hier dargestellten Bewertungen abweichen.

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Für den Standort Sennfeld mit der Gauß-Krüger-Koordinate Rechtswert 4375254 und Hochwert 5546223 werden folgende Feststellungen zu den Standortbedingungen getroffen:

Restriktionen

Der Bau von Erdwärmesondenanlagen ist nicht überall möglich und erlaubt. Es sind wasser- und bergrechtliche Bestimmungen zu beachten.

Der Standort liegt nach den Karten der planungsreifen und festgesetzten Wasserschutzgebiete der bayerischen Umweltverwaltung (Stand Dez. 2007) außerhalb von festgesetzten oder geplanten Wasserschutzgebieten. Nach der allgemeinen Genehmigungspraxis und den Ausführungen im „Leitfaden Erdwärmesonden in Bayern" des StMUGV und StMIVT ist der Bau von Erdwärmesonden innerhalb von Wasserschutzgebieten nicht erlaubt bzw. bedarf in Zone IIIB einer Ausnahmegenehmigung.

Die hydrogeologischen und geologischen Bedingungen am Standort sind günstig für den Bau einer Erdwärmesondenanlage. Die hydraulischen Verhältnisse im Umfeld des Standortes sind ungünstig. Aufgrund der wasserwirtschaftlichen, geologischen oder hydrogeologischen Bedingungen existiert für den Standort eventuell eine Begrenzung der Bohrtiefe.

Erzeugt mit dem Informationssystem Oberflächennahe Geothermie am 6.Februar 2009, 13:26 Uhr — Seite 1 von 2
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Das Abteufen von Bohrungen für Erdwärmesonden ist mit Bohrrisiken verbunden. Ungünstig ist die Lage der Bohransatzpunkte in der unmittelbaren Nähe bestehender ausgebauter Bohrungen, wie Brunnen, Grundwassermessstellen und anderer Erdwärmesonden. Bei der Standortabfrage wurden im direkten Umfeld keine Bohrungen gefunden.

Geothermische Ergiebigkeit

Grundlegend für die Bewertung der geothermischen Ergiebigkeit sind die geologischen und hydraulischen Bedingungen im Untergrund, der Wärmebedarf für das jeweilige Objekt und das Verbraucherverhalten. Die Angaben erfolgen für einen spezifischen Anlagentyp.

Die Berechnung der geothermischen Ergiebigkeit in diesem Informationsdienst erfolgt für eine in der VDI-Richtlinie 4640, Blatt 2 definierten Erdwärmesondenanlage. Dabei handelt es sich um eine 40 bis 100 Meter tiefe Erdwärmesonde ausgeführt als Doppel-U-Sonde mit DN 20, DN 25 oder DN 32 mm oder Koaxialsonde mit mindestens 60 mm Durchmesser. Die angeschlossene Wärmepumpe ist eine Einzelanlage und kann eine Heizleistung bis zu 30 KW im reinen Heizbetrieb (ggf. Warmwasserbereitstellung, keine Kühlung) von 2400 Jahresbetriebsstunden erbringen.

Für die beschriebenen Anlagenspezifikationen liegt das geothermische Potenzial am Standort im Bereich einer wenig effizienten Nutzung.

Geologie

Informationen zu den geologischen und hydrogeologischen Untergrundverhältnissen helfen Risiken und Kosten beim Abteufen von Bohrungen einzuschätzen und die Erdwärmesondenanlage richtig zu dimensionieren. In ungünstigen Fällen können Schäden und erhebliche Folgekosten für den Bauherrn durch das Erbohren hydraulisch unter Druck stehender Grundwasserleiter oder großer Gesteinshohlräume entstehen.

Nach den bisher am LfU bekannten Daten werden am Standort bis 100 m Tiefe Festgestein durchteuft. Im Verlauf der Bohrung können harte und schwer zu bohrende Gesteine angetroffen werden. In unmittelbarer Nähe befinden sich keine tektonischen Störungen, die Auswirkungen auf die Lagerung und die Festigkeit der Gesteine haben können.

Zusammenfassung

Zusammenfassend sind zum Standort folgende Angaben zu treffen:

Gemeinde	Sennfeld	Koordinate	4375254, 5546223	
WSG	Bohrtiefe	Benachbarte Bohrungen	Effizienz	Geologie bis 100 m
außerhalb	eventuell eine Begrenzung der Bohrtiefe	0	wenig effizient	Festgestein

Der Bau und Betrieb einer Erdwärmesondenanlage ist an dem Standort nicht möglich.

Unter Berufung auf § 4 (1) und § 5 (2) Lagerstättengesetz sind dem Bayerischen Landesamt für Umwelt – Geologischer Dienst in angemessener Zeit (vier Wochen) nach Abschluss der Bohrarbeiten die Lage, die Geländehöhe, Schichtenverzeichnisse, Ausbauzeichnungen, angetroffene Grundwasserverhältnisse und ggf. Ergebnisse der geophysikalische Untersuchungen zu übersenden.

Hinweis

Die Auskünfte beruhen auf den Erkenntnissen und Erfahrungen des Bayerischen Landesamtes für Umwelt – Geologischer Dienst. Die Angaben dienen einem orientierenden Überblick und ersetzen keine Detailuntersuchung und Planung durch ein Fachbüro. Es kann nicht ausgeschlossen werden, dass neben den bekannten Bohrrisiken und dem geothermischen Potential andere Bedingungen im Untergrund angetroffen werden. Nähere Erklärungen und Hinweise finden Sie in den Erläuterungen zum Informationssystem Oberflächennahe Geothermie.

Erzeugt mit dem Informationssystem Oberflächennahe Geothermie am 6.Februar 2009, 13:26 Uhr — Seite 2 von 2
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Figure 3 – Downloaded document with information about the site conditions extracted from the Geothermal Information System.

ACKNOWLEDGMENTS

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APPLICATION OF AN ENVIRONMENTAL DATA MANAGEMENT SYSTEM FOR THE COPPERBELT MINING AREAS, ZAMBIA

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KEY WORDS: Environmental Data Management Systems, databases, GIS, Environmental Monitoring, data management, decision support, mining

INTRODUCTION

The Copperbelt Environmental Project (CEP) was formulated to help the Government of the Republic of Zambia (GRZ) to address the environmental problems associated with the mining sector in the country. The GRZ has received a credit from the Nordic Development Fund (NDF) towards the cost of the CEP. With the privatisation of the mining industry the CEP was developed to assess environmental and health impacts of the mining operations in the region and to deal with clean up and mitigation of these impacts falling under the government of Zambia´s responsibility. A sub-component of the CEP deals with environmental management and compliance monitoring. This component of the CEP aims to strengthen the capacity of regulatory agencies, especially the Environmental Council of Zambia (ECZ) and the Mine Safety Department (MSD). One subproject of this component is the "Consulting Services for Environmental Monitoring for the Environmental Council of Zambia (ECZ)". One of the main tasks was to develop an Environmental Data Management System (EDMS) for the ECZ. The final system consists of a GIS platform, a Licensing Information System, a Monitoring Information System and databases containing all environmental regulated facilities and historic monitoring data collected prior to the privatisation of the copper mines.

OBJECTIVES

The main objective of this project is to increase the national capacity for environmental management, auditing procedures, monitoring and data management through the provision of technical assistance to the ECZ, MSD and other strategic authorizing agencies or partners. As a part of this capacity building, one of the project's subtasks was to develop an Environmental Data Management System (EDMS) for the ECZ. The main application for such a system would be:

- to monitor mining activities and the copper processing industries
- to issue environmental licences for environmentally regulated facilities
- produce digital base maps of mining areas and copper processing industries
- produce pollution profiles for air pollution, land degradation, surface and groundwater pollution

The users of the system are the environmental inspectors, monitoring specialists and information system officers of the ECZ in Lusaka and Ndola, as well as the inspectors of mine safety of the MSD in Kitwe.

THE STUDY AREA AND BACKGROUND

The copper industry in Zambia is concentrated in the densely populated Copperbelt area along the border with the D.R. of Congo (see **Figure 1**). Copper mining has been a significant economic activity in the area since the late 1920´s, yet prior to 1980, little attention was paid to the environmental impacts of mining activities. After a decline starting in the 1970s, there has been a significant increase in the production since 2002 boosted by rising copper market prices. Old mines are expanded and new mines are being opened, and it is likely that old production levels will be reached soon. There has been recent studies about the impacts of the mining activities on the environment (Limpitlaw, 2003) and a geochemical baseline study was conducted (Kribek et al, 2007) which indicated serious contamination of top soils and degradation of the environment due to mining activities.

Until now ECZ has not monitored the mining areas itself, it was done by the mines and reported to the ECZ in order to get an environmental license for the mining activity or other environmentally relevant activities. Other relevant activities comprise ore processing facilities such as smelters and concentrators. During the project new environmental monitoring guidelines have been developed (Banda et al, 2008) and new monitoring equipment has been purchased so that ECZ will start to monitor regularly in 2009.

Figure 1 – Location of the Copperbelt within Zambia

MATERIALS AND METHODS

The task of the project was to develop an easy to use, updatable system from existing software available at the ECZ's offices using ESRI's ArcGIS and MS Office applications. By means of site visits and interviews with mine operators and stakeholders in the Copperbelt Region available data and information was collected. Mine sites base maps have been digitised and a model for environmentally regulated facilities was developed and integrated in a GIS. The existing license formats were updated and transferred into digital format resulting in a MS Access database for handling the environmental licences. New monitoring guidelines have been elaborated and existing ECZ monitoring data has been added to a new system resulting in a Monitoring Information System. An overall regional GIS platform was created importing all available data such as topography, infrastructure, river network etc and existing monitoring sites from multiple sources. Topographic data was not only gained by topographic maps but as well from height data available by NASA. With this data a digital elevation model (DEM) was created. All data had to be geo-referenced into the valid UTM coordinate system and datum. Furthermore, data workflows at the ECZ had to be identified in order to organise the new system in such a way that the real world workflows are reflected in the system in a logical order. Different tasks had to be identified and best practical tools developed to execute those tasks. It had to be decided which date types and routines should be handled by a GIS or by a database or by a geo-database. In form of a data management policy data types have been defined and data management guidelines have been elaborated for the handling, processing and storage of data (Kohlemainen et al., 2008).

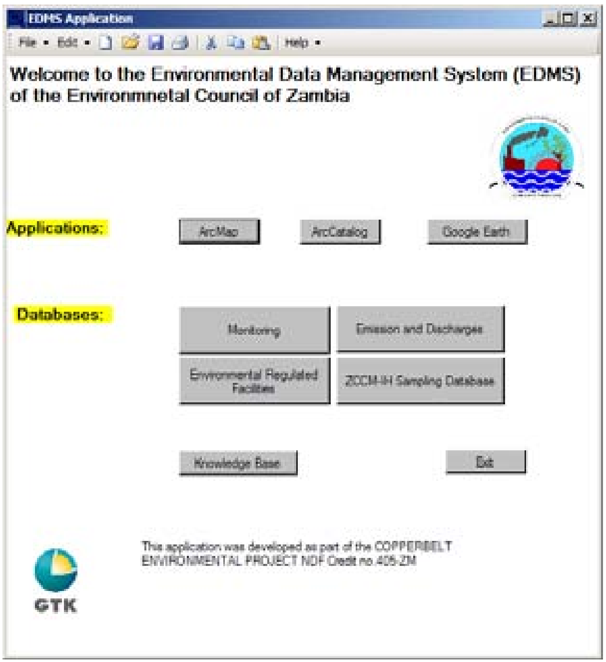

Figure 2 – The user interface of the Environmental Data Management System

RESULTS AND DISCUSSION

The final Environmental Data Management System consists of the following components: 1) a GIS platform, 2) a Licence Information System (LIS) and 3) Monitoring Information System and 4) the Copperbelt Environmental Project database containing all environmental regulated facilities and 5) applications and tools to handle, process or import/export environmental data into the system. The different components are controlled by a user interface which was developed using Microsoft Visual Basic 2005. **Figure 2** shows a screenshot of the user interface.

1) The GIS system

The system contains GIS layers and their attribute information of the mining facilities, monitoring points of surface and ground water, water intake and effluent discharge points as well as emission points to air (copper smelter stacks).The digital mine base maps are available as a map template with a common legend symbology for all relevant environmentally regulated facilities according to the classification given in the Copperbelt Environmental Project database (see sub point 4).

The digital base maps are so far available for the following mining sites/towns:

- Kitwe
- Mulfulira
- Chingola
- Konkola

Each of these mining sites are organised as independent geo-database in the GIS.

The mine base maps can be easily updated in the GIS and used by all ECZ offices having ArcGIS. Stakeholders not having an ESRI software license can open the templates with the free software ArcReader from ESRI and print out the maps.

Furthermore, training was provided to staff in environmental monitoring, data capturing, data management and the overall usage of the EDMS system components to ensure that the ECZ staff is able to maintain and update the system in the future (Staudt, 2007).

2) The Licensing Information System (LIS)

The LIS is a MS Access database which handles the environmental licences of the ECZ and holds information about emissions and discharges from facilities where licences were issued. The system is in prototype stage and will be further developed during 2009.

Every licence applicant has to report environmentally relevant activities in order to get a licence. The system collects information about license holders and contains information for the following licenses being issued by the ECZ:

- Water and waste water
- Air Emission
- Generation and storage of different waste types
- Annual report on import of controlled substances
- Pesticides and toxic substances
- Ozone depleting substances

3) The Monitoring Information System

Hand in hand with the new monitoring guidelines a monitoring information system has been developed consisting of an Access database with data capture forms for the following monitoring types:

- Surface Water
- Groundwater
- Air Emission
- Ambient Air Quality
- Effluent Discharge
- Soil Contamination
- Waste Characterisation

The design of the forms is according to the field measurement form. Given the spatial information of the monitoring point, the information can be easily exported to the GIS and plotted there as a point theme. Ideally, the laboratory analysis can be imported to the system.However the different laboratries have to use the standardised format in future to ensure this functionality.

4) The Copperbelt Environmental Project (CEP) database

A data model was developed to include all mining sites and environmentally relevant facilities. All mining sites had to be identified and a classification of facilities was established. All coordinates available have been entered. The database is an inventory of all environmentally regulated facilities, stakeholders and contact persons relevant to environmental issues and licensing.

5) Other applications and tools

During the implementation of the system the following tools have been identified which come handy for the daily work with environmental data in the ECZ:

- Google Earth Pro for instant satellite images of an area
- KMLer extension for ArcGIS for exchange of spatial data between the GIS and Google Earth
- Garmin Waypoint or similar application to import recorded GPS coordinates from GPS receivers
- Global Mapper for the processing of Nasa height data sets and to import to GIS
- MultiSpec is a free and simple remote sensing application
- The Knowledge Base is a repository containing all training course materials, best practise handbooks, tutorials and checklists used in the training sessions including relevant references and literature.
- Sampling Database of ZCCH-IH prepared for the phase 2 of the CEMP (ZCCM-IH, 2005) containing historical data collected by ZCCM.

Some of these additional software need a commercial license in order to use the whole functionality explained above.

CONCLUSION

The new developed system is a useful tool to organise and management all relevant environmental data in the Copperbelt. The system is open for further improvements and applications. It is planned to use the system structure also for the other provinces in Zambia to handle licences and environmentally relevant data. It is possible to further develop the GIS platform in upcoming projects towards an online application (WebGIS) or even to a National Environmental Information System for Zambia.

ACKNOWLEDGEMENTS

The "Consulting Services for Environmental Monitoring for the Environmental Council of Zambia (ECZ)" is a sub-component of the Copperbelt Environmental Project which was funded by the Nordic Development Fund (NDF). The author would like to thank Mopane Copper Mines Plc. and ZCCM-IH in Kitwe for the provision of their data resources and the staff of ECZ for their support throughout the project.

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SEDIMENTARY MEDIA GIS TOOLS TO IMPROVE GROUNDWATER MODELING

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KEY WORDS: 3D hydrogeological models, geospatial database, Geographic Information System

INTRODUCTION:

The detailed modeling of sedimentary media (alluvial sediments, deltas, etc.) that form important aquifers is very complex for two reasons. The first is the intrinsic natural heterogeneity of the geological medium and the second is that the data management tools (manipulating geological and hydrogeological data) needed to implement them in the hydrogeological models are not developed enough.

This point includes subjects such as the characterisation of groundwater, as well as the dynamics of water systems and their standard distribution in space. In this sense the goal of this work is to define how the spatial distribution standards of the different hydraulic parameters in a 3D sedimentary medium integrate in the habitual hydrogeology modelling methodologies. Thus, the relationship between these obvious values and the effective-type values (which are the ones that actually define the dynamics of the aquifer and what is even more important for water resources, rule its behaviour globally) could be explained. This knowledge is critical in order to correctly characterize an aquifer, as well as to deduce the modelling methodology that is more adequate to solve this problem.

The main objective of this work is to develop tools and methodologies that integrate all the available data into a coherent and logical structure supported by a computing environment that guarantee a proper management and interpretation. Furthermore these tools allow representing the 3D heterogeneity of the sedimentary media.

METODOLOGY:

As connectivity in sedimentary bodies plays an important role, the designed tools should allow representing in the three dimensional space the heterogeneity of the sedimentary strata and their spatial distribution.

In order to do so it is essential (1) to have enough data to allow acquiring detailed geological knowledge of the sedimentary media (2) to integrate the geological processes controlling the geologic formation, (3) to interpolate, regarding the above-points and taking into account the possible application of different methodologies as deterministic and geostatistic models, as well as the petrophysic and hydraulic characteristics to the whole volume of the considered sediments, and (4) to implement all the information into flow and transport models to determine the location and the quality of the hydraulic resources by guaranteeing at the same time their reliable management.

From the technical point of view several requirements were identified as (1) the possibility to work on a geospatial database regrouping hydrogeological spatial features and time-dependent data (2) allow the user defining and modifying interactively on-screen the features representing the contact surfaces (3) easiness in interaction with external software as geostatistical codes (SGeMs, GsLIB) or groundwater modelling packages (ex. TRANSIN, MEDINA, A.; ALCOLE, A.; GALARZA, G. y CARRERA, J. (2004)) and (4) the possibility to import/export the results in a various type of formats.

The first task has been the creation of a geospatial database to store and to allow the management of a great amount of different data types coming from different sources: geophysical, geological, hydraulic, and others. The data structure allows storing an accurate and very detailed core geological description that can be straightforwardly generalized and further up scaled.

The conceptual model of the database is designed in the UML. Several existing patterns and data models have been explored to improve database designe:

• Hydrogeological Database: University of Liège expertise (Gogu et al., 2001);
• ArcHydro: ESRI hydrological data model (Maidment, 2002);
• Groundwater Model: ESRI, Strassberg Ph.D. dissertation (Strassberg, 2006);
• The Australian National Groundwater Data Transfer Standard, (1999);
• XMML (eXploration and Mining Markup Language): as a GML application schema (Cox, 2001);
• GIS database developed in WaterStrategyMan European Project (ProGEA S.r.l, 2004);
• GML: Geography Markup Laguage, currently undergoing standardization as ISO 19136 (Lake, 2005);
• Water Framework Directive and its Geospatial information working group (Vogt, 2002);

The second step was to create tools within a GIS environment allowing querying and visualizing the 3D information. One consists in illustrating the core with the accurate and detailed geological description of the selected borehole (fig.1).

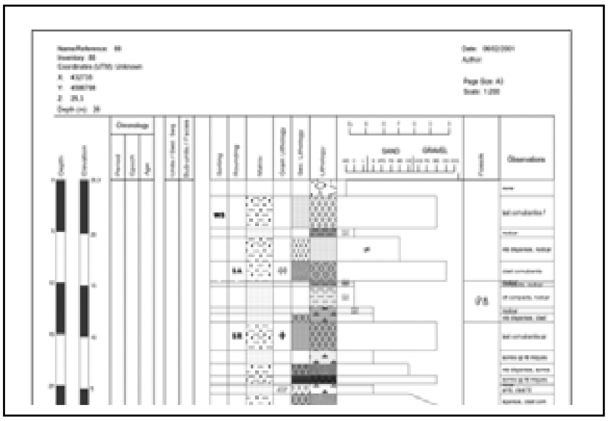

Figure 1 – Visualization of borehole description

A second one generates geologic profiles by using an on screen defined buffer zone selection for the needed boreholes (fig. 2).

The lithological log-description of the boreholes together with the defined stratigraphic subunits appear on screen as a geological profile. Complementary information like the DTM profile, the distance between the boreholes, the depth of each strata complete the geological picture.

The generated geological profile can be transformed in a working environment allowing the geologist to make geological correlations.

This correlation pulls on the modellers wealth of understanding of geological processes, examination of exposures and theoretical knowledge. Following this philosophy the definition of the stratigraphical contact surfaces can be done by digitizing on screen. Attributes describing the interpreted stratigraphical subunits like the type of the contact surface, the position between the geological units or subunits, hydrogeologic parameters can be defined by the user. Further analyses concerning the shape or the hydraulic properties of defined geological units can be performed using statistic and deterministic methods. To date an interactive dictionary of terms describing the possible geological contact surfaces types is on the way to be defined.

The profile interpreted geological units/subunits are saved into a geo-spatial database as 3D information. Further, this information can be processed within the same GIS environment or by external software packages to derive a reliable 3D model.

Several steps in quantifying the grain size distribution of each geological stratum or an entire hydrogeologic subunit in terms of hydraulic conductivities are also been done. The hydraulic conductivity of each lithological stratum is computed on the basis of the grain-size distribution by quantifying as accurate as possible the bore-log lithological description. Literature research, laboratory tests, and tests of existing market software solutions are currently done to improve the described procedure.

The presented tools are grouped within a GIS data-management platform (ArcGis,ESRI). Further steps are now subject of design and development. One of them is a sub-set tool allowing a stochastic analysis of the facies shape in order to derive several possible realizations. Another one will be a stochastic analysis of the hydraulic properties extrapolation in order to extend to the volume of sedimentary bodies. A third one will allow the generation of the 3D geological model. The last main step will be the integration with groundwater modeling software.

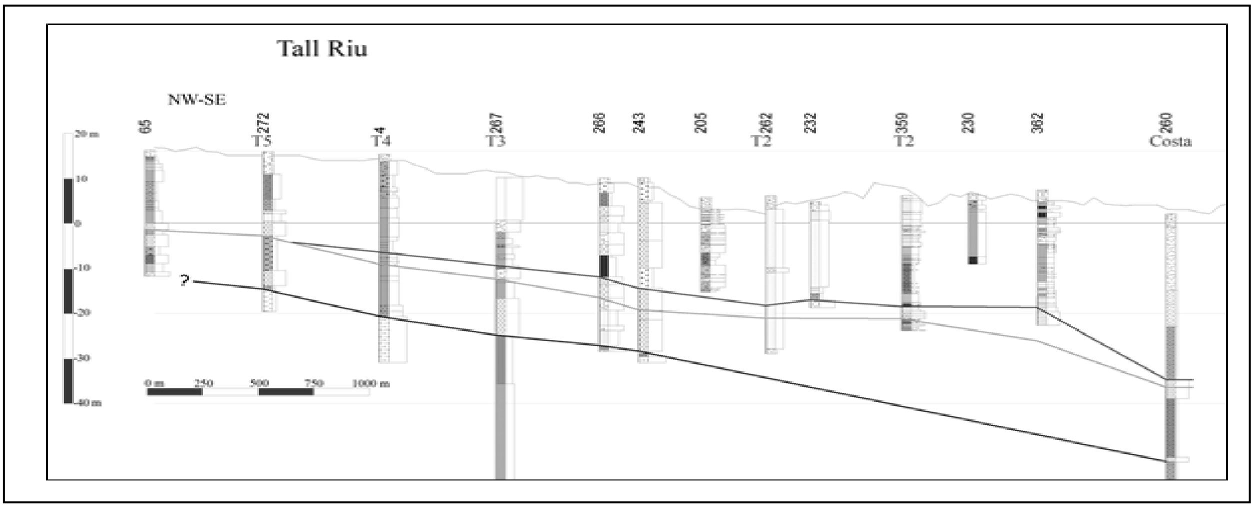

Figure 2-Profile.

CONCLUSIONS:

The presented software platform regrouping a hydrogeological geospatial database and the designed tools optimize the creation of a detailed geological 3D model.

The designed hydraulic parameterization methods are useful to obtain a first approach of the hydraulic conductivity values distribution.

The presented tool-sets represent a base of a larger software platform allowing 3D hydrogeological modeling in sedimentary media.

AKNOWLEDGEMENTS

This work was supported by the Ministry of Education and Science in the scope of the project (CGL2007 -66748) “3D hydrogeological modeling tools in sedimentary media (HEROS)” and by FCC-PROFIT project in the scope of Geo 3D-project.

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THE GEOLOGICAL EXPERT MAPPING APPLICATION GEOKART OF THE BAVARIAN ENVIRONMENT AGENCY - TECHNICAL OUTLINE OF AN ENTIRELY DIGITAL MOBILE DATA CAPTURE SYSTEM.

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KEY WORDS: GeoKart, digital field mapping, mobile data capture, geology, Gispad, Delphi.

INTRODUCTION

GeoKart is an application for mobile field data capture and digital geological mapping that is developed at the Bavarian Environment Agency (Bayerisches Landesamt für Umwelt, ***LfU***).

The development of GeoKart began in the late 1990s within a research project at the former Bavarian Geological Survey (now integrated in the LfU), focusing on the general potential of mobile data capture. All participants in the project were geologists, and the intention was to keep development as close as possible to geological practice.

In the meantime GeoKart became the standard tool for geological mapping and data acquisition for field geologists at the LfU's geological survey. GeoKart is used by about 50 geologists working at or for the LfU.

GENERAL SYSTEM REQUIREMENTS

The development of GeoKart is guided by the idea of providing geologists with a single tool that supports them in their entire field work and that seamlessly integrates into the digital infrastructure of the LfU's working environment.

To ensure the acceptance by the users, the new digital tool must be easy to use, supply all the functionality of the analogue techniques (field book, field map etc.), and provide considerable benefit in relation to the established traditional workflow and, if there are any, inconveniences caused by new technology.

Since the LfU is a Bavarian state authority there are some special requirements defining the working environment.

The LfU has the legal obligation to make environmental information accessible to the public and therefore hosts a central database, the Bavarian Soil Information System (***BIS***). The BIS is a multi-tier architecture system with an Oracle database, a Java based application server and intranet and internet clients. It offers a XML-based interface for data exchange.

Completed geological mapping projects are transferred to the LfU's cartography department where the spatial data is processed using ArcGis geodatabase technology. The maps are published as traditional paper maps, the digital map data is stored in the BIS.

THE BASIS SOFTWARE GISPAD

GeoKart is an application based on a commercial software, the program package ***Gispad*** of the German company con terra (www.conterra.de). Gispad is a software especially designed for mobile data capture that comes with the usual GIS-features like a map window for georeferenced raster images, tools for creating and editing vector geometries, options to enter attributive data for geo-objects, GPS interface etc.

Major reasons to choose Gispad as a base for the development of GeoKart were:

- Gispad is object class based. Prior to capturing data, appropriate object classes have to be defined. An object class can have several geometry types. There are no layers like in a conventional GIS.
- Gispad has a topologic geometry engine. When different objects share parts of their geometries (e.g. points, line segments) the respective vectors exist only once. The editing of an object's geometry that is also part of other objects' geometries changes all objects involved. This is a big advantage for spatial geological mapping.
- Gispad allows the collection of extensive attributive data linked to geo-objects. Data models are described through metadata, and a design tool is offered to create data entry forms with common data aware controls. The attributive data is stored in a conventional database (now MS Access 2000 format).
- Gispad offers many possibilities for customization. External functionalities stored in dynamic link libraries (***DLL***s) can be called by various Gispad events. A comprehensive application programming interface (***API***) is provided to access internal functionalities and object data from external functions.

The fundament of any data acquisition with Gispad is an application definition (ger. *'Verfahren'*). It comprises:

- the definition of available object classes, including their geometry, visualisation, assigned data models and data entry forms,
- the definition of data models (tables, attributes),
- controlled vocabulary with linear and hierarchic lists,
- the assignment of external functions to internal events.

The application definition itself is stored in a database (MS Access). It can be created with the Object Class Editor tool or by direct manipulation of the respective database.

Any data acquisition project in Gispad is built according to a specific application definition. Different projects based on the same application definition have an identical structure.

The project data is saved to an own project directory with a definite folder and file structure containing only project data. All attributive data of geo-objects are stored in a database (MS Access) whose internal structure is defined by the application definition metadata.

GEOKART – GENERAL OUTLINE

GeoKart basically is a Gispad application definition that makes extensive use of Gispad's interfaces for customization and the implementation of particular extensions.

There are two main objectives for the development of GeoKart:

1. capturing of objects and object data for the BIS,
2. the support of spatial geological mapping.

The different natures of these two objectives have significant impact on the development process.

Due to the master character of the BIS there is very little freedom for development in this domain of GeoKart. The data models and the controlled vocabulary are in fact generated from BIS metadata excerpts, and data entry forms are designed to resemble the interfaces of the central database.

Any time there are relevant changes in the BIS metadata, a new update of GeoKart is required to maintain the full compatibility of the two systems. All user requests for enhancements in this domain are disallowed since the primacy for modifications is by definition with the BIS.

On the other hand the GeoKart domain dedicated to support the digital mapping process, the so called ***Mapping Module***, is fairly free from any conditions imposed by outside systems. The elements of the Mapping Module, like object classes, metadata, data entry forms or particular extensions, are internal developments of the project team. All user requests that are reasonable and practicable have a good chance to be implemented in future releases.

GEOKART – TECHNICAL OVERVIEW

From the technical viewpoint GeoKart consists of the following components:

- the application definition database containing the definitions of the available object classes, the metadata of the data models, the controlled vocabulary, the entry forms for attributive data, and some data used for control of internal functions (e.g. metadata for the BIS interface, attribute mapping for cartography),
- a set of DLLs and runtime package libraries (***BPL***s) that contain all particular GeoKart functionalities. The DLLs are thematically split, the BPLs store commonly used elements like general methods and components, constants and global variables, data modules or an encapsulated Gispad API,
- background vector data needed for generating attributive data. We use the ALK-GIAP format which allows an automated import of vectors and their respective attributive data without any user interaction.

The proprietary methods of GeoKart are called by various Gispad events and by configurable menus, toolbars and buttons. Several types of events are available:

- system-wide events (e.g. before or after loading or closing a project; before or after creating or editing an object; on change of geometry; on change of the active object),
- table events in the attributive data, referring to a dataset (after insert; before and after edit; before and after delete),
- attribute events in the attributive data, referring to a single field (on new dataset; on change; on change of geometry; on button click),
- object class specific attribute events in the attributive data, referring to a single field (like the previous attribute events, but assigned to one specific object class only),
- events that are assigned to buttons on data entry forms, custom tool bar buttons or menu items of the GeoKart main menu.

The assignment of external functions to Gispad events is stored in GeoKart's application definition metadata (table, attribute and data entry form button events) or initialization file (system-wide, tool bar and menu events).

GeoKart currently offers 17 different object classes for data capturing (14 in the BIS domain, 3 in the Mapping Module) and 20 more object classes as containers for georeferenced raster data or background vector data. The metadata describe around 120 tables with 1500 attributes. The controlled vocabulary comprises more than 180 lists with 11000 key entries. GeoKart's proprietary functionalities are stored in 10 DLLs and 2 BPLs. The DLLs publish about 250 different functions that are assigned to Gispad/GeoKart events.

GEOKART DEVELOPMENT TOOLS

The Gispad program package contains a powerful tool for the development of application definitions, the ***Object Class Editor***. This tool enables the creation of all common elements of an application definition and controls all their cross references between the different metadata tables and their internal indexing.

In wide parts GeoKart was developed directly on database level. This is less comfortable, but suitable because metadata excerpts from the BIS are used to build the metadata in GeoKart's BIS domain so that all common tables and attributes and the controlled vocabulary have the same internal indexing in GeoKart and the BIS.

The GeoKart DLLs and BPLs containing all external functionalities are written in ***Delphi*** with Borland Developer Studio 2006 (***BDS2006***) as currently used integrated development environment (***IDE***).

The Gispad API is encapsulated by the library gpAPI32.dll in the Gispad program directory. A Pascal/Delphi unit containing all the functions published in this DLL is provided by the software producer and can be easily integrated in the IDE.

Any other IDE that is capable of creating DLLs for a Windows OS can be used as well, but since parts of Gispad, including the API, are written in Delphi itself the choice of this IDE is apparent. Gispad/GeoKart runs on standard Windows OS only.

GEOKART FEATURES

The proprietary developments for GeoKart can be roughly divided into the following groups:

- Functionalities for the project management. They are called on opening and closing of a GeoKart project in order to assure that a project meets the special requirements. This includes for instance the check for all necessary GeoKart settings, the import of background vector data or the ***automated upgrade of project data*** when a new GeoKart version is used for the first time.
- The functions for the BIS domain are mainly concerned with the handling of attributive data. This is due to the fact that some features from the BIS' Oracle data model (e.g. inheritance, special data types) cannot be rebuilt one-to-one in the application definition metadata. There are several assistants to ease data entry, too.
- The ***Import & Export Manager*** for handling the exchange of spatial and attributive data with the BIS through its XML-based interface (details below).
- To increase efficiency in data entry GeoKart offers configurable default values for many attributes that are grouped into sets, the ***User Profiles***. A manager enables the handling of user profiles, including functions for cloning, import and export to other GeoKart projects. A quick selection utility for User Profiles is available.
- GeoKart has own methods to guarantee data integrity that exceed Gispad's built-in functions. The ***data maintenance*** functions ensure project data to always comply with the special requirements for both BIS and Mapping Module objects. This is also a time-saving feature for the developer as objectionable project data states that need repair are much less likely to occur.
- Several tools & helpers have been implemented to increase the ergonomics of the system, many of which were triggered by user requests. One example is a button emulating a right mouse click which is a big help while constructing or editing vector geometries on a pen computer. Another one is two ***Map Switches*** that allow activation or deactivation of configurable sets of georeferenced raster images by a single click on a tool button.
- GeoKart integrates some independent tools & assistants that are in fact small stand-alone programs, like the ***Sketch Editor*** that can be used to create drawings for any geo-object. It comes with a set of graphic and text tools and is able to import digital photos as drawing background. Or the ***Gauss-Krüger Assistant*** that converts coordinate pairs between the different projections used in Bavaria.
- The functionalities of the Mapping Module. Details of this comprehensive GeoKart domain for the support of the spatial geological mapping process are described below.

GEOKART IMPORT & EXPORT INTERFACE

A bi-directional interface enables GeoKart to import and export geo-objects and their attributive data from respectively to the central database BIS. Data exchange is based on XML/GML-files with a proprietarily defined structure.

GeoKart incorporates a XML-reader and a XML-writer that are both semi-generic and controlled by metadata. The metadata regulate the mapping of attributes and attribute conversions. Changes in the BIS data model are usually managed by adapting the metadata and do not require adjustments in the source code of the interface. A fully generic interface is impeded by the fact that the BIS data model cannot be rebuilt exactly in Gispad's MS Access database so that some particular functions are required to handle this divergence.

The Interface can be used to exchange complete geo-objects as well as modifications or additions in the attributive data of already existing objects. GeoKart internally manages the technical IDs that the BIS assigns to all objects and datasets and that are used to distinguish existing from new data. In case of an import of a new geo-object from GeoKart into the BIS there is a function to evaluate the BIS import log files to retrieve the new object and dataset IDs assigned during the import process. By this way data synchronicity between the two systems can be assured.

THE MAPPING MODULE

The GeoKart Mapping Module is a digital approach to spatial geological mapping. Generally geological mapping is a process based on punctual observations of rocks and their classification according to their characteristics. Regions with common characteristics are separated by border lines until the whole mapping area is fragmented into areas containing observation points of the same classification. There are some important aspects:

- Only observations points are classified. Areas inherit the classification from the points they contain.
- Areas are not directly mapped. They result from the mapping of border lines.
- The classification catalogue can evolve during the mapping process.

The GeoKart Mapping Module provides three object classes representing the basic geometry types (***Mapping Point***, ***Mapping Line*** and ***Mapping Area***). Mapping Points and Mapping Areas can be classified with a map unit, Mapping Lines according to their type.

The ***Map Unit Manager*** is the tool for handling map units. Every map unit has a short and a long name, a colour and a comment field, all of which are freely editable. Map units also can be imported from other GeoKart projects. There is a utility to export the whole catalogue as tab sheet to a MS Excel file that can serve as an archive.

Map units can be created, changed or deleted (except a default map unit) at any time. Map units are not part of the controlled vocabulary of the application definition, they are part of the project data. By this way the catalogue of map units can evolve with the mapping process.

Mapping Points and Mapping Areas are displayed in the colour of their assigned map unit, Mapping Lines according to their type. The attribution of Mapping Module objects is cached in the memory of the operating system for better performance. Theoretically there is no limit to the amount of Mapping Module objects and the number of map units that can be held within a GeoKart project. On the practical side, projects with more than 30.000 objects are still running with good performance.

The Mapping Module offers several additional tools for the work with Mapping Module objects:

- A tool for Mapping Areas to inherit a map unit from Mapping Points. The tool searches all Mapping Points that are contained in the active Mapping Area and evaluates their assigned map units. The map units found are displayed in a list ordered by frequency of assignment. A Map unit can then be selected and assigned to the Mapping Area, and optionally to all contained Mapping Points. There are several options for building an object selection set.
- A similar tool for a Mapping Point to inherit a map unit from a Mapping Area containing this point.
- A tool to build selection sets of Mapping Points and Mapping Areas according to their assigned map units. Search criteria can be one or several map units. There are options for the handling of an already existing selection set and the building of the new selection set.
- A tool for the assignment of a map unit to Mapping Points and Mapping Areas contained in an existing selection set. There are several options for manipulating the set of selected objects.
- Tools to build selection sets of Mapping Module objects according to their attribute *type of object* with several options for the handling of an already existing selection set and the building of the new selection set.
- Tools to assign the attribute *type of object* to Mapping Module objects contained in an existing selection set, also with several options for manipulating the set of selected objects.

The attribute *type of object* of all three Mapping Module objects is associated to lists in the controlled vocabulary. There is a cross reference of some list elements (e.g. *border of geological units* from the list for the type of Mapping Line) to a list of cartography attributes. GeoKart takes care of this reference, so these objects do not have to be attributed during the later processing in the cartography department any more.

ACKNOWLEDGEMENT

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THE URBAN RELIEF STABILITY ASSESSMENT USING GIS (A CASE STUDY OF YEREVAN)

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KEY WORDS: Land stability, urban relief, urban construction, GIS, men-made deposits, functional load.

INTRODUCTION

Since the 1970s, global and regional environmental problems and their solutions have been a priority for the state policy of Armenia. Geomorphology, as well as other earth sciences, has many environmental features which require special methodological approaches. One of them is urban relief (lithologic plate) stability assessment as a basis of urban life and vital functions.

BRIEF DESCRIPTION OF THE MORPHO-LITOLOGICAL SYSTEM OF YEREVAN

The relief of urban territories, especially the mountainous ones, plays an important role in urban life organization. So, stability assessment of urban relief is one of the most important problems in environmental geomorphology of urban territories. Definition, estimation and mapping of quantitative and qualitative indices and characteristics are essential for urban construction (Likhachova et al., 2000).

In this respect, the most prospective is the morpho-litho-system approach that regards “relief + geological substrate” and “city + relief + geological substrate” as an urban morpho-lithological system (Likhachova et al., 1991).

The morpho-lithological system of Yerevan represents a complex system of interactions between natural and man-made components of urban morpho-lithosystem. On the territory of more than 230 sq. km, there is a variety of qualitative and quantitative characteristics, particularly hypsometry, surface inclination, dominating exposition of slopes, depth and density of relief dissection.

Anthropogenic deposits are also an issue which describes the land-use patterns in Yerevan (Asmaryan, 2006).

The main goal of this study was to assess the real state of urban surface and reveal the suitable and stable places for Yerevan development in the future.

The tasks to achieve this goal were:

- To study the qualitative and quantitative characteristics of the relief of Yerevan
- To analyze the man-made forms of urban relief.
- To identify the characteristics of distribution of man-made deposits.
- To assess urban relief stability of Yerevan.
- To assess the functional load (characteristics of the distribution of the different morphotypes of functional zones)

MATERIAL AND METHODS

In this study the ArcView GIS 3.2a ArcGIS 9.x software were used with the ArcView Spatial Analyst and 3D Analyst extensions. For TIN model the topographical maps of 1:25000 and 1:10000 scales were digitized for Yerevan city. On the base of TIN model we derived the maps of slope and aspects, depth and density of erosion dissection, which gave us detailed information about the state of surface hypsometry, inclination and slope exposition and barren area (Asmaryan, 2005).

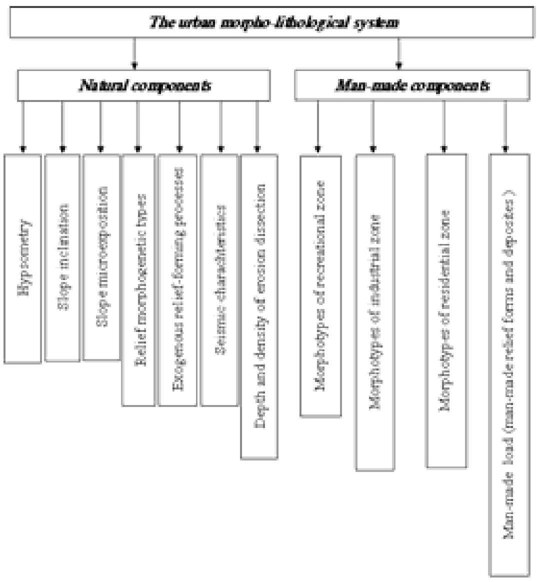

Figure 1-The main components of Yerevan morpho-lithological system

We analyze the data of more than 500 boreholes. Comparing them with the topographical map and satellite imagery of high resolution (Quick bird-0.4m) we derive the maps of the distribution of man-made deposits and land use of the territory of Yerevan city.

The maps of relief morphogenetical types and forms and relief-forming processes were transformed from raster to vector format.

The Figure 1 has shown the main components, which have been chosen for the assessment.

All the layers were georeferenced in ArcView using Image Warp tools. The Weighted overlay process in Model Builder available in Spatial Analyst extension has been used to do the analysis as shown in the Figure 2. To combine input themes with different kinds of data, we assigned the values in the input themes to values on a common evaluation scale. We weighted the themes as to their influence:

- Relief morphogenetical types – 30%
- Exogeneous relief forming processes – 20%
- Man-made relief forms and deposits – 10%
- Seismic characteristics – 5%
- Slope inclination – 5%
- Slope exposition – 5%
- Hydrogeological characteristics – 5%
- Depth of erosion dissection – 5%
- Density of erosion dissection – 5%

We define the weighted overlay table where we specify the percent influence for each theme and a scale value for each input field value.

RESULTS AND DISCUSSIONS

Running the model we get the map of the relief stability of Yerevan city. According to the three-point scale we get three type of territories, viz. one-point as stable, two-point as moderately stable and three-point as unstable territories.

As shown in the Figure 3 the best and stable area is laying in high parts of the hillock and tuff-lava sheets within the western and eastern part of the city, named as the Yeghvard and Arabkir-Qanaqer and Nork volcanic platos.

In the central part of the city at the basins of volcanic and tectonic origins, the alluvial fans of Djrvedj, Voghdjaberd and Getar rivers and within the three fluvial terraces above flood-plan of Hrazdan River we have areas of moderate stability.

The most unstable areas are in the south-eastern part of the city where we have hillock, arid denudation pediments and ropy denudation plato of single beds cover, V-shaped valley steep slopes and escarps.

Hens we can figure out the following:

- the picture of the relief stability of Yerevan city is very complicated: within the urban area we have three types of morphogenetically different territories viz. volcanic platos, arid-denudation and accumulative plans, which define the differences in the morphometrical characteristics of the urban relief and finally make complexity of relief stability.
- In the northern and north-eastern dirrection we have well natural conditions and stable areas for the future urban spatial expantion and development.
- The geomorphological and environmental data base is formed, which we plan to update with the geochemical and geophisical data in order to perform the geomorphological and geochemical risk assessment.

A necessary prerequisite for the improvement of urban environment is rationality of its territorial management – the optimal division of urban sites by their functional predestination. One of approaches aimed to this is functional zonation of the city – a spatial management of basic types of activities – labour, household, recreational.

We divided Yerevan's territory depending on the type of the activities of the populace which predetermine industrial, inhabited, recreation zones with their morphotypes.

The map of functional zonation of the city indicates the zones as ecologically unfavorable, neutral and favorable plots in colours respectively from dark-violet to green.

The produced map allowed us to indicate the optimal level of distribution of ecologically unfavorable, neutral and favorable plots allover the city's territory.

The Figure 4 highlights the results of correlation of areas of unfavorable, neutral and favorable plots by different-level stability territories.

CONCLUSION

The obtained results indicate:

- Disproportion of land balance: the planted area as ecologically favorable plot is very small, especially in the south of the city where the concentration of industrial enterprises as ecologically unfavorable morphotypes, is the highest.
- The southeastern and eastern parts (some 2/3 of the city) as the most unfavorable sites are unsuitable even for agricultural purposes, due to extremely high erosion dissection density and depth factors (4-7km/sq.km and 10m/sq.km) and an inclination to a wide spread of landslide phenomena.
- The northwestern part of the city in the bounds of Yeghvard volcanic plato is the most stable and unloaded. Nearby the north boundary territories lie, undeveloped but rather stable.

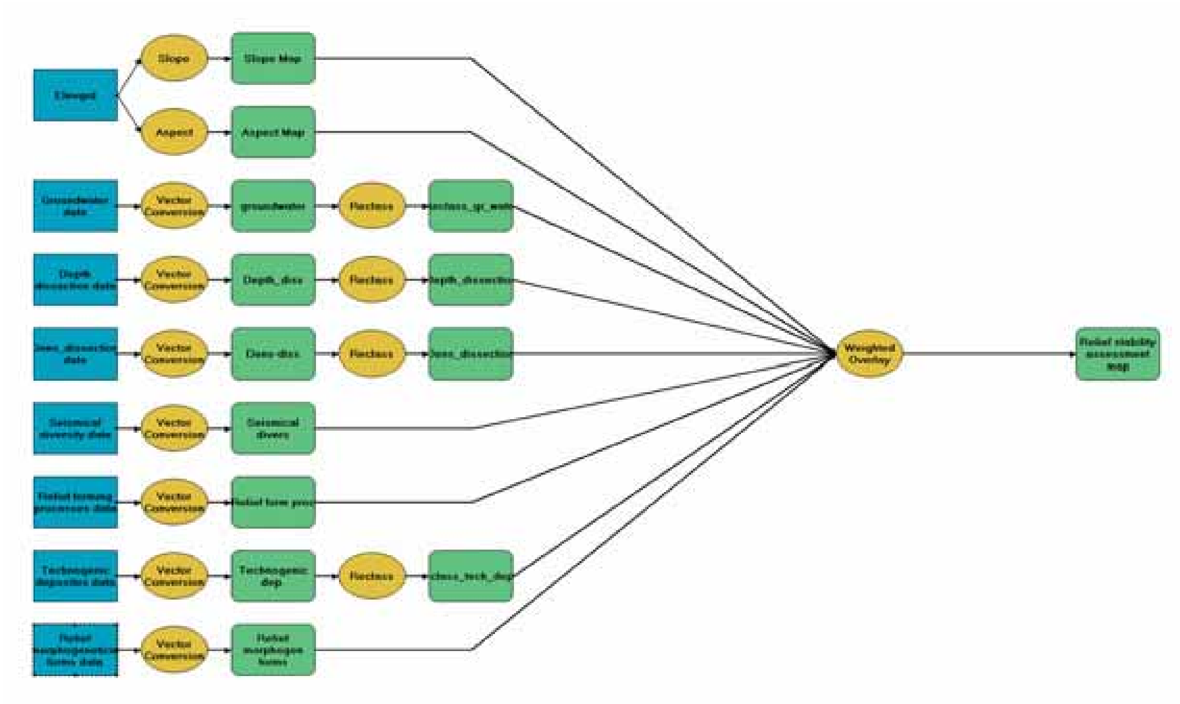

Figure 2 – The model of the weighted overlay process

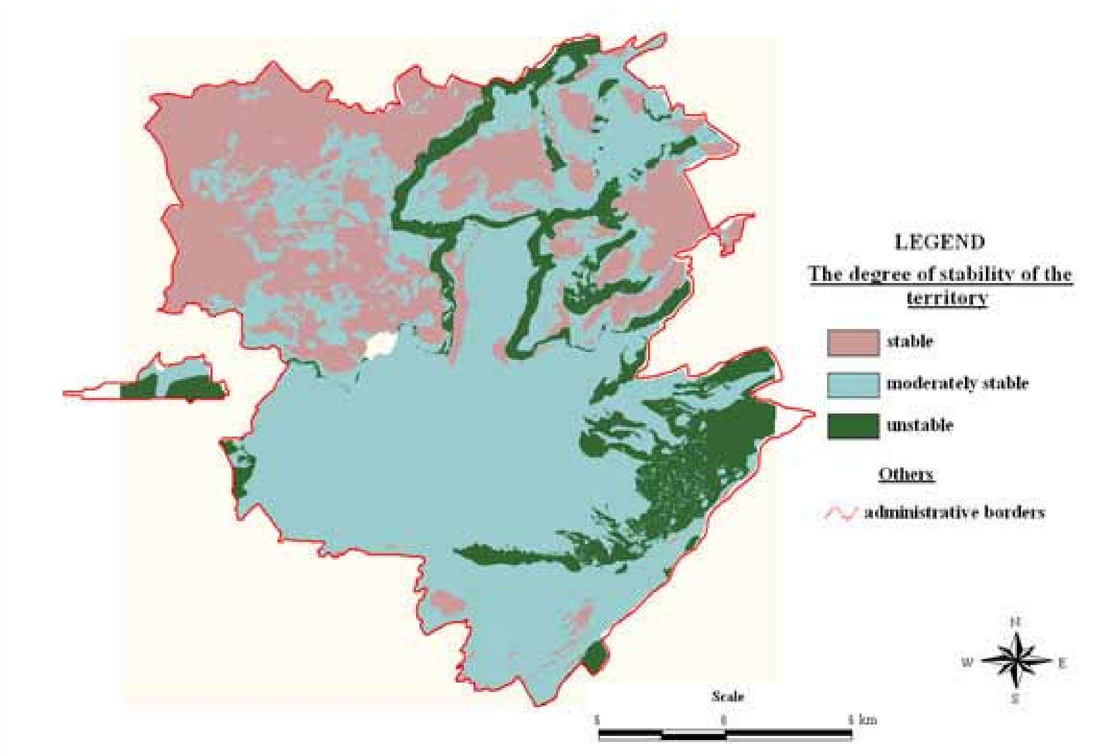

Figure 3 The map of stability of the territory of Yereva

- The central part of the city experiences construction boom. Construction of many-stored houses in the hollow part of the city brings to an increase of their density. For poorly ventilated part of the city this can lead to adverse ecological consequences, especially when houses are constructed at the expense of reduction of planted areas.

This analysis is important for planning civilian, industrial, municipal etc. object, in particular at the stage of designing districts, organizing or more precise definition of general scheme.

ACKNOWLEDGEMENTS

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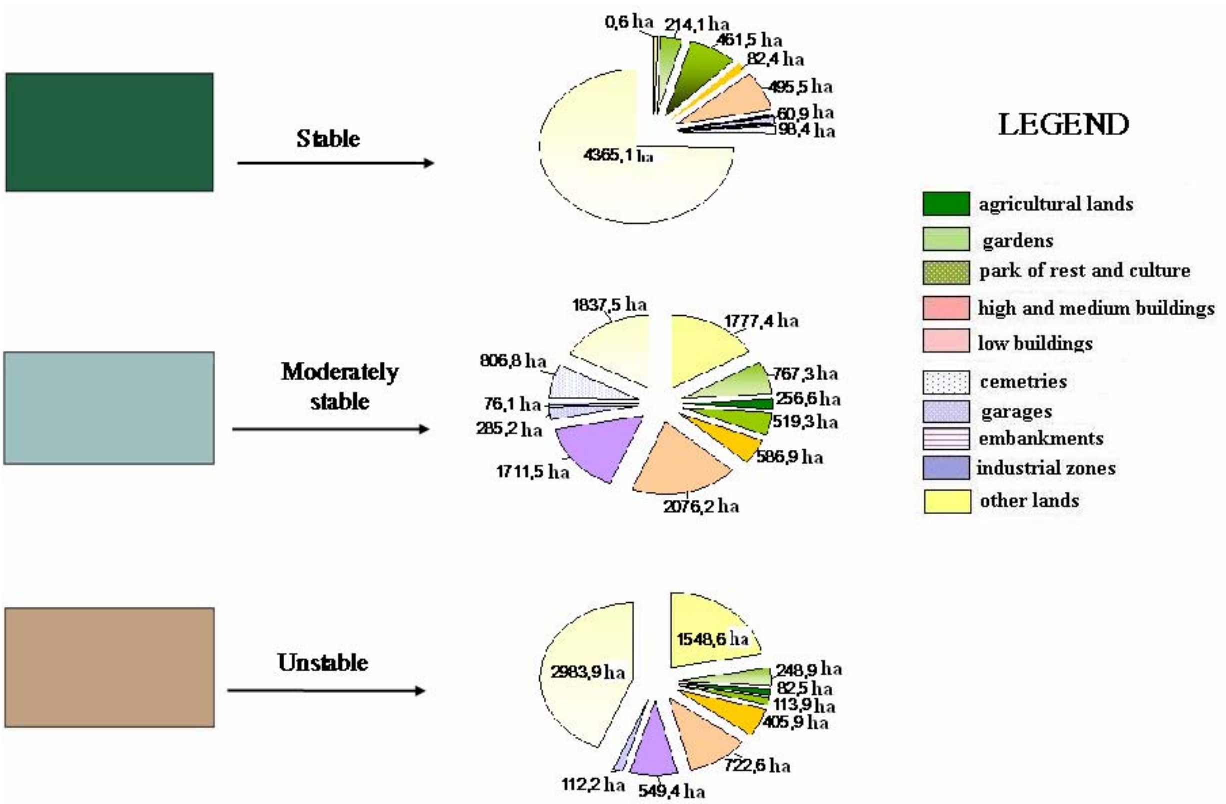

Figure 4 The functional load assessment on the territory of Yerevan (ha – here it means hectare)

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DATABASES AT THE GEOLOGICAL SURVEY OF AUSTRIA: SUBSTRATE UNITS IN THE AUSTRIAN ALPS AT THE SCALE OF 1:200.000

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KEY WORDS: substrate units, data management, data quality.

INTRODUCTION

The Geological Survey of Austria (GBA) represents the geo-management, geological and related geoscientific center of the public sector of Austria.

Integrated in the comprehensive project “Ecological versus historical determinants of plant species distribution in the Austrian Alps (FlorAlp)” the Geological Survey was asked to contribute and provide geological aspects for modelling vegetation habitats.

Beside climatic conditions, regarding altitude and aspect, geology is an essential factor for the nutrient content in soils.

SUBSTRATE UNITS 1:200.000 - SO WHAT?

Covering the Austrian Alps, the digital database of substrate units represents a first and leading product of its kind in the country.

It fills an important gap in the ecological fundamental data pool and will serve as an important tool for environmental issues and spatial approaches in the future.

Based on the original legend text, lithological information and references, the geological features are assigned to 33 substrate units, covering the whole Austrian alpine region. Legend items include:

1) Acidic silicate rocks
2) Intermediate silicate rocks
3) Basic silicate rocks
4) Calc-silicates
5) Clastic silicates (acidic)
6) Clastic silicates (intermediate)
7) Clastic carbonatic sediments
8) Clayey fine clastic sediments (acidic)
9) Clayey fine clastic sediments (intermediate)
10) Clayey fine clastic sediments (basic)
11) Limestones (including marble)
12) Dolomite
13) Sulphates and chlorides (evaporites)
14) Till (siliceous, acidic-intermediate)
15) Till (siliceous, intermediate-basic)
16) Till (siliceous-carbonatic)
17) Till (carbonatic)
18) Talus (siliceous, acidic)
19) Talus (siliceous, intermediate)
20) Talus (siliceous, basic)
21) Talus (siliceous, carbonatic)
22) Talus (carbonatic)
23) Alluvial sediments (acidic-intermediate)
24) Alluvial sediments (intermediate-basic)
25) Alluvial sediments (siliceous-carbonatic)
26) Alluvial sediments (carbonatic)
27) Sand (siliceous)
28) Sand (carbonatic)
29) Loess loam (siliceous)
30) Loess (carbonatic)
31) Organic material
32) Landfill, anthropogenic deposit
33) Ultramafic rocks

Assignments to solid rock result from unique table joins. However, routine assignments to unconsolidated and quaternary rocks cannot be carried out easily because many local conditions have to be taken into consideration.

For example local or remote moraines contain different material depending on the hinterland of the glacier and its pathway through different geological units.

As explicit assignments are often not practicable, the requirement of second choice assignments arose to provide alternatives to first class substrate units.

Additionally each assignment comprises three quality ranks which are applied to each polygon to account for these insecure decisions.

Figure 1 shows secure, less secure and rather unsecured substrate unit assignments while figure 2 shows alternative assignments. In comparison figure 7 shows the actual substrate units.

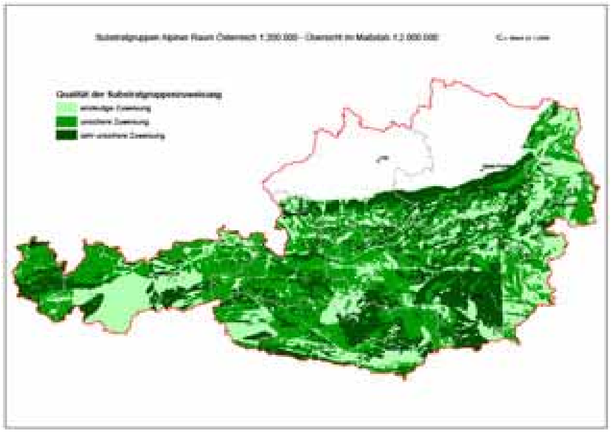

Figure 1 – Assignement quality.

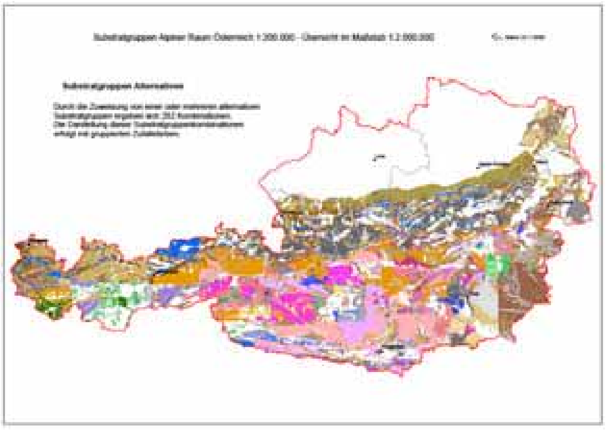

Figure 2 – Alternative Assignements.

DATA ASSEMBLING AND DATA QUALITY MANAGEMENT

Unfortunately there is no complete Austrian wide geologic database at the scale of 1:200.000 which could have been used as input for this project. The primary data source is the digital database of an existing polygon feature class covering the Austrian provinces of Salzburg, Upper- and Lower Austria plus Burgenland, all at the scale of 1:200.000, and Vorarlberg 1:100.000 of the same product series.

Homogeneous data quality varies as uncoverd areas have to be filled with unpublished, foreign or outdated map data of different scales and quality standards.

- Different product sources: digital, analog, published, unpublished.
- Different precision and scales: from 1:100.000 to 1:300.000
- Different data quality and accuracy: mostly latest data, but also some data known to be outdated

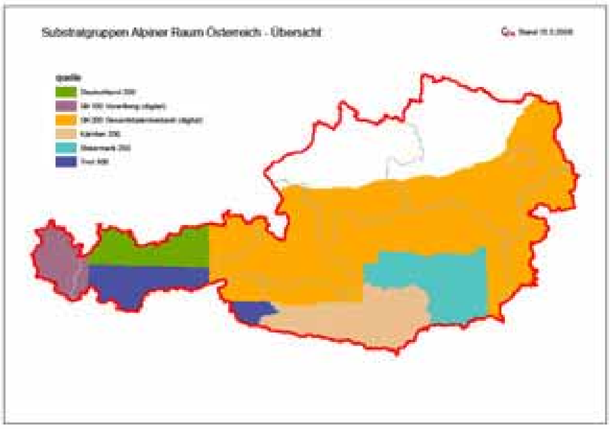

Figure 3 – Product source.

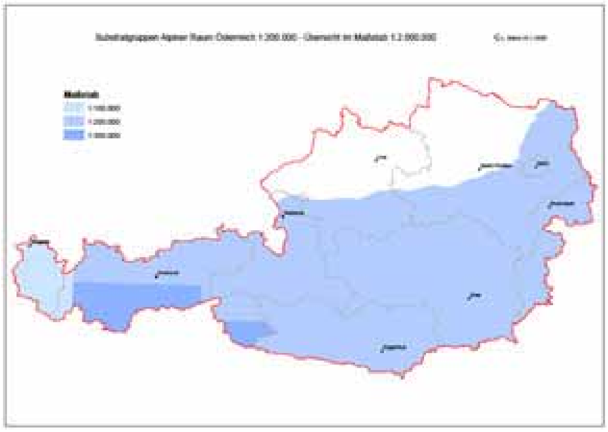

Figure 4 – Scale of geological raw data.

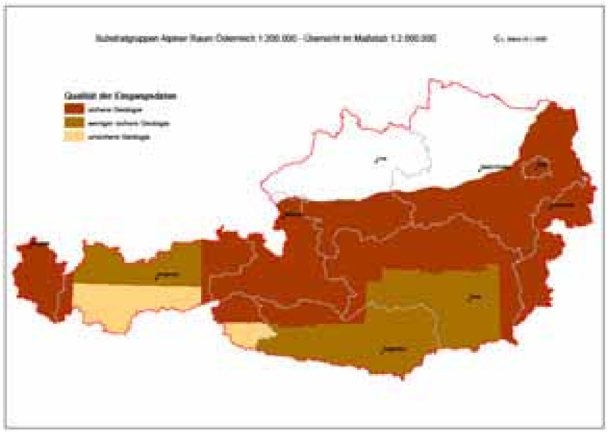

Figure 5 – Quality of geological raw data.

Polygones in the finished database are merged and dissolved according to the newly generated attribute substrate units. Therefore inhomogeneity aspects are not visible anymore. Users must be conscious of quality disparity. Providing information about the source product as well as the quality of geological raw data and the scale as joint attributes or as overview layers can help drawing user's attention to this circumstance.

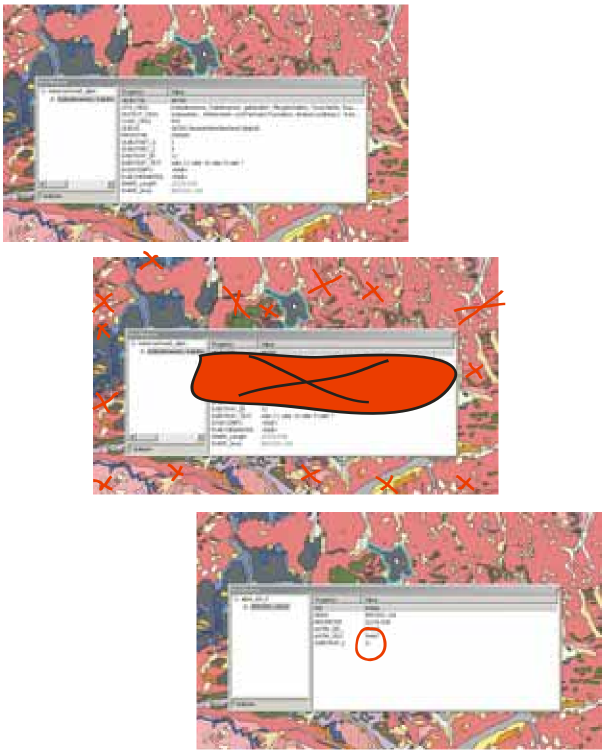

Figure 6 – Loss of information.

Keeping all the details in the basic dataset means some further 10.000 polygons, which makes quite a difference to the handling and processing of the data. Ideological objectives are confronting technical strategies and consistency.

CONCLUSIONS

Data consist of actual data and additional information which cannot be regarded as meta data because it is necessary to understand the substance of data. There is a need to think about and put effort into presenting and integrating quality declarations in the dataset itself.

ACKNOWLEDGEMENT

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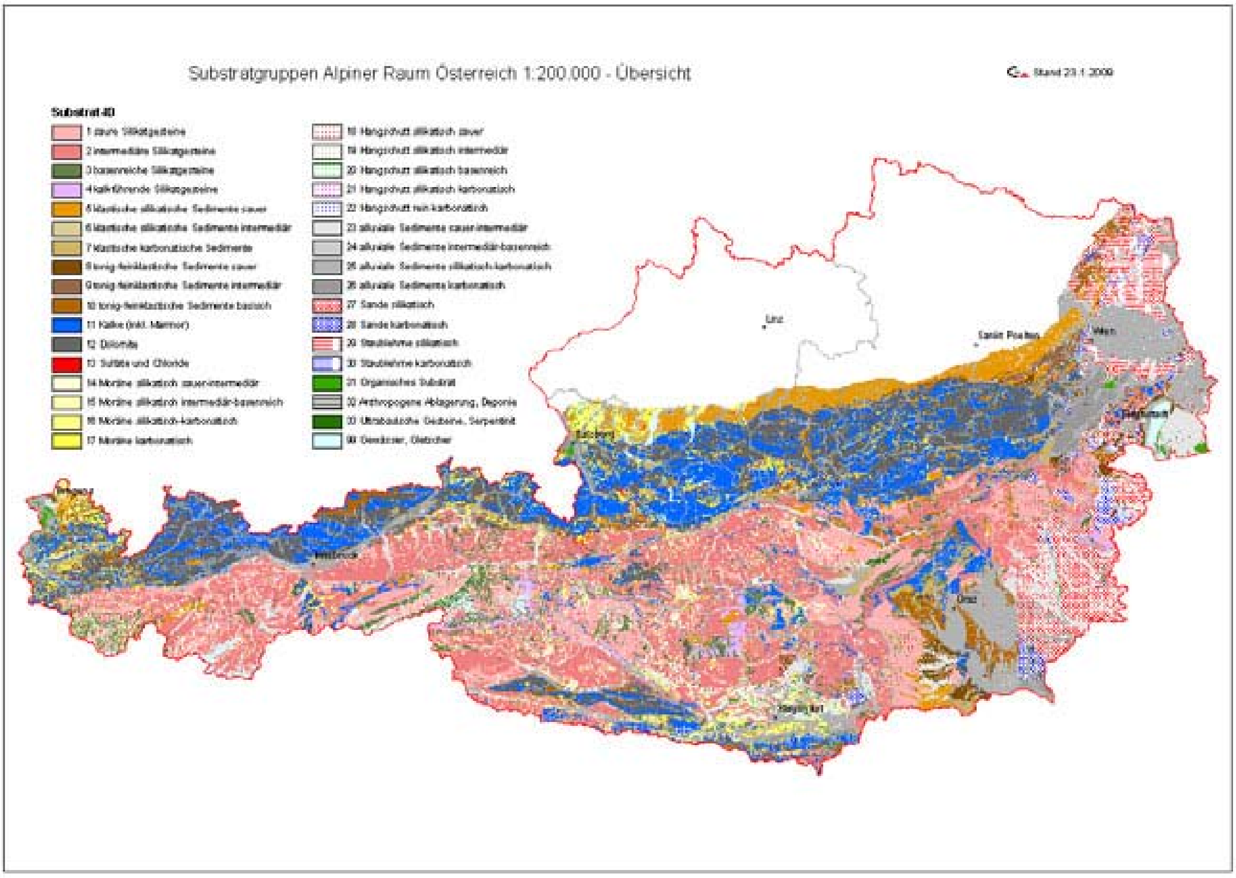

Figure 7 – View of the digital Austrian alpine wide database of substrate units.

HYDROGEOLOGICAL MAP OF BAVARIA 1: 500.000: CARTOGRAPHIC CHALLENGES

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KEY WORDS: hydrogeological outline map, cartography, digital map, aggregation, generalization.

INTRODUCTION

During the production process of the Hydrogeological Map of Bavaria 1:500.000 (HK 500) (LfU, 2009) a number of cartographic challenges have been met. Main points were the consistency of the digital data sets in the map originating from different sources, the aggregation and adaption of geometries from different scales and the topology of the spatial data. The poster shows the different stages of the cartographic production process and some details of the produced map sheets.

Within the scope of the HK 500 the following map sheets were produced:

- „Map Sheet 1: Propagation of Hydrogeological Map Units near to the surface“
- „Map Sheet 2: Classification of Hydrogeological Units“
- „Map Sheet 3: Regional aquifers and groundwater contours“
- „Map Sheet 4: Groundwater recharge through precipitation based on a long-time average“

BASIC DATA

For the production of the HK500 different data bases were used. All four map sheets contain a reduced topography, which was extracted from the “General map of Bavaria” (ÜK 500) (LVG, 2007). For the map sheets 1 to 3 the geometries of the “Hydrogeological Map of Germany 1:200.000” (HÜK 200) (BGR, 2008) and the tectonic faults of the “Geological Map of Bavaria 1:500.000” (GK 500) (GLA, 1996) were used as a starting point. For the production of map sheet 2 numerous groundwater contour maps from different sources and scale ranges have been archived and evaluated. The visualisation of the groundwater recharge in map sheet 4 is based on raster data.

CARTOGRAPHIC PROCESSING

Preparing the topographic base data:

The topographic features of the digital ÜK500 were reduced and represented in a cartographic simplified form. Since the scientific data are limited to the extent of Bavaria the topographic data outside Bavaria were reduced to a minimum. Thus the users view isn’t distracted from the principal theme.

Preparing the HÜK 200 data:

The spatial data of map sheets 1 to 3 were derived from the geometries of the HÜK 200. As the HÜK 200 was available in different map sheets, it was necessary to adjust geometries at the boundaries in order to get a seamless map. Additionally covering layers were removed and the water bodies of the HÜK 200 were replaced by those of the ÜK 500.

Aggregation and generalization of the HK 500 spatial data:

To ensure the legibility and comprehensibility of the HK 500 the rather detailed geometries of the HÜK 200 had to be reduced. The first step was an aggregation of the hydrogeological units from around 270 units in the HÜK 200 to around 90 units in the HK 500. The next step was the adaption of the geometries to the scale 1:500.000. The following points had to be addressed considering cartographic minimum dimensions:

- Elimination,
- Enlargement,
- Grouping,
- Smoothing and
- Displacement of geo-spatial features

Which option is the appropriate one has to be decided for each element individually and depends on cartographic and scientific criteria. For this reason the generalization was a very time consuming task. To accomplish this within the time schedule, the total area was divided between three cartographers and generalized simultaneously. The main challenge was then to produce a homogeneously generalized map. To achieve this, an agreement on common rules such as the above mentioned ones and a close communication between the cartographers during the whole generalization process were essential. Figure 1 shows a detail of map sheet 1 before and after the generalization process.

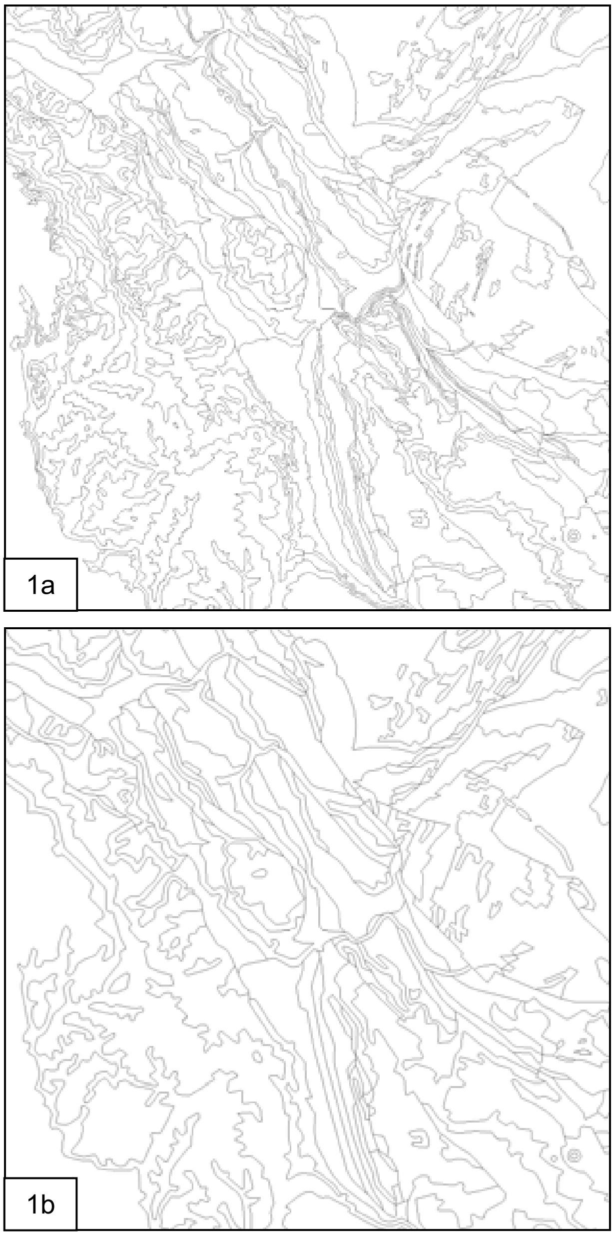

Figure 1: Detail of polygon geometry before (a) and after (b) the generalization process: geo-spatial features are eliminated, enlarged, grouped, simplified or displaced considering cartographic and scientific criteria.

Integration of spatial data:

The goal of spatial data integration is to reach topological and scientific consistency of the data. In case of the HK 500 the spatial data integration plays an important role because of the different data sources. For example the generalized hydrogeological units had to be adapted to the drainage network of the ÜK 500 and the tectonic faults of the GK 500 (Figure 2) as well as the groundwater contours had to be adapted to the geometries of the hydrogeological units.

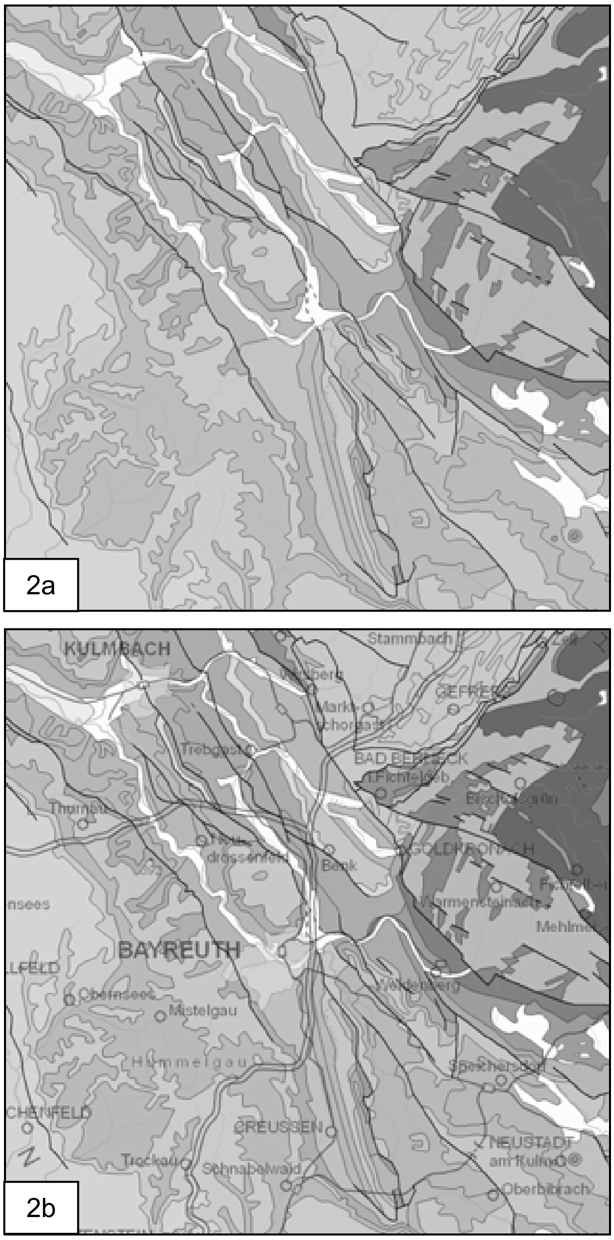

Figure 2: Detail of map sheet 1 “Propagation of Hydrogeological Map Units near to the surface“, after generalization, data integration (a) and including topographic data (b).

Map Layout:

The HK 500 is planned as an outline map series and its layout and format should support that view. For this reason the different complex map legends of the map sheets 1-4 were placed inside the map surface (Figure 3). This gives the possibility to arrange the legend individually for each sheet and to utilise the whole space between the map frame and thematic data. Another advantage is that the size of the folded and unfolded map sheets are identical, which gives a better presentation of the whole map series.

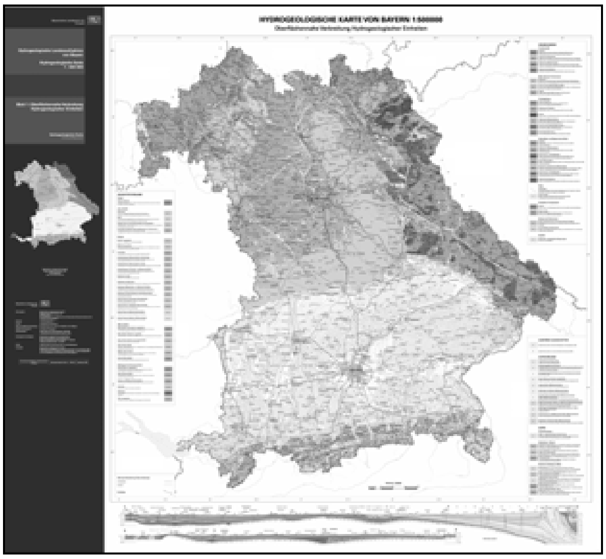

Figure 3: The basic map layout of the HK 500.

To ensure the legibility and comprehensibility of the HK 500 the cartographic adaption of spatial data from different sources and the generalization of the hydrogeological units was essential.
Especially the change of scale from the HÜK 200 to the HK 500 and the aggregation of hydrogeological units required a lot of cartographic and scientific resources. The production of the HK 500 makes clear, how important it is to reduce geometries and content in order to provide legible spatial information to the user. This is an important point, because it shows, that also in the digital era, where it becomes always easier to compose maps with layers from different sources, cartographic expertise will be essential to maintain consistency and legibility of the maps.

ACKNOWLEDGEMENT

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CONCLUSIONS

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OPEN SOURCE SOFTWARE AS A TOOL FOR MULTIDIMENSIONAL GEOLOGICAL AND GLACIOLOGICAL MODELING (TWO EXAMPLES FROM POLISH TATRA MTS.)

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KEY WORDS: 3D modelling, opensource software, Tatra Mts, deglaciation, Eocene.

INTRODUCTION

Multidimensional modeling and visualization of geological and geomorphological data permit fundamental advances in Earth Sciences. However, as numerous commercial applications devoted to such modeling are either expensive or unable to manipulate all available data, open-source software is a noteworthy alternative.

This contribution discusses two different models: one is a semi-4D model of the youngest Pleistocene deglaciation of two valleys in Polish High Tatra Mountains, the other is a 3D geological model of Nummulitic Eocene deposits in the Tatra Mts. Both models were created using only free and opensource software: GrassGIS (www.grass.itc.it), Qgis (www.qgis.org) and Paraview (www.para-view.org). This software is available in the Internet and can be freely downloaded.

4D DEGLACIATION MODEL

The aim of this project was to model the recession of a mountain glacier flowing into two High Tatra mountain valleys: Roztoka and Rybi Potok (Makos et al., 2009). The 4D deglaciation model (Fig. 1) is based on geological and geomorphological data (location of glacier trimlines and moraine ridges), detailed digital elevation model (horizontal resolution of 5x5 m) and an analysis of aerial and satellite images.

Based on three generations of glacier trimlines, which show horizontal extension of individual deglaciation phases, three spatial models of the glacier extension have been constructed and subsequently combined to produce a 4D deglaciation model. This model allows to compute volume and surface area of the glacier in subsequent phases of its evolution.

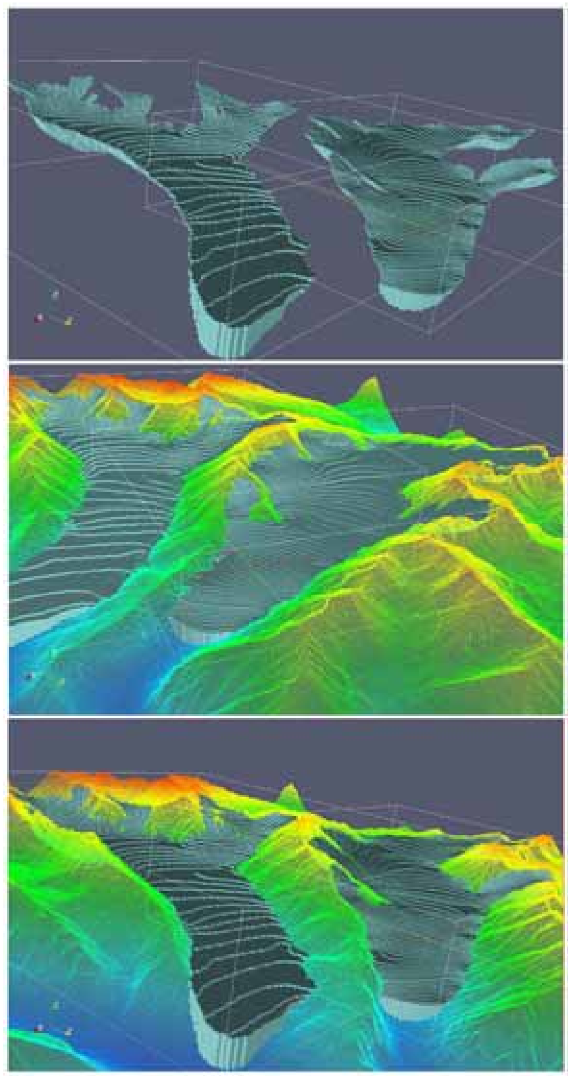

Figure 1 – 3D model of the accumulation area of the Roztoka and Rybi Potok glacier - the last glacial maximum.

3D GEOLOGICAL MODEL OF THE NUMMULITIC EOCENE IN TATRA MTS

The study area is located in the northern part of the Tatra Mts. The 3D geological model of the Nummulitic Eocene is based on geological surface data, cross-sections as well as digital elevation model (Tomaszczyk et al., 2009). The model *(Fig. 2)* contains six lithological units: nummulitic limestones *(Ew)*, detritic limestones *(Ej)*, dolomitic sandstones *(Ep)*, grey conglomerates *(Ezs)*, red conglomerates *(Ezc)*, undivided Mesozoic rocks *(Mz)* and also comprises two vertical faults. Geological model allows to create solids, surfaces and various horizontal and vertical sections. Based on these it was possible to estimate spatial distribution and thickness variations of modeled units and to verify the position of geological contacts. An analysis of the model defined fault's displacement parameters and confirmed synsedimentary origin of faults.

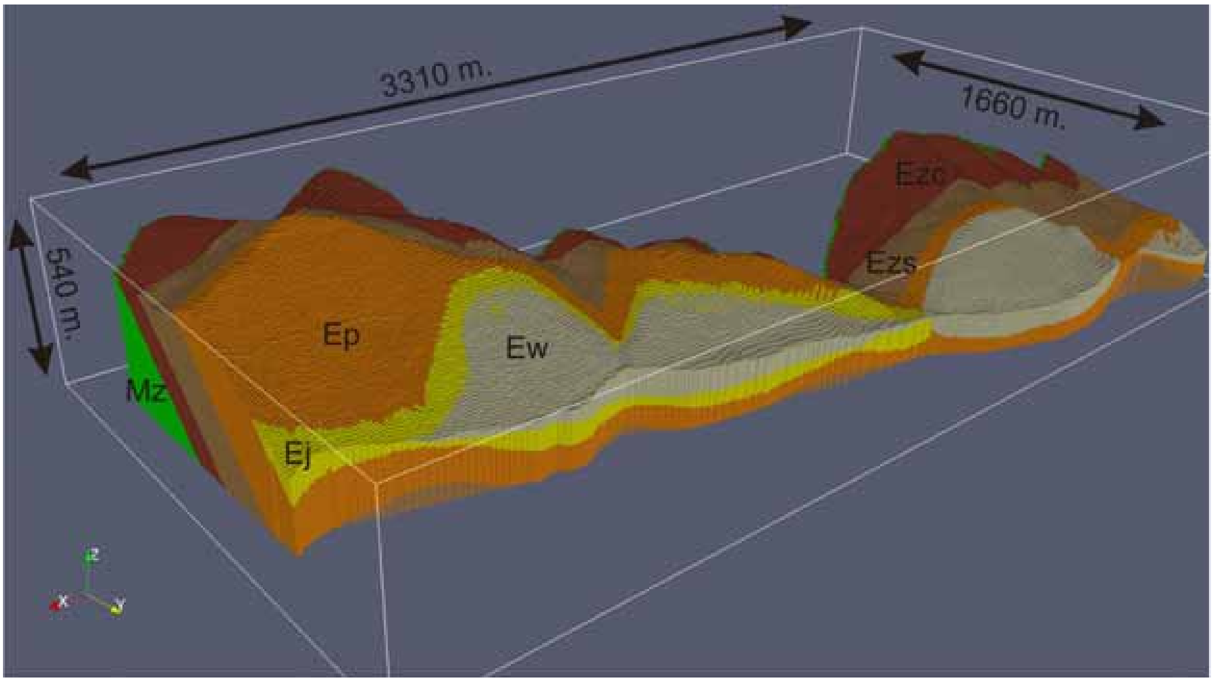

Figure 2 – 3D voxel model of the central part of Nummulitic Eocene in the West Tatra Mts.

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THE 1:25000 GEOANTHROPIC MAP OF CATALONIA: A PICTURE OF NATURAL AND MAN-MADE CONSTRAINTS TO LAND PLANNING.

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KEY WORDS: active processes, anthropic activity, Catalonia.

INTRODUCTION

The GeoAnthropic map of Catalonia is a new geothematic map series at 1:25000 scale performed by the Geological Institute of Catalonia (IGC). This new series is a complement of the 1:25000 scale geological map, providing data of the current geomorphic processes and the man-made activities that transform the territory. Data portrayed in this map series will be useful for land planning and hazard assessment. GeoAnthropic is an acronym meaning active geomorphic processes and anthropic activity.

The project commenced in the year 2007 and is planned to be finished by the year 2023. The whole land of Catalonia will be covered by this series, totalizing an area of 32144 km^2 to be mapped in 16 years (Fig. 1).

Figure 1 – Map of Catalonia showing the progress of the GeoAntrhopic map (coloured areas).The grid is the 1:25000 topographic sheet distribution. Solid lines are the county borders.

The GeoAnthropic map series will be published according to the 1:25000 topographic grid of Catalonia (304 sheets). A database related to this map series is currently under construction.

At present, three preliminary sheets are completed, and works in 13 sheets are in progress.

MAP CONTENTS

The 1:25000 GeoAntropic map of Catalonia and its related database has to fulfill the following items:

- Active geomorphic processes inventory.
- Geotechnical and geochemical properties of problematic soils.
- Active geomorphic processes map.
- Anthropic artifacts map
- Regolith and residuals soils map.

AIMS OF THE GEOANTHROPIC MAP

The GeoAnthropic map is though to be a complement of the general geological map and provide data for hazard assessment.

The main goals of this geothematic map are to map the active geomorphic processes occurring in the territory (landslides, badlands areas, etc), and depict the man-made or anthropic works (infillings, road cuttings, etc) that have reshaped the landscape (Fig. 2 and 3).

Reclassify the bedrock geology is also an important task to do in this map series. The lithological units portrayed in the general geological map will be grouped according their geotechnical properties. The reason to do that is to know the areas made up of problematic soils such as shrinking and swelling clays, dispersible soils and collapsible soils.

Regolith and residual soils mapping is a further goal to achieve in this series. Weathering fronts are not generally depicted in geological maps. Mapping weathered rock types is important because the mechanical and chemical properties of weathered rocks are totally different from the properties of the parent rock from which they form.

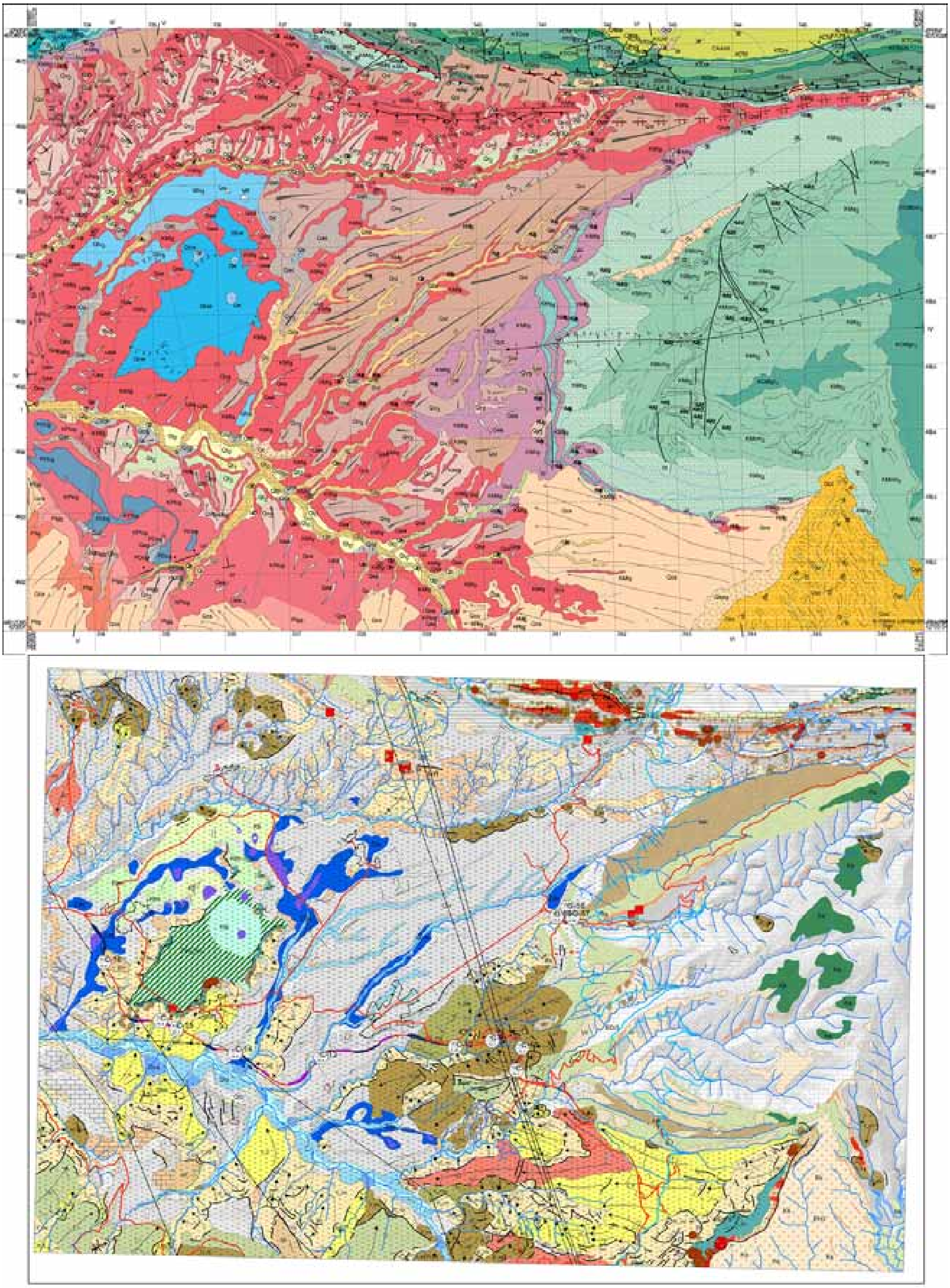

Figure 2 – The upper map is the regular geological map at 1:25000 scale of Isona (sheet 66-23). The lower map is the GeoAntropic map of the same area. Both maps are complementary. The geological map depicts the bedrock geology that makes up the territory. The GeoAnthropic map, instead, portrays the active geomorphic processes occurring in the territory and the man-made artifacts that have reshaped the natural landscape.

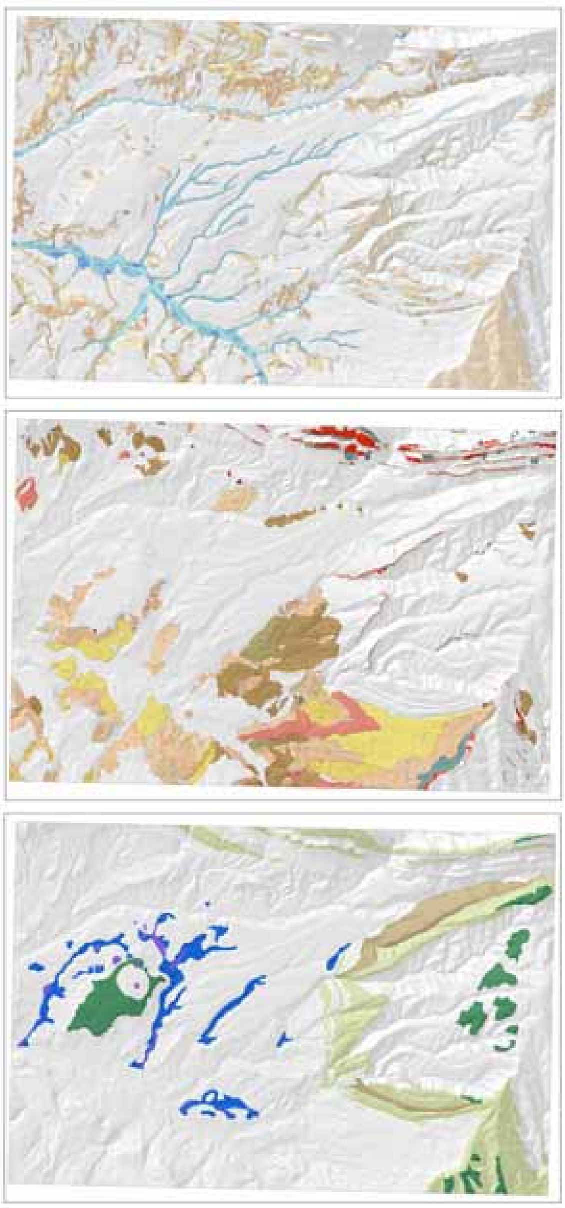

Figure 3 – Active geomorphic processes occurring in one of the preliminary completed sheets (sheet 66-23, Isona). The upper map shows the areas affected by fluvial processes and erosion. The map of the middle portrays active landslides. The lower map depicts current karstic phenomena.

BENEFITS TO SOCIETY

Mapping and realizing the inventory of the active geomorphic processes of the whole territory is essential for land planning and hazard assessment.

Recognizing and mapping man-made artifacts, such as infillings, road cuttings and embankments it is also of crucial value, because they may trigger or reactivate dormant landslides, or cause erosion or unexpected floods.

Identifying areas where problematic soils occur (expansive, dispersive or collapsible soils) is also critical for hazard assessment. Shrinking and swelling clays, dispersive and collapsible soils can cause damage to homes.

ACKNOWLEDGEMENTS

Funds for the GeoAntrhopic map of Catalonia at 1:25000 scale are provided by the Catalan State Ministry of Land Planning and Public Works. The authors are grateful to the IGC executive direction for their encouragement to present the ongoing works related to this map series.

THE 1:5000 URBAN GEOLOGICAL MAP OF CATALONIA: MAPPING THE SUBSURFACE GEOLOGY OF THE URBAN AREAS IN DETAIL.

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KEY WORDS: urban geology, digital elevation models, man-made infilling, Catalonia.

INTRODUCTION

The Geologic Institute of (IGC) runs an urban geologic mapping project, at 1:5000 scale, to fill the gap of information on ground and underground geology of the major towns and cities of Catalonia.

The aim of the project is to provide accurate geologic information for urban planning, major city works and urban environmental issues.

The zones to map include the urban areas of county capitals and towns of more than 10000 inhabitants. The project commenced in 2007 and is planned to be finished by 2022. The urban zones of 131 towns will be surveyed for this project, totalizing an area of about 2109 km^2 to be mapped in 15 years (Fig. 1). According to the 2008 census, the 82% of the population of Catalonia lives in the areas to be mapped in this project

At present, in the area of Barcelona, two preliminary maps are already done, and works in the cities of Barcelona, Tarragona, Lleida and Girona are in progress.

Figure 1 – Map of Catalonia showing the urban areas to be mapped (coloured areas). Boxes depict ongoing urban mapping around province capitals, the grid is the 1:5000 topographic sheet distribution. Solid lines are the county borders.

The geological maps of this series will be published according to the 1:5000 topographic grid of Catalonia. A database with geological, geotechnical and geochemical data is currently under construction.

MAP CONTENTS

The 1:5000 scale urban geological map of Catalonia has to fulfill the following items:

- Outcrop inventory.
- Borehole inventory.
- Geotechnical properties of soils and rocks.
- Map the Man-made infilling materials map
- Subsurface bedrock geology map.
- Quaternary map.
- Thickness of Quaternary sediments and anthropic infilling.
- Environmental geochemistry of urban soils.

DATA GATHERING

In urban areas, acquiring geological data is a difficult issue. Former cropping out zones do no longer exist or are very scarce (Fig. 2). In this context, direct geological observation is very unlikely and can only be performed in few available outcrops and in borehole core collections. However, valuable information may come from historical geological maps, old aerial photographs, geotechnical reports and digital elevation models (DEMs).

Analyzing historical geological maps and old aerial photographs taken before the urban sprawl, provide relevant guidelines about the geology of urban areas now concealed by a layer of concrete and asphalt.

Geotechnical reports from city works are, with no doubt, the most valuable source of data for urban subsurface geology. Big cities are plenty of geotechnical studies which require a large number of boreholes and geotechnical tests to be achieved. The thickness of the geological units and the mechanical properties of rocks and soils underneath the urban network can be gathered from these reports.

Hillshade images derived from DEMs of old aerial photographs may depict geological or geomorphological elements that are either, hidden or destroyed by the urban sprawl. Man-made

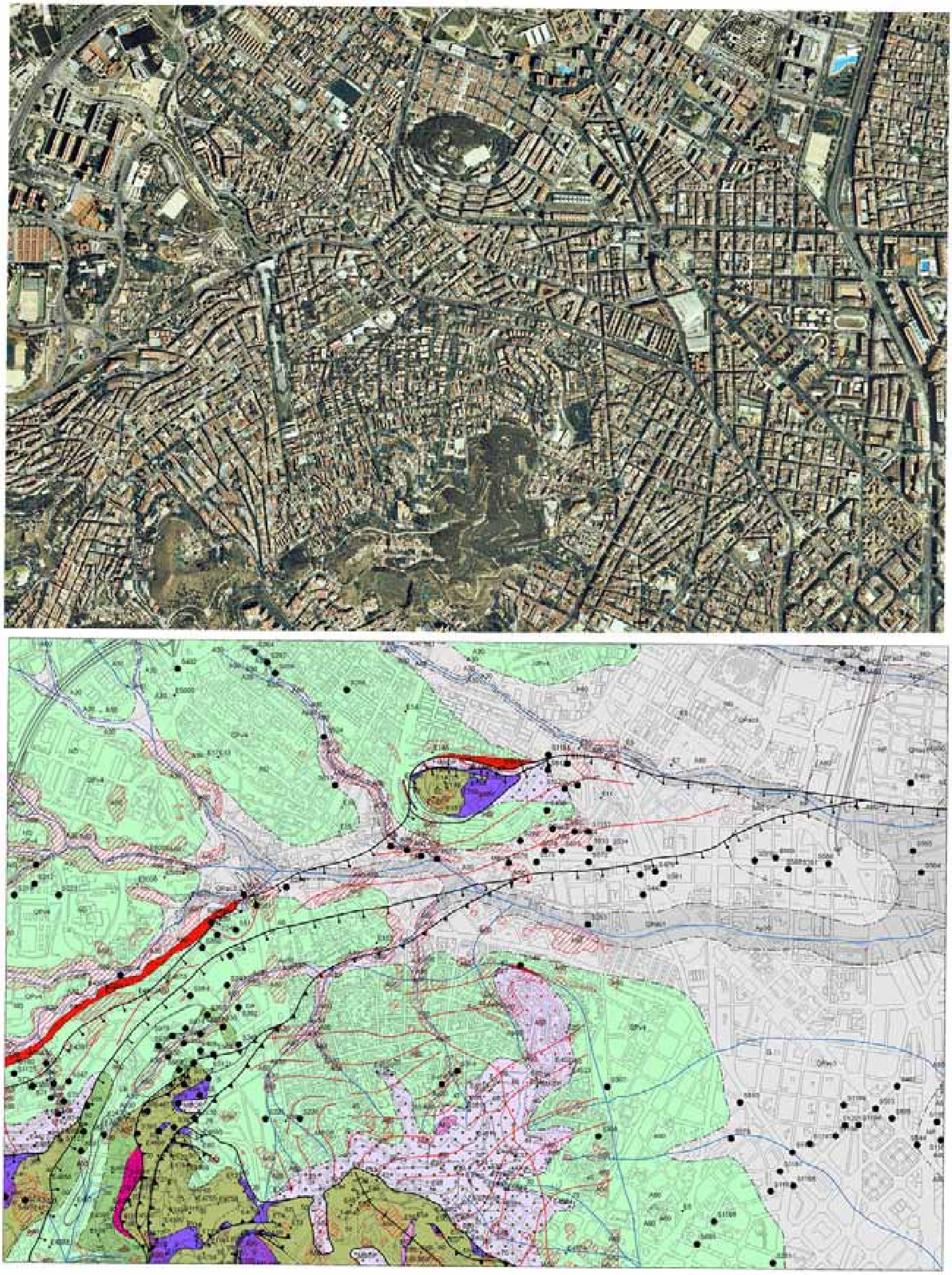

Figure 2 – Orthophotoimage and the corresponding 1:5000 urban geological map (sheet 289-124, Barcelona-Horta). Most of the mapped area is blanketed by the urban network. Cropping out zones are restricted to two spots in the upper and lower central parts of the sheet. The black dots in the map are the boreholes used for the underground geological reconstruction.

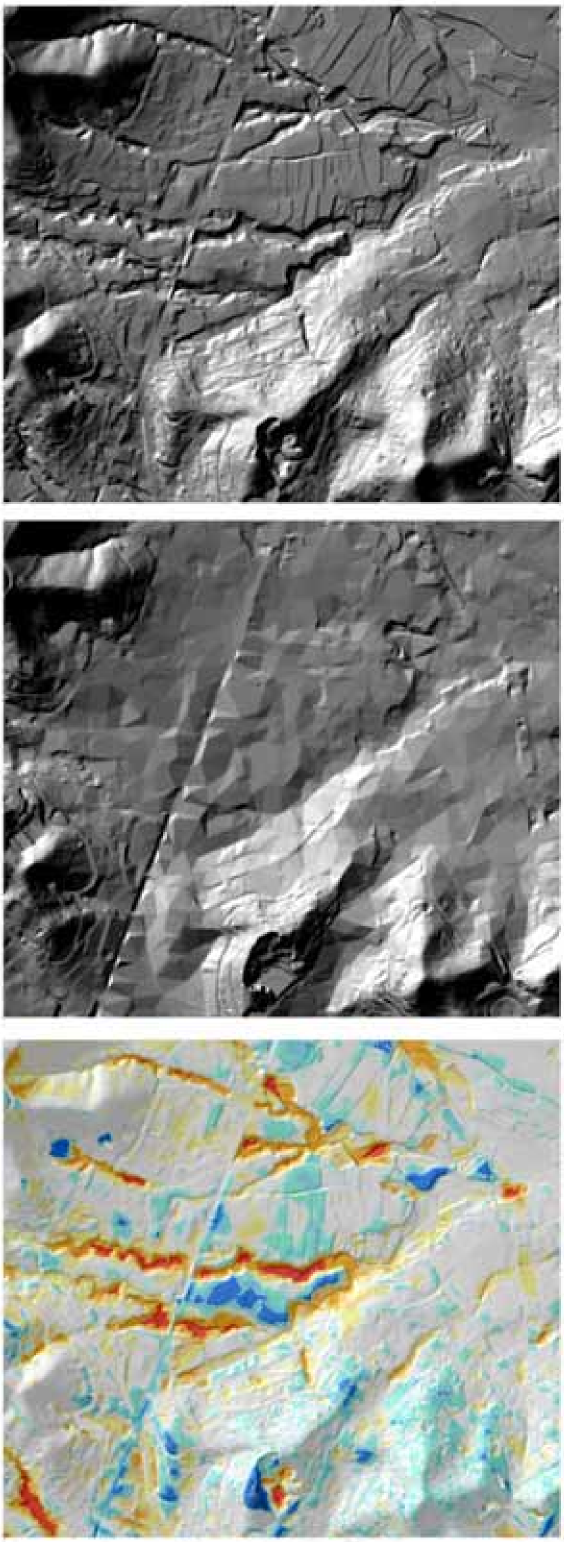

Figure 3 –. The upper image is a hillshade depicting the landscape that existed in 1961. A deeply incised stream network can be observed. The image of the middle is a hillshade derived from a 2008 DEM, in this image the former stream network does not exists anymore. The lower image has been obtained by subtracting the elevation data of the two DEMs (1961 and 2008). Red and orange colours point out man-made infillings, mainly localized in the former streams.

infilled zones can be portrayed by the subtraction of two DEMs realized by means of different aerial photograph flights (Fig. 3).

BENEFITS TO SOCIETY

The knowledge of the subsurface geology of urban areas is essential for planning and designing major underground works involving tunneling. For instance, in the city of Barcelona there are 47 km of underground railway currently under construction and, in the next 6 years 64 km of deep tunnels will be drilled.

Mapping man-made infilling is particularly important for urban planning. In most cities, filling temporary streams with waste materials, has been a common practice to gain terrain for housing. Which may result in subsidence problems and unexpected floods in built areas.

Geochemical mapping of hazardous elements from urban soils is critical to prevent health problems. Large parts of the cities have been built on former industrial areas. Thus, a high part of the population is exposed to the effects of contaminated soils.

ACKNOWLEDGEMENTS

Funds for the urban geological map of Catalonia at 1:5000 scale are provided by the Catalan State Ministry of Land Planning and Public Works. The authors are grateful to the IGC executive direction for their encouragement to present the ongoing works related to this map series.

GIS-BASED CALCULATION TO FORESEEING ANGULAR DISTORTION AT URBAN STRUCTURES DUE TO LAND SUBSIDENCE NEARBY MINING CAVITIES IN CATALONIA

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KEY WORDS: mining subsidence, building damage, angular distortion, GIS-Based processing

OBJECTIVES

Urban zones above or nearby underground mining excavations, in Catalonia, are already affected by land subsidence and actual urban growth makes necessary evaluations for future damages on edifices due to land deformation.

In order to attend this urban planning need, a new GIS-based methodology is presented here to evaluate critical future deformation in structures on the basis of field monitoring of land deformation by topographic surveys. The objective is to develop a tool to help on subsidence management hazards and urban planning.

INTRODUCTION

Subsidence due to historic and recent mining activities is affecting urban zones at the Potassic Catalonian Basin at the urban zones of Sallent, Cardona, Balsareny and Suria municipalities nearby salt exploitations with underground excavations. Due to rapid growth of population is necessary to evaluate and prevent ground deformations at new developing urban areas within the affected municipalities and evaluate somehow possible structural damages for buildings and infrastructures.

The most basic approximation to quantify structural damage was proposed in 1956 by Skempton and McDonald. They introduced the concept of angular distortion as the difference of settlement between two structural elements and divided by the distance they are separated, Figure 1 and Equation 1.

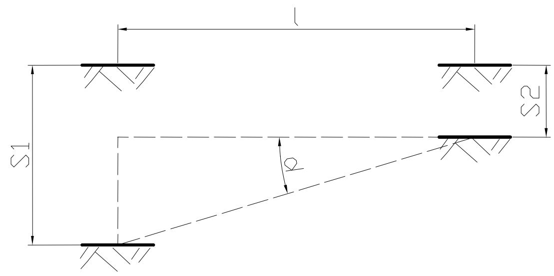

Figure 1 –Angular distortion calculation (Skempton and McDonald, 1956).

$$\beta = \frac{S1 - S2}{l} = \tan d \qquad \text{Equation 1}$$

Where:
β: Angular distortion
$S1$: Settlement of structural element 1
$S2$: Settlement of structural element 2
l: distance in the horizontal plane between structural elements
d: angle of distortion

Based on published data on building settlements, the angular distortion approximation classifies structural damage on the following way:

β	Observed Damages
1/1000	Very slight damage. Hair-width cracks
1/750	Very slight damage. Lower limit where constructing equipment can be sensitive to settlements
1/600	Lower limit for cracking in framed doors
1/500	Lower limit for securiting buildings where cracking is not admitted
1/300	Cracking of brick panels in frame buildings or load bearing brick walls is likely to occur
1/150	Structural damage to columns and beas is like to occurse

Table 1. Estructural damages related to ranges of angular distortion according to Bjerrum (1963) definition.

By characterizing the existing deformation at zones affected by subsidence, the Catalonian Institute of Geology (IGC), has developed an GIS based approach using pre-existing terrain periodic topographic survey data and implementing the angular distortion concept into a GIS tool.

METHODOLOGY

The obtained results are predictive maps that represent the angular distortion of the terrain for different periods of time projected in the future from a date of interest.

The velocity rate calculated from last topographic survey at the date of interest is assumed to be constant in time. With this assumption deformation scenarios are calculated for a time period of interest. Since the main objective of this study is to be an urban planning tool, the suggested period of time for calculations is the useful life of buildings to be constructed e.g. for the Catalonia case were considered 10, 30 and 50 years periods.

Implementation of semi-automatic calculation the Skempton and McDonald concept of angular distorsion consisted in the following steps:

1. Periodic Topographic surveying. As longer the time period better the data to calculate deformation rate tendencies.
2. Calculation of deformation rates on each point of the surveying network. The use of raw data or fitting curves to obtain deformation tendencies will might define abrupt changes or would soft the final angular distortion values.
3. Calculation of deformation for the predicting period. On the basis of "constant" deformation rates, for each point calculate future deformations to deformation values from the moment of calculation to the time of interest.
4. Interpolation and generation of the deformation grid. The size of the cell is defined on the basis of average of the minimum building dimension already existing or to be constructed in the zone of interest. The cell size will define the maximum the value of l on Equation 1.
   Also, absolute values of the deformation depend on the interpolation method though definition of critical zones always has the same general distribution.
5. Application of ARCView Maximum Slope and maximum flow direction (MDF) algorithms. On the resulting deformation grid use these two algorithms to calculate angular distortion (β) and flow direction respectively.
6. By reclassifying the resulting MDF grid, the vector of maximum deformation direction is plotted. Overlying the resulting grid of Maximum slope and classifying it according to the ranges of Table 1 along with and the MDF resulting vectors, a comprehensive figure of isovalues of angular distortion and the direction it has is generated

Steps 3 to 6 were implemented in the in ArcGIS v. 9.2 Model Builder to automatized the calculations, Figure 2.

CALIBRATION

As example of the of the implemented algorithm for angular distortion calculations, the case of Sallent City is used in this paper. At that place some neighbourhoods were developed in the 1950's above mining underground excavations. In 1996 building damage began to be reported. Since then, monthly topographic surveying is taking place at the most affected site.

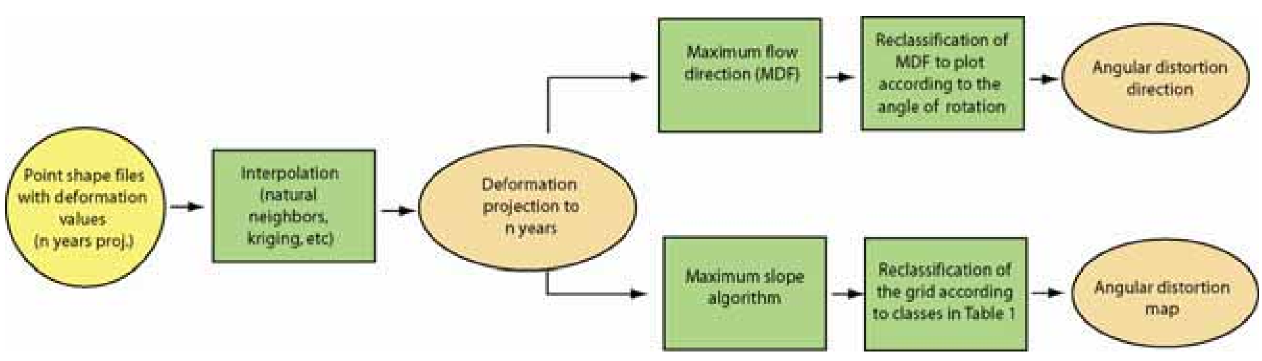

Figure 2 – Calculation of angular distorsion implemented within Model Builder Arc View 9.2

The first assumption to perform the analysis was that the measured points have constant deformation rates. Considering those velocities, calculations of future deformation were performed for 10, 30 and 50 years. Deformation grids were generated with a cell size of 5 m on the base of the shortest edifice dimension at the site (minimum value of l value on Equation 1).

Figure 3 and 4 show the angular distortion sceneries and direction for 10 and 30 years from present day respectively. Figure 5 shows the buildings with the largest structural damage from the beginning of controlling topography in 1997 to the present day. There is clearly a deformation a zone at the Estación neighbourhood and the NW-SE band with the most intense angular distorsion that correlates with the edifices with the that posses the largest damage, even though, that present approximation doesn't considers the structural characteristics of the buildings and only the terrain deformation.

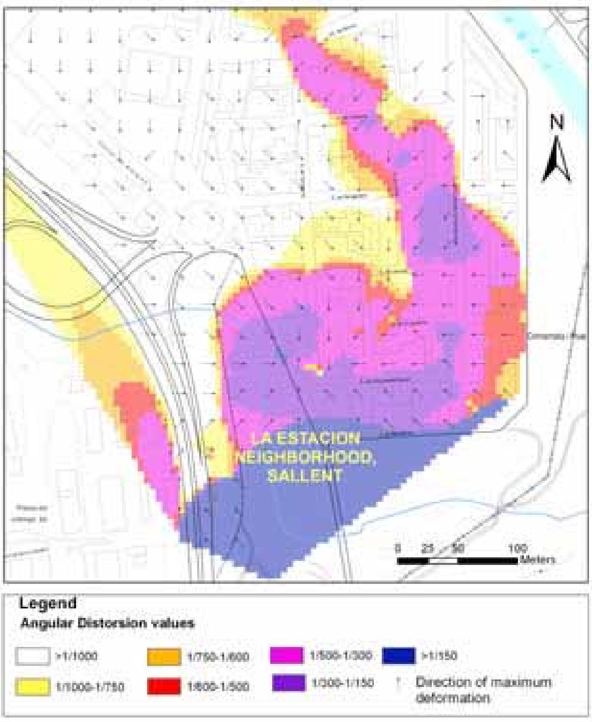

Figure 3 –Angular distortion calculation for 10 year period from present day

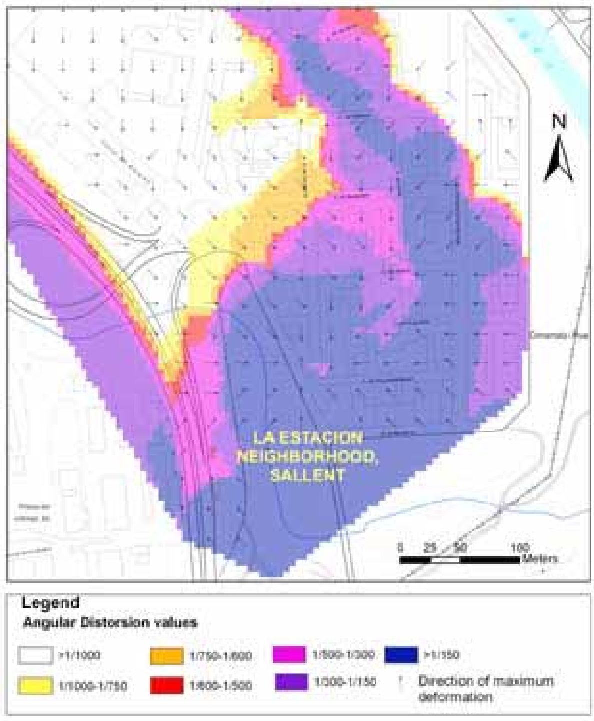

Figure 4 –Angular distortion calculation for 30 year period from present day

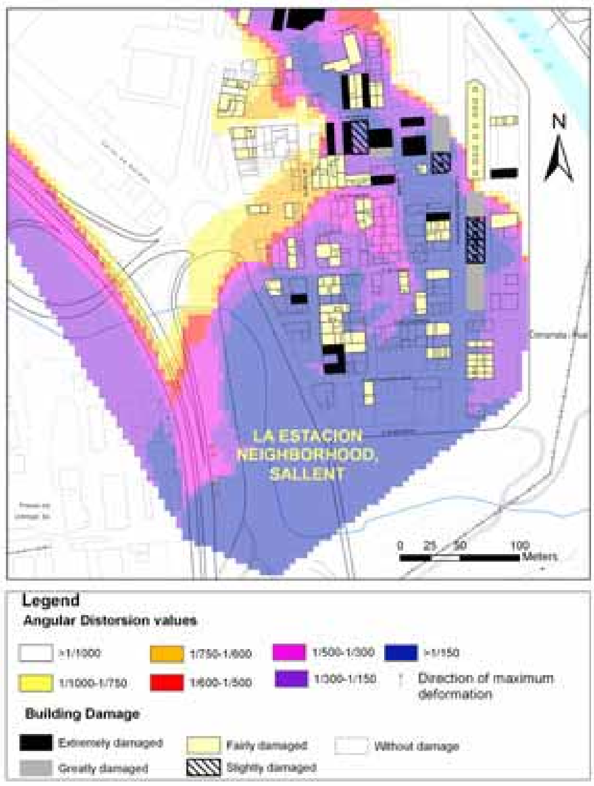

Figure 5 –Angular distortion calculation for 30 years and present day building damage

CONCLUSIONS

Both, maximum vertical distortion and flow vectors make a comprehensive figures to evaluate structural building damages and to foreseeing zones where maximum angular distortion and its orientation occur. Though the assumptions of constant deformation rates, these predictions might help on defining potentials zones to suffer structural damage due to land subsidence and help to define different levels of hazards and improve urban planning. The use of the angular distortion concept has been considered useful in the management of areas affected by subsidence. Evaluations of future sceneries by increment of terrain deformation, for the Catalonian case (Sallent), are coherent with the observed evolution of structural damages and have been useful in the evaluation of future risk and civil protection sceneries.

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METHANE IN AN ANTHROPOGENIC LAKE IN THE NEW CENTRAL GERMAN LAKE DISTRICT (NEUSEENLAND) -A GIS SUPPORTED STUDY-

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KEY WORDS: gas emission, Central Germany, methane, freshwater lake.

Introduction

In Central Germany till 2050 one of the largest technogenic lake landscapes in Europe will be created by flooding of former open-cast lignite mines. The new lake landscape (Neuseenland – New Central German Lake District) will consist of more than 500 mostly artificial lakes as a consequence of open cast lignite mining. More than 100 lakes will have areas of more than 50 hectares. Its recent and future potential for methane emission is widely unknown. The results in this paper on the CH_4 emission using the Lake Muldestausee, an older artificial lake of the Central German Lake district are targeted at closing this gap in our knowledge. Further samples of more different lakes focusing on studies on the composition and isotope signature of gas is documented in Nitzsche & Czegka et al (2009).

Regional frame

The Mulde River, one of the most polluted tributaries of the Elbe River, has been conducted through the residual void of the former Muldenstein lignite mine since 1975. This mine /lake is situated about 5 km from the city of Bitterfeld-Wolfen in the eastern parts of the German state of Saxony-Anhalt. The so called Lake Muldestausee (sometime also called Lake Muldenstein) consists morphologically of two partial basins -former open pits- with more than 20 m depth (the Friedersdorf Basin and the Main basin) which that are linked by a threshold which has an average depth about 5 m (the so called connecting bed). The lake Muldestausee has been the main sedimentation trap from this time for the freight of suspended matter from the catchment area of the Mulde Rivers (i.e. the Zwickau, Freiberg and United Mulde River). The Lake Muldestausee (area: 6.1 km^2, volume: 118 million m^3; catchment area: 6,170 km^2 , Zerling et al. 2001) also forms an extraordinarily effective sedimentation trap for the solid matter, suspended matter and nutrients reaching the lake. Furthermore, the mass of sediments deposited in the Lake Muldestausee since 1975 is estimated to be approximately maximal 8.4 million metric tonnes The estimations depend upon used methods. Detailed information on hydrodynamics, on sedimentation action and the retention capacity during flood events are published in Zerling et al. 2001. The lake sediments that have settled in the artificial lake since 1975 range between 0.6 m (Friedersdorf Basin) and 1.35 m thick (Main Basin) consisting of a fine silt rhythmically layered and rich in organic matter (on the average C_{org} 7,8%).
As an artificial reservoirs integrated into the river course. The lake Muldestausee are predestined for sedimentation of fine-grained muds. The flow velocity is reduced when passing through the reservoir. Suspended matter arriving with the river is deposited. Depending upon the hydrological situation and the catchment area of the river the formation of lake sediments rich in organic matter is possible. Under the conditions of high nutrient contents an intensive internal lake algae formation processes (i.e., a trend towards eutrophic stadium) take place and a high level of organic matter in the lake sediment is formed consequently. The anoxic conditions frequently found on the floor of the lake in the reservoir provide the prerequisites for the multi-stage process of decomposing the organic substance resulting in methane formation.
During a sonic depth measurement campaign of the Saxon Academy gas bubbles were observed to be released on the surface (so called ebullition). It was also possible to identify the rise of gas bubbles through the body of water in the registered echograms. Gas analyses based on these first samples taken by the observations proved that methane is being spontaneously released in the lake Muldestausee which was the occasion for the advanced studies documented in this paper.

Materials and Methods

For the sampling of the gas bubbles we used an inverted funnel with known diameter. The slender end of the funnel was connected to an inverted 500 ml screw bottle while the enlarged part was loaded with lead weights. On the one hand this arrangement permits a vertical position within the water to catch the gas bubbles spontaneously rising within the water column. On the other hand it allows slackening the top sediment layer to liberate gases stored there. The whole system was filled with lake water before using the funnel. After sampling time the bottle was removed from the funnel and closed with a screw cap always submerged by lake water. One day later in the laboratory the gas phase was exhausted by syringe and its volume was determined. Part of the gas was transferred to a 20 ml glass vial with septum and partly filled with a blocking liquid. The vial was used for gas and isotope analyses. The physicochemical parameters temperature, pH, electrical conductivity, dissolved oxygen (WTW pH 90/96, WTW LF96, WTW Oxi 96), Chlorophyll A (BackScat I-Fluorometer Black-Scat 1101.6 LP/eexCHIa/2R from Haardt Optik & Microelektronik) were measured in situ using probes each attached to a separate cable. Discrete depths for gas sampling were selected based on the results of the hydrographical profile.

The gas samples were analysed using a GC Chrompack 9001 system equipped with a CarboPlot P7 column and a thermoconductivity detector (TCD). Sometimes a molsieve A5 column was used for more detailed analysis of oxygen nitrogen ratios or a GC system with a flame ionisation detector (FID) for detecting hydrocarbons. 100 pi of gas was transferred from the vial to the GC system with a gas-tight Hamilton syringe for analysis. Specific calibration factors were used for the evaluation of the chromatograms compounds.

Further details – especially on stable isotope analyses ($^{13}C/^{12}C$) – which is not documented here is given in Nitzsche & Czegka et al. 2009. The spatial analyses were made with the open source software SAGA 2.02 (comp. Czegka & Junge 2008).

Hydrochemistry – Hydrology Lake Muldestausee

Lake Muldestausee is mainly feeded by the river Mulde, in minor by some creeks like “Rote Bach” (Red Creek) witch are partly feeded by tailings, but Mulde river water is predominant. This water is a hydrogencarbonatic – sulphatic water of variable average content, the pH lays between 7.2- 8.5 (seasonal variation) the conductivity ranges between 480 – 680 µScm-1 (seasonal variation). The Mulde river flows in a lake which is a little bit more harder and more alkaline than the river. Fig 1 shows us the distribution of the conductivity (summer season) Figure 2 the pH distribution at the same day. In Figure 1 we can also see the stream path of the Mulde river water inside the lake Muldestausee as a pattern of the conductivity distribution.

There is also a constant influx of nutrients that comes with Mulde stream path into the lake. One of the significant sign for this nutrient inflow is the chlorophyll- α content visualised in Fig 3.

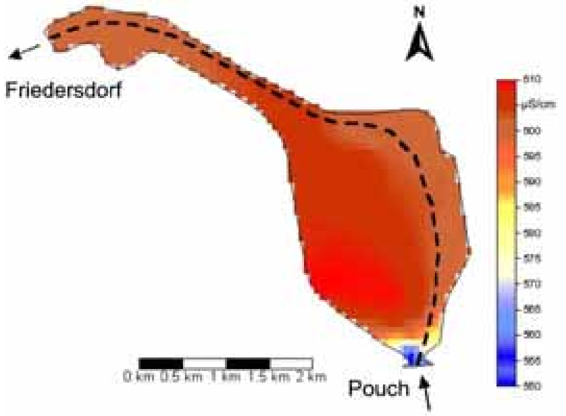

Figure 1: Conductibility in µScm^{-1} in Lake Muldestausee. The dotted line indicates the river course inside the lake

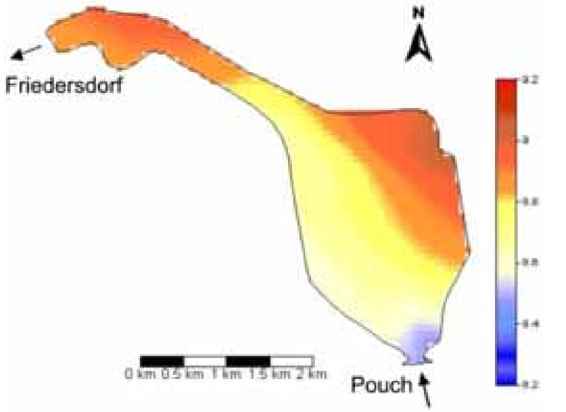

Figure 2: Distribution of pH in Lake Muldestausee (summer term)

The mean Chlorophyll-α content in the lake is between 5.1- 8.8. µg/L. Only inside the inflowing path chlorophyll-a content rise up to 34 µg/L. Also very obvious in the chlorophyll pattern is the region were the inflowing water is diving down. This continuous flow of nutrient reflects in the ignition loss of bottom sediments. Fig 4 shows us the ignition loss (Glühverlust) of the top- bottom sediments. The ignition loss corresponds strongly with the organic content (e.g. C_{org}). At the parameter ignition loss also a spatial distribution becomes noticeable (Fig 4). Inside the two basins and out side the flow path of the Mulde stream

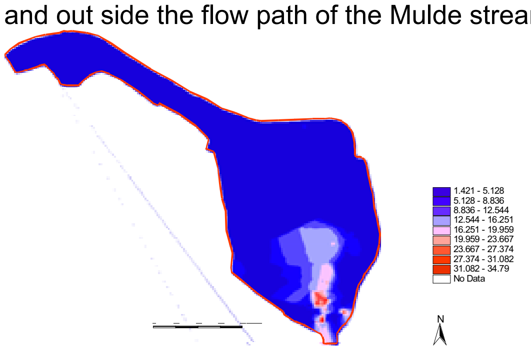

Figure 3: Chlorophyll-α in µg/L (surface water)

an accumulation of organic matter, which is constantly feeded and sets the base for methane production.

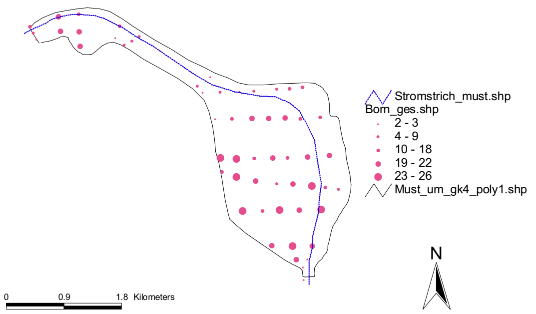

Figure 4: Ignition loss (in %) in top bottom sediments

Gases

Methane production is one of the key terminal processes in anaerobic decomposition of organic matter in sediments. Because sulphate is usually limited in fresh water lakes, methanogenic degradation of organic matter becomes the dominant process. The immediate substrates for CH_4 production are acetate and CO_2. In which extend the both methanogenetic pathways - CO_2-reduction by H_2 or fermentation of acetate contribute to the CH_4 production processes is influenced by the conditions in the sediment, the supply of organic substrate and temperature.

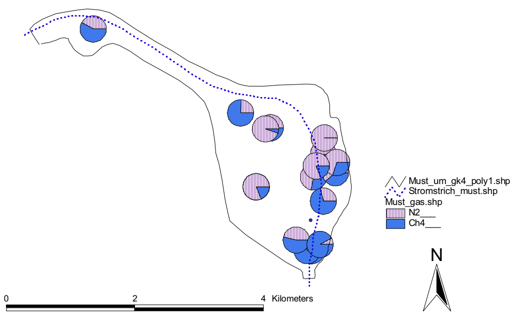

Figure 5: Methane and Nitrogen distributionin gas bubbles at Lake Muldestausee

For the statistical evaluation of the measured results in the following the median values is used. The calculation of medians is a popular technique in summary statistics and summarizing statistical data, since it is easy to calculate, while also giving a measure that is more robust in the presence of outlier values than is the mean.

The median gas composition of all samples studied from the Lake Muldestausee is 34.8% methane, 0.7% carbon dioxide, 54.1% nitrogen and 2.6% oxygen, although single values may vary significantly. For instance, the measurements for methane range between 0.0 and 84.8%, between 0.0 and 6.0% for carbon dioxide, between 7.4 and 94.0% for nitrogen and between 0.3 and 23.5% for oxygen. The median isotope values of all samples studied from the lake Muldestausee are -54.0 $^{o}/_{oo}$ for methane (-62.6 through -37.7 $^{o}/_{oo}$) and -23.8 $^{o}/_{oo}$ for carbon dioxide (-36.1 through -13.6 $^{o}/_{oo}$).

Figure 5 indicates the distribution of methane and nitrogen where the maximum methane concentration follows the course of the Mulde river within the reservoir. It decreases in the stream course of the Mulde river inside the lake Muldestausee. At the nutrient rich confluence of the Mulde river into the main basin methane is dominant in the gas bubbles – following the stream line in to the parts of the lake with lower nutrient content nitrogen is predominant. Figure 6 shows the distribution of CO_2 and O_2. Concerning CO_2 no discrete spatial pattern is obvious.

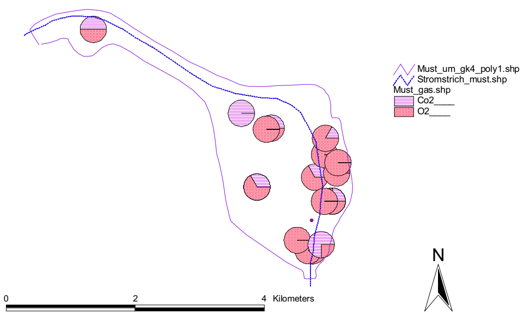

Figure 6: Distribution of carbon dioxide (CO_2) and oxygen (O_2)

Measurements of the parameters temperature, oxygen saturation, and chlorophyll-a concentration in the water column carried out at the same time as the gas studies indicate that the Lake Muldestausee is typically seasonal differentiated into a upper zone rich in oxygen (epilimnion) and a lower zone low in or free of oxygen (meta- to hypolimnion).

Conclusions

- Some of the upcoming artificial lakes in the New Central German Lake District (like lake Muldestausee) have a high potential of methane formation, caused by their accumulation potential for organic matter.
- The methane discharge in lake Muldestausee is not only driven by diffusive processes but also by ebullition (gas bubble discharge). There is a considerable methane emission in the atmosphere.
- Further investigations with a focus on a quantitative estimation of the total gas flow will be done in future.

Acknowledgement

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Institute of Non Classical Chemistry (INC) at the University of Leipzig, Germany.

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LASER SCANNING PROJECT PROVIDES FOUNDATION FOR PREDICTING NATURAL HAZARDS IN THE BAVARIAN ALPS

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KEY WORDS: Lidar, laser scanning, DTM, natural hazards, relief

Transnational laser scanning project in Tyrol (Austria) and Bavaria (Germany)

Computer models that are as precise as possible are required to predict natural hazards in the Alps, such as floods, mudflows, slides, rockfalls and avalanches. An important foundation for this is the digital terrain model (DTM). Airborne laser scanning (ALS) has proven to be a method with high precision and a large sampling density.

Due to the limited flight times and the great differences in elevation, laser scanning in the Alps is significantly more difficult than in the lowlands. The surface area covered in the project is 3193 km² on the Bavarian side and approx. 9400 km² on the Tyrol side. The EU grant for the INTERREG program provided an important contribution for the fruition of the project.

Figure 1: Study area in Bavaria

The previous DTM for the Bavarian Alps provided by the Bavarian State Agency for Surveying and Geographic Information originated from photogrammetric evaluations from 1960 to 1995. With a grid width of 10 m and a height precision of approx. 1-3 m, the data could be used only to a limited extent for e.g. flood simulations

The laser scanning project provided a sampling density of 1 point per m² in Bavaria. The mean height error for level control surfaces was ±0.08 m (rms). The low- and high-elevation areas were flown in different seasons because, as a rule, laser scanning should be carried out only when there are no leaves on the deciduous trees, when there is no snow and when rivers are not flooding.

Documentation of mass displacements due to hillside slides

The slope of the terrain plays an important role in hillside slides. Using the laser scanning DTM, it will be possible in the future to detect areas that are threatened by large mass shifts.
Figures 2 and 3 show hillside slides on the Immenstädter Horn in Allgäu. The laser scanning flight occurred after the main rock mass had undergone a hillside slide. It was possible to calculate the mass shift using comparisons with older DTM data that originated from a photogrammetric evaluation of aerial photos from the time before the slides.

Figure 2: Hillside slide on the southeast slope of the Immenstädter Horn

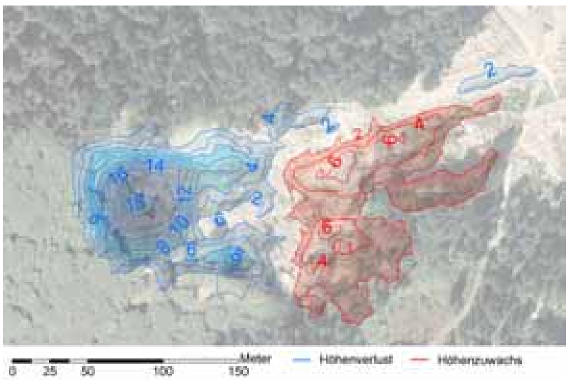

Figure 3: Mass displacement calculated from DTM differences. Mass loss is shown as blue isolines, mass gain by red ones.

Retreat of the Zugspitze Glacier

The surface of the terrain changes due to human influences or natural processes. An example for change is the retreat of the glaciers, which is also a possible result of climate warming. It was possible to detect the retreat of the glacier on Germany's highest mountain, the Zugspitze (2962 m), in the laser scanning data. By comparing the current laser scanning data with 40-year-old terrain data that originated from a photogrammetric evaluation of aerial photos from 1966, a decrease in the thickness of Schneeferner Glacier of up to 40 m was demonstrated. Höllentalferner Glacier, which is located to the northeast of the Zugspitze, is surrounded by high rock walls. As a result of this location, on the north side and in shadow, the mass loss of the Höllentalferner Glacier was not as high. The greatest reduction in the thickness of the glacier is approx. 15 meters in the area of the current glacier snout.

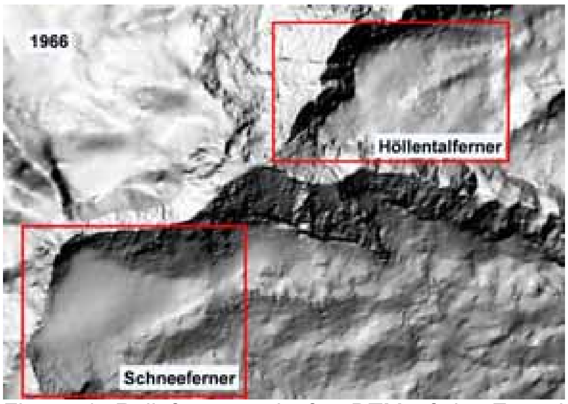

Figure 4: Relief portrayal of a DTM of the Zugspitze, derived from a photogrammetric evaluation of aerial photos.

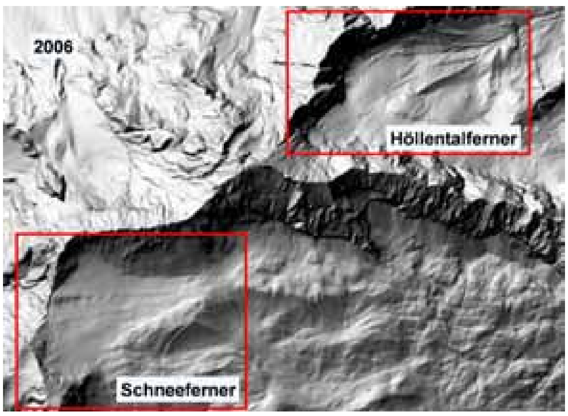

Figure 5: Relief portrayal of a DTM of the Zugspitze, calculated from the laser scanning data from a flight in Fall 2006.

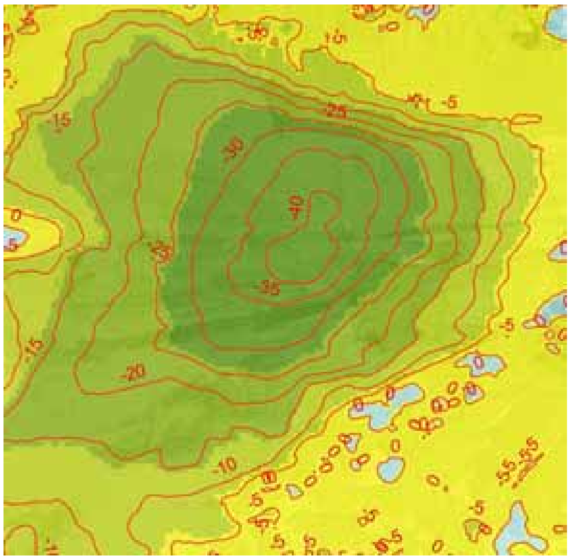
Figure 6: Shrinkage of the Schneeferner Glacier calculated from the difference in the DTMs in Figures 4 and 5. The darker the area, the greater the mass loss. The thickness of the glacier decreased by up to 40 m.


Figure 7: Shrinkage of the Höllentalferner Glacier calculated from the difference in the DTMs in Figures 4 and 5. The darker the area, the greater the mass loss. The thickness of the glacier decreased by up to 15 m.

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THE COMBINED USAGE OF GIS AND GEO-INDICATORS FOR EVALUATING AND MAPPING GROUNDWATER POLLUTION RISK

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KEY WORDS: Groundwater contamination risk, GIS, Nitrate pollution, geoindicators.

INTRODUCTION

Nitrate contamination of groundwater is increasing on a worldwide scale, due, principally, to the high use of fertilizers, to the leaking from the sewage network and to the presence of old septic systems.

The research reported herein presents a method for groundwater contamination risk assessment based on a previous experience of the author in terms of nitrate risk evaluation (DUCCI et al. 2007).

This paper starts from a definition of the GIS layers used for the application of the method based on the geo-indicators. Afterward, the protocol to overlap the layers and the weight of these is explained. The methodology is applied in a large flat area of southern Italy, with, in a wide sector, very high concentrations in NO3.

HYDROGEOLOGICAL SETTING OF THE STUDY AREA

The large plain of the Volturno River (1340 km^2) is surrounded by the Mesozoic limestone mountains of the Southern Apennines (N and E), by the extinct Roccamonfina volcano (N), by the Somma-Vesuvius volcano (S), the Phlegrean Fields pyroclastic hills (SW) and the Tyrrhenian Sea (S and W) (Fig. 1).

The plain is made up of Quaternary alluvial-pyroclastic and pyroclastic porous deposits. Campanian Ignimbrite is a large-volume trachytic tuff which erupted from the Phlegrean Fields (37–39 ka BP) and consisted of a fallout deposit overlain by ignimbrite (CORNIELLO & DUCCI, 2007 and related references). Almost everywhere the Campanian Ignimbrite tuffs cross or underlie the above-mentioned alluvial and pyroclastic sediments and overlie Plio-Pleistocene lacustrine, palustrine, and marine deposits. In the eastern part of the town of Naples the tuffs are absent and there are a succession of volcanic-pyroclastics and alluvial sediments interbedded with peat levels and marine deposits. Close to the Volturno river the tuffs are absent or very thin for the river erosion.

The main aquifer of the Volturno River Plain is located in the alluvial, pyroclastic and marine porous sediments underlying the Campanian Ignimbrite tuffs. The hydrogeological setting is strongly related to the thickness and the physical characteristics (lithification, granulometry, amount of scoria, etc.) of Campanian Ignimbrite, which plays the role of semi-confining or confining bed. The aquifer is confined especially in the northern sector, where it is underlain by the Campanian Ignimbrite tuffs and oldest tuffs, semi-confined almost everywhere in the southern sector and phreatic in the central part. Although it is possible to zone areas with different hydrogeological conditions, the aquifers of the Campanian Plain can be considered a single groundwater body (CORNIELLO & DUCCI, 2007).

In the plain the groundwater contamination is considerable, for the widespread presence of intensive agriculture and for the high population density, especially in the south-eastern part. Many wells show very high nitrate concentrations and in the southern part of the Volturno river more than 60% of the area is over the WHO threshold of 50 mg/l (also recognised by European Union and Italian drinking water legislation).

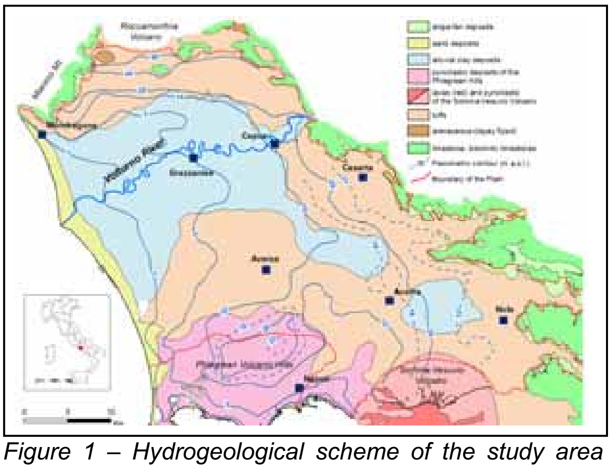

Figure 1 – Hydrogeological scheme of the study area (CORNIELLO & DUCCI, 2007, modified).

THE METHOD

The previous experience of the author, in terms of groundwater risk contamination evaluation and geoindicators (DUCCI et al. 2007) is the starting point for this method. Recent papers about this topic (DUCCI et al. 2008; PERLES ROSELLÓ et al., 2009) go in the same direction and appear to confirm the validity of the methodology. The methodology proposed with Argentine colleagues is here re-proposed (Fig. 2), changing only the layers combination criteria. The map combination process here applied is very easy, is an algebraic combination or an index overlay combination, considering all maps of equal weight. In fact the output values are equals the arithmetic average of input values, starting from 1 (very low) to 5 (very high).

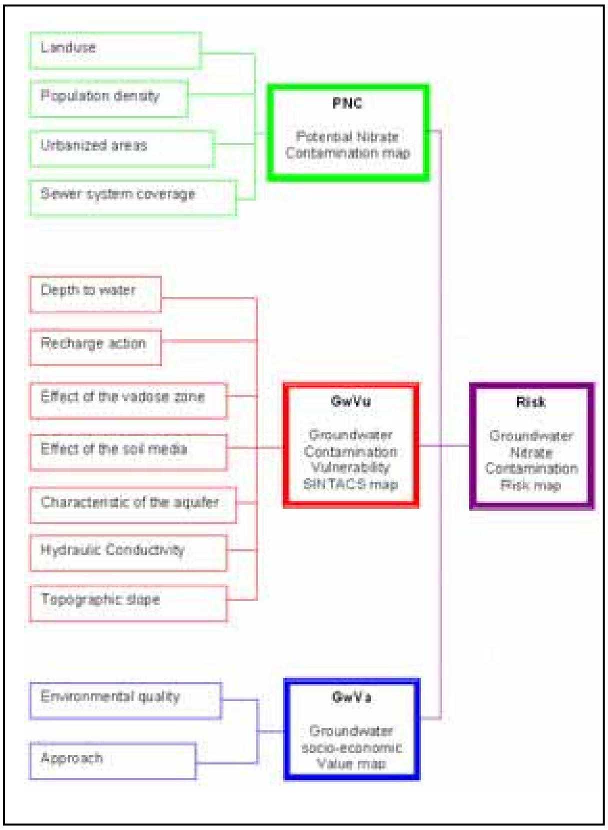

Figure 2 – Scheme of work to draw up the Groundwater Nitrate Contamination Risk map.

The Potential Nitrate Contamination map (PNC)

The Potential Nitrate Contamination (PNC) is considered as deriving from three sources: agricultural (APNC: Agricultural Potential Nitrate Contamination), urban (UPNC: Urban Potential Nitrate Contamination) and periurban (PuPNC: Peri-urban Potential Nitrate Contamination). The first one is related with the use of fertilizers. For this reason the landuse map is classified on the basis of the requirements in terms of fertilizers, as shown in Table 1.

CLC	Corine Description	Nitrate pollution potential
1.1	Urban fabric	Low
1.2	Industrial, commercial and transport units	Low
1.3	Mine, dump and construction sites	Low
1.4	Artificial, non-agric. vegetated areas	Low
2.1	Arable land	Very high
2.2	Permanent crops	High
2.3	Pastures	Moderate
2.4	Heterogeneous agricultural areas	High
3.1	Forests	Very low
3.2	Scrub/herbaceous vegetation association	Very low
3.3	Open spaces with little or no vegetation	Very low
4.2	Maritime coastlands	Low
5.1	Inland waters	Low

Table 1 – Land use (Corine level 2) classification.

The urban source is the possibility of leaks from the sewage network and, consequently, is linked to the anthropogenic pressure, expressed by the population density.The choice of the classes of population density is derived from a synthesis of different examples (e.g. http://soils.usda.gov/use/worldsoils/mapindex/popden.html) and it is reported in Table 2. These data derive principally from national and regional statistical archives data, and is aggregate for municipality. In the study area there are 120 municipalities, with population density ranging between 60 and 12.000 inhabitants/km² (half of the municipalities have more than 1,000 inhabitants/km²).
To link this layer to the territory, more than to the administrative limits, the density class is increased in the urbanized areas of the municipality and decreased in the other parts, as indicated in Table 2. In the study area the urbanized areas are 17%.

Population Density per sq km	Nitrate Pollution Potential	Urbanized Area	Uninhabited areas
< 5	Very low	Low	Very low
5 - 25	Low	Moderate	Very low
25 - 250	Moderate	High	Low
250 -1000	High	Very high	Moderate
> 1000	Very high	Very high	High

Table 2 – Population density classes and re-classification on the basis of the urbanization.

The periurban sources include the unsewered areas, especially present in the periurban context, where illegal sewage connections coexist with on-site sewage disposal (cesspools, septic tanks and pit latrines). The adopted classes are indicated in Table 3.
The mean of the sewer coverage in the study area is 85%.
The Potential nitrate contamination map (PNC – Fig. 3) is produced by overlaying the agricultural (APNC), urban (UPNC) and periurban (PuPNC) maps.

Sewer System Coverage (%)	Nitrate pollution potential
> 90	Very low
70 - 90	Low
50 - 70	Moderate
25 - 50	High
< 25	Very high

Table 3 – Sewer system coverage classes.

The Groundwater contamination vulnerability map (GwVu)

In the scientific literature, a large number of vulnerability assessment methods are available. In the parametric system methods the validity of the vulnerability map is strictly depending, more than on the choice of the method, on the accuracy of the parameters estimation procedure. For the risk assessment with the proposed method every contamination vulnerability method can be used: the method just requires a classification in five classes.

In the case study, the Groundwater contamination vulnerability (GwVu) was assessed using previous documents produced using the SINTACS method (CIVITA & DE MAIO 2000): in the northern part of the Volturno River the vulnerability map was drawn up by CORNIELLO et al. 2009. In the southern part of he Volturno River the vulnerability map was drawn up by CORNIELLO et al. 2005.

The SINTACS method (CIVITA & DE MAIO 2000) uses the same seven parameters as DRASTIC (S: Depth to Water; I: Recharge action; N: Vadose zone attenuation capacity, T: Soil/ overburden attenuation capacity; A: Hydrogeologic characteristics of the aquifer; C: Hydraulic conductivity; S: Topographic surface slope), but the rating and weighting procedure is more flexible. It provides five weight classifications: Normal, Severe, Seepage, Karst and Fissured. Normal and Severe reflect the density of human settlement and the intensity of landuse. The selected ratings of each factor can be multiplied by a selected weight classification to give the score of the factor. The addition of the seven scores gives the SINTACS index. The index has to be divided into six vulnerability classes, from 1 (Very Low) to 6 (Extremely High).

In the case study the layers of the two previous adjacent maps (CORNIELLO et al., 2005; 2009) were merged and reclassified in five classes (Fig. 3).

The Groundwater socio-economic Value map (GwVa)

The Groundwater socio-economic value map GwVa come from the approach of Chiras and Reganold (2005) in the sense of “sustainability” and considering its relation with the concept of “environmental quality” (SCOPE, 1995) defined by four main functions: naturalness, source of resources, support of activities and sink of wastes. These four functions (DUCCI et al., 2007) are mapped (Fig. 3) on the basis of the landuse (Table 4).

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Function	Corine Code level 3	Socio-economic value Class
Sink of wastes	132	Very low
Naturalness	131,141,311,312,313,321,322,323, 324,331,332,333,334,335,411,412, 421,422,423,521,522,523	Moderate
Support of activities	111,112,121,122,123,124,133,142	High
Source of resources	211,212,213,221,222,223,231,241, 242,243,244,511,512	Very high

Table 4 – Groundwater socio-economic value classes on the basis of the “Function” following the sustainability Approach (SCOPE,1995; Chiras and Reganold, 2005).

THE RISK MAP

The risk map in the Volturno river plain area shows 70% of the whole area under high groundwater nitrate contamination risk conditions and 30% under moderate risk (Fig. 3).

The map reflects only in the southern part of the Volturno river, the actual state of groundwater contamination by nitrate. The contamination seems to be more coincident with the potential contaminant load due to very high human pressure (in terms of population density and intensive agriculture) and with the vulnerability map. The very high socio-economic value seems to overestimate the risk in the northern sector, where the nitrate levels are high only in correspondance with the Volturno river mouth, and in some isolated areas (CORNIELLO & DUCCI, 2007) and the groundwater needs are less, for the lower human pressure.

CONCLUSIONS

The pollution risk map of the study area has been obtained by combining three basic thematic maps: the Potential nitrate contamination map (PNC), the Groundwater contamination vulnerability map (GwVu) and the Groundwater socio-economic value

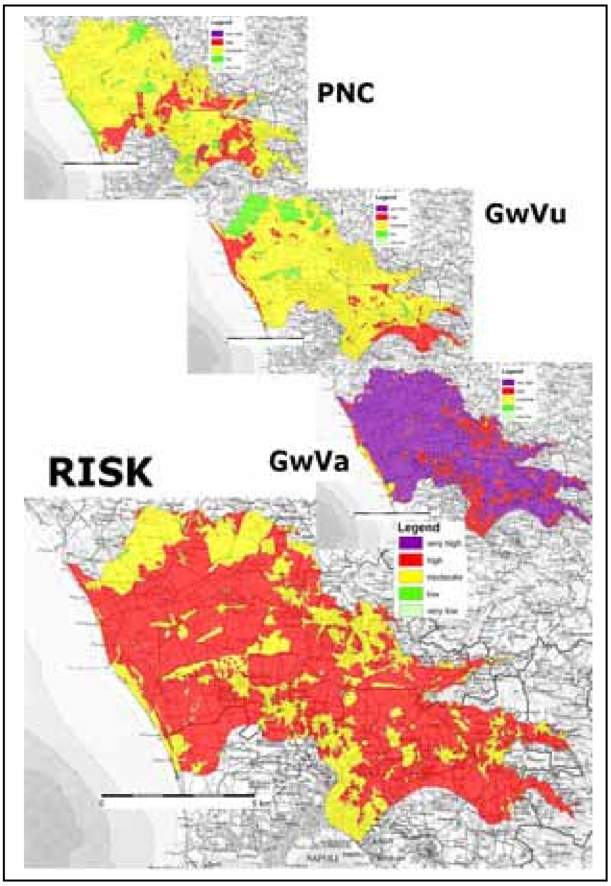

Figure 3 – The Groundwater Nitrate Contamination Risk map (RISK) of the plain of the Volturno river drawn up by overlaying the Potential nitrate contamination (PNC), the Groundwater contamination vulnerability (GwVu) and the Groundwater socio-economic value (GwVa) layers.

(GwVa) map. The criterion for the linkages of the different GIS layers, proposed in this paper, is very easy, corresponding to an algebraic combination. The procedures used to evaluate the risk and the observation of the resulting maps suggest the following considerations:

- the layers of potential nitrate contamination load and vulnerability reflect very well the real contamination;
- the socio-economic value of the groundwater resource is the weak point in the groundwater risk evaluation. “Groundwater is difficult to value” (ZAPOROZEC, 2004);
- the concept of socio-economic value is not subjective, but depends on the local context: the socio-economic value in an area can be very scarce as groundwater resources (in terms of quality and quantity) but of primary importance for the activities in such area;
- in agreement with ZAPOROZEC (2004), the groundwater socio-economic value has to depend on abstraction rate, on water use, water quality, and on the ecological value of groundwater. The problem that has to be solved in the next studies is the selection of the basic data and the definition and combination of these GIS layers.

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MULTIPURPOSE GEOCHEMICAL MAPPING OF RUSSIA ON THE BASIS OF GIS TECHNOLOGY

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KEY WORDS: multipurpose geochemical mapping, GIS technology.

INNOVATIVE TECHNOLOGY – THE MULTIPURPOSE GEOCHEMICAL MAPPING

IMGRE (Russia) develops an innovative regional mapping technology – the 1:1,000,000-scale Multipurpose Geochemical Mapping (MPGCM-1000) since 1991.

MPGCM-1000 is a technological process comprising integrated studies of natural geological environment (NGE) of large areas ranked as metallogenic provinces, zones and ore regions; interpretation and differentiation of natural and technogenic heterogeneities of structure and composition of anomalous geochemical fields; assessment of prospects for useful minerals; ecological hazard degree of NGE areas polluted by toxic chemical elements; agricultural areas' state; presentation of results obtained in multipurpose maps; data storage sheet by sheet in database on the basis of GIS technology.

MPGCM-1000 technology based on a system of scientific and methodological principles differs from standard geochemical surveys. These differences are as follows:

- Replacement of random regular grid geochemical sampling by deterministic sampling of quasi-homogeneous areas (in structural-material, landscape-geochemical and geographical-economic aspects) with average density equal to 1 sampling point per 1cm^2 of a map in a corresponding scale allocated on the basis of GIS technology, thus ensuring representativeness of assessments obtained;
- Replacement of "plane" sampling of one NGE component by integrated section sampling, i.e. sampling of bedrocks, soil (B-BC- and A-horizons) and bottom sediments, thus ensuring study complexity, increasing reliability of anomalous geochemical fields' allocation, interpretation and prognostic-metallogenic assessment, as well as integrated system assessment of geochemical state parameters of all NGE media;
- Analysis of samples on a wide range of tracer, toxic and biophile chemical elements;
- Generation of compilation schematic maps reflecting location of surface facilities belonging to the same functional type on the basis of matching the results of navigation mapping (Mobile Mapping) and Earth remote sensing data;
- Use of a set of direct quantitative prospecting geochemical features, geological and geophysical preconditions, modern computer methods of data collection, storage and processing. The developed and implemented technology of geochemical mapping is relatively cheap and allows solving the vast set of economic and scientific (prognostic, geological, ecological, agrochemical, etc.) tasks, thus allowing creating the conservation grounds;
- Use of GIS modeling in processing & mapping of geochemical data and its processing results;
- Allocation and sampling of quasi-homogeneous areas based on multiple-factor territory zoning is an important MPGCM difference from the international global geochemical mapping technology.

MPGM results in a set of digital geoinformation models and databases containing analytical and attribute data. This set includes the following maps:

- Geochemical knowledge degree;
- Geochemical sampling results; geological complexes;
- Land use;
- Integral geochemical anomalous fields; typomorphic geochemical complexes;
- Landscape geochemical;
- Geochemical specialization of geological formations;
- Geochemical prognostic;
- Ecological geochemical;
- Agricultural geochemical;
- Geochemical base of the rational natural resources management.

Map of integral geochemical anomalous fields (IGAF) (figure 1) has been designed in Russia especially for the MPGM project. This map shows development areas of geochemical fields contoured in all NGE media sampled their complexity, matching zones of geochemical anomalies in two and more NGE media. IGAF map analysis allows revealing the AGF nature and sources, as well as ore-controlling factors' establishing.

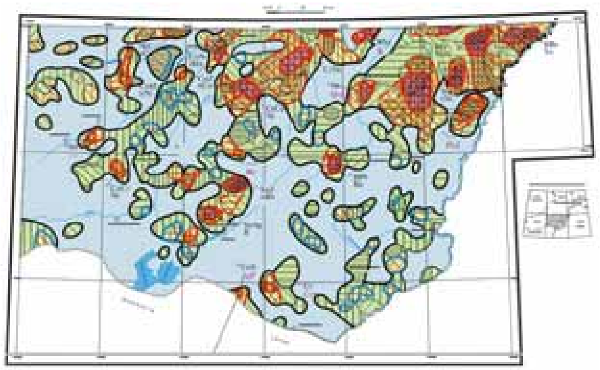

Figure 1 – East Transbaikalia area: map of Integral geochemical anomalous fields (IGAF).

Landscape geochemical map shows landscape-geochemical conditions of a territory; technogenic modifications and geochemical features of landscapes; territory zoning by self-purification potential of natural landscapes. The map allows revealing the role of zonal landscape-geochemical processes in secondary geochemical dispersion halos' formation and in formation of technogenic pollution; allows conducting interpretation of integrated geochemical anomalous fields, determining the most informative soil horizon for allocating ore-genic and technogenic anomalies.

Map of geochemical specialization of geological formations showing geochemical peculiarities of structural-formation complexes gives an opportunity to analyze spatial and in-time distribution patterns of geochemically specialized geological complexes, to study the ties of anomalous geochemical fields and mineral deposits with geochemical specialization of geological complexes.

Geochemical prognostic map (figure 2) shows the following: contours and composition of ore-genic AGF; their prospects by a set of favorable preconditions and features; cadastre features of ore-genic geochemical anomalies. The map groups ore-genic AGF inpotential ore joints, regions and metallogenic zones, thus allowing conducting the metallogenic zoning of a territory, prospects refining of known and newly allocated variously ranked potential ore objects, evaluating their metallogenic potential and substantiating recommendations on further exploration works.

Ecological geochemical map (figure 3) shows envirogeochemical state of the NGE media, ecological state assessment of a territory and cadastre geochemical characteristic of areas. The map allows establish pollution type and degree of the NGE media, differentiate territories by ecological hazard pollution damage degrees and give environmental assessment of natural potential of specified area.

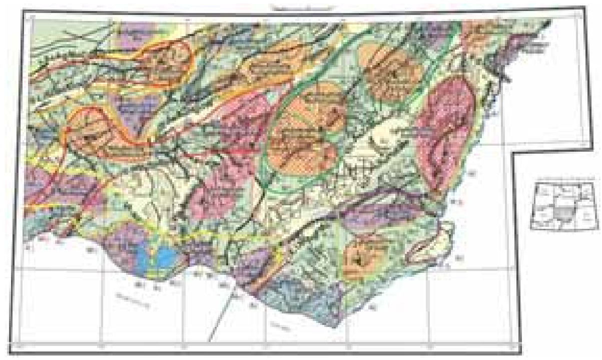

Figure 2 – East Transbaikalia area: geochemical prognostic map.

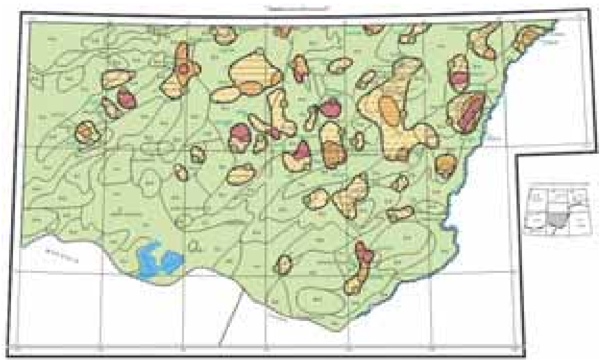

Figure 3 – East Transbaikalia area: Ecological geochemical map.

Agricultural geochemical map shows geochemical potential of land lots, soil pollution and agrogeochemical zoning of agricultural land. The map allows allocating areas, which are favorable in different degree for farming of ecologically clean production. The map allows conducting farm land zoning by a set of their productivity and pollution, as well as developing agrogeochemical recommendations.

Geochemical constraints on rational nature management map (figure 4) has been designed in Russia (in IMGRE). This map reflects land use zoning of a territory, envirogeochemical condition of a territory, its mineragenic potential, quality of agricultural land, relative land costs, recommendations on economic activity regulation from the conservation point of view, i.e. integrated use of natural geological environment for ensuring human vital functions on the basis of system analysis of ecological, resource, economic and social factors, minimizing the fallouts and profit maximizing.

Foreign papers don't give enough attention to geochemical anomalies' interpretation and their prospects evaluation. Geochemical maps with integrated interpretation and evaluation are missing, though practical need in such map type increases in Russian regional studies.

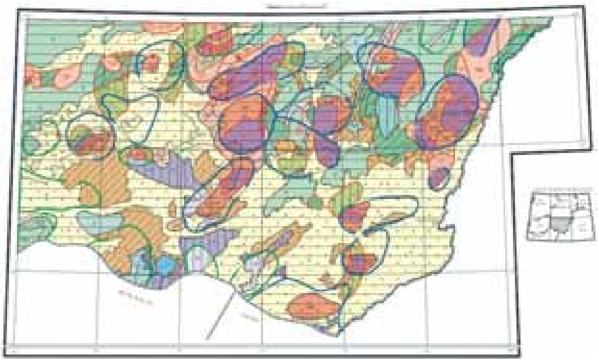

Figure 4 – East Transbaikalia area: geochemical constraints on rational nature management map.

GIS TECHNOLOGIES AS THE BASIS OF MGCM

Wide application of GIS technologies in analytical data processing, interpretation and mapping is a typical feature of the MPGM project. Digital models (DM) and per sheet geochemical databases created from the beginning contain analytical, cartographic, attribute and text data, which are filled up constantly.

MPGM planning stage requires the following information: detailed data on regional metallogeny and geological structure of the territory studied, data on geochemical knowledge quality and degree. 1:100,000-1:1,000,000-scale geochemical knowledge database of Russia that was created and is filling up constantly gives information about geochemical knowledge quality and degree. The area of geochemical works conducted within a territory serves as a registration unit. The unit has the following main characteristics: report name, type of geochemical works conducted, method of geochemical works, sampling uniformity, analytical methods used, list of chemical elements analyzed and data integrity. These characteristics allows evaluating the quality of geochemical works conducted, as well as integrity degree of retrospective geochemical data.

Cartographic models are generated as multi-layer covers using GIS technologies (see Figure 1). All objects of thematic layers have a set of attributes ensuring their full geochemical characteristics and mapping ability. GIS structures of four final cartographic models tied with digital model of the topobase are given as an example.

Digital model of the IGAF map hosts the following thematic layers:

- Poly-elemental AGF in bedrock;
- Poly-elemental AGF in B-C soil horizon;
- Poly-elemental AGF in A soil horizon;
- Poly-elemental AGF in bottom sediments;
- Poly-elemental AGF in surface water;
- IGAF boundaries;
- Integrated geochemical fields;
- IGAF structure.

Objects of the main thematic layer (IGAF structure) have the following attributes: ID, structure element, structure element classifier, core area, number of NGE media, NGE media, associations of anomalous chemical elements in bedrock, associations of anomalous chemical elements in D-C soil horizon, associations of anomalous chemical elements in A soil horizon, associations of anomalous chemical elements in bottom sediments, associations of anomalous chemical elements in surface water.

Digital model of geochemical prognostic map hosts the following thematic layers:

- Potentially ore-bearing geological formations;
- Known ore objects;
- Metallogenic regions;
- Contours of ore-genic AGF – zones, regions and joints;
- Faults.

Objects of the main thematic layer (contours of ore-genic anomalous geochemical regions and joints) have the following attributes: AGF ID, AGF nomenclature, name, intensity, sampled NGE media, geochemical characteristic, metallogenic characteristic, AGF prospects, geochemical typification and predicted ore formations.

Digital model of ecological geochemical map hosts the following thematic layers:

- Geochemical and economic features of landscapes;
- Soil pollution level;
- Pollution level of bottom sediments;
- Pollution level of surface water;
- Envirogeochemical state assessment;
- Territories with unfavorable ecological settings.

Objects of the main thematic layer (territories with unfavorable ecological settings) have the following attributes: ID, area, ecological state, ecological state classifier, area number on a map, NGE media, chemical pollution intensity in the soil, bottom sediments and surface water; natural ecological hazard of landscapes and bedrock, geochemical and economic characteristic of landscape.

Digital model of the geochemical base of the rational natural resources management map hosts the following thematic layers:

- Administrative districts;
- Homogeneous land use site;
- Ecological state assessment of an allotment;
- Mineragenic potential of an allotment;
- Geochemical potential assessment of allotment soil;
- Conflict zones;
- Relative land cost;
- Recommendations on economic activity regulation.

Objects of the main thematic layer (areas with different economic activity) have the following attributes: ID, economic use type classifier, land use type index, land use type, ecological state, ecological state classifier, recommendations on economic activity regulation, recommendations'' classifier, name of ore region, mineragenic potential, mineragenic potential classifier, index of recommendations, land cost, land cost classifier.

MPGM-1000 RESULTS

1:1,000,000-scale MPGM project is completed currently for more than two million sq. km covering different regions of Russia.

As a result, the following tasks were accomplished:

- Geochemical characteristics of geological formations were obtained and their boundaries were refined, which allowed us to achieve greater reliability and better prognosis of the 1:1,000,000-scale State Geological Map (3rd edition);
- Boundaries of known prospective ore areas were refined and 138 new prospecttive areas were contoured; qualitative estimate of mineral potential was made using geochemical data, thus allowing expanding considerably Russian mineral resource base for precious, rare, non-ferrous and ferrous metals, uranium, diamonds and some nonmetallic useful minerals;
- Ecological state assessment of areas has been made. Character and intensity of the environmental change polluted by toxic and chemical elements and compounds under impact of technogenic and natural processes were assessed. Recommendations on environmental protection were made;
- Potential geochemical endemicity of regions has been evaluated;
- Agrochemical zoning of agricultural areas was carried out and land resources were assessed; agricultural lands suitable for growing ecologically clean products were allocated;
- Integrated geochemical principles and recommendations on nature conservation aimed at sustainable development were developed.

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COMPONENTS OF A GEOLOGICAL MAP PUBLISHED BY THE BAVARIAN ENVIRONMENT AGENCY (LfU)

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KEY WORDS: cartography, geological map, geologic information

INTRODUCTION

The geological map series is one of the most complex publications within the Bavarian Environment Agency (LfU). Therefore the cartographic composition and visualization during the long process of production requires a large amount of work. Nowadays the application of geographic information systems (GIS) in combination with geoscientific data is very common. But due to the large amount of detail and information it is still a great challenge to create a „paper map" that is comprehensible and of high quality cartography – without being able to switch on and off different layers of geology.

The main work in the range of geoscientific maps of the LfU is the geological map on a scale of 1:25.000 (GK25). Based on this map series selected components and their development will be illustrated in the following. The map sheet 6741 Cham West is chosen as example.

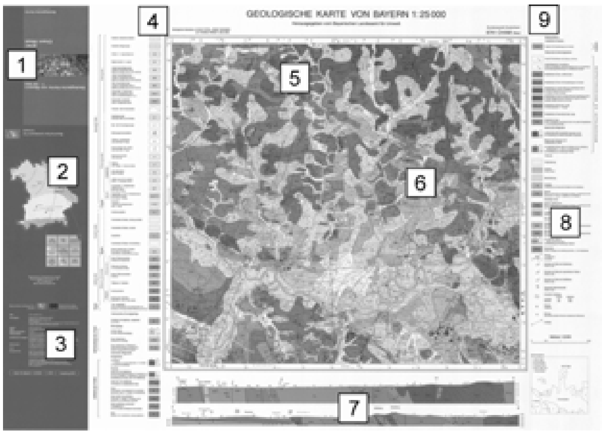

Figure 1 – Overview of described components (sectors 1–9) of the geological map 1:25.000.

DESCRIPTION OF SELECTED COMPONENTS

Sector 1: Cover illustration

The geological map with various scale ranges (1:25.000/1:75.000/1:100.000/1:150.000/1:500.00) is published for e. g. municipal and state authorities, consulting engineers and for interested amateurs in the category „UmweltThema" by the LfU. In addition to this publication, further categories are "UmweltBasis" for the general public and „UmweltSpezial" for the target group of experts.

There are three different kinds of layout-guidelines (in each case: title plus inner section) for the three categories. Also the chosen cover illustration depends on this classification. UmweltThema is characterized by a slim picture format displaying distinct geological landscapes, rock formations, outcrop details, etc. In case of the map sheet GK25 6741 Cham West the picture shows a geological unit found in the area of field mapping.

Figure 2 – Cover illustration.

Sector 2: Index map

Apart from the imprint and cover illustration, the title column of the map also contains a survey map of Bavaria with the sheet lines of the GK25. This index map can be used to locate the position of the map sheet within Bavaria. Furthermore this illustration gives an overview of the main geological regional units: Crystalline basement, Mesozoic cover, molasse basin and the Alps. In addition, the extracted map detail (3x3 raster) allows the identification of neighbouring map sheets with numbers and names.

Further information on the state of publication of the geoscientific map series within the LfU can be found on the poster „Overview of the publication and processing status of the geoscientific map works in the Bavarian Environment Agency“ by Astrid Schröder and Elke Graßmann (this volume).

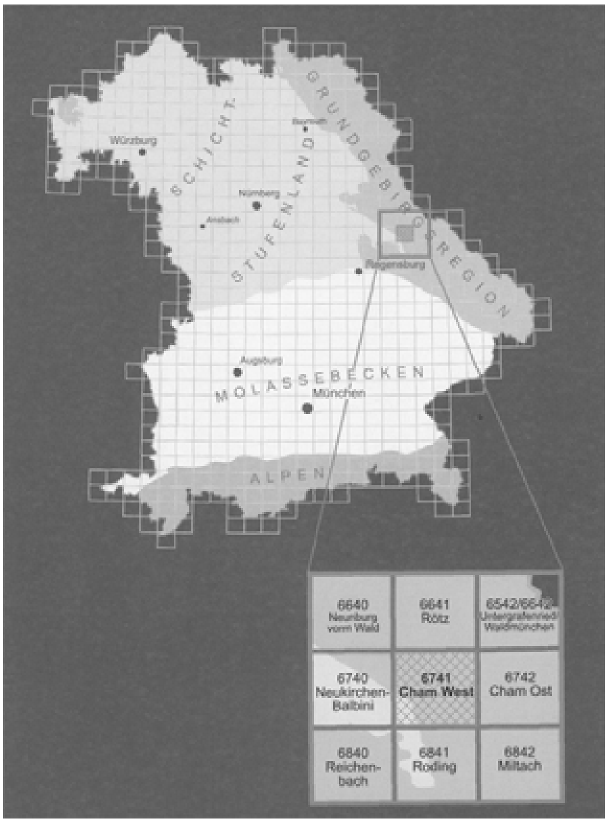

Figure 3 – Index map.

Sector 3: Map Sheet and projection

The GK25 uses the sheet line system of the topographic map 1:25.000 (TK25) published by the Bavarian Office for Surveying and Geographic Information (LVG). The format is delimited by 10 longitude and 6 latitude minutes – this adds up to an inner map format of approx. 48 cm x 44,5 cm (width x height). Because of meridian convergence the width of map sheets in Northern Bavaria is approx. 3 cm less than the width of southern map sheets (N → approx. 47 cm, S → approx. 50 cm). The height is always the same. The dimension of the whole map (including marginal data and title) is 84 cm x 60 cm.

Geodetic datum: Potsdam-Datum (Fundamental station Rauenberg). The GK25 refers to Gauß-Krüger projection with Bessel-Ellipsoid 1841.

The map frame contains two kinds of coordinate systems: Geographic and Gauß-Krüger, DHDN Zone 4.

It is necessary for the later map layout to rotate the geological information, topography and map frame into a horizontal position: Depending on how far the georeferenced map is located away from the middle meridian, the more or less inclined the map will be within the paper frame.

Sector 4: Data import

The geological information of the individual map sheets are delivered in different ways from the geological survey into the cartography unit of the LfU: On the one hand there is the classical handmade manuscript map, digitized by an external company. On the other hand the data are already digitally collected with the aid of field computers using the software product GeoKart (Annau et al., Wölfl et al., this volume).

At present the platform for producing the GK25 is UNIX-based ArcInfo-Workstation (ESRI). The data are stored in ArcInfo-Coverage format. Because of this and for the subsequent treatment in the cartography unit the data collected with GeoKart need to be converted into shape format via ArcGIS 9.x and afterwards into coverage format. Following this process the data have to be implemented to the given layer-structure (see sector 5).

There may be a solution in the near future, which helps to avoid a platform change between GeoKart, ArcGIS 9.x and ArcInfo-Workstation. This would help to reduce many possible sources of problems like conversion errors or limitation of automation. Of particular importance beyond these problems is the lack of previous knowledge of applicants in ArcInfo-Workstation and the end of ESRI support for ArcInfo-Workstation. At present the preparations for a complete platform change to ArcGIS 9.x are running. (see oral “Leaving the ‘UNIX-Ice floe’: The migration of GIS-based map production from ArcInfo-Workstation to ArcGIS 9.x” by Mathias Boedecker, this volume).

Sector 5: Data structure

This is how the data base of the GK25 is built up:

- Topographic Information (build-up-area, traffic network, hydrography, contours)
- Polygon information (main geological units, overlaying strata)
- Points (drill holes, locality of small geological units or fossils, strike and dip of strata, etc.)
- Lines (faults, terrace edge, dunes, etc.)
- Annotations (= text, i. e. the labelling of the whole map is not automatically produced)

The contents of the specific categories (polygons, lines, points) are subdivided into multiple coverages reflecting different layers of information. I. e. there is not only one coverage for all of the line, point or polygon information but for example a

- Terrace edge layer
- Fault layer
- Drilling layer
- Overlaying strata layer

In addition to the geological information layers there are also coverages for legend, map frame, cross section and other cartographic contents. The outcome of this concept is a number of approx. 40 possible coverages – of which on average about 20 coverages per map sheet are filled with content.

Sector 6: Drilling and BIS

The drillings displayed on the map are also available in the BIS (Bodeninformationssystem Bayern - Bavarian Soil Information System). The utilisation occurs for the general public via internet (www.bis.bayern.de -figure 4a) and for internal use via intranet (figure 4b). The user can navigate to specific drilling points using all kinds of localisation methods (map sheet numbers, administrative units, zoom in/out) in order to access more detailed information about the drilling points (list of strata, final depth of the drill hole, results of chemical analysis, etc).

Figure 4a – Topographic map → drilling → BIS/internet → detail: ordering data.

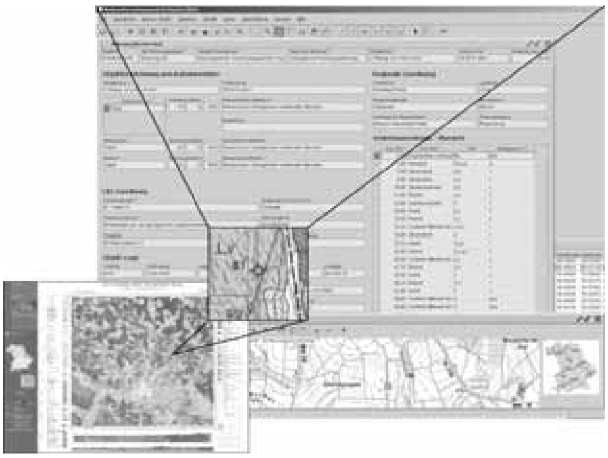

Figure 4b – Geological map → drilling → BIS/intranet → detail: list of strata.

Sector 7: Cross section

The top edge of the cross section is built through an intersection of

- DGM25 (digital terrain model, grid size 50 m)
- Line of cross section and
- Geological units plus overlaying strata.

Normally this digital terrain model is sufficient to display the ground surface on a scale of 1:25.000. In some rare cases there is a need to refine distinct terrain edges by hand. Afterwards the geological information of the bedrock is added (based on a drawing of the geologist who is responsible for the map sheet) and finally the cross section is completed with regard to cartographic visualization and labelling.

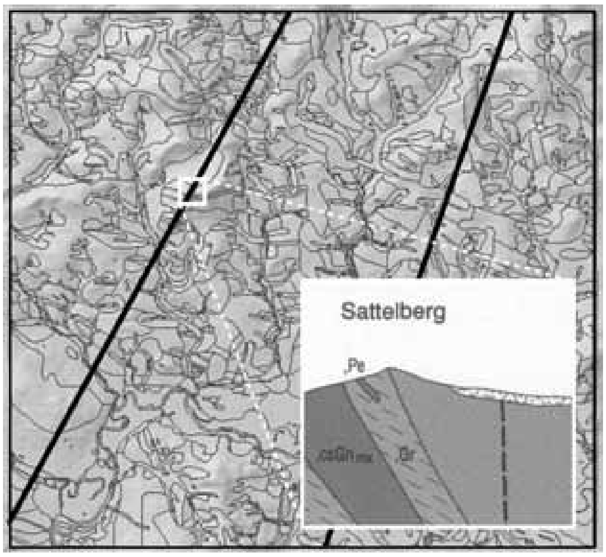

Figure 5 – Cross section derived from the DGM25.

Sector 8: Legend

The colouring of geology on the basis of a cartographic legend is performed consistently for Bavaria - not only for a single map sheet. Therefore the demands on the cartographic visualisation of multifaceted geological information are enormous. For example: At present the symbol library includes approx. 170 polygon signatures, approx. 400 point symbols and approx. 150 line signatures. This is the basis for arranging approximately 2500 different geological objects (for further information see poster „Visualizing geological data and managing quality in printed geological maps at the Bavarian Environment Agency“ by Toni Richtmann, this volume). Legend construction and positioning is still done by hand. In the current workflow an automatically generated legend would only be suitable to a limited extent and with loss of cartographic quality. This kind of procedure is more likely to occur after the migration to ArcGIS 9.x.

Sector 9: Basis for different products

The final product of the GK25 is released in different formats and for different purposes:

- For sale as printed map (folded/unfolded), as georeferenced raster or vector map, as (vector/raster-) PDF
- As data set for the import into the BIS – access is possible via internet (www.bis.bayern.de) for all users and intranet for internal users
- As data set for different geoscientific maps. An example: Hydrogeological Map 1:50.000 - Geological map without overlaying strata as basis for the map sheet „Propagation of hydrogeological units“
- As data set for map series with scale ranges < 1:25.000 in a generalized version - for example „Geological map of the Bavarian Forest 1:150.000“

THE ROLE OF GIS TO MAP THE IMPACT OF CLIMATE CHANGES ON EFFECTIVE INFILTRATION RATE IN CENTRAL ITALY

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KEY WORDS: Hydrological GIS, zonal statistics, raster overlay.

INTRODUCTION

Temperature and rainfall variations recorded in Central Italy over the last decades directly affected the springs recharge through the modification of the effective infiltration rate values and patterns. This situation may open a real management problem in the near future, especially if an accurate planning of drinkable water resource will not be carried out.

In this work, GIS modelling was used to characterize the recharge area of S. Susanna spring (*5.5* $m^3 \cdot s^{-1}$; *Boni* et al.*, 1986)* in the Reatini Mountains (Central Apennines, Italy). This area was used as a test site to develop a specific workflow useful to forecast the possible effects of current climate trend over the effective infiltration rate.

For this reason we designed a data processing procedure, within a GIS environment, capable to:

a) give reliable information on the geographic and geological boundaries of the recharge area of the spring;

b) estimate the relative influence of the main geographic (slope and land use) and climate (rainfall and temperature) factors influencing the S. Susanna spring discharge rate;

c) investigate how discharge rate may be affected in the future by the ongoing climatic trends in this region.

DISCUSSION

Cartographic data, climate alphanumeric databases and hydrologic balance equations were processed in a georeferenced environment using the raster overlay functions embedded in a GIS.

The study area was discretized in cells of 100x100 m used as fundamental elements to perform the calculation of hydrological parameters.

The standard hydrological balance equation was used to calculate the effective infiltration rate value, I_e:

$$I_e = P - Et - R$$

where P is the annual average precipitation, Et is the real evapotranspiration and R is the runoff.

The procedure took into consideration $\delta^{18}O$ and δD isotopic values of the water recorded at the spring itself and at a series of rain gauges placed at different altitudes inside the recharge area. The isotopic fractionation vs. altitude regression curve was calculated and applied to the DEM to support the analysis. Topography, derived from SRTM DEM, was considered in terms of slope and altitude, the latter being also linked both to the temperature and to the rainfall (average annual and monthly). Land use was linked to the infiltration process through the Kennessey equations (Kennessey, 1930). Finally evapotranspiration was calculated by means of the empirical equation proposed by Turc (1954).

The workflow we developed is divided into two steps which maximized the use of the available information. The first part (figure 1) led to the geographical identification of S. Susanna spring recharge area by comparison between measured and expected values of discharge, $\delta^{18}O$ *and* δD. In particular, the actual extension of the S. Susanna spring recharge area (figure 3) was identified by testing the different hypothesis, represented by different polygons, by calculating the total infiltration as summation of the infiltration estimated in each 100x100m pixel (zonal statistics).

The second part of the procedure (figure 2) took into consideration the historical climate series to forecast the possible changes in the parameters of hydrologic balance equation and, as a consequence, in the expected discharge rate.

CONCLUSIONS

The application of zonal statistics functions to different possible hydrogeological conceptual models allowed to determine the boundaries of S. Susanna spring recharge area. This area extends over about 300 km^2 in the Reatini Mountains belt and geologically includes the internal Mount Terminillo thrust unit.

When these results about the hydrological budget are combined with the spatial distribution of a water stable isotope data and a rough velocity flow calculation, data converge to indicate an average residence time of water inside the aquifer of about 15-20 years.

The GIS workflow application highlighted that there is an ongoing negative recharge/discharge trend at the S. Susanna spring and her feeding aquifer which leaded to a water recharge reduction above 30% in last two decades. This situation need to be taken into account for the future planning of water resource exploitation in this area.

The GIS-hydrogeological modelling workflow, can also be adopted for monitoring time evolution of the recharge in the central Apennines, even outside the study area. Finally, the logical process can be applied in the field of land planning to assess the influence on groundwater recharge of possible land use changes on a wide scale.

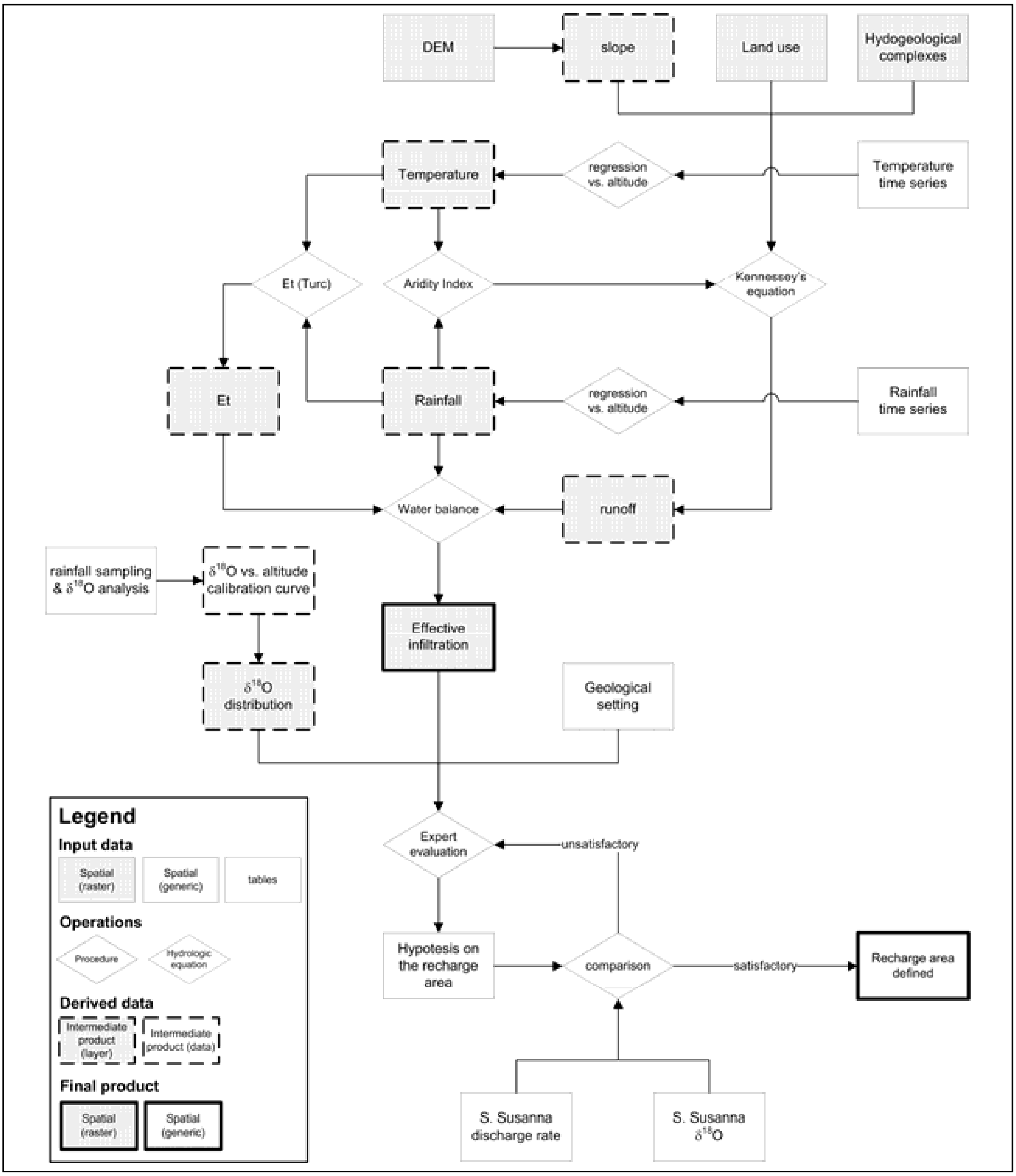

Figure 1 – Workflow, step 1.

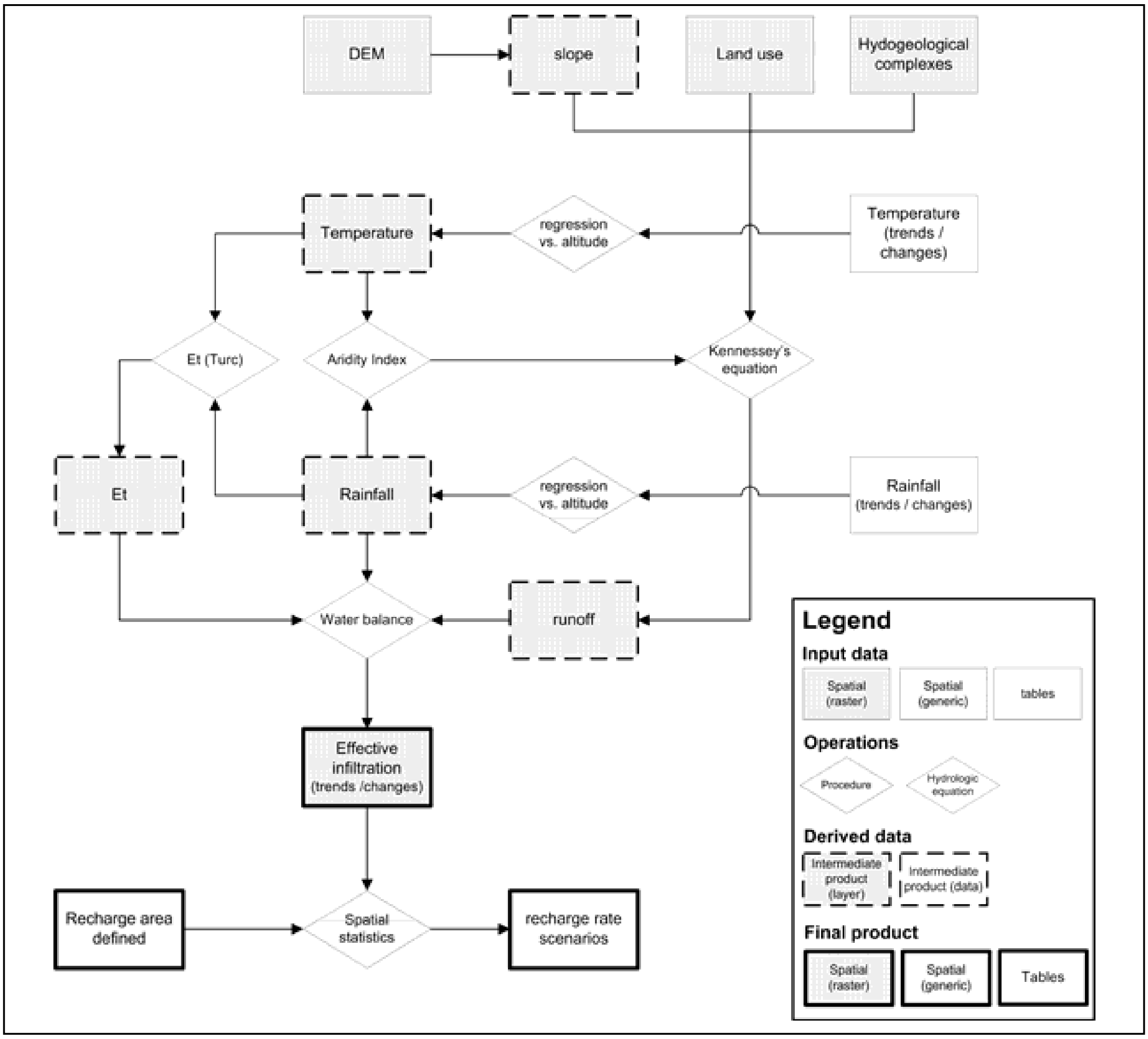

Figure 2 – Workflow, step 2.

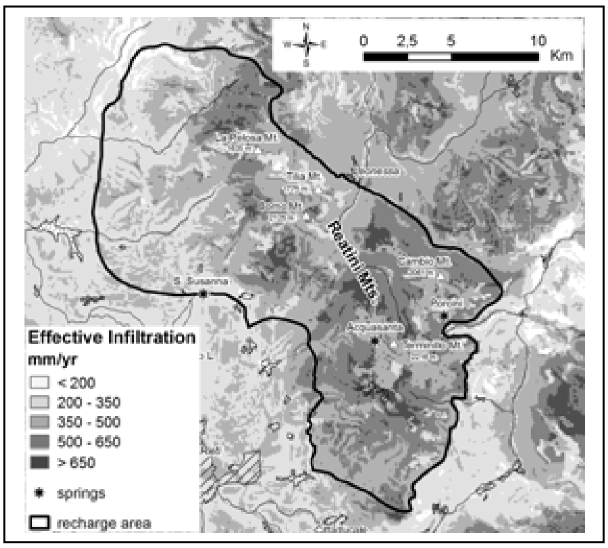

Figure 3 – S. Susanna spring

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INFORMATION SERVICE FOR NATURAL HAZARDS IN ALPINE REGIONS OF BAVARIA (IAN)

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KEY WORDS: natural hazards, web map service, 3-D terrain visualisation, ISO 19115 metadata

IAN 2.0 is now online

The IAN map service, which provides an easy and quick overview about natural hazards in the alpine regions of Bavaria for professionals, municipalities, consultants and interested citizens, has been online since July 2003. This map service has since been redesigned technically, optically and in handling (figure 1). It is now more user-friendly and the option to create three-dimensional visualisations for a map scene (figure 2) makes the readability of the shown information easier. The new version is accessible via the internet at http://www.ian.bayern.de since December 2008.

Figure 1 – IAN map service

What information is included?

The map service's starting link is located on a short intro page with background information and a help index. After starting the IAN, the user can access more than 10,000 documented natural hazard phenomenons like

- avalanches
- floods
- debris flow
- land slide and rock fall
- events in torrents since the year 964 A.D.

The IAN also provides basics for the assessment of risk like

- maps with risk and process indication
- information about land slide and rock fall activity
- areas with protected forest

All information can be combined with topographical maps or aerial photographs.

Functions of the map service

Besides common map service functionality the IAN has tools to support spatial navigation offering a quick search for townships, water bodies or mountain ranges. Query tools provide information on mouse click or by searching for key words and selection criteria. Also helpful is a tool to measure distances and the possibility to print or export the current map in PDF format.

The map service is also part of the Bavarian and German geo-data infrastructure (GDI-BY, GDI-DE). All topics have a set of ISO 19115 metadata and various Web Map Services (WMS) can be included to allow the IAN to combine its own maps with additional information.

Another feature of the new version is the three dimensional visualization of the currently displayed map section (figure 2). Especially in the alpine region a 3-D scene is very helpful for interpretation. This functionality is based on the terrainServer software by con terra GmbH. The three dimensional view is a rendered combination of the currently displayed map and a terrain model, which is generated from the elevation data of the requested coordinates. The view can be modified by rotating the scene, exaggerating the elevation or changing the viewing angle and distance.

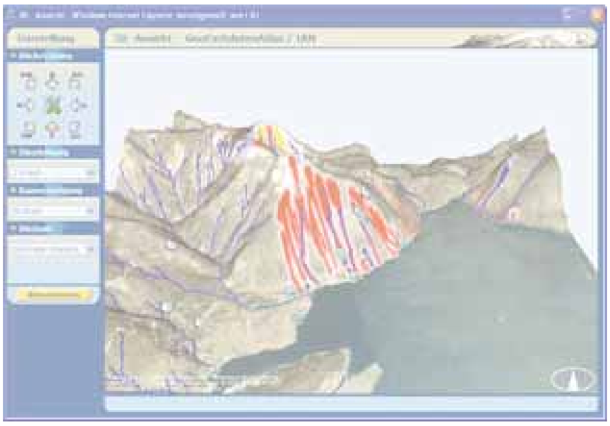

Figure 2 – IAN's 3-D terrain visualisation

Data origin and data flow

The merger of the Bavarian agencies for geology, water and environment protection forming the new Bavarian environment agency (LfU) in 2005 determined that the data storage for various spatial information systems is very heterogeneous. One source is the Bavarian soil information system (BIS), which holds, amongst others, maps with risk indication and data about land slide and rock fall (so-called GEORISK). All other data is maintained and distributed by the geographical information system of water economy (GIS-Was) (figure 3).

BIS and GIS-Was data are the primary data sources. To publish the information on the internet, a secondary data pool is created with the help of ETL (extract – transform – load) processes. Hereby most of the data is pre-processed, and protected information, e.g. for official use only, is filtered out. This secondary data pool is completed by basic geographic data of the Bavarian ordnance survey and web map services covering southern Bavaria.

Then, all of the IAN's information is presented on the internet on a website, which has been developed by the LfU and external partners. The software components mapClient, terrainServer and terraCatalog, which are all additionally part of the sdi.suite by con terra GmbH, Germany and used to display maps, 3-D visualisation and metadata, all make up the main part of the application. The server-side map software is ArcIMS by ESRI and additional data is stored in an Oracle 10g database. This combination forms the basic technology of the LfU's web map application called GeoFachdatenAtlas.

In addition to the IAN, there are similar websites based on this platform for displaying maps about geology and soil, noise measurements and the European Water Framework Directive. Thus, the IAN is one map service amongst an ever growing number of map services hosted by the Bavarian environment agency, whose aim it is to ensure the publication of current data about environmental topics on the internet.

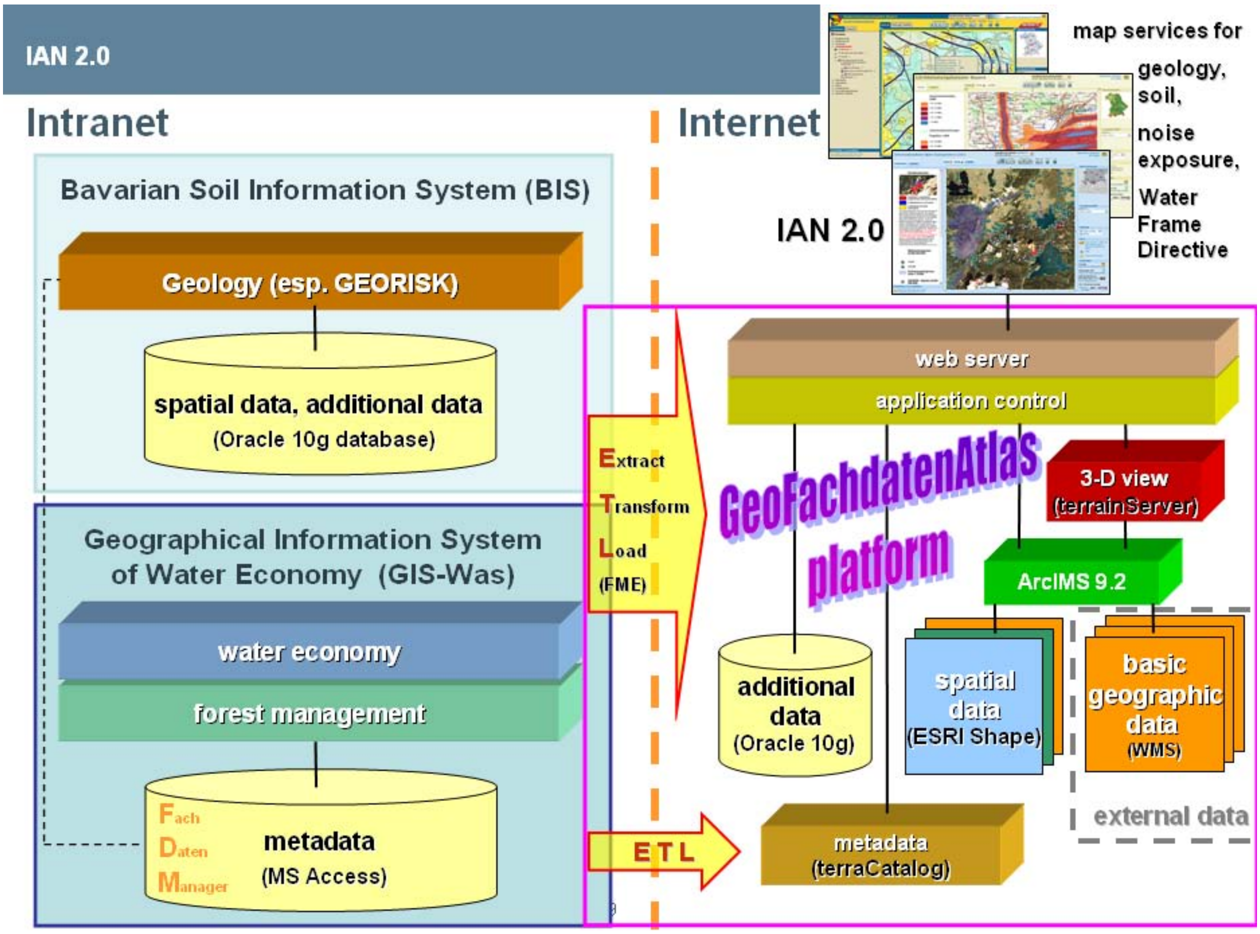

Figure 3 – data flow and system architecture

MAP SERVER ON WWW.GEOLOGY.SK

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KEY WORDS: Geology, Map Server, Web Application, Digital Archive

SGUDS – STATE GEOLOGICAL ISTITUTE OF DIONYZ STUR

SGUDS is a state contributory organization and its budget is a compound of the State Budget. The budget consists of the fund to support scientific-technical projects commissioned by the national government and other tasks assigned trough the Section of the Geology and Natural Resources of the Ministry of Environment and a fund to finance publishing, activity of registration (mentioned below), map printing, Central Geological Library, sample storage and laboratories activities. Major informatics activities are concentrated into two sections of SGUDS: to the Geofond Division and to the Division of Information Systems.

Department of Geological Information Systems is holder of a project "Geological Information System" (GeoIS) which started at the end of 2005 and it's mission is to develop a web application, providing access to spatial geological information, namely (maps), regional geological (structural, tectonic…), engineering-geological, hydrogeological, geochemical and geophysical. In cooperation with Geofond division (Archive) GeoIS will participate on developing of digital archive of geological reports as well.

Two important services were provided to the public on 1st April, 2008. The Digital archive and the Map server are to public disposal on the web address: www.geology.sk. All map services except of the Digital geological map in the scale 1:50 000 are accessible also in the English language mutation. At the moment there are out of 26 map works 19 in the English language.

GEOIS – GEOLOGICAL INFORMATION SYSTEM

Main objectives:
- Open information system on geology including geological databases and access to information through internet.
- Final report in written and electronic form and GeoIS portal ŠGÚDŠ itself.

Partial objectives of the project:
- Obligatory structures of individual themes of geological data elaborated based upon analysis of to date state and demands of all respective components.
- Creation of and system architecture, user's hierarchy and system security included.
- Data base creation and maintenance.
- Client application development.
- Possibly best elaborated and made available reliable geological data.

Geological data themes
- Regional geology – the ground-layer is a GM50, autonomous part of works: database of Fossils, Isotope analyses, electron microprobe analyses
- Hydrogeological data – HG50, hydrogeological conditions of Slovakia, mining waters and isotope composition of groundwaters
- Geochemical data – maps of natural water quality in 50K, gch atlases, hydrogeochemistry, pedogeochemistry, lithogeochemistry, alluvial deposits and geomedicine
- Engineering geological data – EG maps of zones, subzones and geodynamic phenomena, engineering geological borehole, water aggressiveness, engineering geological properties of rocks
- Information system on raw mineral deposits, occurrences and prognoses of raw minerals
- Geophysical information system – groud-based and aerial gamma spectrometry, magnetometry, radon exploration, activity of Cs, gravimetry, VES..
- Digital archive of Geofond

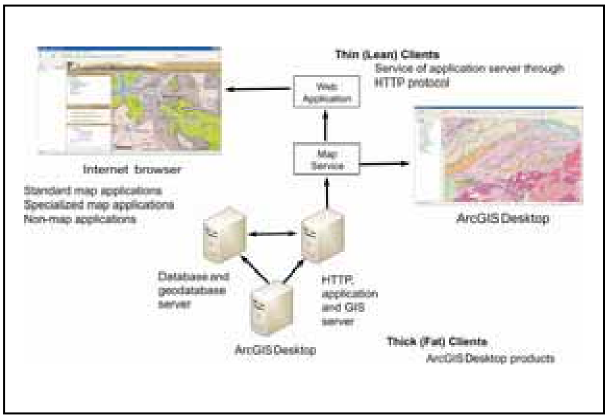

Figure 1 – Scheme of data and services setup.

Figure 2 – Portal of Map server ŠGÚDŠ on www.geology.sk

LIST OF MAP SERVER APPLICATIONS

1. Geological Maps Slovac Republic M 1:50 000 contains the following independent layers:
- list of used groundworks
- categorization (duality layer)
- review of carried out mapping
- structure scheme

The areal information of the digital map consists of:
- unified legend
- original legend
- characterization
- occurrence of distinguished lithotypes covering the whole SR territory

Figure 3 – Unit and Original legend of Geological Maps SR M 1 : 50 000.

2. Geological Division of Europe M 1:20 000 000. The structural scheme of Europe represents the situation of Slovakia (the Carpathians and the Pannonian Basin) in the context of the geological building of the whole continent. It combines the basic tectonic elements with some elements of the geological building (by dissection of the sedimentary cover) of the platforms by age. Slovakia is situated in the northern branch of the alpid belt with orogenic development in the Mesozoic and Tertiary eras. This belt has developed on the ruins of the Caledonian or Variscan orogenic belt in the southern part of the European continent. Part of these older orogens are included into the alpine zone and represent part of its geological building.

3. General Geological Maps.
The data in this application are available in separate layers: Structural scheme of the Western Carpathians and adjacent areas, J. Lexa et al., 2000, scale 1 : 2 000 000; Geological map of the Slovak Republic, J. Vozár, Š. Káčer et al., 1998, scale 1 : 1 000 000 and Geological map of the Western Carpathians and adjacent areas, J. Lexa et al., 2000, scale 1 : 500 000. Individual maps are depicted in accord with respective scales. The extent of available information corresponds to respective legends of individual regional maps printouts.

Figure 4 – Geological Maps SR M 1 : 1 000 000.

4. General Maps of Slovak Republic M 1: 500 000 (Tectonic map of Slovakia, Neotectonic map of Slovakia, Metallogenetic map of Slovakia, Map of lithogeochemical types of Sovakia, Geochemical atlas of the Slovak Republic,)
5. Landscape Atlas Maps M 1 : 1 000 000 (Quaternary deposits, Principal Hydrogeological Regions, Soil susceptibility to acidification, Suitability of territory for waste deposition)
6. Landscape Atlas Maps M 1 : 500 000 (Engineering-geological zoning, Geothermal and mineral water sources, Soil contamination, Selected geodynamic phenomena,)
7. Hydrogeological Map of Slovakia M 1 : 200 000
In the period of 1971 – 1978, the whole area of Slovakia, 49,030 km2 in total, was covered by the uniformly created basic hydrogeological maps in the scale of 1:200,000. 12 map sheets, each

ideally covering 7,448 km2 (98 km x 76 km) were produced as manuscripts and their printed versions came later (gradually in the period of 1983 – 1991). Up to now; this is the only edition of hydrogeological maps that is covering the whole area of Slovakia. Methodology of construction of these maps in the scale of 1:200,000 was adopting the IAH/UNESCO rules.

GEOLOGICAL ATLAS OF CATALONIA 1:50.000: A NEW TOOL FOR MAKING KNOWN TO SOCIETY THE GEOLOGICAL CONSTITUTION OF THE TERRITORY

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KEY WORDS: Atlas, geological maps, regional geology, Catalonia.

INTRODUCTION AND OBJECTIVES

The Geological Atlas of Catalonia 1:50.000 is a new project carried out by the Institut Geològic de Catalunya (IGC) and the Institut Cartogràfic de Catalunya (ICC) to bring knowledge about the geological constitution of the territory closer to society.

This work presents the Geological Map of Catalonia, 1:50.000, in a format and a content structure similar to those of a conventional atlas; that is to say, the strictly cartographic part is accompanied by introductory pages jointly prepared with the University of Barcelona, with additional information to facilitate the consultation and the understanding for the non-specialized reader. The idea is to have a reference book for the office, or just a book to glance through, and not a field reference work, which is the case of the conventional geological maps.

It contributes an approach which includes innovative ingredients in the way of transmitting the geological constitution of the territory, the history of its formation and evolution, some of its peculiarities and an accessible summary of Catalonian geology.

The Geological Map of Catalonia 1:50.000, which constitutes the cartographic part of the Atlas, has already been published in the conventional format in a series of 41 sheets, one for each Catalonian county (Mapa geològic comarcal de Catalunya, 1:50.000, IGC and ICC, 2005 to 2007). This article deals specifically with the introductory part and with the rest of the information that accompanies and complements the geological map.

STRUCTURE

The Geological Atlas of Catalonia, at a scale of 1:50.000, has been structured in two clearly differentiated parts: the first part, introductory, with a strictly geological content and a second one with a cartographic content with the geological map 1:50.000, its legend and an explanation of the methodology used in the formation of the Geological Database of Catalonia (Puig et al., 2000), wherefrom the Geological Map of Catalonia 1:50.000 is derived.

The introductory part provides a regional geological framework aimed at facilitating the understanding of the entire Atlas, not only for the non-specialized reader but also for those users with a partial knowledge or with an interest in certain subjects. We should not forget that many people are mineral or fossil enthusiasts, or they like collecting coloured pebbles, or just like to know on which rock they are stepping when trekking or assuring their pitons when climbing.

So, the first part is the most innovative, where a real effort has been made in trying to find the best way of conveying the knowledge on the geological constitution of the country in a plain and pleasant manner, without compromising the rigor of the content.

With these objectives we established the content structure and the formats to facilitate the finding and the understanding of each one of the subjects dealt with in the volume.

- Format / structure: each subject occupies an independent double page spread (or several if necessary); this structure is typical of the conventional atlas, where the different aspects of the territory, the population, the climate, etc. are individually dealt with. This allows the reader to easily locate the subject which he/she is interested in.
- Contents: it provides, for each subject, an general overview of what is expressed or can be deduced from the geological map. The contents are developed in the following section.
- Language: an attempt has been made to use a relatively plain language. Of course, the terminology is typical of the geological sciences, but avoids the use of technical terms.
- Graphics: in the entire first part of the Atlas, the graphic expression of the geological content has been homogenised, i.e. we have used the colour codes internationally established for rocks of each age, expressed in the Geological Time Table (IGC, 2006), and the standard ornamentation for each rock type. This unification, in addition to providing coherency to the whole, also facilitates immediate information of a geological nature.

CONTENTS

The first chapter is devoted to geological maps: what are they, the history of their development as a means for summarizing and transmitting the geological knowledge and, especially, as a prospective and predictive tool. These values are often difficult for the general public to understand, but they are very important, as the social value of geology lies in this predictive ability.

We have included a collection of reproductions of historical maps and of the current cartographic series, at different scales and with approaches which have enormously evolved during the last few years, following the advances in the theory of geological sciences and the requirements of the epoch.

Finally, the different geological subjects which can be cartographically represented constitute what we have called geo-thematic maps: one map per subject. All the maps grouped in this chapter, either already published or specifically prepared for the Atlas, have been represented on the same scale and have a common treatment, with an explanatory text on the specific geological content.

In the first place, there is a map of physiographic (or relief) units, which provides the geographical framework for the entire work. This map has been expressly compiled for the Atlas and also sets out the regional toponymy used in the entire work, including the continental platform.

The remaining geo-thematic maps represent the geological constitution of the territory (the conventional geological map), the lithologic types (Figure 1) and the superficial and underground waters, all of them extractions from the Geological Map of Catalonia 1:250.000 and from the Geological Database of Catalonia 1:250.000 (BGC250M); part of the content of the structural and the geomorphologic maps, prepared especially for the Atlas, also derives from BGC250M. Finally, the last map tackles seismicity.

Figure 1 – A Geo-thematic map devoted to the lithology.

The geo-thematic map, which shows the lithologic constitution of the substratum, also includes a simple explanation of the types of rocks and of unconsolidated deposits outcropping in Catalonia, illustrated by pictures. In this section we have followed the classical genetic classification of rocks, which can be found in any manual or text book. The aim of these pages is to provide an image of the lithologic diversity which forms the geological records of Catalonia.

Of course, many more geo-thematic maps could have been included, but we have restricted the Atlas content to those maps already published by the IGC (mainly on a 1:250.000 scale) and to those summarizing the geo-morphological features, the geological structure and the major structural units, indispensable for providing a framework for the entire work.

The second chapter is devoted to geological history. Catalonia has a long and complex geological record and, from this point of view, it can be considered a privileged country. In a territory of 32.182 sq. km. the sedimentary record of the last 550 million years can be studied. We have excellent examples of structures generated in compressive and extensive tectonic contexts, a large variety of intrusive and effusive igneous rocks and the imprint of hercynian metamorphic processes.

In the first place, we explain the concept of Geological Time, very difficult to capture for the non-specialized reader, and the Geological Time Scale, the chronological dimension which embraces the Earth’s history. This scale also permits the evaluation of the speed of some geological processes.

Then, we explain the geological history in a continuous text, intended for more curious readers. This section is illustrated with many palaeographic reconstructions of different scope and summary table of the geological events which have occurred in Catalonia and its surroundings.

The geological record is expressed in a set of pages (Figure 2) arranged in a geochronological order, from the oldest to the newest. These pages include, besides the sedimentary record, the igneous and metamorphic events. The way of presenting the information is the same in each section, regardless the subject, although the age intervals become smaller as we advance in the geological time.

The difficulty in this chapter lies in the fact that some processes, within the geological record, are easier to capture for the non-specialized reader due to their proximity and the consequent easiness to intuitively apply the principles of actualism and uniformitarism; good examples of these are the expansion of a delta or the erosion inland. On the contrary, some of them are very difficult to understand, even for professional geologists, such as the metamorphism and certain deformation processes.

The Geological Time Table is present on all pages devoted to the geological record, with a clear indication of the specific time lapse considered.

Each page has a diagram with the outcrops distribution of the rocks under consideration; this has been included to provide, at the first glance, a clear picture of the situation of a determined group of rocks within the territory. This information would be difficult to capture from the general geological map. It can give, even to professional geologists, an approach which is different from the one we are used to.

The rest of the content is a short text of a general and regional nature, with a collection of pictures and photographs illustrating the aspects mentioned in the text, synthetic stratigraphic series, correlation panels, details of representative outcrops, interpreted photographs, etc.

This chapter also reflects the human action on the territory, with a page of the same structure and type of content as the rest of the pages.

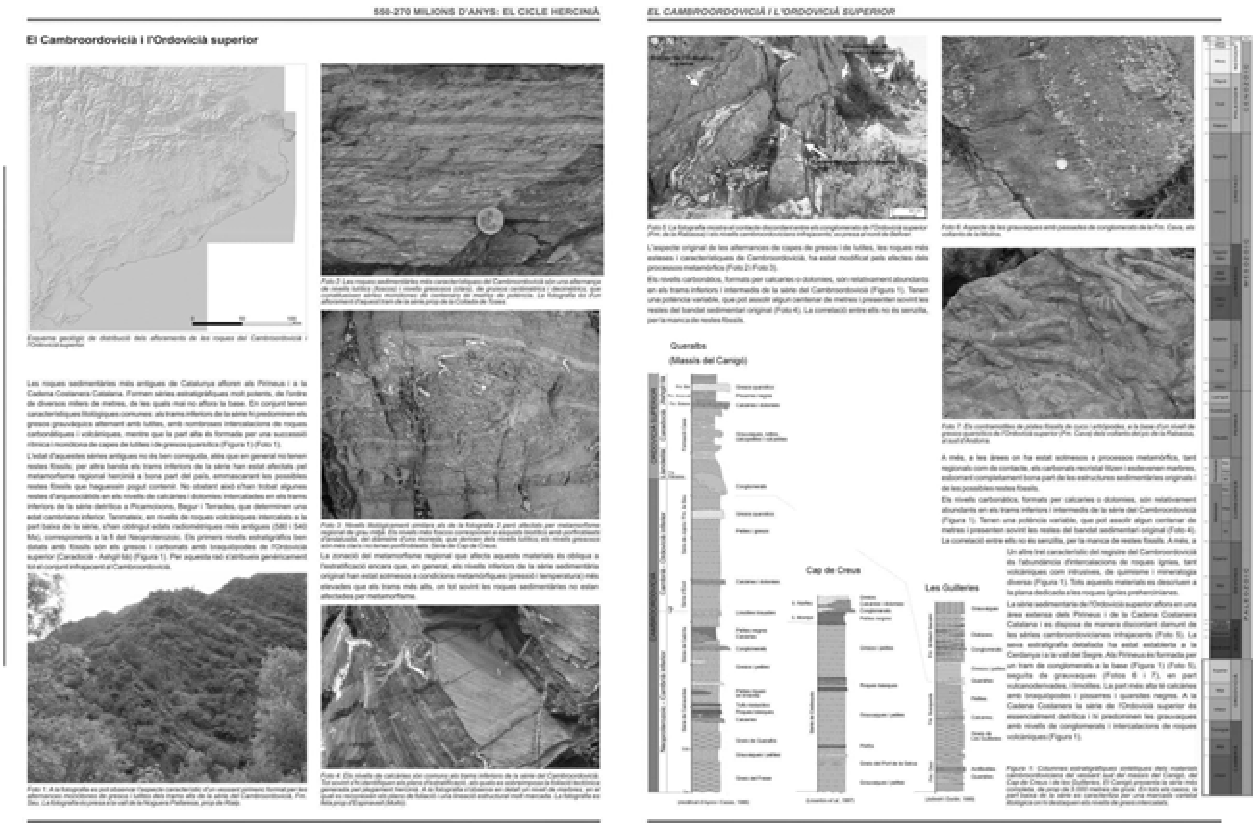

Figure 2: Example of a draft page of the Atlas, specifically that devoted to Cambrian and Ordovician periods. The scheme of outcrops distribution and the geological time table on the right hand side of the page are common to all of them.

The geological structure of Catalonia is expressed through a map of structural units, derived from and complementary to the structural map, and a series of cross-sections with different ranges, distributed through areas of diverse contexts and structural styles. As in the former sections, we have drawn up a short introduction to facilitate the understanding of what a geological cross-section expresses, where the procedures used in their construction, the methods for obtaining underground data and the restrictions limiting their depth are explained.

In this section, the geological cross-sections are shown in a double-page spread with a location diagram, an introduction to the geological context and partial details, interpreted photographs, restored cross-sections and other information complementing each one of them.

All together, 10 geological cross-sections are presented, which show the tectonic alpine evolution, compressive and extensive, with some details of the hercynian structure. Two of these cross-sections have a larger depth range. We have taken advantage to explain in more detail the Pyrenees formation and the evolution of the Valencia Trough.

Finally, there is a lithospheric scale cross-section of this portion of the Iberian Plate within its context, i.e. as a piece which has evolved back from the Triassic period, 250 million years ago, up to the present time between the larger European and African tectonic plates.

We have tried to summarize all this, and even more, in the introductory part of this Atlas.

The second part of the geological Atlas is strictly devoted to the Geological Map of Catalonia, 1:50.000. There is an introduction where we explain the formation of the BDGC50M (Puig et al, 2000) and its graphic representation (de Paz et al, 2006), which culminates with the publication of the Atlas.

The geological map has the conventional format of a geographic atlas, with the entire map divided into pages, 201 pages in total.

The legend consists of 1.047 cartographic units, identified by an alphanumeric epigraph and an index number. They are filed in geochronologic order, from the most recent to the oldest. To facilitate the location of a unit in the legend, there is an alphabetic list of all the epigraphs with their index number.

The legend in the cartographic units is very concise; it only mentions the dominant lithology, the minority lithology (if necessary), some typical fossil remains, the mineralogical composition, the formal name (if this exists) and the age. The list of conventional signs is also quite reduced, because the geological map does not graphically express all the information gathered in the BDGC50M.

All geological terms (or those with a specific meaning in geology) appearing in the legends have been compiled and a glossary has been expressly prepared for this work; it consists of 581 words or expressions and has been attached as an appendix to the legends to facilitate the consultation for non-specialized users. Common patterns have been established for the drawing-up of the definitions in each group of subjects; so, all the rocks, minerals, sediment components, fossil remains, etc. are described following the same structure and criteria. The terminology used in these definitions is accessible to any inquiring (or curious) reader.

A short etymology has also been included for the words identifying the geo-chronological units set out in the Geological Time Scale, 164 terms in total. This work was undertaken in order to translate into Catalan the current Geological Time Table (Gradstein et al., 2004, IGC 2006) and is one of the “curiosities” the readers will probably appreciate.

As any conventional Atlas, it has a toponym index and also includes an index of the pages where each cartographic unit is located.

DISTRIBUTION AND DERIVED PRODUCTS

To assure the maximum diffusion of this work, it will be distributed to those Public Administrations entities which have some kind of relationship with Earth sciences and territory management and to other entities, such as museums, totally or partially devoted to subjects related to geology.

In a parallel way, it will be distributed to central and regional libraries, university documentation centres, research centres and pedagogic resources centres, among others.

An important part of the content will be uploaded, duly adapted, to the web page of the IGC: the chapters devoted to geological maps, glossaries and some of the new geo-thematic maps on a scale 1:1.100.000. The translation into Spanish and English is being considered.

SUMMARY

The Geological Atlas of Catalonia 1:50.000 is intended to be a reference work and, at the same time, a pleasant book to glance through, with simple explanations in spite of the diversity and difficulty of some of the subjects dealt with.

The objective is to improve the citizens’ perception of the geology of Catalonia by making available to them a new tool which facilitates the understanding of the geological constitution and the succession of processes which have led to its present configuration.

This Atlas will also provide students and teachers in the high schools where matters related with Earth sciences are being taught with a reference tool for better recognizing their geological environment.

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3D MODELLING OF DISCONTINUITIES IN A DIMENSION STONE QUARRY

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KEY WORDS: granodiorite, 3D, discontinuities, joints, rock quality, GPR, stereophotography, Mäntsälä, Southern Finland

ABSTRACT

A structural geological mapping and ground penetrating radar (GPR) measurement were made in a dimension stone quarry in Southern Finland. The radar lines, parallel to the walls of the quarry, were measured with two to three meters interval. The mapped orientations of the joint sets were compared to rock fractures traced with ground penetrating radar. The SiroVision images were used to combine the reflections from parallel GPR-profiles to models in 3D and a 3D map of rock quality will be compiled.

BACKGROUND

Rock quality is usually determined in 2D as surface maps and cross cuts from tunnels or rock walls. Rock quality could be determined in 3D with the modern modelling softwares if geophysical methods producing indirect information of the rock mass were utilised.

A test to determine rock quality in a dimension stone quarry in Mäntsälä, Southern Finland, was carried out using rock surface mapping methods and GPR measurements. In addition to the geological mapping using Q-systems parameters (Barton, 1974, 2002), GPR (David and Annan, 1989) gave information about number of joint sets, trace lengths and joint spacing deeper in the rock mass.

The dimension stone quarry consists of migmatitic medium grained granodiorite with 35% of coarse grained granite leucosomes. In addition, amphibolite occurs as inter-bed layers and dykes in the granodiorite. The rock has been folded at least in two deformation stages.

METHODS

Structural geological mapping consisted of determining the following parameters: rock types, tectonic parameters, fault orientations and inner properties, number of joint sets, their orientations, type, trace length, spacing, straightness, surface roughness, alteration and relation to other tectonic structures. Mapping was carried out at three parts of the quarry, each covering a 15 to 25 metres wide area of the walls, at three different excavation levels of the quarry. The walls were photographed.

Scanline mapping was carried out on the wall. Every fracture cutting the scanline were studied, and their orientation, type, trace length, type of ending, straightness, aperture, roughness, alteration and waviness were determined when possible.

The quarry was stereophotographed to create a 3D model of it and to map the joints too high to reach. Two points were marked to the wall and their locations were determined with GPS, then two digital photographs covering the same area of the wall were taken from two different points, approximately 1 meter away from each others. Location of also these points was determined with GPS. The photographs were processed with SiroVision and joint analyse was carried out with SiroJoint (CSIRO). SiroJoint fits 3D planes to the marked joints and cleavages and gives orientations to the created planes.

Persistency of the fractures deeper into the rock mass was solved with GPR studies. GPR profiles were measured with 2-3 metres intervals parallel to the walls of the quarry. Studies were carried out at four excavation levels. The equipment used for the GPR survey consists of a laptop PC; RAMAC/GPR CUII control unit with 500 and 800 MHz shielded RAMAC/GPR surface antennas; and a trigger wheel. The reflection data was interpreted with Reflexw 4.5 (Sandmeier Scientifc Software).

Surfaces depicting the jointing were created between similar strings seen on more than one GPR profiles. To connect the strings in a reasonable way, information of the mapped structures was required. Average orientations of the surfaces were determined by fitting a plane created with Matlab (The MathWorks™) on top of them.

RESULTS

Rock is sparsely jointed, but the joints are persistent. Many vertical and some horizontal joints can be followed approximately 25 meters in the highest rock wall at the back of the quarry. Mean joint orientations, according to a 25 meter scanline mapping on the quarry's wall, are 321/88, 282/82, 217/75, 040/41, 268/43 and 085/14 (Fig. 1).

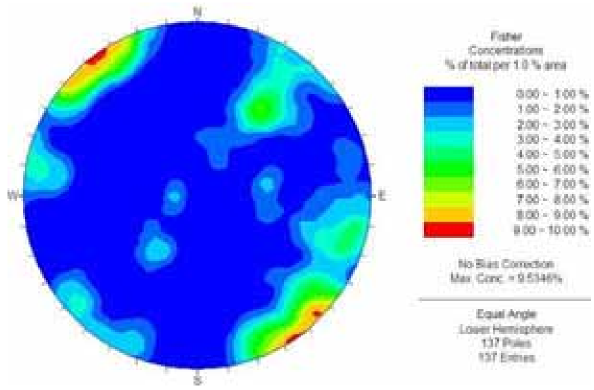

Figure 1 – Joint orientations recorded in a 25 meter scanline mapping at the quarry's wall.

The part of the quarry seen in Fig. 2 was selected to this presentation because of its homogeneity of rock type. The vertical joints in Fig. 1 are slicken slides with hematite cover.

Figure 2 – An example of the walls in the dimension stone quarry. The wall was mapped and photographed.

The stereophotograph analysis gave orientations for the planes fit to the joint seen on the wall (Fig. 3). Orientation of the blue and orange jointing is 110/33 without the short fracture at the upper left corner (006/60) and red jointing is 306/49.

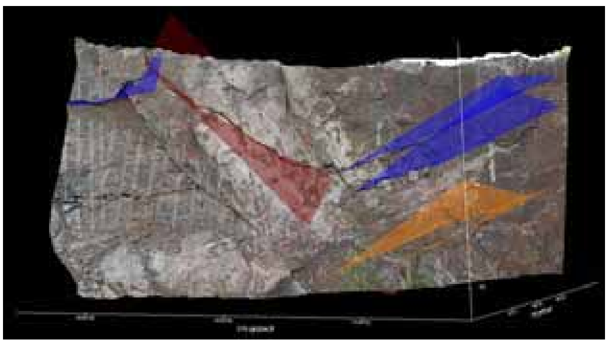

Figure 3 – The joint planes interpreted from the stereophotographs with SiroJoint.

The GPR sections were processed with a sequence of filters before they could be interpreted. Fist filter moved the first arrivals of radar signal to the origin of the time axis. Then the DC component was removed from each trace along a section. After that a gain function filter was applied to the data to strengthen the deeper weak signals. In some cases also a filter removing background noise was utilized. Travelling speed of the signal in rock was postulated to be 0.13m/s. The open joints (see Fig. 2) were seen as strong reflectors (Fig. 4). Reflections were recorded from depth of 6 meters, the same as the approximate wall height.

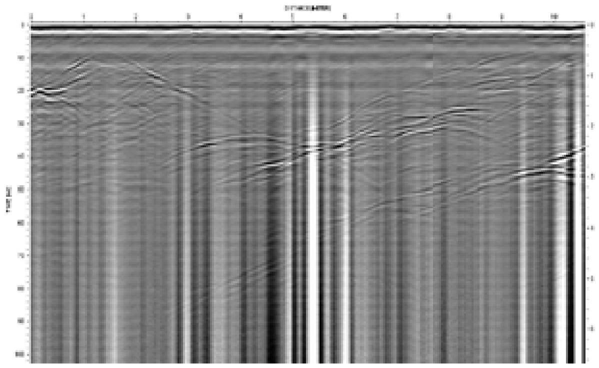

Figure 4 – A processed GPR measurement line of the wall seen in Fig. 1.

The reflections seen in the GPR profiles were interpreted as jointing, and their global coordinates were calculated to able 3D-visualization (Fig. 5). The reflections were distributed based on their orientation, how strong and straight they were.

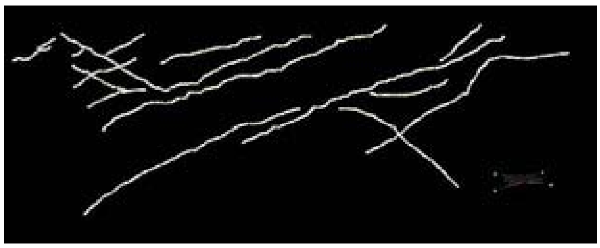

Figure 5 – Joints interpreted from the GPR measurement line seen in Fig. 3. Traces are converted into 3D objects.

The reflections with similar characteristics were combined with GoCAD to form a surface with distinct colour to depict reflection's characteristics (Fig. 6). Mean orientation of the blue (undulating) and orange (straight) jointing is 055/25 and the lilac jointing is 193/35.

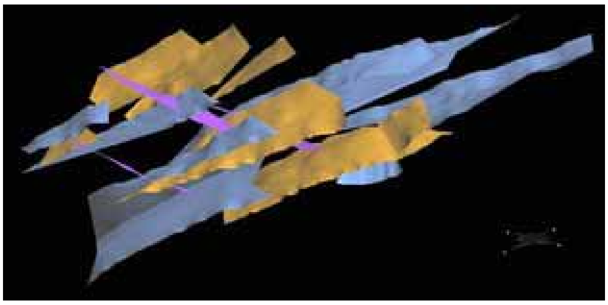

Figure 6 – 3D joint surfaces were created by connecting similar strings seen on adjacent GPR profiles. The jointing in Figure 1 can be seen here in 3D.

A 10 cm resolution voxel was created into the space between the two GPR lines closest to the rock wall. Rock tunneling quality index parameter J_v, number of joints in a cubic meter of rock mass, was calculated in the voxels (Fig. 7).

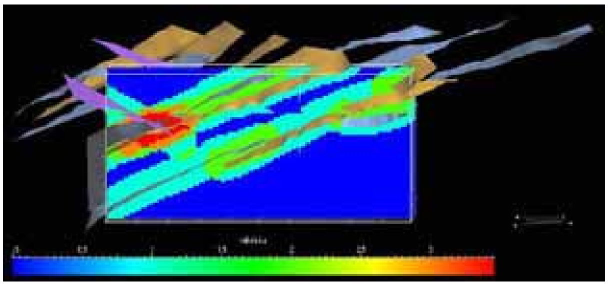

Figure 7 – Number of joints in a cubic meter in the rock mass between the two GPR lines closest to the rock wall.

Rock quality designation (RQD) value was counted from the J_v with formula $RQD=115-3.3*J_v$ (Fig. 8).

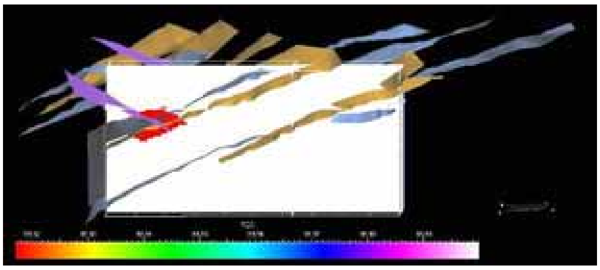

Figure 8 – RQD counted from Q-parameter J_v.

The 3D rock quality map will be completed with the information of trace length, aperture, alteration, roughness, fracture fillings, joint straightness and number of joint sets.

CONCLUSIONS

Picking out the joint surfaces from stereophotographs and following the discontinuities deeper into the rock mass was successful with the SiroJoint and processed GPR data. These data was needed in the modelling and visualisation phase.

3D modelling of the discontinuities is handy with the sophisticated softwares available today. Geological judgement was needed in this phase.

Joint orientation given by the stereophotograph analysis with SiroVision and SiroJoint differ from the orientation measured from the surfaces created from the GPR observations. Reason for this can be that the undulating fractures follow the structures caused by strain history. Planar features interpreted by SiroJoint differ from the real undulating rock discontinuity surfaces. The planar plane has to be fitted to the mean orientation of an undulating surface, otherwise the deviation may increase with a large dimensions of the feature.

ACKNOWLEDGEMENTS

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DATA BASE ELABORATION FOR GEOTECHNICAL MAPS IN OUED SMAR AND BABEZZOUAR (ALGIERS)

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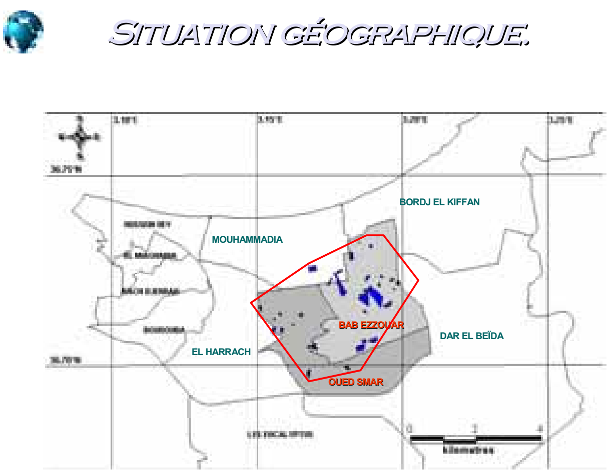
INTRODUCTION

Large cities in Algeria have encountered a very accelerated urbanization pace, from 25% in 1966 to 60% in 1977. From the seventies, to solve this problem, the state launched a program for new habitation zones (ZUHN). In the case of Algiers city, the 1975 general orientation plan (POG) was approved and the development was toward the east rather than the west for economic and accessibility reasons, which took place up to now. Urban development needed numerous geological and geotechnical investigations to better understand and define stability of construction project in time. These investigations brought a large amount of data that were piled up in archive rooms. To integrate these data in a geological information system (GIS) become a must, according to its storage capacity and treatment and extraction of useful information.

GEOGRAPHIC LOCATION

The study area is about the two neighbouring communes of Bab Ezzouar and Oued Smar, located 10 km east of Algiers city.



TOPOGRAPHY

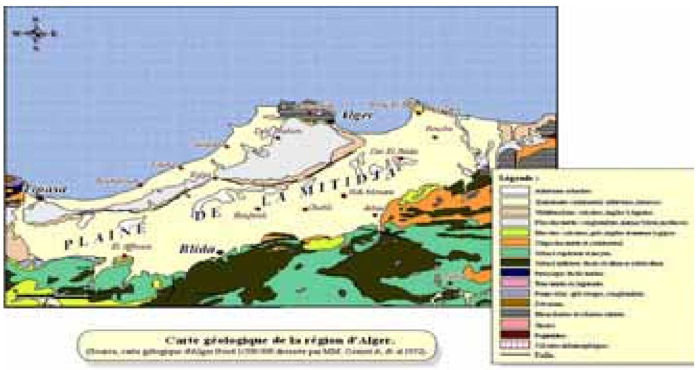
The area is relatively flat with low altitude from 3 to 46m and smooth slope less than 13°. The numerical terrain model emphasises two morphological zones :

- An elevated zone with hill slopes
- A depression with flat bottom

GEOLOGICAL ASPECT

The Mitidja plain is a depression oriented ENE-WSW, located in the central northern Tellian Atlas. It is limited to the west by Chenoua mountains, to the east by Thenia-Zemmouri piedmont. The Blideean Atlas is its meridional boarder and its septentrional boarder is a relatively elevated littoralregion named Sahel. It's highest elevation reachs 250m southwest of Bouharoun and 60m in Heraoua region. The geomorphological structures in the region are:

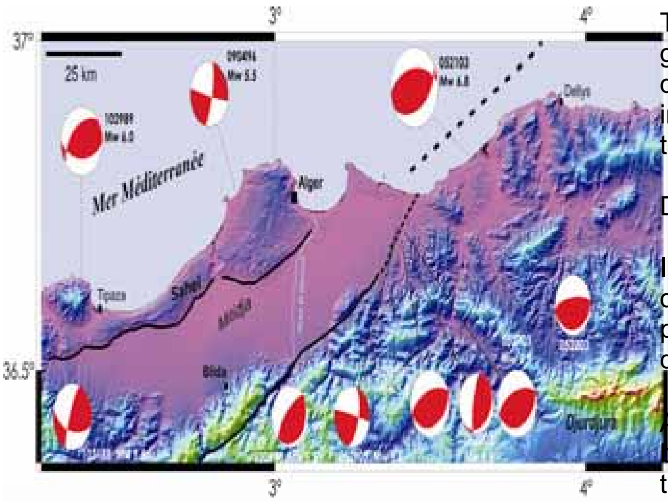
- The Blidean Atlas, a massive mountain
- The Piedmont Atlas, a dejection zone resulting from dynamic mountains erosion
- The Mitidja basin, a syncline depression oriented ENE-WSW
- The Sahel, an anticline also oriented ENE-WSW with 250m average height



SISMOTECTONIC STUDY OF ALGIER'S REGION

Seismological investigations showed that some Alpine structure, like Sahel and Blidean Atlas, were the source of numerous geological events very close to the seismic region. Meanwhile, some shocks were strongly felt in Algiers and Blida whereas their focuses were located at the Mediterranean sea.

SEISMOTECTONIC CHARACTERISTICS



Carte sismotectonique de la région de la Mitidja (Meghraoui, 1988).
Les mécanismes au foyer des séismes (Mw > 5.5) sont extraits des CMT - Harvard.
La faille du séisme de Zemmouri 2003 (Mw 6.8) est représentée en mer en fonction du soulèvement côtier (Meghraoui et al; 2004).

Seismotectonic map analysis of Algiers region show that special distribution of focuses linked to contemporary seismic activity matched perfectly faulting zone (seismotectonic map). We note in this region two zones with intense activity: Mitidja zone and Blidean Atlas zone.

GEOTECHNICAL CHARACTERISTICS

The geotechnical tests analysis as well as the lithologic, seismotectonic, hydrologic and hydrogeologic parameters are taken into account for geotechnical map elaboration including the different combined thematic maps, namely slope maps, surface formation maps and flood maps. All these maps lead to divide the study area in different distinct zones, with their common characteristics and according to their degree of stability. The final document is the geotechnical zoning map.

DATA BASE CONCEPTION

During the data base elaboration, we followed all the classical procedure, from data collection to its complete treatment in the geotechnical mapping data collection. The operation of collecting data was realized in the main office and in the national laboratory for housing and construction (LNHC). We treated all files concerning our study zone, and selected 40 projects for our data base. We had 130 borings, 250 heavy dynamic penetrometers, 136 heavy static penetrometers, 54 pressiometers and 209 samples.

ELABORATION OF BEZ/OS DATA BASE

The procedure requires a scanning and a georeference in the field of all mass plans of different projects (boring distribution plans and insitu tests). Then we needed to implement on site tests and different borings for each project.

DATA TREATMENT

In our data base, we have two different type of data: descriptive data that is lithologic nature, project name, location, name of engineer, and quantitative data that are value of W, γ_d, S_r, R_p, E/P_l

All these data are registered and organized in bidimensionnal table where columns correspond to different entities called recordings. We also have different requests, simple or multiple, special or on special. For multiple requests, for example, they are carried in a number of tables at the same time : determine the lithologic nature of all borings at 5m depth. For this request, the table used are BORING and LITHO-SOND.

LOCAL GEOLOGY

Geological information encountered belongs to the Mitidja neogen filling basin. They are generally recent alluvial formations presenting a great heterogeneity in the time and space. To present a geological synthesis of our study zone, we choosed the realisation of lithological maps at different depths, in order to show the horizontal and vertical evolution of existing surface formations. No need to mention that our study area was subdivided in two zones:

Zone I: Bab Ezzouar commune
Zone II: Oued Smar commune

The whole area presents a high lithologic heterogeneity. This facies diversity is due to the morphological aspect of the region, as a subsiding basin and fill. The main facies encountered are :

- Sands (thin to coarse sand with clay)
- Clays (sandy to gravel clays and carbonate clays)
- Sandy marls (in zone II)

GEOTECHNICAL SYNTHSIS

The heterogeneity of the formation lead to built a geotechnical synthesis from data base considering physico-mecanical parameters of formation and in situ tests results.

PENETROMETER MAPS

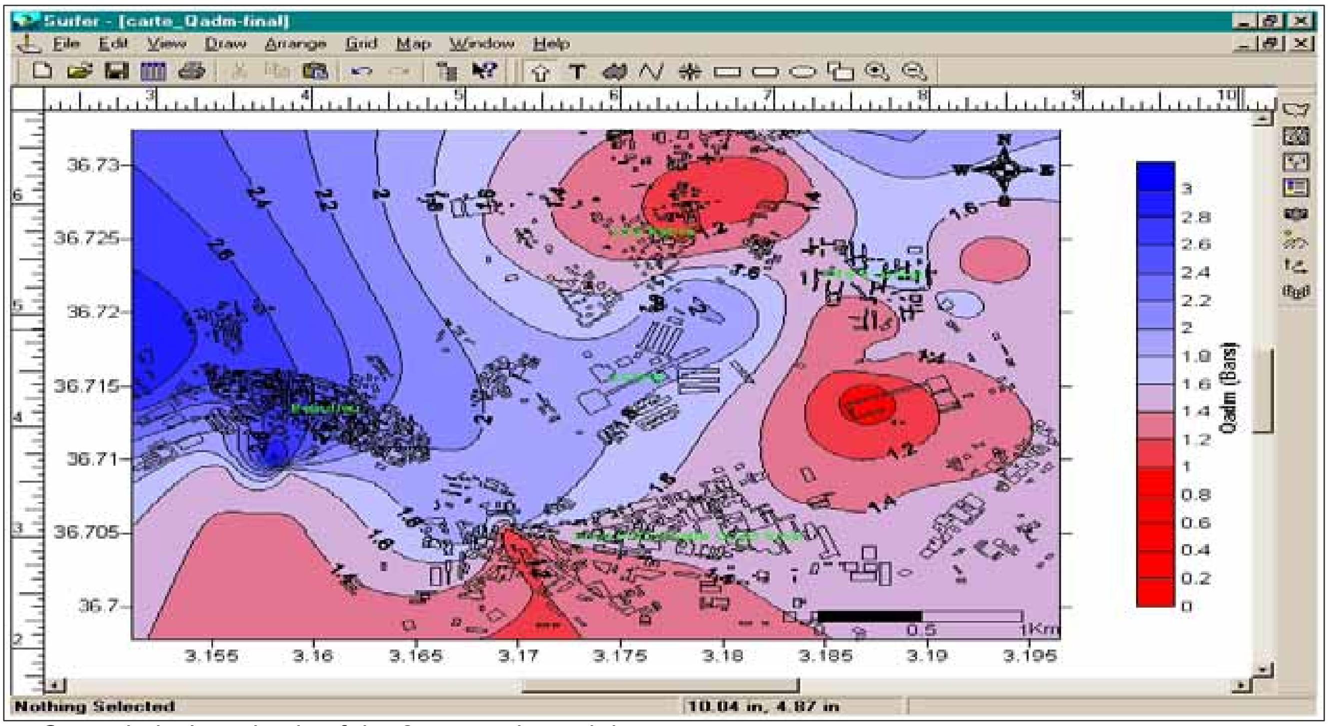
They were realized in order to see vertical and horizontal evolution of soils penetrometer-resistance and understand the relation between this characteristic and the lithologic formation. These maps were realized at different depths (up to 12m) by interpolation using surfer 7.0. -

CONCLUSION

Geotechnical synthesis of the 2 zones showed that our area was essentially:

Clayey formations presenting mediocre geotechnical characteristics (very plastic, compressible inflating soils, with organic matters) and weak bearing capacity lowering with depth.

Sandy formations with good to average geotechnical characteristics. These formations are generally of lenticular aspect with very good bearing capacity even at shallow depth.



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INTEGRATED ENVIRONMENTAL SPATIAL INFORMATION SYSTEM (IESIS)

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KEY WORDS: 3D geological model, spatial planning, resource management, local authorities.

INTRODUCTION

Until now local authorities in Poland, who are responsible for spatial planning at the scale of counties and communes, use a 2- and 2.5-D GIS system describing surface information (land use, infrastructure etc.). They still lack an efficient, digital tool integrating subsurface geology with surface information, which would allow them to make faster and much better informed decisions.

Integrated Environmental Spatial Information System (ESIS) is an answer to these needs. Except currently used surface information layers (infrastructure, land use, resources and planning) (Nita et al., 2004, Werner, 1992) it includes a true 3-D geologic model down to 30 m below terrain level (Fig. 1). Thus it describes geology most relevant to local spatial planning (30 m is a depth of infrastructure impact, the majority of resources is located in this zone etc.). Open architecture of the system allows to adjust it to the needs of users.

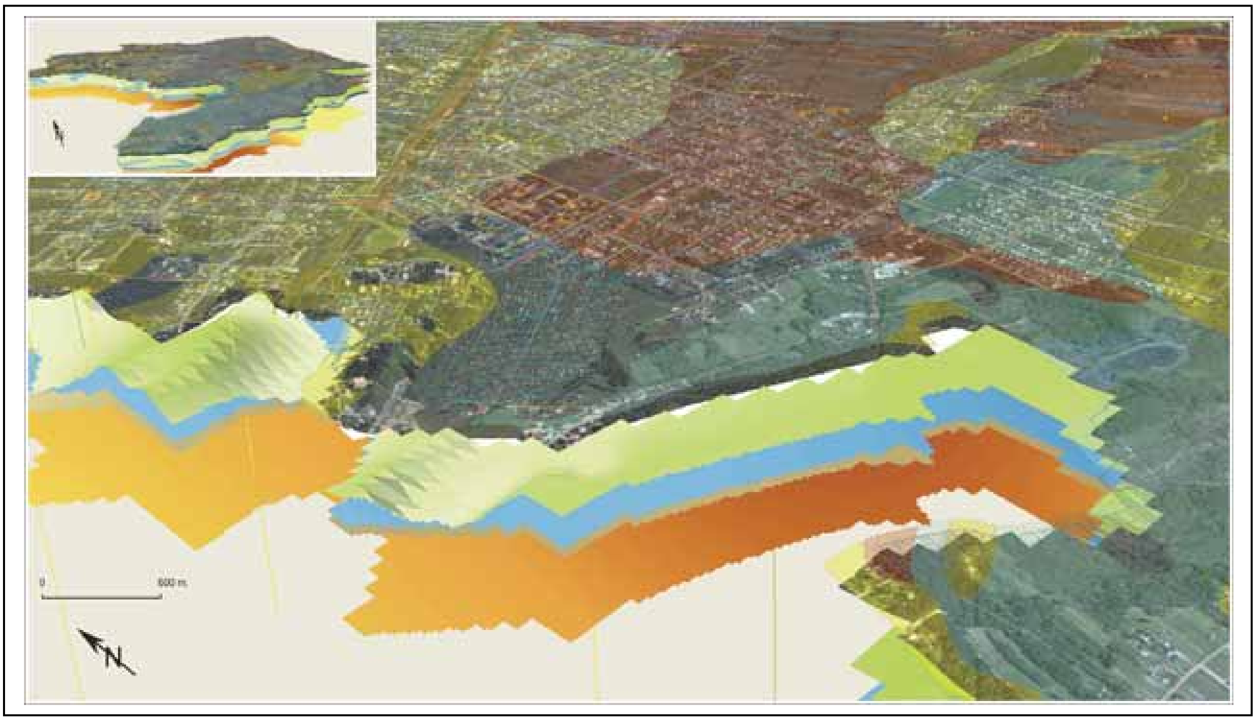

Figure 1 – Geological layers, groundwater table and surface infrastructure of Wołomin commune (visualization – ArcScene ArcGIS).

METHODS

IESIS extends currently used 2D system to third dimension by including a true 3D geologic model as well as by allowing to place subsurface information currently shown as 2D maps (mineral resources mining infrastructure, groundwater resources etc.) in true 3D context. Existing raw (borehole logs, outcrop descriptions etc.) and interpreted (maps and cross-sections) data were used for geologic model construction. Original lithologic units in raw data were grouped so that the output model (Fig. 2) includes nine generalised units and main groundwater table.

Two open-source software systems were used to construct geologic model layers: Geographic Resources Analysis Support System (GRASS GIS, www.grass.itc.it, Neteler and

Mitasova, 2007), and Qgis (www.qgis.org, Sherman, 2007). Data were interpolated using Regular Splines with Tension (RST) method within GRASS GIS. Open-source software — GRASS-nviz and ParaView (www.paraview.org) — and proprietary applications ArcGIS (www.esri.com) and Gocad (www.gocad.org) were used for visualisations. Impact analyses (see below) were done with CommunityViz (Decewicz, 2006) software.

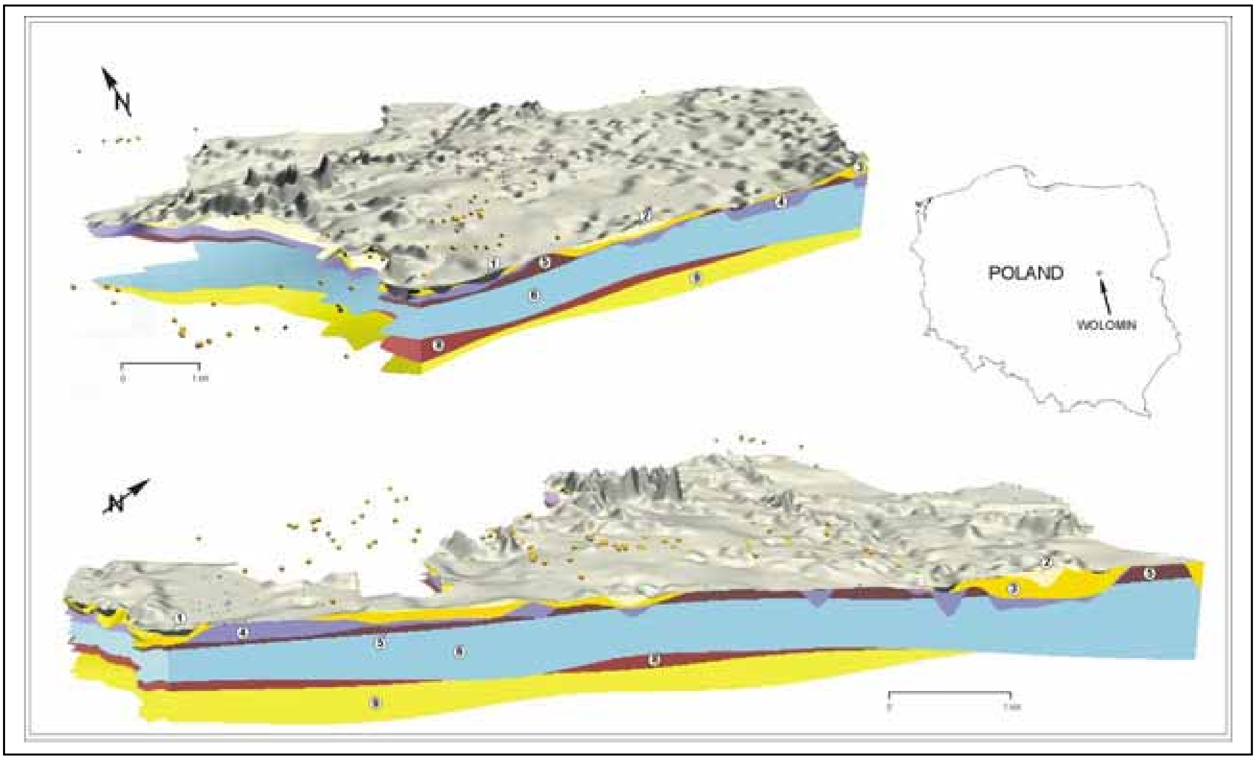

Figure 2 – Fragment of the Digital Spatial 3D Model of Geological Structure of the Wołomin commune, visualization in GRASS-nviz – vertical scale is 30x horizontal scale. (1) peats, (2) eolic sands, (3) upper sands, (4) upper clays, (5) upper tills, (6) middle sands, (8) middle tills, (9) lower sands.

APPLICATION OF IESIS

Advantages of IESIS become clear when it is used for impact analyses. An example of such analysis is a waste dump site location study. Data used for this analysis included the following:

- geologic unit permeability,
- roads and urbanised land location,
- cost-effectivenes of particular solutions.

Combining these data within IESIS permits very fast decision making, as feasibility and exploitation costs at available locations can be calculated with a few mouse clicks.

IESIS can also be applied to natural resource monitoring and management e.g., groundwater pollution monitoring or (near instantaneous) estimation of available resources in current and prospective mining sites.

Another important usage is geohazard evaluation, including floods and landslide risk. Mitigation and remediation strategies become easier to formulate, what leads to saving of lives and property.

IESIS has been devised to aid local authorities in decision-making processes, especially in spatial planning activities. These activities include assessment of mineral reserves, natural resources monitoring and geohazard evaluation.

IESIS may however also be used by general public, as true 3D geoinformation describes all available data without need to reduce spatial knowledge to 2D maps. As such it is much more understandable for non-specialists. Hence these data can be used by investors and stakeholders for both knowledge acquisition and business development.

CONCLUSIONS

Combining geologic, infrastructure and planning data in IESIS allows to:

- simultaneous viewing of all available spatial data, what facilitates interpretation of these data thus improving quality of results

- instantaneous updating of documentation when new data is acquired,
- outstanding improvement in multivariate calculation results.

All these save huge amount of time, effort and money, allowing to better manage available resources, mitigate geohazards more efficiently, and make better informed planning decisions.

Last but not least, IESIS has been developed in open-source software, what allows unconstrained usage adapted to every local authority preference and possibilities. We propose user-friendly, free QGis tool, to be a basic platform for management, edition and export of data, and CommunityViz for impact analyses.

ACKNOWLEDGEMENTS

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GROUNDWATER FOR THE FUTURE. THE HYDROGEOLOGICAL MAP OF CATALONIA 1:25.000.

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KEY WORDS: Groundwater, hydrogeological database and maps, Vulnerability maps.

INTRODUCTION

The Geological Institute of Catalonia (IGC) is a public entity of the Catalonian government created for the study, research and compilation of information of the ground and underground characteristics and conditions of the Catalonian territory.
One of the main IGC competences is the generation of geothematic maps at 1:25 000 scale. The hydrogeological map is part of the geological database. The main IGC's objective is to generate a clear map displaying of hydrogeological data. Nevertheless, IGC is not the main water management agency). The institution in charge of the water policies in an integral way to manage and plan the whole water cycle in order to maintain ecosystems equilibrium is the Catalan Water Agency (ACA). The IGC hydrogeological database and maps are based in information from different institutions, and the main source of the information is ACA database on the complete cycle of water complemented with other sources and own specific fieldwork. Consequently, both institutions, IGC and ACA are implicated in the generation of the hydrogeological map of Catalonia.

THE HYDROGEOLOGICAL MAP OF CATALONIA

The hydrogeological map of Catalonia is GIS-based. It represents all those characteristics and phenomena related with the groundwater and surface water relative to the rock-water relationship as a system in which the variables change.
The influence of atmospheric and anthropic aspects is also represented adding a degree of complexity to the maps. Considered phenomena are exploitation volumes, water quality, geodynamic processes and environmental protection.
Other sources of point type of information that are included in the map are water quality and measurements data from Catalonian Water Agency, Hydrographical Confederation of Ebre River (CHE), Geological Institute of Spain(IGME), Spanish Mines Bureau, and others from the municipalities.
The main reason to generate a map at 1:25000 scale is the existence of a geological and topographic maps of quality at the same scale. Cartographic elements and map legend is based in Struckmeier and Margat(1995), and Vrba and Zaporozec (1994) guidelines.
The map is divided in three levels of information that combined among them allow to generate graphically the different hydrogeological aspects:

1 Hydrogeological structure (aquifer thicknes, depth, extent, etc)
2 Ground water dynamics Data (water table depth, extraction points, etc.)
3 Water quality data

MAIN MAP

The main map will be a 1:25 000 scale where some intrinsic and variable characteristics related with the cycle of the water will be represented.
Firstly, a relation is established between lithology and permeability (Figure 1). The criterion is deduced from geological data base, pumping tests and bibliography information.

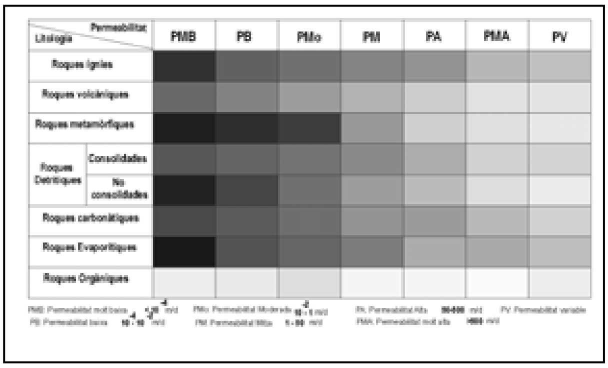

Figure 1: Table of rank of permeability versus lithology

The hydrogeological formations and their extent (aquifers and impermeable units) are taken from ACA definition. Modifications to their extent are

made on the basis of geological units from the geological map.
Hydrological surface elements are extracted from topographic maps to establish aquifer relationships: flow data (maximums and minimums), calculation of river basin area, presence and quantities of irrigation, and presence of dams and lakes.
The piezometric surface morphology and evolution is characterized on the ACA information and represented in the map. The ACA provides all the information on aspects such extractions, artificial reload, regenerated waters, hydraulic barriers, etc., to characterize water levels, Figure 2.

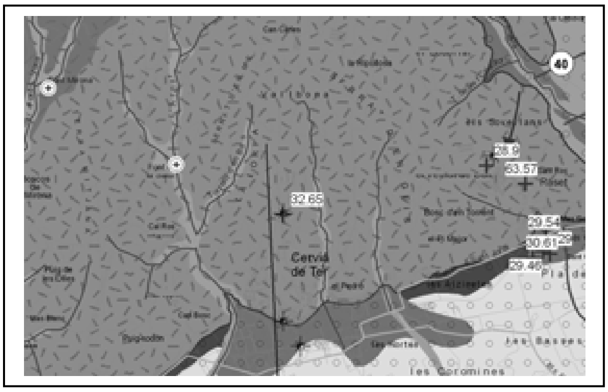

Figure 2: Portion of hydrogeological map showing piezometry, permeability, surface water information, aquifers, etc.

The Catalan Water Agency's monitoring network for groundwater consists of 405 groundwater points that are taken on a monthly basis. Series dating back over 30 years are available for more than 300 of these points. In order to complete the network and adapt it to the criteria of the European Water Framework Directive (WFD), a total of 160 new water level points with a total forecast perforation length of approximately 13,000 m are under construction.

COMPLEMENTARY MAPS

Hidrogeochemical map

The base of the map will be a conversion of geological units to geochemical units. Data from four monitoring quality control and piezometric networks will be incorporate in this map and database.
Two maps will be developed:
Maps that show the intrusion of saline water and its time evolution.
Maps showing the different types of water according to the ionic content (Evolution graphics will be presented associated to this maps, see Figure 3).

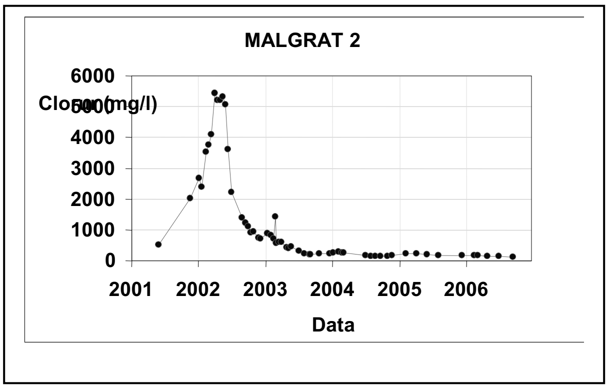

Figure 3: Chlorides at the Tordera deep aquifer (Niñerola and Ortuño, 2008)

Porosity type map

The porosity map is based on the conversion of geological to porosity units. The criterion for conversion is based on the geological data base and bibliography information (see Figure 4).

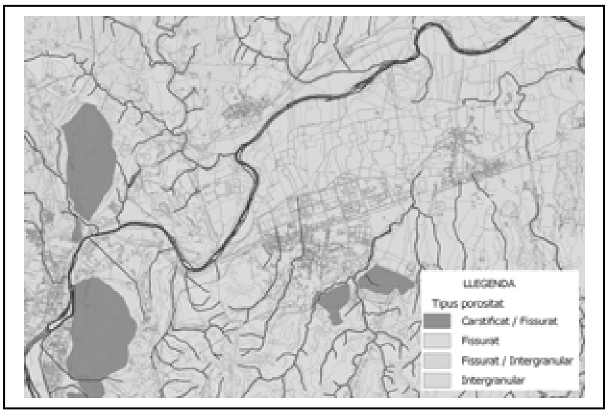

Figure 4: Map of porosity type of Sarrià de Ter.

Vulnerability map

The WFD states that prevention and protection criteria must be coherent with all legislation concerning nutrients, and in particular with European Directive 91/676/EEC concerning on the protection of waters against pollution caused by nitrates from agricultural sources (definition of vulnerable zones).
Nitrates and pesticides are the only substances with concentrations that are subject to quality regulations.
The Catalan Water Agency's pesticides operational control network has 88 control points with a six-monthly testing frequency. The Pesticide monitoring and control plan came into operation in 2007, in compliance with Article 8 of the Water Framework Directive.

The Catalan Water Agency's nitrates operational control network has 765 control points with a six-month testing frequency and has 694 control points with an annual testing frequency.
Once the bodies of water were defined, the stressing aspects affecting them were analysed. Stress is understood as the potential of those human activities that may affect the flow or the chemical composition of groundwater. The main stressing aspects affecting the groundwater bodies in Catalonia are those listed in Table 1.

Affection to the state	**Kind of stressing aspects**	**Pressure**
Chemical	Local	Industrial spills
		Waste disposal
		Construction and demolition waste
		Contaminated soils
		Waste Water Treatment Plant
		Tip mining
		Buried tanks
	Diffuse	Application of livestock manure
		Fertilisation practices
		Returns of irrigation
		Sewage system
		Pipe lines

Table 1: Main pressures affecting the groundwater in Catalonia (Niñerola and Ortuño, 2008)

Aquifers intrinsic vulnerability to pollution by nitrates and/or pesticides is evaluated. The map is generated by the parameter weithging method DRASTIC (Aller et al., 1987) (see figure 5).

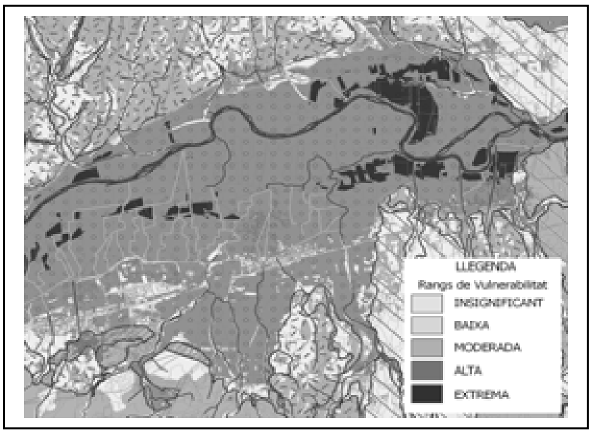

Figure 5: Map vulnerability against Nitrates of Sarrià de Ter.

OTHER COMPLEMENTARY ELEMENTS

The map also represents the groundwater particularities in chemical composition or temperature, or the conceptual hydrogeologic functioning model. It is represented showing geometry and relationships between aquifers (see figure 6).

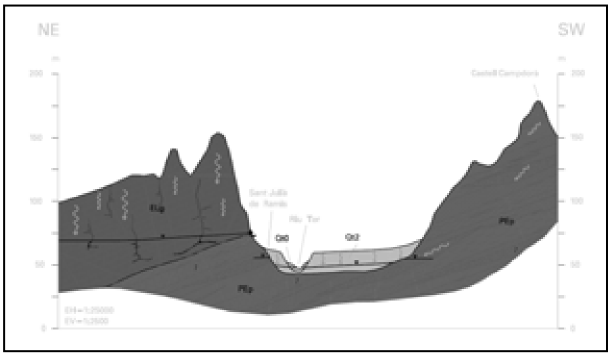

Figure 6: Hydrogeology system functioning sketch.

Climatology aspects will be represented in the map as rainfall distribution, thermal regime, and its influence in evaporation.

CONCLUSIONS

The hydrogeologic data of Catalonia will be incorporated and systematized within a GIS and associated data base, in a way that new data and information will be updated and changed easily for the map not to lose validity through time.
The hydrogeological map of Catalonia is generated to become the management tool of groundwater and surface water in Catalonia.

ACKNOWLEDGEMENT

We are grateful to Aline Concha for their suggestions.

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VISUALIZING GEOLOGICAL DATA AND MANAGING QUALITY IN PRINTED GEOLOGICAL MAPS AT THE BAVARIAN ENVIRONMENT AGENCY (LFU)

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KEY WORDS: geological symbolization, quality standard of printed maps

INTRODUCTION

Geological maps belong to the most complex and pretentious maps referring to their content. So the demands on the cartographic representation of geological phenomena are very high. It is a great challenge for the cartography of the Bavarian Environment Agency (LfU) to visualize the results of geological fieldwork on a map adequately.

The basic geological map series of LfU is the Geological Map 1:25 000 of Bavaria (GK25). Due to the large scale many details of the geological survey can be mapped. The underlying base map is the Topographical Map 1:25 000, provided by the Bavarian Agency for Surveying and Geographic Information. This base map is the reference and offers the connection between the geological objects and the topographical information such as relief, water and traffic networks, settlements etc.

The quality of the finished GK25 depends on the knowledge and the experience of the involved geologists and cartographers as well as on the mutual communication and coordination. The pre-condition for a successful presentation of geo-objects within the map is an intensive interdisciplinary cooperation of the geological author of the map sheet and the geological and cartographical editorial staff.

THE PROCESS OF CARTOGRAPHICAL SYMBOLISATION OF THE GK25

The process scheme gives an overview of the parameters that are important for the creation of cartographic symbols for geologic phenomena (Figure 1).

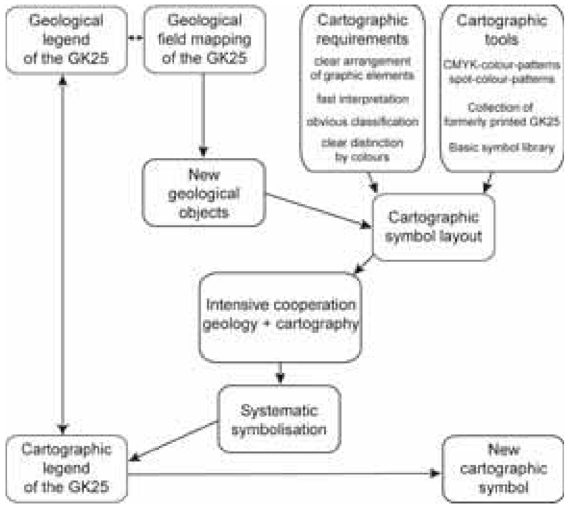

Figure 1 – The Process of Cartographic Symbolisation

The geological legend is the thematic base for all map symbols of the GK25 (Figure 2). It is fundamental for the geological field work and provides an obligatory guideline for the acquisition of geological objects and their cartographical representation. The geological legend still is in a state of systematic organisation. At the time it consists of about 2,500 objects. Since so far only around 55 % of the Bavarian map sheets have been covered by geologic maps at a scale of 1:25.000, it is expected that the number of geological units will increase far beyond the 2.500 geological objects. Its basic elements are the legend unit and the associate abbreviation. The latter provides the key item of geometric and attribute data within the geographical information system (GIS). Furthermore it involves the join for the cartographical symbolisation of polygon, line and point objects.

Chronostratigr. Einstufung von	bis	Legendeneinheit (Langtext)	Erläuternder Zusatz	Kürzel
		Variszisches Grundgebirge		
		Variszische Magmatite		
		Ganggesteine		
c	p	Pegmatit	z.T. mit bis 2 cm großen Muscoviten, z.T. mit Schörl	OW,Pe
c	p	Pegmatit-Einschaltung		+E*Pe
		Plutonite		
c	p	Granit, fein- bis mittelkörnig	Biotit überwiegt gegenüber Muscovit; z.T. porphyrisch mit bis 2 cm großen Feldspat-Einsprenglingen; z.T. Fließregelung, z.T. deformiert	OW,Grfm
c	p	Einschaltung von Granit, fein- bis mittelkörnig		+E*Grfm
c	p	Granit, fein- bis mittelkörnig mit Schollen von diatektischem Gneis		OW,Grfm* Gndx

Figure 2 – Extract of the geological legend of the GK25 map sheet 6741 Cham West.

The following tools provide a systematic cartographic conversion of geo-objects:

- CMYK-colour-pattern:
  The consistent colour-standard of GK25 previously printed with spot colours should be sustained after a far-reaching change to CMYK-colours (Cyan, Magenta, Yellow, Key-Black). For this purpose a reference book with CMYK-colour-patterns has been designed. It was printed on the same special map paper and under the same conditions as the production print of GK25.
- Collection of printed GK25:
  A collection of all previously printed GK25 offers a fast overview of all existing geological units. It is the base for a consistent and systematic symbolisation of new geological objects.
- Basic symbol library:
  All basic symbols of the various object types (polygon, line and point symbols) are stored within a central symbol library that offers shared access for all cartographers. The basic symbols are invariable and clearly defined by their symbol number (Figure 3). They are the base for complex symbols that are stored within one special symbol set for every map sheet.

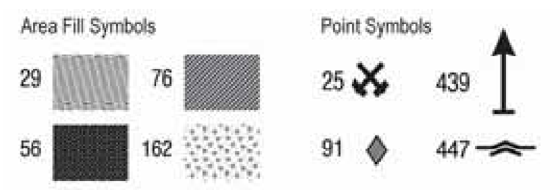

Figure 3 – Some symbols of the basic symbol library created by LfU-cartography.

Subsequently, the essential requirements on cartographic symbolisation are specified:

- The map should be clearly arranged and readable.
- It should allow a fast interpretation and a clear classification of all map objects.
- Symbols should be obviously different referring to their colours and patterns.

According to these requirements the cartographic symbolisation of geological objects has to consider some important parameters:

- The basic color of geological area units should immediately provide the chrono-stratigraphic classification for the user of the map.
- The function of structural patterns is to point out special characteristics of geology like granularity, stratification, mineral components etc.
- Hatches are mainly used to represent strata laying over basic geological units. They must clearly differ from the underlying color and topographic objects (Figure 4).
- The topographic information shoud remain visible even under dark colors.
- The abbreviation for the geologic unit should provide the clear allocation of the labelled objects.

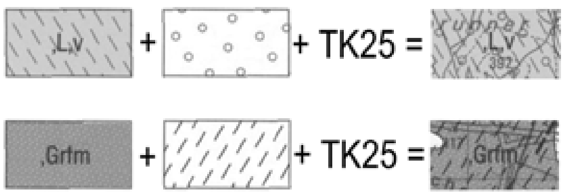

Figure 4 – Samples for the cartographic symbolisation of geologic objects
Above: weathering loam with overlying gravel and topography
Below: Fine- to medium-grained granites, partially weathered, and topography

Considering the graphic features noted above the cartographic legend (Figure 5) is derived from the geological legend. It specifies exactly all graphic attributes to symbolise geological objects:

Kurzel	Anno-tation	Legendeneinheit (Langtext)	Farbe und Rasterwinklung / Erläuternder Zusatz (Langtext)	Cyan 15°	Magenta 75°	Gelb 0°	Schwarz 45°	1. Rot 45°	Grün 75°	Violett 45°
		Variszische Magmatite								
		Ganggesteine								
OW,Pe	OW,Pe	Pegmatit	z.T. mit bis 2 cm großen Muscoviten, z.T. mit Schörl		75%			100%		
+E*Pe	Pe	Pegmatit-Einschaltung			M95 Füllung: 75%		M95 Kontur	M95 Füllung: 100%		
		Plutonite								
OW,Grfm	OW,Grfm	Granit, fein- bis mittelkörnig	Biotit überwiegt gegenüber Muscovit; z.T. porphyrisch mit bis 2 cm großen Feldspat-Einsprenglingen; z.T. Fließregelung; z.T. deformiert					170 Negativ + 40%		
+E*Grfm	Grfm	Einschaltung von Granit, fein- bis mittelkörnig					M423 Kontur	M423 Füllung: 100%		
OW,Grfm* Gndx	OW,Grfm...	Granit, fein- bis mittelkörnig mit Schollen von diatektischem Gneis		167 8%	167 40%	167 13%		170 Negativ + 40%		
,Gr	,Gr	Granit	überwiegend hellgrau; unterschiedlich stark (kataklastisch bis mylonitisch) deformierter Granit, z.T. mit dunkelgrauen Meso- bis Ultramyloniten					00%		
OW,Grmg	OW,Grmg	Granit, mittel- bis grobkörnig	meist rötlich, z.T. hellgrau, mittel- bis grobkörnig, z.T. feinkörnig; meist hydrothermal und kataklastisch überprägt					179 Negativ + 40%		
RW,Grg,po	RW,Grg,po	Granit, grobkörnig, porphyrisch ("Kristallgranit I")	mit bis 5 cm großen Kalifeldspat-Einsprenglingen					142 Negativ		
BW,Dr	BW,Dr	Diorit	grüngrau, fein- bis grobkörnig, massig; gangförmig	16%	4%				00%	
		Moldanubikum								
		Anatektische Gesteine								
M,Dx+Gr	M,Dx+Gr	Diatexit mit Einschaltungen von Granit						78/45° 2.Layer: 100%		78/45° 1.Layer: 40%

Figure 5 – Extract of the cartographic legend for the GK25 map sheet 6741 Cham West.

HIGH QUALITY PRINTING OF GEOLOGICAL MAPS

One has to note some critical aspects in order to get standardized plot copies of GK25 maps containing precise colour nuances:

- All installed plotting devices need to be calibrated with a colour management system in order to get approximately the same colour impression as on the printed offset map.
- The print settings for all plotters should be equal.
- The plot is carried out with standard colours on high quality paper.

The plot provides the final control of the GK25 for the responsible geologist. After finishing the last cartographic works the pre-press process starts (s oral presentation of M. Boedecker: “Leaving the ‘Unix-Ice-Floe’: The Migration of GIS-based Map Production from ArcInfo Workstation to ArcGIS 9.x”). Using a graphic programme the present workflow implies that vector data, EPS-files exported from GIS, are combined with transparent raster data that contain the base map TK25. Furthermore the title is integrated and all pre-print settings are performed like the over-printing of black elements. Finally the composite data is stored to a PDF using the appropriate PDF-settings.

The Raster Image Processor (RIP) manages the colour separation of the composite PDF to CMYK by means of an amplitude-modulated raster (AM) with high resolution (205 lines per inch or 80 lines per cm). Colour separated data are copied on printing films (computer to film). While processing the films the matching colour profile has to be applied to customise the following processes of copying printing plates and offset printing. Due to the high resolution delicate structures and fine hatches consisting of multiple colours can be reproduced without any visible aliasing.

Several control mechanisms are used to ensure high quality results during the offset printing of the GK25:

- The colour density of a colour bar on the edge of the sheet is measured by a densitometer in order to match the actually printed colours to pre-defined reference values.
- The precision of register marks is continuously controlled and the printing plates are adjusted if required.

The following requirements have to be considered to achieve high quality results during the offset printing of the GK25:

- The high quality standard of GK25-cartography has to be sustained when successive maps are printed.

Above all, the precise distinction of the colours of geological objects has to be regarded.
- Colours have to be printed consistently. While applying many different colour mixings of CMYK- and spot colours the same results have to be ensured compared to previously printed maps.
- Equal colour tones of neighbouring map sheets should match exactly.
- The colour tone of the GK25-title has to be kept constant (s. Poster 2: Components of a Geological Map, Figure 1 – 3)
- During the printing of up to 8 colours a very high precision of register has to be observed.

Formerly, the GK25 has been printed with spot colours only. Spot colours are printing colours which are mixed especially to reproduce a definite colour tone constantly. Each spot colour has to be printed separately, that is the GK25 has been printed with up to 18 colours. Yet another disadvantage is that spot colours can not be printed with the current CMYK-devices, that implies there is no way to get standardized plot or digital proof results. A hard proof running under the same conditions as the production print is inevitable to check the quality of spot colours. So the cartography of the LfU presently is giving up the use of spot colours as far as possible to ease the printing process and to reduce the costs of printing maps. The high quality standard of the previously printed GK25 with spot colours, that are 288 sheets out of 546 GK25 of Bavaria, however, should be retained even after most colours have been converted to CMYK-colours. By means of the CMYK-colour-patterns exact CMYK-colour tones could be defined for geological units that nearly match the original spot colours.

To check the quality of four-colour printing an identical sheet of the GK25 has been printed with CMYK-colours after it had been printed with spot colours (see the corresponding poster presentation).

Meanwhile, CMYK-printing provides very good results, so that most of the spot colours could be replaced by equivalent CMYK-colour mixings. To maintain its high quality standard the GK25 is printed with only few additional spot colours that could not be covered by four-colour printing: luminous purple, green or red tones.

PROSPECT

To match the increasing demands on the efficiency of map production, some processes of the GK25-workflow should be automatized. An important measure may be to store the geological legend in a shared data base. After the creation of the matching mapping symbols, this should ensure a permanent representation of geological units during the entire mapping process. Moreover, the data base should provide the automatic generation of the map legend. A team of cartographers and geologists of the LfU is working on this project. (see oral presentation of M. Boedecker: “Leaving the ‘Unix-Ice-Floe’: The Migration of GIS-based Map Production from ArcInfo Workstation to ArcGIS 9.x”).

CONTRIBUTION OF SEISMIC PROFILES, HISTORICAL MAPS, AND DIGITAL ELEVATION MODEL TO DEFINE BURIED GEOMORPHOLOGICAL FEATURES IN THE VENICE LAGOON SUBSOIL (ITALY)

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KEY WORDS: Venice Lagoon, geomorphology, paleochannels, paleo-coastlines.

INTRODUCTION

Recently, the integrated analysis of Very High Resolution Seismic (VHRS) profiles, satellite images, aerial photographs, maps, and topographic/bathymetric data has given an important contribution to the identification of buried geomorphological features in the Venice lagoon subsoil down to about 30 m b.s.l. (Figure 1). Investigations allow to attribute these features to the Late Pleistocene and the Holocene and to point out their relation with the evolution of the lagoon basin.

Results of this study are also assuming great importance in relation to coastal environmental problems. Relict sandy geomorphological features, characterized by high permeability, act as preferred pathways for groundwater flow and solute transport, enhancing saltwater intrusion in the watershed (Carbognin & Tosi, 2003; Carbognin et al., 2005; Pousa et al., 2007). Furthermore, salinization process can also trigger land subsidence induced by clayey particles rearrangement (Meade, 1964).

In addition, the different kinds of deposits that characterize geomorphological features are responsible for a differential lowering of the territory (Teatini et al., 2005).

MATERIALS AND METHODS

Aerial photograph and satellite image interpretations, analysis of historical and recent maps, field surveys, and topographic/bathymetric investigations were first used to identify the main buried and surface geomorphological features. Afterwards, an important contribution to the present study was given by a single channel VHR seismic system, optimized for surveys in shallow water less than 1 m depth (Brancolini et al., 2006; Brancolini et al., 2007).

Seismic profiles were calibrated and validated using geological information obtained from existing cores.

The detailed reconstruction of the seismic-morpho-stratigraphic units present in the subsoil of the Venice Lagoon is still in progress. It is obtained integrating results of the investigations previously described with sedimentological, stratigraphic, geotechnical, mineralogical, textural, and paleoenvironmental data, and ^{14}C dating (Serandrei Barbero et al., 2006; Tosi et al., 2007a; Tosi et al., 2007b).

RESULTS AND DISCUSSION

The combined interpretation of results obtained from remote sensing investigations, topographic/bathymetric measurements, VHRS surveys, and analysis of multidisciplinary geological data allowed the discovery and characterization of buried paleoriver beds, ancient tidal channels, and paleobeach ridges (Figure 2) and pointed out the relation among geomorphological features occurring in the lagoon basin and in the watershed.

In fact, most of the features recognized in the mainland, which apparently come to an end in correspondence to the lagoon margin, continue into the lagoon basin, where their identification is made difficult by the presence of water and by depositional/erosive processes active in this kind of environment.

Data show that relict geomorphological features composed of high permeability deposits provide the hydraulic connection between freshwater aquifers and the sea. In particular, results of the present study point out that well developed paleoriver systems, intersecting the southern lagoon margin and the nearby coastline and characterized by permeable sediments, represent preferential way of communication among waters having different salinity. By contrast thick silty-clayey layers preclude the salty pollution in the aquifers from the lagoon and the sea.

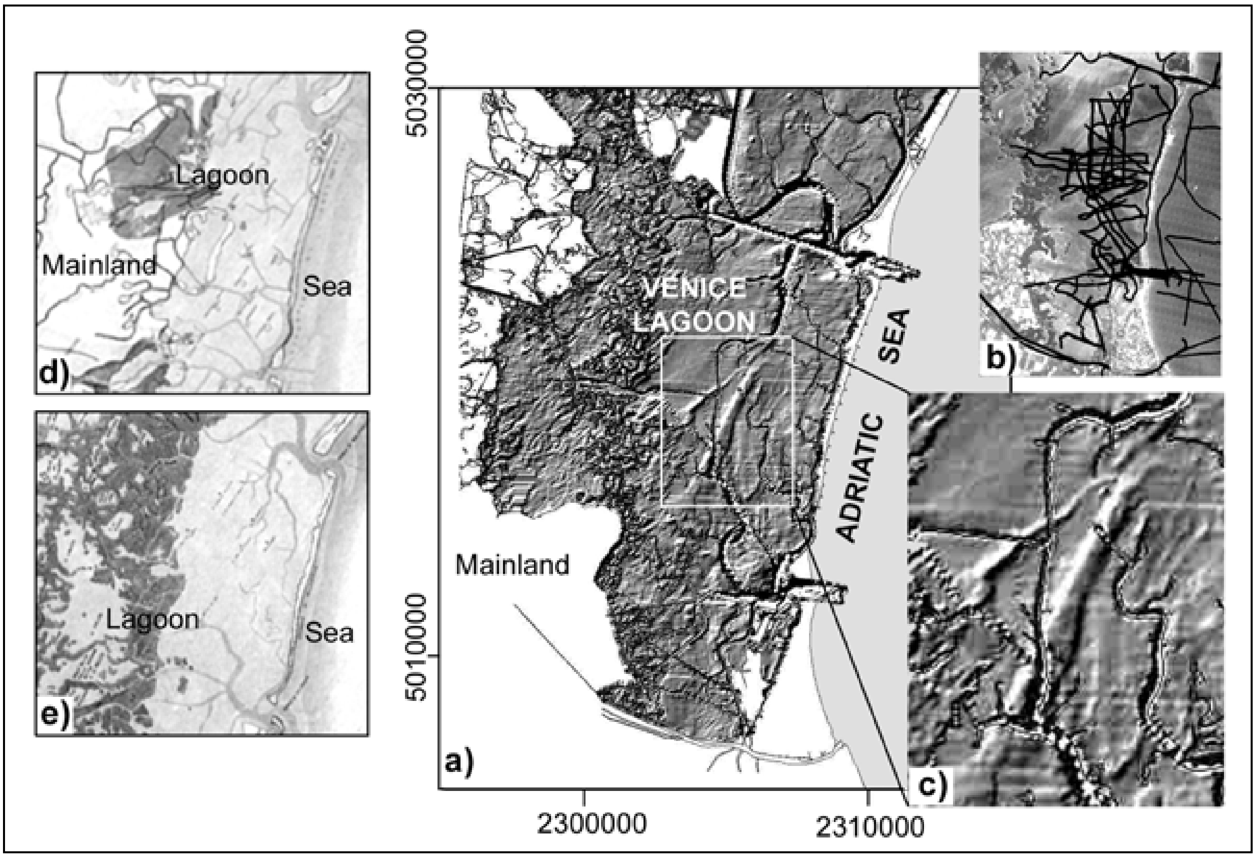

Figure 1 – Digital Elevation model (a) and network of seismic lines (b) carried out in the southern Venice Lagoon. An enlargement of the studied area, characterized by clear evidences of paleo-coastlines, is displayed in a separate window (c). The maps indicated as (d) and (e) represent the lagoon setting in 1556 and 1780, respectively.

As pointed out close to the lagoon margin (Rizzetto et al., 2003), the different kinds of deposits, related to the presence of distinct geomorphological features, contribute to the differential lowering of the lagoon basin (Teatini et al., 2005). In particular, organic soils correspond to highly sinking areas, whereas sandy-silty sediments, which constitute fluvial and beach ridges, are more stable.

Future investigations have to be addressed to the quantitative geomorphological analysis aimed to know the past hydrologic conditions of the drainage systems, and to analyze the formative processes that control the morphological setting and evolution of lowland fluvial river and tidal creek systems.

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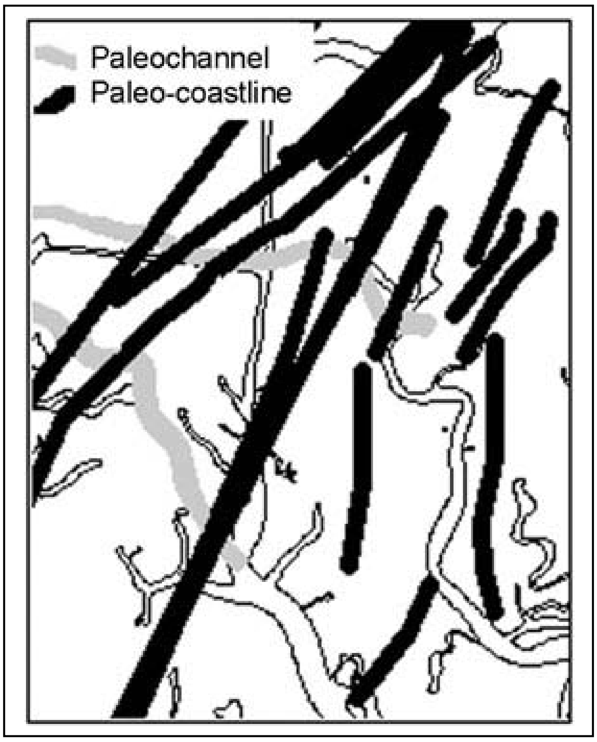

Figure 2 – Paleochannels and paleo-coastlines identified in the area of Figure 1c using multidisciplinary investigations.

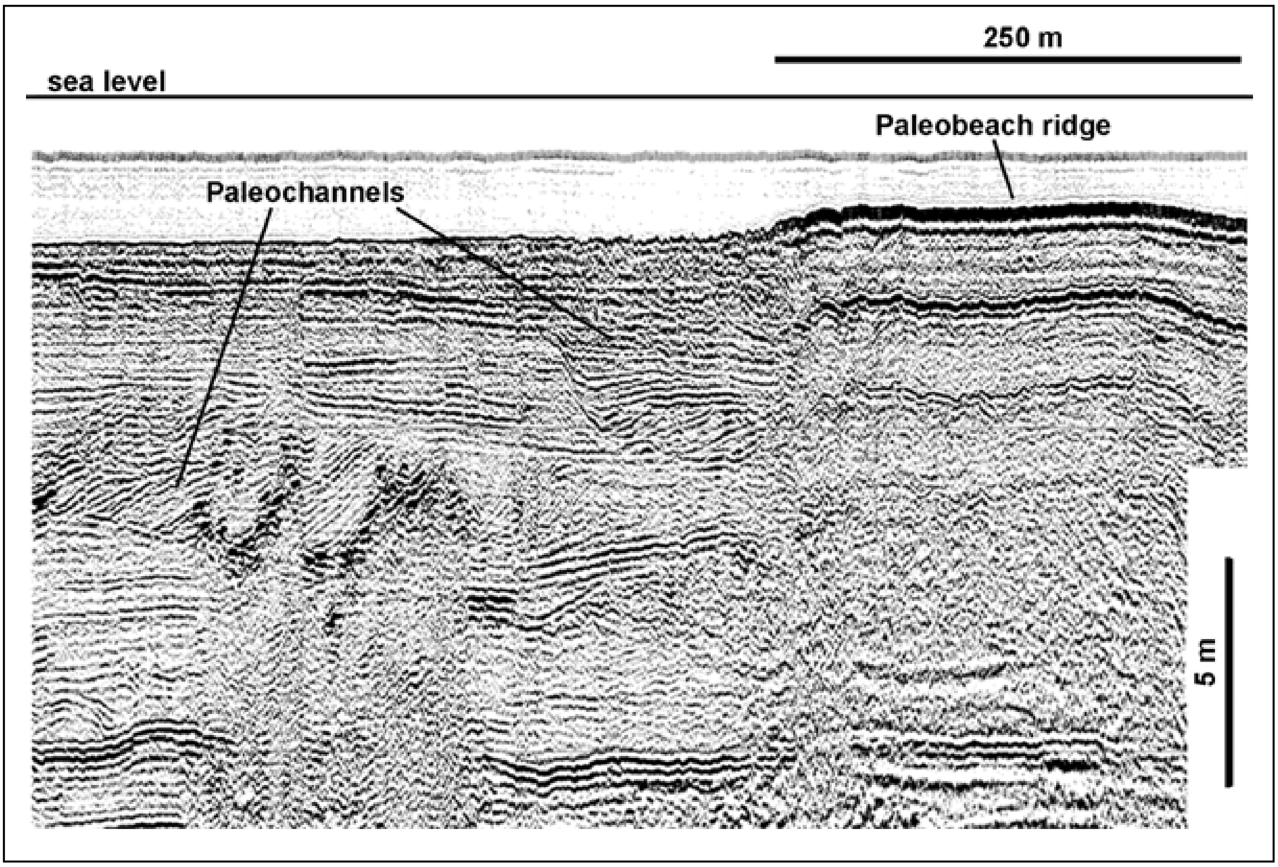

Figure 3 – Example of geomorphological features recognized in a seismic profile realized across the southern Venice Lagoon.

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GEOLOGICAL CHARACTERIZATION OF THE ALLUVIAL PLAIN AROUND CASERTA (SOUTHERN ITALY).

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KEY WORDS: geological subsoil characterization, GIS, Campania Plain.

ABSTRACT

A new approach to understanding aquifer architecture is to use stratigraphic techniques for delineating reservoir geometry. By evaluting subsurface data the geologic architecture of the northeastern region of the Campania Plain (southern Italy) have been defined and in particular the geometry and distribution of aquifer and aquitard sediments. The data, managed into a GIS project, have permitted to make a 3D restoration of the stratigraphic architecture.

GEOLOGICAL SETTING

The Campania Plain is a broad, complex graben closely controlled by NE-SW, NW-SE and E-W normal fault activity, estabilished in Late Pliocene (Ippolito *et alii*, 1973) or the Early Pleistocene (Cinque *et alii*, 1987; 2000) along the Tyrrhenian side of the Apennine Mountains.

The Plain's subsoil is formed by the succession of different units whose sedimentation has been influenced by non-homogeneous tectonics (Romano *et alii*, 1994).

The reconstructed stratigraphic sequences ranges from Middle-Late Pleistocene to Recent.

In detail, above the faulted Apennine carbonate bedrock, five units have been defined: two are of marine-transitional facies (M1 and M2) and have been recognized exclusively in the subsurface; the other three units (V1, TGC, TGN) consist mainly of pyroclastic deposits (Putignano *et alii*, 2007).

The units M1 and M2 are binded to positive glacioeustatic fluctuations occurred during the Middle-Upper Pleistocene; between them is interposed the unit V1 formed by mostly incoherent volcanic deposits correlatable with the Durazzano Ignimbrite (116 ky B.P., Rolandi *et alii*, 2003) outcropping along the eastern border of the Plain and binded to intensive volcanic activity and falling sea level.

The pyroclastic flow deposits of the Campania Grey Tuff (TGC 39 ky B.P., De Vivo *et alii*, 2001) overlie the three units: they blanket the whole area filling morphological depressions and dipping gently towards the central region of the Plain.

The uppermost unit of the reconstructed stratigraphic succession is represented by thin deposits of the Neapolitan Yellow Tuff (TGN 15 ky B.P., Deino *et alii*, 2004) which are separated, in some drilling, from underlying TGC by a paleosoil of 50-100 cm thickness.

A subsequent continental stage is witnessed by Upper Pleistocene to Recent alluvial and detrital colluvial deposits covering the two volcanic units.

DISCUSSION

The northeastern sector of the Campania Plain, in province of Caserta, is an example of area with strong anthropic impact according to urban growth and to agricultural and industrial activity.

Moreover the presence, in the Plain, of numerous quarrying and uncontrolled waste's storage is added.

This activities are further danger signals for soil-subsoil system. On basis of that, the need to make a geo-environmental and geo-lithological characterization of subsurface for 165 km2 part of the Plain is arised.

A detailed reconstruction of stratigraphic subsurface architecture based on remarkable geodatabase available in Cartography Territorial Laboratory of Environmental Department in Caserta, was carried out.

The geodatabase concerns with well log stratigraphies, interpreted and homogenized in terms of lithologic units. Data on field's analyses and deep drilling have been obtained and examined too. Then, a study of different surface sediments and lithofacies together with valutation of the relationships between upper and depth units was made.

All of these informations inferred from stratigraphic logs have been managed into a GIS project, in detail a database in Microsoft Access has been realized to control the great amount of data and to find quickly the necessary informations through query (Fig. 1).

This database is a relational frame that considers single entity under many side (lithological, stratigraphical, petrophysical, geomechanical and hydrological).

The geological data processing have been graphically restored with use of software Rockworks 2006 to obtain bi- and tridimensional models of the stratigraphic units, sections, profiles, fence-diagram in 2D and 3D on all thickness of subsurface (Fig. 2).

		T = Soil.
DETRITAL COLLUVIAL DEPOSITS		**a1** = Heaps of debris formed by reorganized pyroclastiti and locally by discontinuous levels made of calcareous pebbles.
		dt2 = Little dense pyroclastiti with sandy-maddy grains and little spoiled pumice, and sometimes scoriae. Often called as Pozzolana.
		dt1 = Debris fall. Brown pyroclastiti with calcareous debris, pumice, lapillus and scoriae.
PYROCLASTIC UNITS	TGN	**Neapolitan Yellow Tuff** = Basal phreato-plinian deposits of alterning white edged pumice and ash.
	P	**Paleosoil** = Brown sandy-maddy sediments with poor bright grey pumice of little size.
	CAMPANIA GREY TUFF	**Tgz** = Yellow tuff with yellow ashy and coherent matrix, yellow and/or black scoriae and pumice of great size.
		Tg = Grey tuff from pseudo coherent to coherent, with dark grey scoriae and sometimes with big black pumice placed in chaotic way.
		Cn = Bright grey incoherent ash with big grey pumice.
DEEP UNITS		**M2** = Sands, clays and conglomerate with fossils.
		V1 = Alternations of tuff little coherent and yellow pozzolane ascribed to Durazzano Ignimbrite.
		M1 = Yellow and grey sands, grey-blue clays with calcareous cement and reorganized pyroclastiti with sea fossil.
		C = Carbonatic sediments.

Figure 1 – Table of the recognized stratigraphic units.

Fence-diagram that show stratigraphic succession of the more surface units have been realized in order to analyse the great fluctuations in the structure of the detrital covering and in the thickness of the paleosoil between the two volcanic units (TGC and TGN).

The paleosoil is a buried layer with permeability lower than underlying unit represented by facies of grey tuff or ashy tuff; therefore for its lithological features and permeability is defined as aquitard. That is fundamental in all the areas with strong anthropic impact because it represents a lithological body also able to slacken the transfer of pollutants from soil to aquifer and/or ground water.

The further analysis has regarded the display of the surface's structure of top of TGC in connection with paleosoil's isopache (Fig. 3).

At last, a study of anthropic impacts caused by different agricultural use of soil in relation with geolithological features, morphology, kind of soil and presence of aquitards has been executed. As a conclusion, we can say that the above approach has allowed to improve the knowledge of subsoil and to define a qualitative/quantitative method to assess the potential vulnerability for the aquifer.

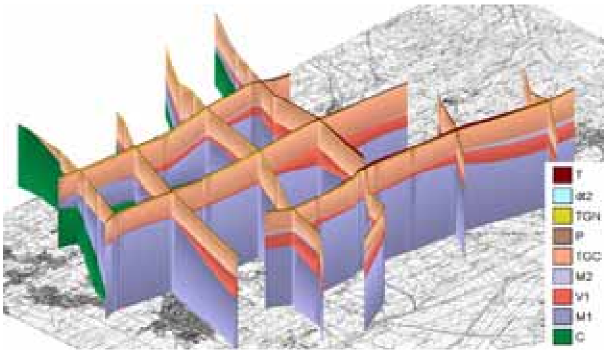

Figure 2 – Fence-diagram.

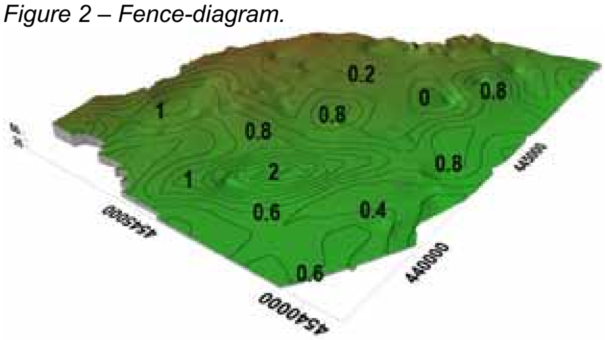

Figure 3 – Digital Subsurface Model of top TGC with paleosoil's isopache (thickness in meters).

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A 3D STRUCTURAL MODEL OF THE BAVARIAN BASEMENT

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KEY WORDS: geomodelling, GOCAD, crystalline basement, structural model, seismic velocity model.

OBJECTIVE

In most regions of Bavaria the Variscan basement is covered by up to several thousand meters of younger rocks. The basement is exposed at surface only in the northeastern part of Bavaria and in the Spessart region in the northwest. Therefore the input data for a model of the top-basement surface is distributed quite unevenly. This study is an approach to incorporate the available data of the Bavarian basement into a 3D structural model despite of their different scales. The result can be used as the bottommost layer for regional 3D models as well as to provide a basis for a first state-wide seismic velocity model.

OVERVIEW

During the Cretaceous basement was uplifted predominantly along normal strike-slip faults across the whole northeastern part of Bavaria with throws of more than 2000m locally. The whole northeast of Bavaria is cut by a NW-SE striking network of interconnected faults, often covered by cainozoic sediments. In the south, basement is overthrusted by the tectonic alpine front. The first E-W thrust marks the frontier of the alpine orogene with the basement at 7km depth (Lemcke 1988). This front was taken as the southern limit for modelling.

Basement is covered mainly by a continuous succession of younger palaeozoic and mesozoic sediments that make up to 1500m (BayGLA 1996) in permian troughs. These are rather narrow and probably not interconnected basin fills.

BASEMENT DATA

Data from several sources, types and scales was taken into account to create a three-dimensional surface of the variscan basement in Bavaria. First of all outcrop-data was derived from the geological overview maps at a scale of 1 : 200 000. The digital map data was merged in ArcGIS to generate polylines of the outcrop-lines of the basement. Furthermore polygon shapes were generated for the areas where the basement is exposed at surface, in the northeastern part of Bavaria and in the Spessart region in the northwest.

A structural contour map of the basement surface in northern Bavaria created by combining geophysical measurements and drilling data was used as additional constraint for the central part of Bavaria (BayStMWIVT 2004, Bader 1995, Bader 2001). Punctiform seismic interpretation along some seismic cross-sections was used within the molasse-basin in the south.

At last, stratigraphic data from more than 80 boreholes reaching the basement was collected and prepared for 3D modelling (figure 1). At the moment we are aiming to include also some well-data from surrounding states.

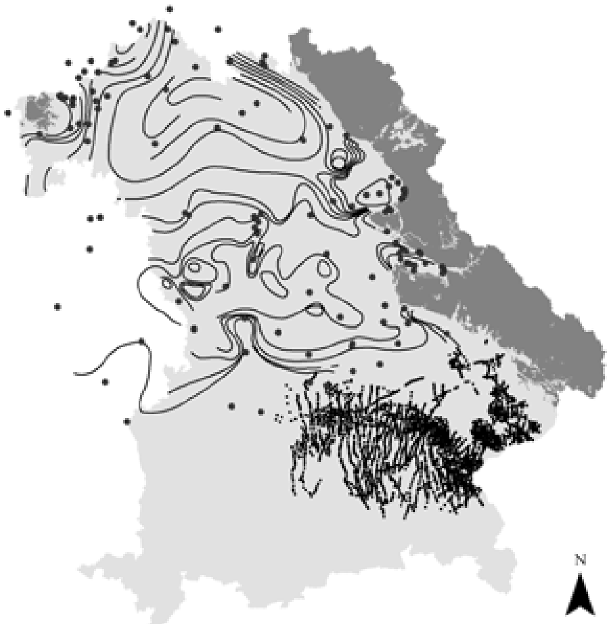

Figure 1 – Spatial distribution of input data, showing outcrop areas (dark grey), point data from boreholes and punctiform seismic interpretation, and curve data from structural contour maps.

CREATING A FAULT NETWORK

Fault-networks and data of basement differ in scale and level of detail. The approach was to combine these various datasets in a best way.

In areas where the basement is exposed at the earth's surface no faults were incorporated into the model. Instead, the basement surface was adapted to the digital elevation model in these regions.

In regions where the outcrop is linked to fault activity, the geological overview maps at a scale of 1 : 200 000 published by the Geological Survey of the Environment Agency was used as a common data basis for both the outcrops and the faults.

In the remaining regions especially in the northwest that shows a lack of subsurface data the fault data was derived from the tectonic overview map of Bavaria at a scale of 1 : 1 000 000 (BayGLA 1996).

The various fault data sets differing in scale, were merged and adjusted in adjacent or overlapping areas to create a consistent fault-network.

MODELLING THE BASEMENT SURFACE WITH GOCAD

All data was incorporated into the 3D geomodelling software GOCAD®. As a first step a non-faulted basement surface was created from the outcrop lines, the borehole data, the seismic cross-sections and the structural contour maps (figure 2). In a second step this surface was cut with the fault network using the built-in Structural Workflow to create a faulted basement surface. As described before first-order (resp. borehole) data is distributed unevenly. Thus the reliability of the final surface varies significantly in space. 3D gravity and magnetic modelling might set additional constraints in the future.

Using the faulted surface as an input a stratigraphic grid (SGrid) was created using the 3D Reservoir Grid Builder Workflow in GOCAD.

Figure 2 – The non-faulted basement surface with a preliminary simplified fault network.

ENHANCING THE MODEL AND FURTHER USE

For simplicity and due to its small scale all fault surfaces were set as vertical in this first approach. It is intended to refine the model by assigning dip values to the faults. Setting faults as non-vertical imply much more fault-fault connections at depth and considerable more ambiguity.

Furthermore it is planned to incorporate the top of the Upper Jurassic (Malm) into the model (BayStMWIVT 2004). It can be used as a basis for a state-wide seismic velocity model consisting of three layers (basement, mesozoic, cainozoic) which might lead to improved localisation of earthquakes.

ACKNOWLEDGMENTS

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OVERVIEW OF THE PUBLICATION AND PROCESSING STATUS OF THE GEOSCIENTIFIC MAP WORKS IN THE BAVARIAN ENVIRONMENT AGENCY (LFU)

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KEY WORDS: geoscientific map, publication, geological map, hydrogeological map

INTRODUCTION

The Bavarian Environment Agency (LfU) deals with issues concerning environment protection, nature conservation, water management and geology. In addition to different kinds of publications for the above-mentioned categories yet another main emphasis is put on geoscientific map series. The following scale ranges and output formats are available:

- Geological maps
- Soil maps
- Hydrogeological maps
- Raw material maps

The maps are distributed as:

- Printed maps and plot-on-demand
- Georeferenced raster maps (tiff, jpg)
- Raster-/Vector-PDF of the maps with corresponding explanatory notes
- Digital data sets via the internet or BIS (Bavarian Soil Information System, www.bis.bayern.de)

The internet shop can be reached via the following site:
www.lfu.bayern.de/publikationen.

GEOLOGICAL MAPS

Geological maps (GK) contain information about the type, age, allocation and bedding of rocks on the surface and bellow. In addition to different overview and speciality maps the geological map on a scale of 1:25,000 is a basis for other geoscientific map series produced by the LfU. Explanatory notes with numerous illustrations and pictures are also available for this map scale.

Scale ranges and types of geological maps:

- GK 1:25,000 / 1:75,000 / 1:100,000 / 1:150,000 / 1:500,000
- Geological overview and special maps
- Historic geological maps
- Geological manuscript maps

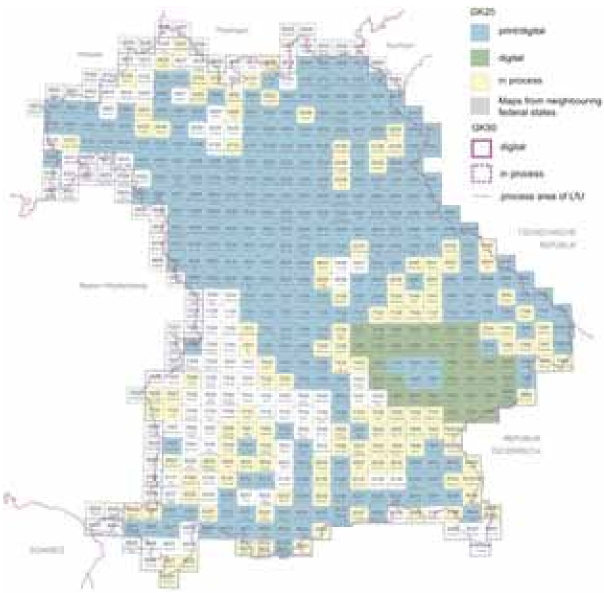

Figure 1 – Status of publication of geological maps 1:25 000 & 1:50 000

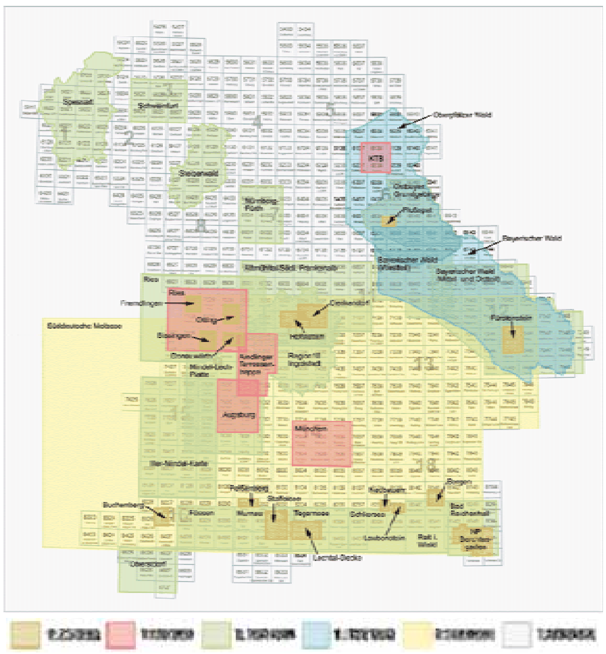

Figure 2 – Status of publication of geological maps – special editions

SOIL MAPS

Soil maps are the result of the pedological survey at the LfU. The following different soil characteristics are determined by field mapping and laboratory analysis:

- Parent material
- Genesis
- Soil type
- Site characteristics
- Possibility of utilization (land use potential)

The following map series are produced:

- As a pre-product for The Federal Institute for Geosciences and Natural Resources (BGR): Soil general map 1:200,000
- Soil site map 1:50,000 und 1:25,000
- Soil map 1:25,000
- General soil map 1:25,000
- Soil function map 1:25,000
- Soil assessment map 1:25,000
- Background value map 1:500,000

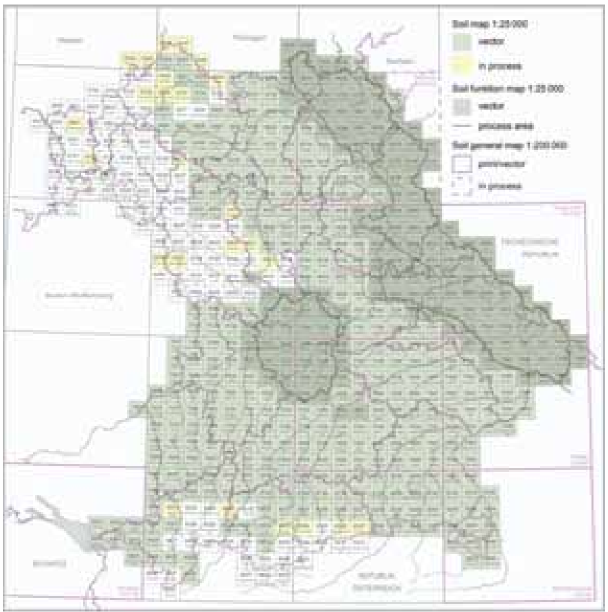

Figure 3 – Processing status for soil maps

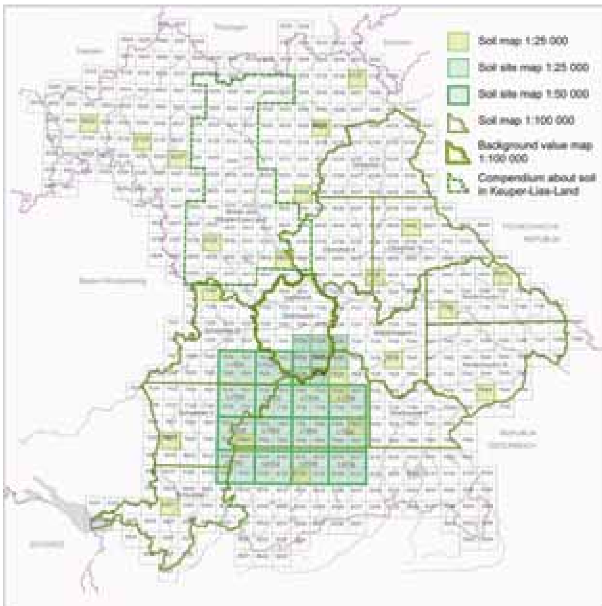

Figure 4 – Status of publication of soil maps – special editions

HYDROGEOLOGICAL MAPS

These maps incorporate information on the hydrogeological structure and properties of the subsurface as well as the availability of groundwater resources, flow dynamics and hydrochemical composition. The results of the statewide hydrogeological survey are published as sets of maps on a scale of 1:50,000 (HK 50). In addition, hydrogeological general maps each depicting one of Bavaria's planning regions are produced on a scale of 1:100,000.

Figure 5 – Processing status for hydrogeological maps

RAW MATERIAL MAPS

The raw material maps show the position of the raw material deposits and mines. They also provide information about areas that prevent mining and exploitation in the long run.

The first raw material map in a new and more differentiated system appeared in 2002 and shows the Ingolstadt Region (South Bavaria) on a scale of 1:100,000 based on raw material-geological manuscript maps on a scale of 1:25,000. These manuscript maps were revised for a publication and are now available for the public as raw material maps (RK 25) in a raster file format.

Moreover the Bavarian KOR 200 maps (map of near-surface raw materials, 1:200,000) of the BGR are based on the RK 25 raw material maps.

Because of data protection, at present the sale of the vectorized raw material maps including attributed data is not intended.

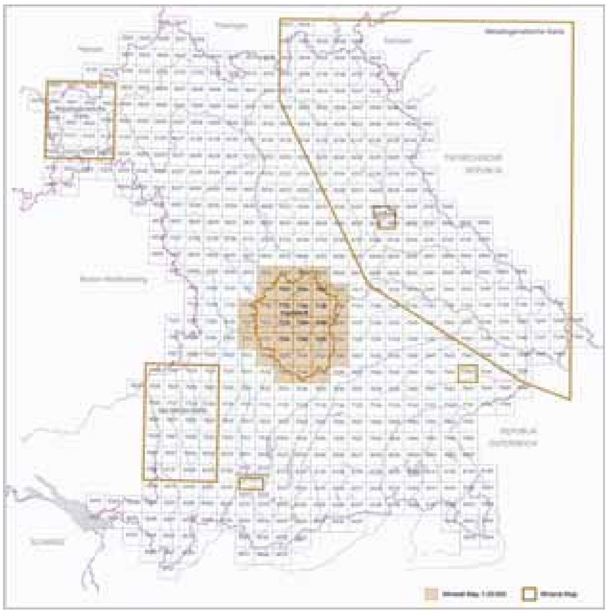

Figure 6 – Status of publication of mineral maps

DESIGNING A DATABASE TO SUPPORT SUBSURFACE MODELLING FOR SEISMIC MICROZONATION

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KEY WORDS: database, subsurface modelling, seismic microzonation.

INTRODUCTION

Seismic microzonation is an evaluation procedure of the local hazard consisting in the identification of areas characterized by an homogeneous seismic behaviour (GRUPPO DI LAVORO MS, 2009).

In 2007, a five year technical agreement was signed between the National Civil Protection Department and the National Research Council with the aim to develop theoretical and technical instruments to support the civil protection activities over the Italian territory, including the spread of seismic microzonation studies (URBISIT project).

During the first year of this project a working commission of experts on the different technical disciplines involved in seismic hazard evaluation, like geology, geotechnics, hydrogeology, applied geophysics, geomorphology, and geostatistics, discussed and drew up a document describing a *Subsurface Model* (SM) suitable to act as a theoretical reference instrument for the seismic microzonation studies in Italy (Cavinato et al., 2008). The SM identified the fundamental physical parameters (variables) and the base cartographic information required to produce seismic microzonation studies, accordingly to the three steps of classification recommended by the Italian laws, from a general to a very detailed level.

During the second phase of the project, a specific sub-commission started to design a comprehensive database optimized both for the storage and the handling of all the information required for the operative definition of the SM within the seismic microzonation studies.

CONCEPTUAL SCHEME OF THE DATABASE

The conceptual scheme of the database has been developed accordingly to the two classes of data required to identify the 3D seismically homogeneous bodies in the subsoil (figure 1).

First the cartographic data, which give the base information to recognize the geological settings and to describe the geomorphologic processes on the surface.

Second the subsurface data, obtained through drilling or other indirect measurements techniques, which have to be stored in an alphanumeric database (ADB) before their spatial processing.

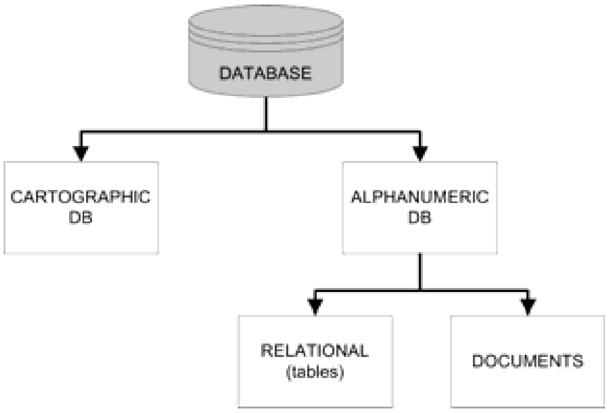

Figure 1 – The two branches of the database.

The database conceptual scheme was initially designed using the ESRI© geodatabase model and is shown in figure 2. The ADB is linked to the carthographic section through external keys shared with the feature classes that represent the position of the surveys in field.

The different characteristics of surveys drive the ADB structure which is consequently divided into two branches to store: a) the parameters measured at or related to specific points in the subsurface and whose position can be represented with a “point” on a 2D map; b) the information linked to a vertical geologic or seismic section and whose position on the surface can be graphically represented by a polyline.

A documental section is also included in the database to store a copy of the original reports associated with the surveys and the tables (matrices) containing the data measured in the laboratories or in field, by using *.pdf* or *ASCII* formats.

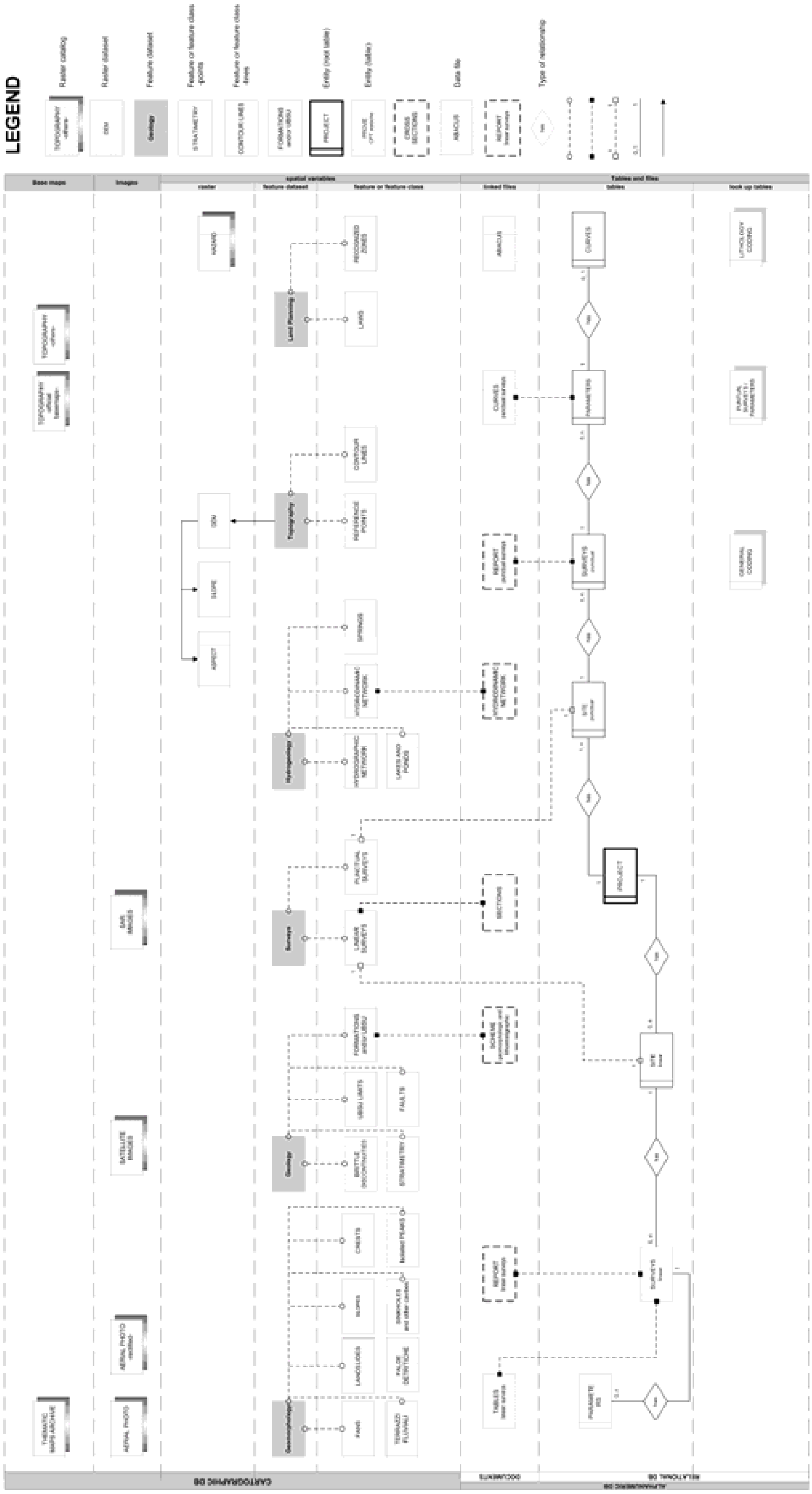

Figure 2 – Conceptual scheme of the database.

The implementation of ADB also required a very accurate work on the coding system. In fact, this is a key point to grant the diffusion of the database by assuring the use of standardized measurement units for recording the measured parameters along with a really comprehensible, easy to use, mnemonic and standardized coding of descriptive attributes.

In this paper, we illustrate only the new coding system introduced for the description of loose sediments which represents one the main parameter for the definition of seismic hazard.

This coding system is based on the combination of 5 characters, respectively representatives of the type of layer and relative abundance of the different particle size, accordingly to the scheme in figure 3.

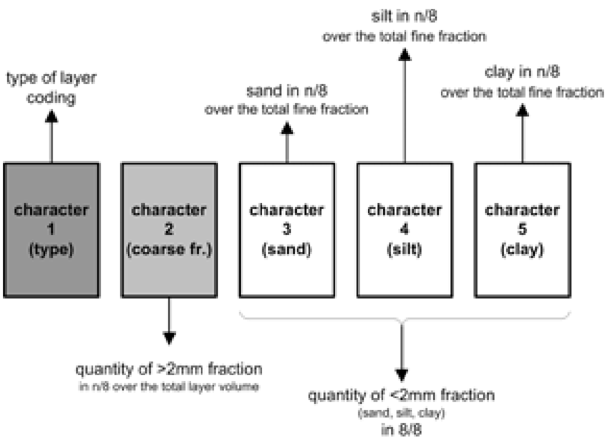

Figure 3 – Coding system for lithology

In particular:

- position 1 is occupied by a conventional alphanumeric code describing the homogeneity and/or nature of the layer (e.g. "S" for homogeneous layer; "Q" for fractured rock; and so on.);
- position 2 represents the quantity of gravel/stones in the layer in a scale ranging between 1 (very few) and 8 (100%);
- position 3, 4 and 5 record the relative abundance respectively of sand, silt and clay using an integer numeric figure in n/8 (the sum of these three figures has to be 8 in order to reach 8/8).

This coding system has been thought to correspond to the usual semi-quantitative and conversational style description of the lithologies which are given by geologists in field. As an example, accordingly to this system, the code (last three characters) for a pure "clay" is 008, for a "silty clay" is 026, for "silt and clay" is 044, and so on.

This way we obtained the undoubted advantage of homogenize and make comparable a great variety of different descriptions, reducing at minimum, at the same time, the possibility of misclassification and subjective errors.

The code also contain a semi-quantitative description of the granulometry that is grossly ranked by the numeric characters

CONCLUSIONS

Presently the both the conceptual and the physical structure of a database suitable to support seismic microzonation studies have been created and described in a specific technical report within the URBISIT project.

The database itself is now undergone to a testing phase consisting in the data storage and subsequent processing from 30 selected sites (villages and small cities), spread over the Italian territory. The database was built in fully agreement with a theoretical reference document which describes the subsurface model and was tought to store all cartographic data and subsoil physical parameters required for producing seismic microzonation studies.

This is only the first phase of a long term work, in which possible further revisions can be suggested by the experts of the discipline involved in seismic modelling and by the local administrations responsible for data storage. The official adoption of a successive version of this database system is expected in the near future as a first step towards a wider diffusion of the seismic microzonation studies in the most critical areas of the Italian territory.

AKNOWLEDGMENTS

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This project has been funded by the "Dipartimento della Protezione Civile" within the DPC-CNR Progetto URBISIT.

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INFORMATION SYSTEMS FOR SHALLOW GEOTHERMAL APPLICATIONS IN BAVARIA

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KEY WORDS: shallow geothermal energy, heat pump plant, hydrogeology, groundwater, drinking water, geothermal potential, mapping, water rights.

INTRODUCTION

Geothermal energy is an increasing sector in heating and cooling technologies. Knowledge of (hydro-)geological conditions at a planned site is important for the correct design of geothermal plants. Therefore a mapping project was started at the Bavarian Environment Agency in order to provide countrywide three-dimensional data of hydrogeological units. These data are being reprocessed to give relevant information such as sensitive areas or optimized drilling depth for ground source heat pumps or well systems.

METHODS

The preceded hydrogeological mapping project yields borehole logs, horizontal extents of geological units, hydrogeological profiles as well as three-dimensional underground models. Spatial boundaries of the (hydro-)geological layers and groundwater conditions are input parameters for determination of basic conditions for geothermal energy use.

The following cases are distinguished:

- favourable condition for ground source heat pumps
- unfavourable condition for ground source heat pumps
- singular case decision on ground source heat pumps
- favourable condition for groundwater wells
- unfavourable condition for groundwater wells
- singular case decision on groundwater wells

Water protection areas and mineral water protection areas are very important, as strong regulations apply for the installation of heat pump plants:

- heat pump plants are not allowed in narrower parts of the water protection areas (“Wasserschutzzone 1 und 2”)
- heat pump plants are possible, partly by singular case decision, in outer parts of protection areas (“Wasserschutzzone 3b”)

Hydraulically critical areas such as artesian basins are also shown in the maps.

Sensitive groundwater uses like water wells or mineral water extraction wells are also displayed in the maps.

To give relevant information about the surroundings of the site of interest, existing boreholes such as

- cased wells for private use
- heat pump plants with groundwater wells
- heat pump plants with borehole heat exchangers

are also displayed in the map. These point data are derived from the Bavarian geological database that contains more than 120,000 boreholes.

More information provided in additional maps are

- areas with additional groundwater information
- areas with restrictions of drilling depth

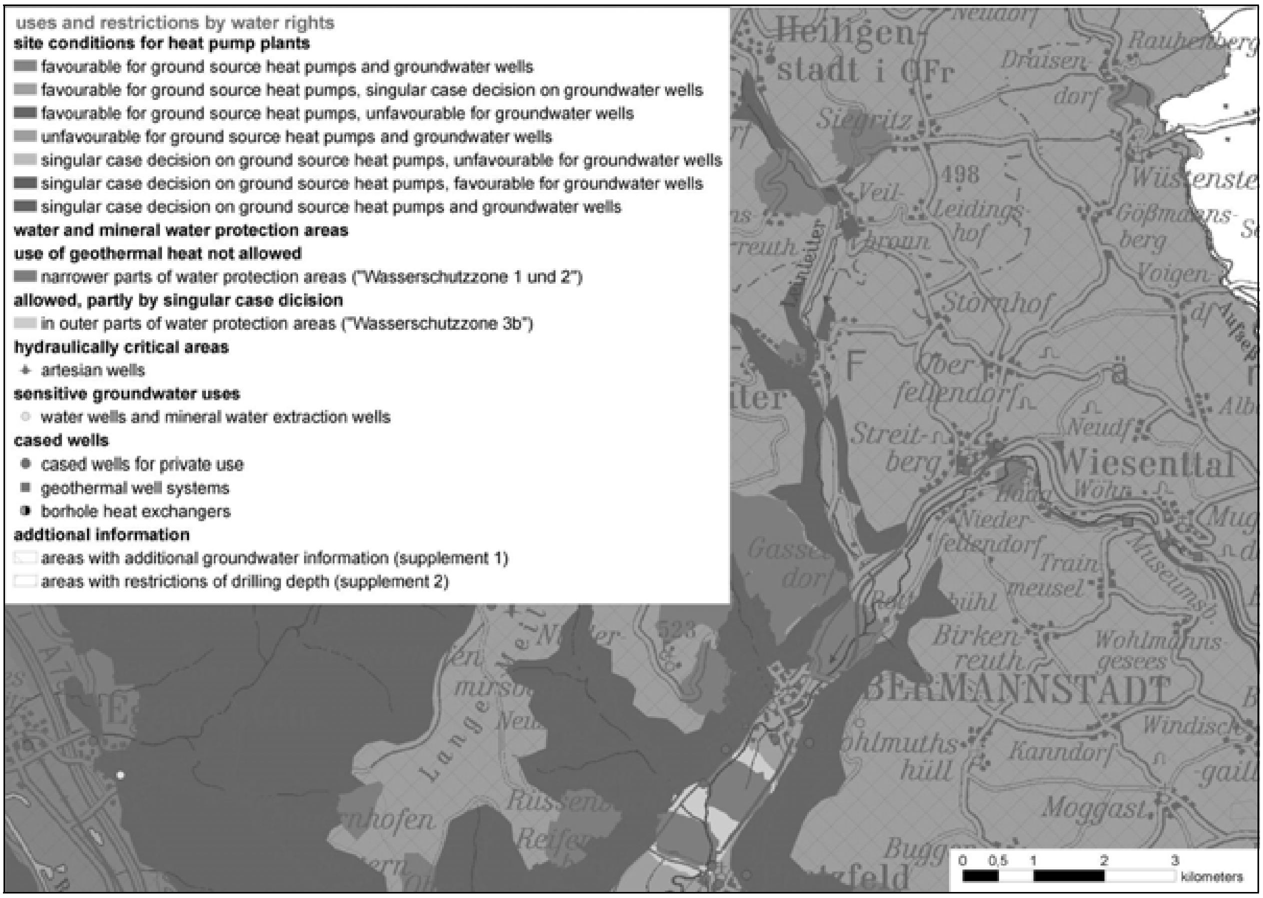

Figure 1 – Legend of basic conditions for shallow geothermal plants.

INFORMATION SYSTEM

The information system contains a map of base conditions for ground source heat exchangers and groundwater wells as described in *METHODS*. From that interested clients can derive the potential for the use of geothermal energy for their property.

Another map gives groundwater information which helps to decide which type of geothermal technique (e.g. borehole heat exchanger or groundwater heat pump) is most advisable at the site.

Furthermore the regulatory authorities will be provided with an additional map showing maximum drilling depths depending on the hydrogeolocal situation in certain locations. Restrictions of drilling depths are mainly imposed in order to prevent hydraulic short circuits in aquifers.

After finishing the detailed mapping and the interpretation of the maps with respect to geothermal energy uses, the maps will be published in the internet portal of the Bavarian Environment Authority under www.bis.bayern.de.

ACKNOWLEDGMENTS

The project described in this article is financed by the Bavarian State Ministry of the Environment and Public Health. Major parts of the project are supported by the European Regional Development Fund (ERDF).

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METHODOLOGICAL APPROACH TO A HYDROGEOLOGICAL 3D STRUCTURE MODEL OF THE GORLEBEN SALT DOME OVERBURDEN, NORTHERN GERMANY

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KEY WORDS: Gorleben, salt dome overburden, Tertiary, Quaternary, hydrogeological 3D structure model, openGEO, AutoCAD, construction principles.

INTRODUCTION

The salt dome of Gorleben as potential repository for nuclear waste is situated in Northern Germany between Hamburg and Berlin (figure 1). A crucial question concerning ultimate nuclear waste storage in salt domes is the possibility and probability of contaminants migrating from salt dome surface to ground surface. Therefore, the overburden of the Gorleben salt dome was investigated intensively by means of an extensive drilling and exploration programme from 1979 to 1998.

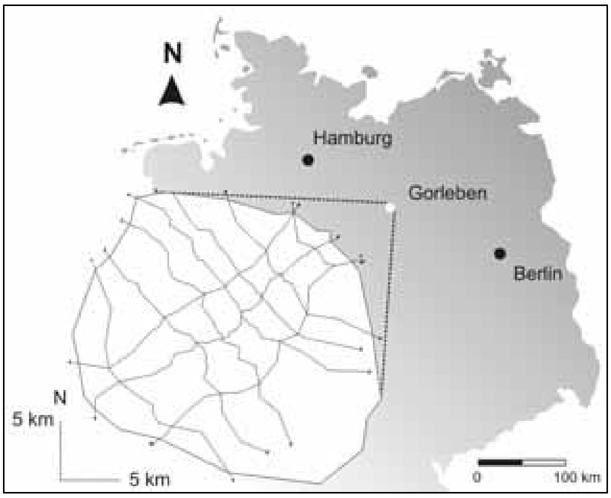

Figure 1 – Map of Northern Germany showing the site of Gorleben. Model area and locations of 10 main cross-sections as well enlarged.

The geological and hydrogeological evaluation of data has been performed separately. We now verify all data and combine them to one consistent hydrogeological 3D structure model.

In contrast to the widespread and common approach of surface generation by means of interpolation algorithms we adopt the method of constructing geo-bodies as 3D polyline networks. Modelling software is openGEO.

DATABASE

The model is based upon 456 well logs described in BAHARIAN-SHIRAZ & ZWIRNER (2002). Further data sources are ten geological main cross-sections (figure 1 and 5) and several contour maps of geological units including subcrops (ZIRNGAST et al. 2003). Details of the geological and hydrogeological investigations can be looked up in KÖTHE et al. (2007) and KLINGE et al. (1998, 2007).

The modelling software openGEO has been developed commercially by the company bicad. OpenGEO requires AutoCAD as application environment. Basic construction elements are lines. Surfaces are built up as polyline networks (TIN = Triangulate Irregular Network), leaving input data unmodified (figure 2).

DISCUSSION

Generally, there are two kinds of construction principles realised in modelling software:

- Smoothing of surfaces by means of interpolation algorithms is a widespread technique.
- Alternatively, input data without modification can be used for TIN construction.

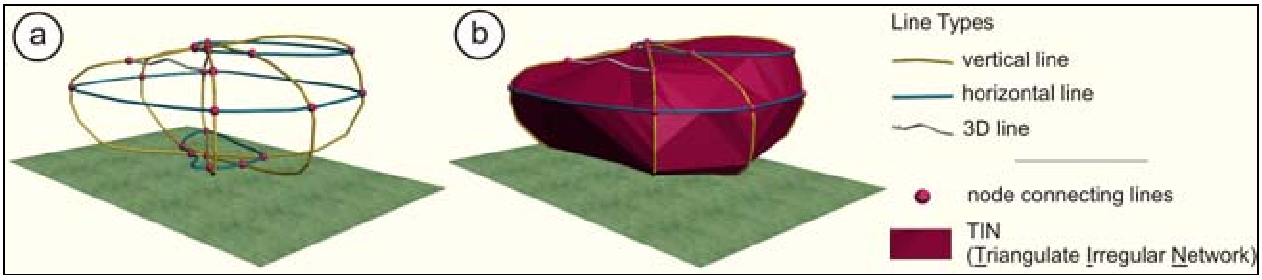

Figure 2 – Lines as basic elements of model construction.

In geosciences, data often are very heterogeneous, irregularly scattered, and differ in scale. Therefore, smoothing of surfaces is used as a method of averaging data. On the other hand, this can cause mistakes like penetration of thin layered surfaces or subcrops not being in direct contact with the surrounding surfaces (figure 3). The construction of surfaces by interpolation algorithms can be a helpful and time-saving tool if there are only few data available or if only regional interpretation of the resulting model is intended.

The construction of geo-bodies using input data without alternation as 3D points for TIN construction is a geometrically accurate method. This is more time-consuming but guarantees the reasonable construction of geo-bodies in model areas without input data or the realistic construction of complex layered geological units like the Quaternary in the Gorleben area.

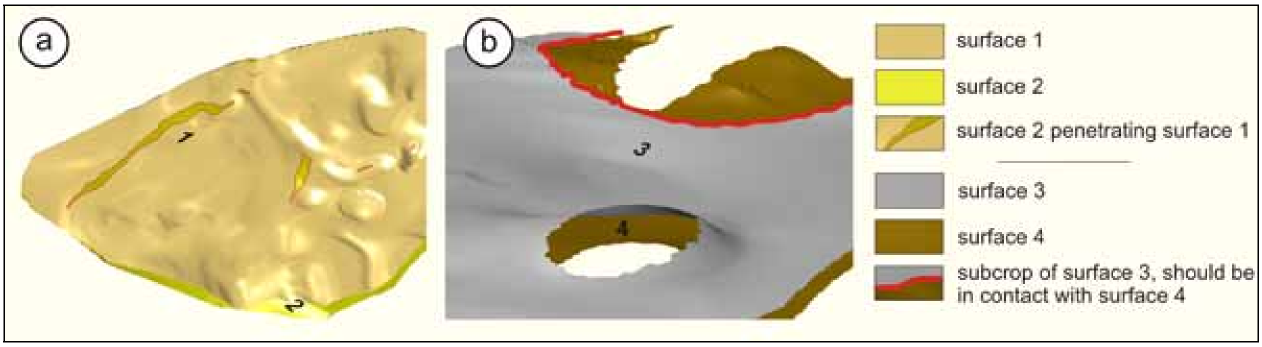

Figure 3 – Examples showing inconsistencies caused by interpolation algorithms.

RESULTS AND OUTLOOK

The hydrogeological 3D structure model of Gorleben visualises the salt dome overburden. The salt dome and its cap rock are covered by sediments of Tertiary and Quaternary age. In the rim synclines Caenozoic sediments are underlain by Mesozoic successions (not shown in figure 4 and 5). At the ground surface Holocene and Weichselian deposits widely cover all older units. The Oligocene Rupel Clay is regarded as base of the groundwater system. Between Rupel Clay and Hamburg Clay, the Lower Lignite Sands of Miocene age have aquifer quality. In Quaternary, lower Elsterian sands are divided from highly inhomogeneous Saalian deposits by the Lauenburg Clay Complex. Since the lower Quaternary sediments are deposited in channels incised into the Tertiary layers, the Tertiary Hamburg Clay and the Quaternary Lauenburg Clay Complex together build up one aquitard which widely separates a narrow fresh water deposit from a deeper one mainly consisting of higher concentrated brine. These two aquifers are connected to each other locally (figure 4 and 5).

Especially the Saalian deposits are locally difficult to construct. In one well, they form a succession of layers (together with intercalations of other sediments) and in another well they are connected to one thick layer. Another feature of special emphasis is the construction of faults which sometimes just shift parts of geo-bodies against each other and sometimes separate them to isolated geo-bodies.

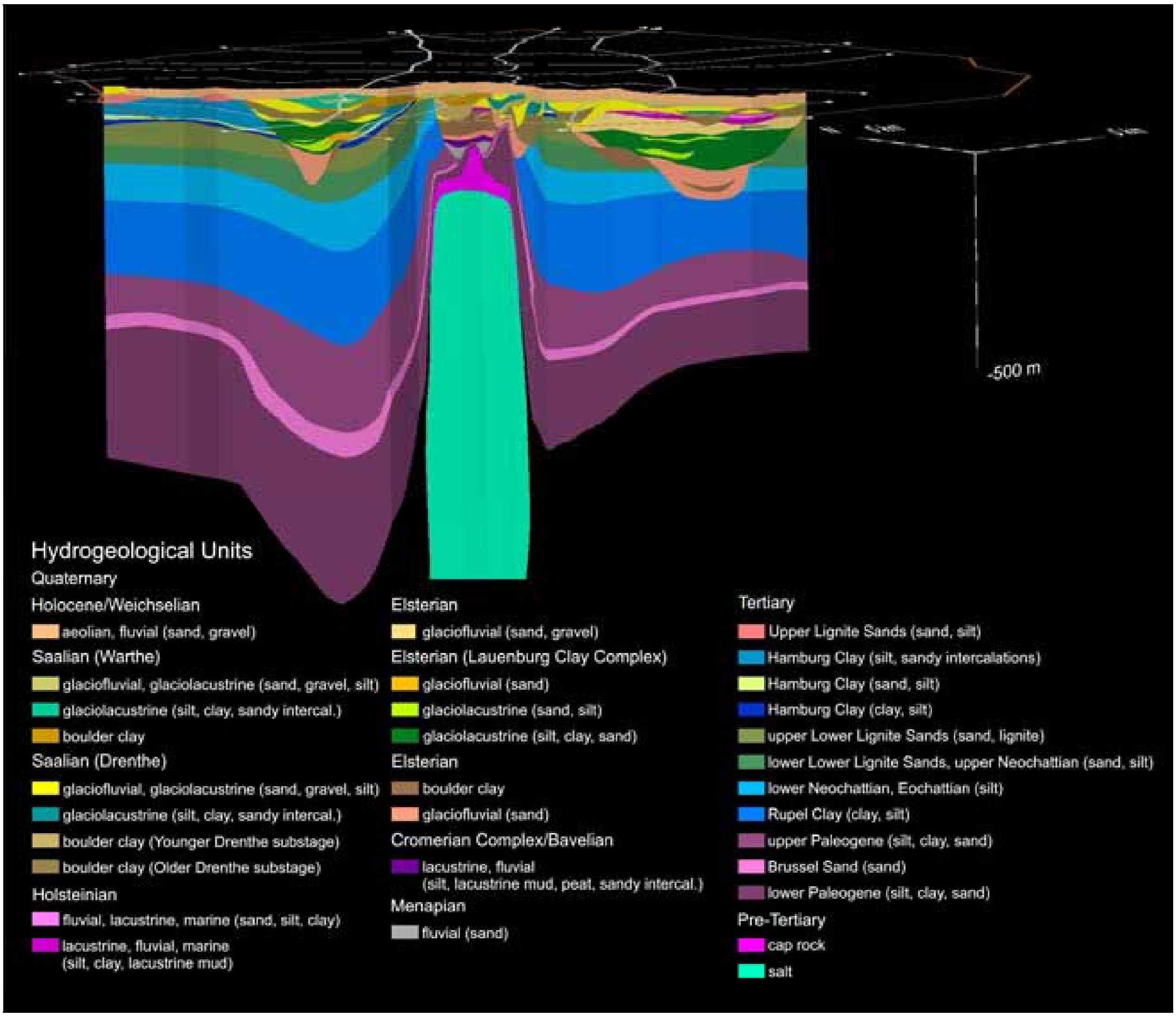

Figure 4 – Cross-section 2 showing the Gorleben salt dome with its overburden. There are three Quaternary channels incised into the Tertiary layers, two in the rim synclines and one at the top of the salt dome. The cross-section crosses the salt dome in its south-western part where Quaternary sediments of pre-Elsterian age are preserved. Model area outline (amber), locations of cross-sections 1 to 10, and scale at 0 m b.s.l.

For this model, an approach has been chosen without smoothing of surfaces and without interpolation algorithms for the construction of geo-bodies to get a realistic model controlled by the model designer and allowing detailed interpretation. The model is intended to serve as base for three-dimensional numerical modelling of hydrogeological parameters with special emphasis on spatial changes in groundwater density as a function of salt concentration.

ACKNOWLEDGEMENT

The hydrogeological 3D structure modelling of the Gorleben salt dome overburden takes place at the Federal Institute for Geosciences and Natural Resources (BGR) on behalf of the Federal Office for Radiation Protection (BfS).

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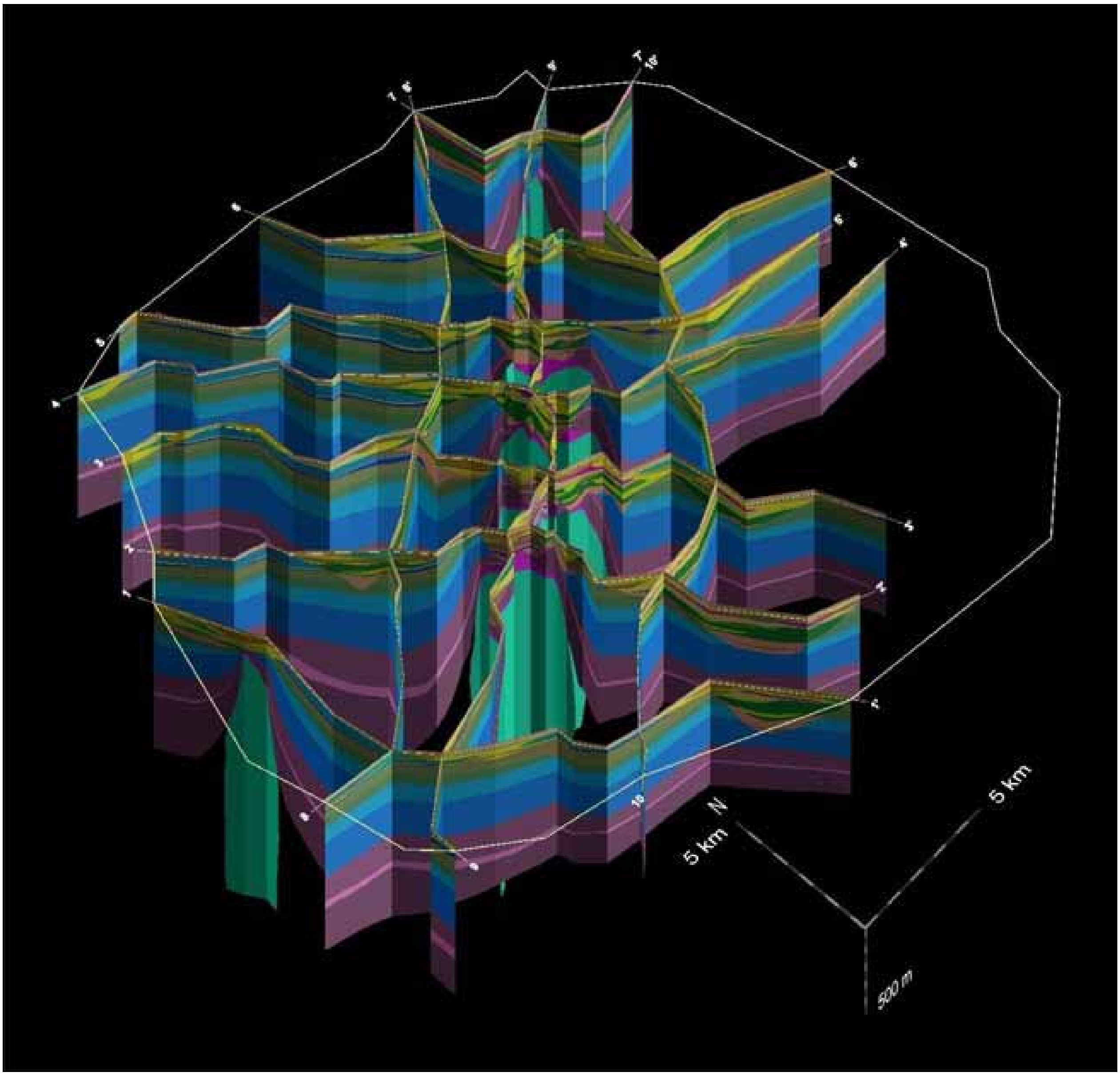

Figure 5 – Hydrogeological 3D structure model of the Gorleben salt dome overburden built up by 10 main cross-sections. View from south-west along the axis of the salt dome. In cross-section 1, there is another salt dome visible (Groß Heide-Siemen). Model area outline (amber), locations of cross-sections 1 to 10, and scale at 0 m b.s.l., for names of hydrogeological units see figure 4.

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THE BAVARIAN INFORMATION SYSTEM FOR SHALLOW GEOTHERMAL ENERGY (IOG) – A TECHNICAL OUTLINE

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KEY WORDS: shallow geothermal energy, information system, IOG, heat exchanger, map server, decision support system.

INTRODUCTION

Shallow geothermal energy represents an important renewable and eco-friendly energy. Technologies for economic extraction of shallow geothermal energy are already established on the market. The issue receives a special focus through political programs propagating climate protection activities. This is reflected by several programs promoting the further employment of this technology.

In order to enable a decision for the use of shallow geothermal energy, information about the geological, hydrogeological and geothermal conditions at a building site are required. Therefore several geological surveys or environmental agencies already offer information systems on this topic that are accessible to the public as well as to professionals via internet.

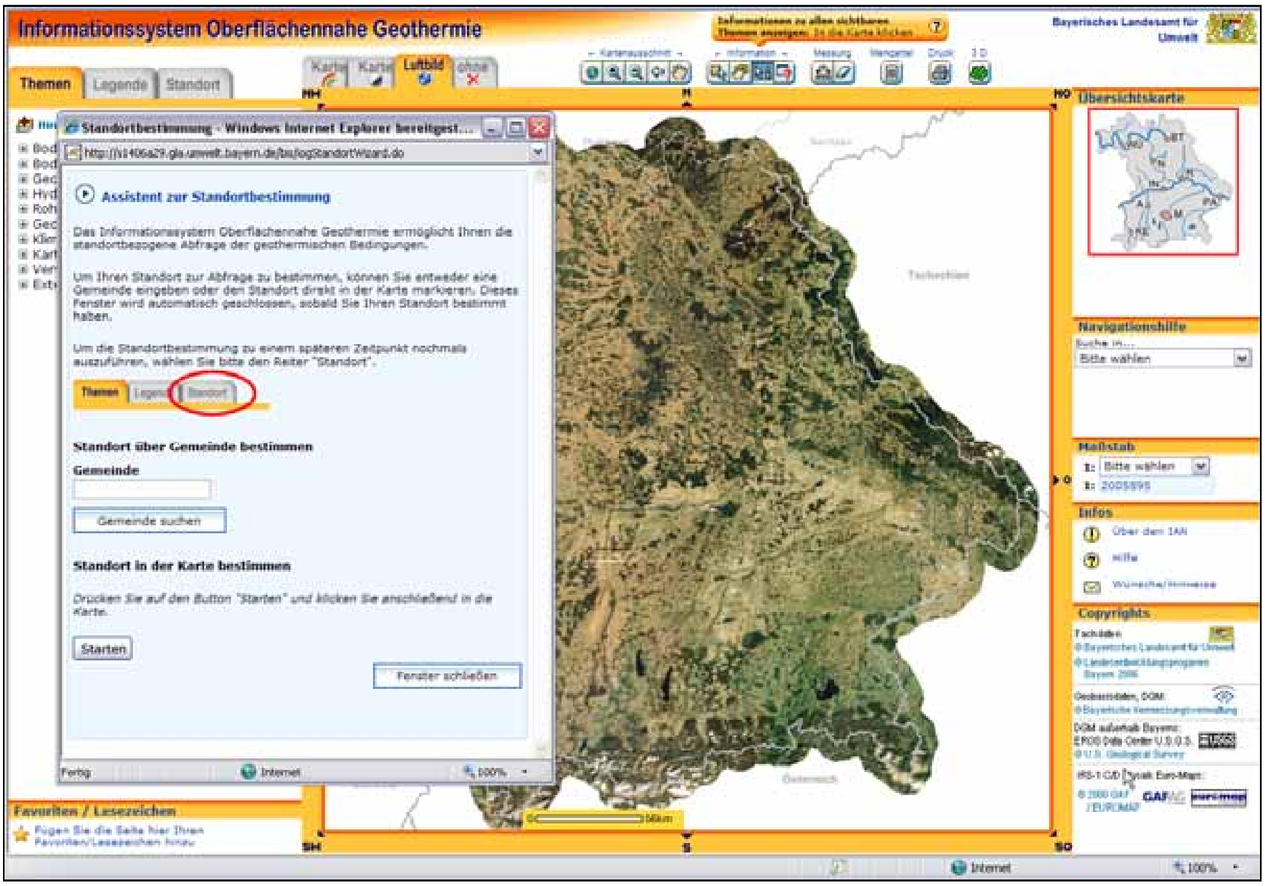


Figure 1 – The IOG after starting the application.

PUBLIC GEOTHERMAL INFORMATION SYSTEMS IN GERMANY

So far geothermal information systems have been set up in several German States. The most comprehensive systems have been established in North Rhine-Westphalia and Baden Württemberg.

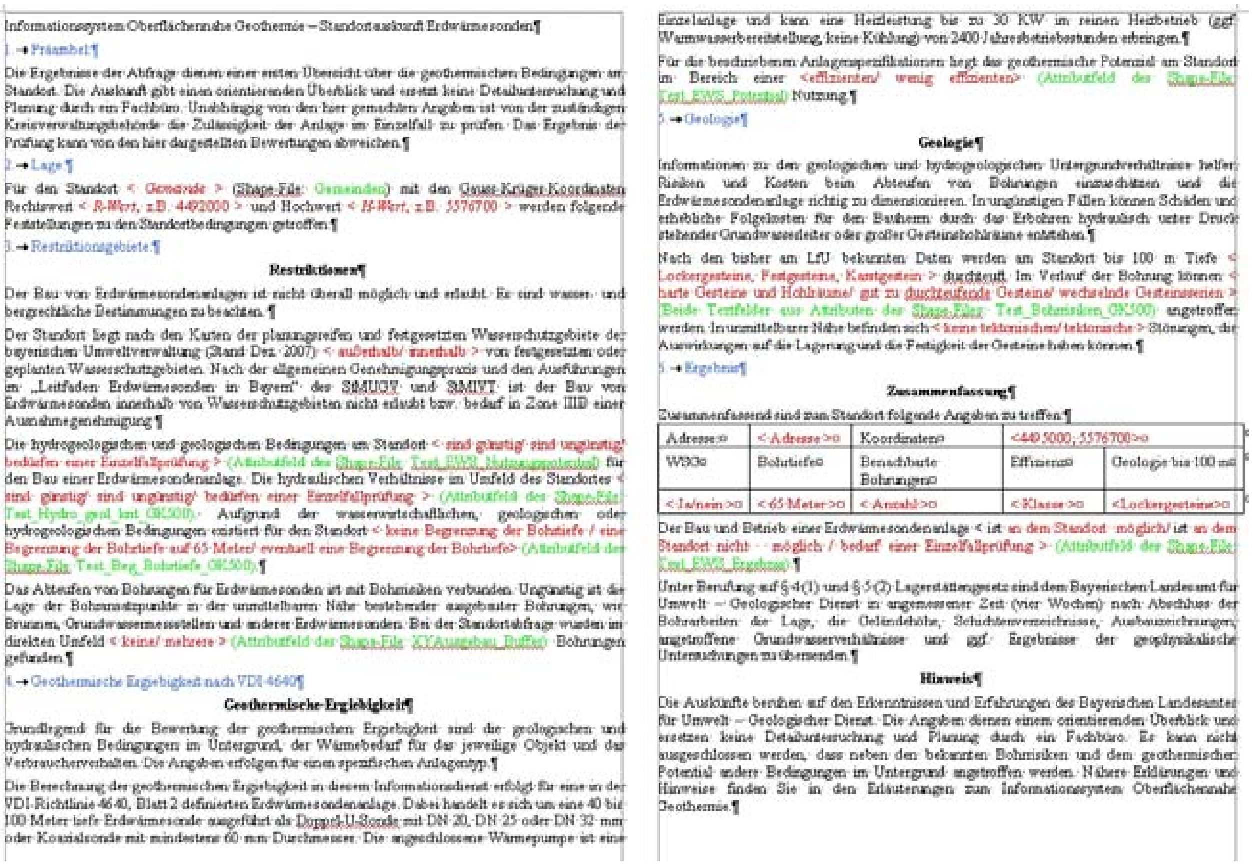
These two systems are quite similar regarding content and technical solution. Some differences result from different statutory regulations, water rights and water management objectives in the two German states.

Both systems are web services publishing information on shallow geothermal conditions for any specific location. Gazetteer services are implemented for navigation by address data. The site information can be retrieved as downloadable document.

Furthermore both systems additionally offer detailed information necessary for the actual planning of geothermal plants, like specific heat extraction, thermal conductivity of the underground or borehole profiles. This additional information is available for registered professionals only and not free of charge.

Last year the comprehensive project ***Information Offensive Shallow Geothermal Energy***, supported by the European Union, was launched by Bavarian Environment Agency (***LfU***). One of the main objectives of the project is the development of an ***Information System for Shallow Geothermal Energy (IOG)*** covering Bavaria.

The appearance and functionality of the IOG is quite similar to the other information systems on shallow geothermal energy already existing in Germany. The following text will focus on the technical realisation of the IOG.


Informationssystem Oberflächennahe Geothermie – Standortauskunft Erdwärmesonden

1. → Präambel

Die Ergebnisse der Abfrage dienen einer ersten Übersicht über die geothermischen Bedingungen am Standort. Die Auskunft gibt einen orientierenden Überblick und ersetzt keine Detailuntersuchung und Planung durch ein Fachbüro. Unabhängig von den hier gemachten Angaben ist von der zuständigen Kreisverwaltungsbehörde die Zulässigkeit der Anlage im Einzelfall zu prüfen. Das Ergebnis der Prüfung kann von den hier dargestellten Bewertungen abweichen.

2. → Lage

Für den Standort < Gemeinde > (Shape-File: Gemeinden) mit den Gauss-Krüger-Koordinaten Rechtswert < R-Wert, z.B. 4492000 > und Hochwert < H-Wert, z.B. 5576700 > werden folgende Feststellungen zu den Standortbedingungen getroffen.

3. → Restriktionsgebiete

Restriktionen

Der Bau von Erdwärmesondenanlagen ist nicht überall möglich und erlaubt. Es sind wasser- und bergrechtliche Bestimmungen zu beachten.

Der Standort liegt nach den Karten der planungsreifen und festgesetzten Wasserschutzgebiete der bayerischen Umweltverwaltung (Stand Dez. 2007) < außerhalb/ innerhalb > von festgesetzten oder geplanten Wasserschutzgebieten. Nach der allgemeinen Genehmigungspraxis und den Ausführungen im „Leitfaden Erdwärmesonden in Bayern" des StMUGV und StMIVT ist der Bau von Erdwärmesonden innerhalb von Wasserschutzgebieten nicht erlaubt bzw. bedarf in Zone IIIB einer Ausnahmegenehmigung.

Die hydrogeologischen und geologischen Bedingungen am Standort < sind günstig/ sind ungünstig/ bedürfen einer Einzelfallprüfung > (Attributfeld des Shape-File: Test_EWS_Nutzungspotential) für den Bau einer Erdwärmesondenanlage. Die hydraulischen Verhältnisse im Umfeld des Standortes < sind günstig/ sind ungünstig/ bedürfen einer Einzelfallprüfung > (Attributfeld des Shape-File: Test_Hydro_geol_krit_GK500). Aufgrund der wasserwirtschaftlichen, geologischen oder hydrogeologischen Bedingungen existiert für den Standort < keine Begrenzung der Bohrtiefe / eine Begrenzung der Bohrtiefe auf 65 Meter/ eventuell eine Begrenzung der Bohrtiefe> (Attributfeld des Shape-File: Test_Beg_Bohrtiefe_GK500).

Das Abteufen von Bohrungen für Erdwärmesonden ist mit Bohrrisiken verbunden. Ungünstig ist die Lage der Bohransatzpunkte in der unmittelbaren Nähe bestehender ausgebauter Bohrungen, wie Brunnen, Grundwassermessstellen und anderer Erdwärmesonden. Bei der Standortabfrage wurden im direkten Umfeld < keine/ mehrere > (Attributfeld des Shape-File: XYAusgebau_Buffer) Bohrungen gefunden.

4. → Geothermische Ergiebigkeit nach VDI 4640

Geothermische Ergiebigkeit

Grundlegend für die Bewertung der geothermischen Ergiebigkeit sind die geologischen und hydraulischen Bedingungen im Untergrund, der Wärmebedarf für das jeweilige Objekt und das Verbraucherverhalten. Die Angaben erfolgen für einen spezifischen Anlagentyp.

Die Berechnung der geothermischen Ergiebigkeit in diesem Informationsdienst erfolgt für eine in der VDI-Richtlinie 4640, Blatt 2 definierten Erdwärmesondenanlage. Dabei handelt es sich um eine 40 bis 100 Meter tiefe Erdwärmesonde ausgeführt als Doppel-U-Sonde mit DN 20, DN 25 oder DN 32 mm oder Koaxialsonde mit mindestens 60 mm Durchmesser. Die angeschlossene Wärmepumpe ist eine Einzelanlage und kann eine Heizleistung bis zu 30 KW im reinen Heizbetrieb (ggf. Warmwasserbereitstellung, keine Kühlung) von 2400 Jahresbetriebsstunden erbringen.

Für die beschriebenen Anlagenspezifikationen liegt das geothermische Potenzial am Standort im Bereich einer <effizienten/ wenig effizienten> (Attributfeld des Shape-File: Test_EWS_Potential) Nutzung.

5. → Geologie

Geologie

Informationen zu den geologischen und hydrogeologischen Untergrundverhältnisse helfen Risiken und Kosten beim Abteufen von Bohrungen einzuschätzen und die Erdwärmesondenanlage richtig zu dimensionieren. In ungünstigen Fällen können Schäden und erhebliche Folgekosten für den Bauherrn durch das Erbohren hydraulisch unter Druck stehender Grundwasserleiter oder großer Gesteinshohlräume entstehen.

Nach den bisher am LfU bekannten Daten werden am Standort bis 100 m Tiefe < Lockergesteine, Festgesteine, Karstgestein > durchteuft. Im Verlauf der Bohrung können < harte Gesteine und Hohlräume/ gut zu durchteufende Gesteine/ wechselnde Gesteinsserien > (Beide Textfelder aus Attributen des Shape-Files: Test_Bohrrisiken_GK500) angetroffen werden. In unmittelbarer Nähe befinden sich < keine tektonischen/ tektonische > Störungen, die Auswirkungen auf die Lagerung und die Festigkeit der Gesteine haben können.

6. → Ergebnis

Zusammenfassung

Zusammenfassend sind zum Standort folgende Angaben zu treffen:

Adresse	< Adresse >	Koordinaten	<4495000; 5576700>	
WSG	Bohrtiefe	Benachbarte Bohrungen	Effizienz	Geologie bis 100 m
< Ja/nein >	< 65 Meter >	< Anzahl >	< Klasse >	<Lockergesteine>

Der Bau und Betrieb einer Erdwärmesondenanlage < ist an dem Standort möglich/ ist an dem Standort nicht möglich / bedarf einer Einzelfallprüfung > (Attributfeld des Shape-File: Test_EWS_Ergebnis)

Unter Berufung auf § 4 (1) und § 5 (2) Lagerstättengesetz sind dem Bayerischen Landesamt für Umwelt – Geologischer Dienst in angemessener Zeit (vier Wochen) nach Abschluss der Bohrarbeiten die Lage, die Geländehöhe, Schichtenverzeichnisse, Ausbauzeichnungen, angetroffene Grundwasserverhältnisse und ggf. Ergebnisse der geophysikalische Untersuchungen zu übersenden.

Hinweis

Die Auskünfte beruhen auf den Erkenntnissen und Erfahrungen des Bayerischen Landesamtes für Umwelt – Geologischer Dienst. Die Angaben dienen einem orientierenden Überblick und ersetzen keine Detailuntersuchung und Planung durch ein Fachbüro. Es kann nicht ausgeschlossen werden, dass neben den bekannten Bohrrisiken und dem geothermischen Potential andere Bedingungen im Untergrund angetroffen werden. Nähere Erklärungen und Hinweise finden Sie in den Erläuterungen zum Informationssystem Oberflächennahe Geothermie.

Figure 2 – Clote text template of the report with a specific location showing the gaps generated from vector data.

TECHNICAL PLATFORM

The IOG is the latest internet map service published by the LfU on basis of the ***GABY*** and ***GeoFachdatenAtlas*** platforms.

GABY (***G****enerische* ***A****nwendungsplattform* ***Bay****ern*) is the generic application platform for environmental information systems used at the LfU for the development of enterprise information systems like the Bavarian Soil Information System (***BIS***) or the Bavarian Water Atlas (***GWA***). These systems are our primary data storage and intended for internal use only, as they also contain data subject to privacy. They are accessible through the Bavarian state intranet only with clients requiring authentication.

The GeoFachdatenAtlas platform was developed by the LfU in cooperation with the company con terra (www.conterra.de) as external partner. It is a toolkit to create publicly available web services that publish selected data of the primary information systems. The platform is based on components of con terra's sdi.suite framework. These components like mapClient, terraCatalog or terrainServer facilitate the visualisation of data and maps in 2D and 3D and the management of metadata. The platform is open for extensions and customizing. Any enhancements can synergetically be reused by all services based on the platform.

The IOG does not directly publish data of the primary systems, but of a secondary data pool. An Oracle 10g database is used to store attributive data and metadata. An ArcIMS 9.2 handles the spatial data that are provided as ESRI shapes or as Web Map Services (WMS) from external sources. External data are mainly geographic background data (e.g. maps, aerial photographs, addresses) or special thematic services.

The primary data is transferred to this secondary system via ETL (extract – transform – load) processes using the Feature Manipulation Engine (FME) technology. Through this the primary data can be manipulated and pre-processed, sensible data subject to privacy are filtered out.

The secondary data pool is shared by all internet map services of the GeoFachdatenAtlas platform. Other already published services concern the topics geology, alpine natural hazards (see also HARTMANN & BENDA, this volume), the European Water Framework Directive and an ambient noise register.

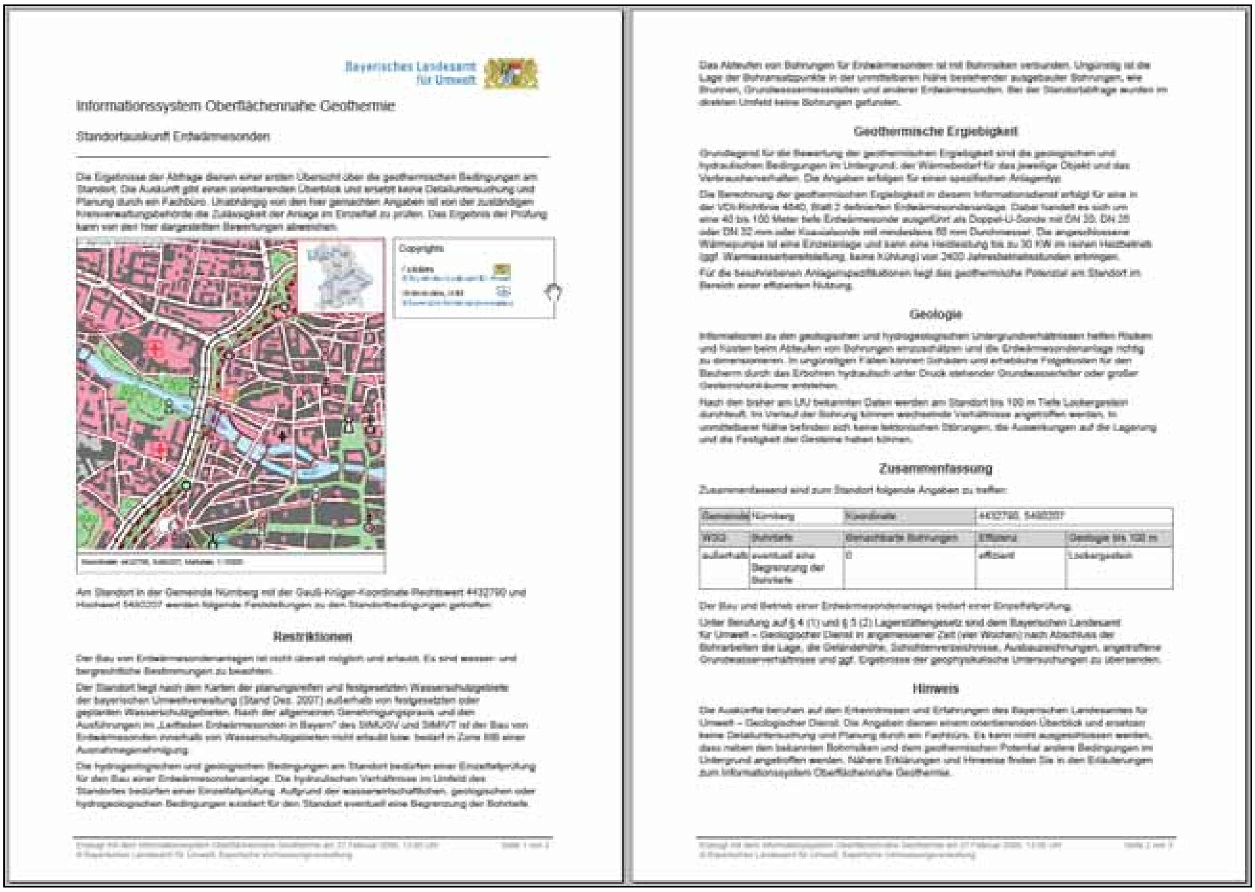


Figure 3 – PDF Dokument generated for a specific location.

IOG FEATURES

There are two main objectives of the IOG:

- provide to the interested public all kinds of general information related to the use of shallow geothermal energy, the requirements and the restrictions of ground heat exchanger systems for the whole of Bavaria,
- provide relevant information about shallow geothermal conditions for a specific location that can be determined by a user who is interested to install a ground heat exchanger system.

The IOG comes with the common features of an internet map and information service like a map window, a tabbed pane for layer control, and other functions, tool bars and additional helpers.

The central map window can be shown with topographic maps (coloured or black and white) or aerial photographs as background. Sets of different accuracy are automatically displayed according to the actual scale of the map window. Tool buttons offer zoom and pan functions. The map scale can also be picked from a drop down control or individually entered by numbers.

The pane on the left side has three tabs for the control of the several information *themes* (layers), for the *legends* of the displayed layers and for handling the specific *location* for which geothermal information can be retrieved.

The current first version of the IOG offers information layers for these topics:

- geothermal conditions for the installation of borehole heat exchangers, horizontal ground heat exchangers and the thermal use of groundwater;
- groundwater, with themes like protection areas, location of wells, high pressure in aquifers or deeper groundwater levels;
- hydrogeology, with sensitive areas and hydrogeological maps in various scales;
- geology, including location of boreholes, sensitive areas and geological maps in various scales.

Several tools allow the users to obtain further information and metadata for objects of the different thematic layers. There is also the option to load further background layers from other publicly accessible Web Map Services.

REPORTS FOR A SPECIFIC LOCATION

When the IOG is started a pop-up window explains the feature for retrieving geothermal information for a specific location and directly offers the two tools for setting the location.

These tools are always accessible on the *location* tab in the pane on the left side of the IOG. A municipality search function will place the location marker in the centre of the selected municipality. The second tool enables free positioning of the marker by a mouse click in the map window.

Once a specific location is set, the location tab shows some basic information for this location and a button for downloading a report for this location as PDF document.

The report is generated on basis of a cloze text template. The gaps are automatically filled from attributes of vector objects of underlying reference layers at the specific location. The themes that are evaluated include:

- general topographic information,
- ground water protection areas,
- hydrological and geological criteria,
- hydraulic circumstances and limitations
- limitation of borehole depth,
- neighbouring equipped boreholes,
- geothermal potential,
- subsurface geology (rock types and quality, tectonic situation),
- general recommendations for the installation of borehole heat exchangers.

The report also shows a topographic map showing the location marker and its surrounding in a fixed scale.

The location based report is a concise principal information on the geothermal conditions for the selected location. Besides general and legal advice it contains sections on restrictions for borehole heat exchangers, the geothermal productivity and the geologic situation. The location based report is not intended to substitute a professional expertise.

FUTURE DEVELOPMENTS

In the first version of the IOG the positioning of the point of individual interest is supported by a municipality search function. It is planned to implement a gazetteer service supporting the positioning by address data in the future.

The reports for specific locations cover borehole heat exchangers only. The next version of the IOG is supposed to create reports for horizontal ground heat exchangers and the thermal use of groundwater as well.

ACKNOWLEDGEMENTS

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APPLICATION OF GIS TECHNIQUES FOR THE EVALUATION, MANAGEMENT AND ANALYSIS OF THE UK ARCHAEOMAGNETIC SECULAR VARIATION DATABASE.

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KEY WORDS: archaeomagnetic database, GIS, geodatabase, Google Earth

UK SECULAR VARIATION DATABASE

The application of earth science principles and techniques to the understanding of the archaeological record has become a common practice. In the framework of geoarchaeological studies archaeomagnetic dating is often used for the accurate determination of archaeological chronologies. It involves the comparison of the archaeomagnetic direction and/or intensity, determined by laboratory measurements of samples from artefacts or archaeological features, with the known secular variation record of changes in the Earth's magnetic field over archaeological timescales. Thus, to ensure the accuracy of archaeomagnetic dating, a robust and detailed secular variation record has to be established. However, the complexity of archaeomagnetic data, and the necessity to constantly update the database, requires a flexible system for storage and processing allowing interactions with data from neighbouring countries.

We present an example for the U.K. archaeomagnetic database, accomplished within the framework of a Geographic Information System. The GIS elaboration involved database updating, digitizing e.g. maps, lithological columns, archaeological sketches, and space-time data analysis.

The dataset compiled by Zananiri et al. (2007), for the past 4000 years, is the most complete available in the UK, including published results, PhD theses, English Heritage Ancient Monuments Laboratory reports and other unpublished laboratory reports. It comprises 620 archaeomagnetic directional data with all relevant information available about the site (latitude, longitude, locality and type of archaeological structure), the archaeomagnetic direction (inclination, declination, statistical parameters and laboratory procedures) and the archaeological age (age limits and method employed), along with the corresponding references.

APPLICATION OF GIS TECHNIQUES

The systematic use of tools provided in Geographic Information Systems in data mapping (e.g. Koutsopoulos, 2002) makes easy the management of the information concerning the secular variation of the Earth's magnetic field. The first step of the proposed methodology concerns the creation of a geodatabase and entails the task of defining a coding system, suitable for regional and national scales, which translates all the information (e.g. archaeological structure type, laboratory procedures etc.) from the Zananiri et al. (2007) archaeomagnetic database into alpha-numeric codes. This step is realized in a GIS environment, exploiting the available tools to store, manage, analyze and visualize the following data layers:

- Points representing site location of archaeomagnetic data
- 2D polygonal features and related attributes representing the spatial distribution of UK counties.

Time period	Nr of data
2000 BC – 1000 BC	10
1000 BC – 0 AD	67
0 AD – 1000 AD	233
1000 AD – 2000 AD	310

Table 1 – Temporal distribution of data.

Selecting data from the database is a helpful tool in the evaluation of the available information and the elaboration of small scale studies. Towards this scope, separate data layers with various archaeological structures, namely kilns, hearths and burnt material, are compiled, indicating the predominance of kiln structures, which provide very reliable archaeomagnetic data, enhancing,

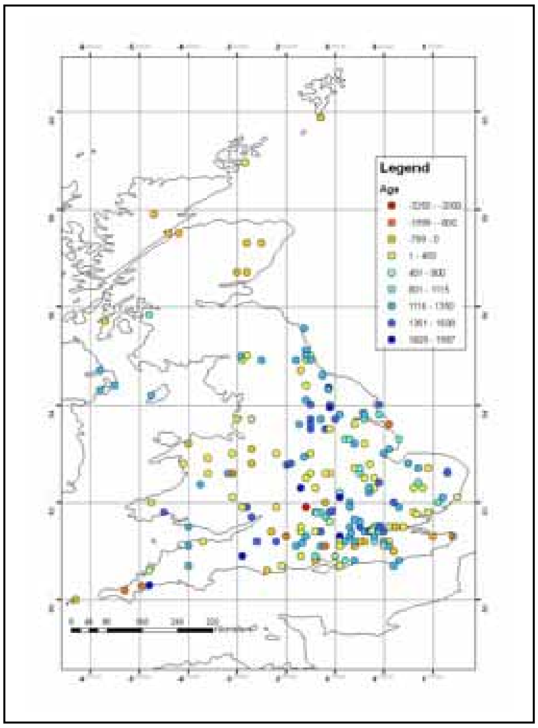

Figure 1 – Spatial distribution of archaeomagnetic data sites in Britain. Various colours correspond to different eras.

thus, the reliability of the Earth's magnetic field secular variation record. Similarly, a spatial and temporal (Table 1) evaluation of the data was performed, in order to identify the areas and time periods with scarcity of data and assist the organised planning of future archaeomagnetic work. Finally, the maintenance of the archaeo-magnetic database in a GIS environment facilitates update with input of new data that are automatically incorporated in the mapping and evaluation processes.

GOOGLE EARTH

Online tools, such as those pioneered by Google Earth™ (GE), are changing the way in which scientists and the general public interact with geospatial data in a virtual environment. In the few years since its 2005 introduction, GE has found numerous applications, in geosciences as well as in many socio-economic disciplines. In the present study critical information from the archaeo-magnetic geodatabase were imported in Google Earth and stored as a Keywhole Markup Language zipped (KMZ) file, rendering a 2-D layer in GE directly, to facilitate dissemination amongst the scientific society. The study of some of the sites (Figure 2) dated back to the 1950's, where Global Positioning System techniques were not developed.

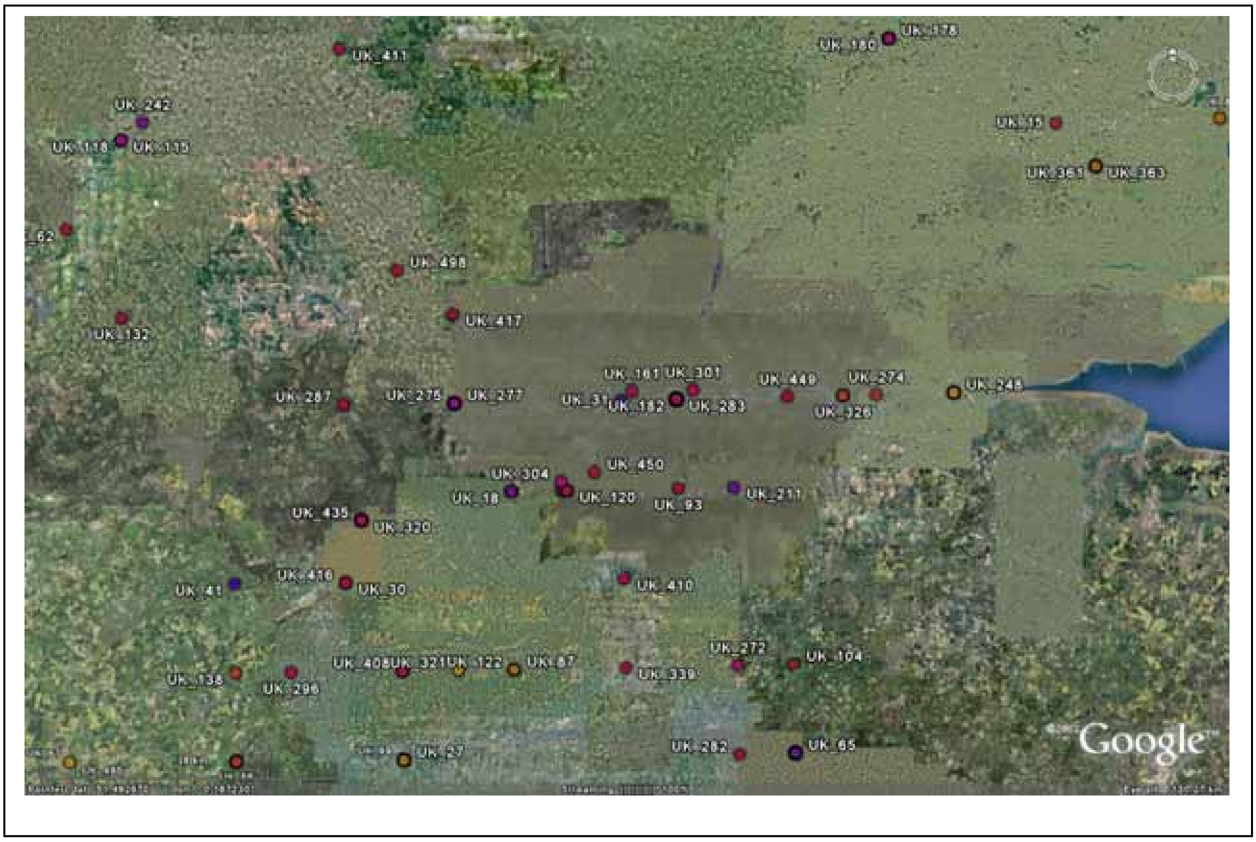

Figure 2 – Mapping in Google Earth™ of archaeomagnetic sites from the UK secular variation database.

The GE platform combines satellite imagery, aerial photography and spatial data, and provides the resolution required for an evaluation of the location (latitude/longitude) accuracy of the data and correction where needed. To accomplish this locality name and other archaeological information were used in order to define the exact location of the site in question.

ACKNOWLEDGEMENTS

Google and Google Earth are trademarks of Google, Inc. English Heritage, Clwyd-Powys Archaeological Trust, SUAT Ltd. and Gwynedd Archaeological Trust are warmly thanked for their co-operation in our search for data.

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FROM ANALOGICAL TO 1:50.000 DIGITAL GEOLOGICAL MAPS OF I.G.M.E.: DIGITIZING, INTEGRATED GEOLOGICAL DATABASE AND CARTOSYNTHESIS

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KEY WORDS: integrated geological database, digital maps, unified legend, cartosynthesis, data harmonization, GIS.

DATA DIGITIZING, INTEGRATED GEOLOGICAL DATABASE

The Institute of Geology and Mineral Exploration of Greece (I.G.M.E.), founded in 1976, is the enacted technical state adviser on geoscientific issues. One of its main research fields is the geological mapping of the entire country which constitutes an infrastructural work for the planning and implementation of local, regional and national developmental projects.

The Institute, in the framework of CSF 2000 – 2006 (Operational Program “Information society”), implemented the project called “Data digitizing for the Geoinformation System of I.G.M.E”. The basic aims of the project were the digitizing – vectorization of 325 analogical geological map sheets covering the Greek territory (scale 1:50.000) and the creation of an integrated, specifically designed, geological database (figure 1 & 2).

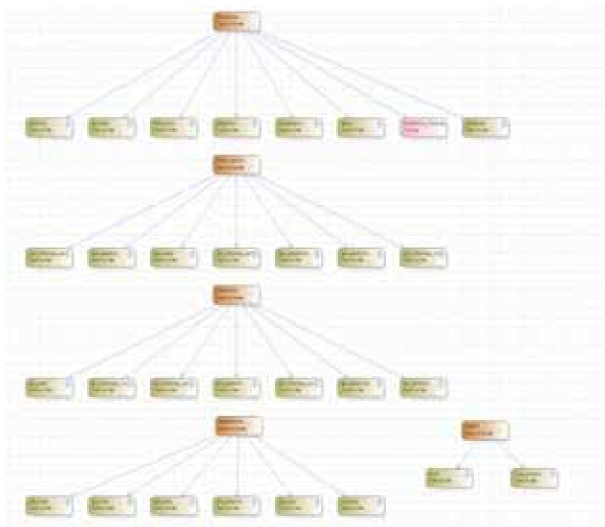

Figure 1 – Integrated geological database schema

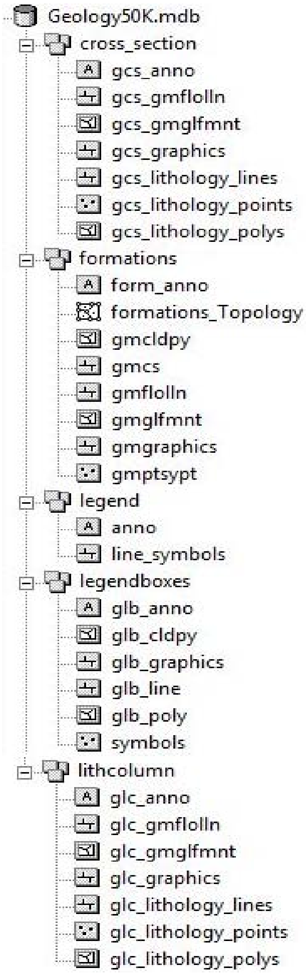

Figure 2 – Structure and content of the integrated geological database

The complexity of the digital geological information derived from geological maps was stored and processed within the framework of a Geographic Information System.

The GIS elaboration comprised the following stages (Koutsopoulos K., 2002):

- Design and creation of the geographic - geological database
- Digitizing (map, cross sections, lithostratigraphical column, legend boxes, other special features)
- Descriptive information

- Data management (Spatial adjustments, local adjustments, edge matching etc.)
- Topology

CARTOSYNTHESIS PROJECT

Since 2008 another relative project has been implemented, in the framework of CSF 2000 – 2006, entitled "Cartosynthesis of modern geological maps at a scale of 1:50.000 for the Geoinformation System of I.G.M.E.". The main objective of this project is the creation of a high quality digital cartographic database consisting of 325 geological map sheets (scale 1:50.000) and the production of digital files in various formats available for printing. During the project implementation, a digital library containing geological symbols (point, linear, polygonal symbols) has been created, harmonized with the international specifications.

The derived digital geological maps incorporating all the basic (map theme, legend) and additional geological information (cross section, lithostratigraphic column) are produced in GIS environment (figure 3).

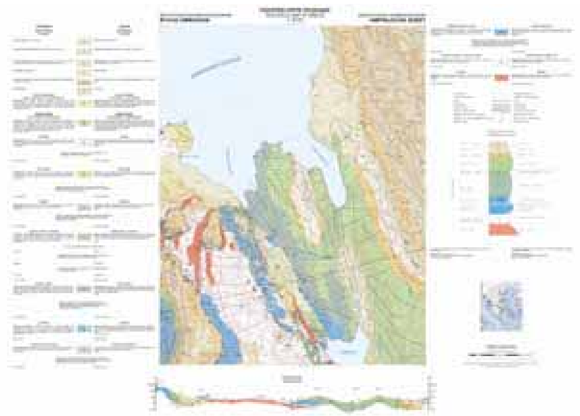

Figure 3 – New digital geological map sheet "AMPHILOCHIA" at a scale of 1:50.000.

The geological maps carry the IGME trademark and a specially customized watermark, which both certify the map origin and authenticity.

DATA HARMONIZATION

Being close to the completion of the above mentioned projects, several problems have emerged, summarized in the following:

- Heterogenity, inconsistency, discontinuity of geological features (formations, tectonic lines, etc) between adjacent geological map sheets.
- An enormous number of geological formations occurring in the 325 geological map sheets.

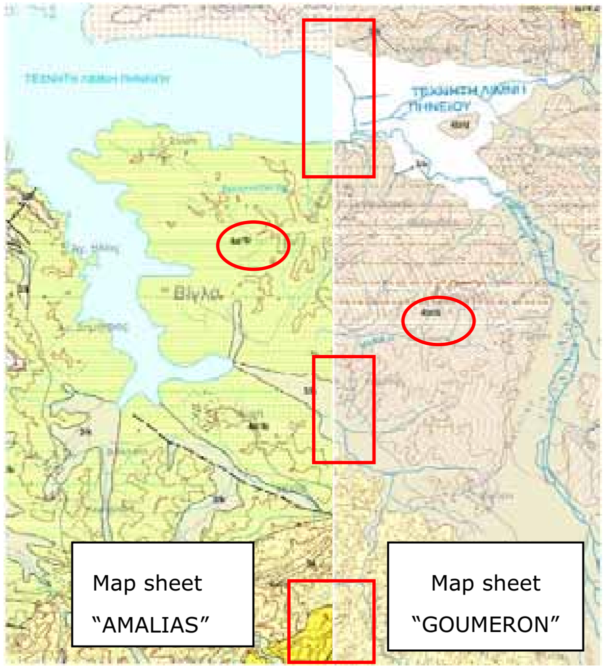

Figure 4 – Cartographic – geological discontinuity between two adjacent geological map sheets.

These problems mostly reflect different geological approach and interpretation concerning the Greek territory, due to the fact that geological mapping in Greece has been carried out during the last six decades, at different periods, by many geologists supporting different geological and geotectonic theories.

All mentioned above demonstrate today the need for harmonization, generalization and synthesis of all geological data derived from the digital geological map sheets. The final objective would be an interactive communication of the integrated generalized geological legend with the digital geological background data.

The harmonization process entails the cartographic and geological harmonization, generalization and synthesis of all geological entities included in geological maps (formations, linear features, point features) and their legends.

Towards this scope the following work tasks are required:

- Field work
- Remote sensing processing
- GIS processing

The "Data Harmonization" project described above is under planning today by I.G.M.E. It will actually follow the methodology that is currently applied in other geological institutes (BRGM) and similar European projects (IGME 5000 - The 1:5 Million International Geological map of Europe and Adjacent areas, Asch K., 2003) and will be based on international geological standards.

The final derived product will reflect the modern perceptions - interpretations for the geological structure of the country and will constitute background knowledge for the implementation of specific geological projects regarding engineering geology, geophysics, hydrogeology, geochemistry, geothermal energy etc.

ACKNOWLEDMENTS

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Topic – Geodata infrastructures

DEFINING GEOLOGY FOR INSPIRE – THE MAJOR CHALLENGE FOR ONEGEOLOGY-EUROPE

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KEY WORDS: Geology, EC-Directive, INSPIRE, Data specifications, classification, OneGeology-Europe.

The EC INSPIRE Directive which came into force in May 2007 set out how the Member States of the European Union would describe, discover and provide access to spatial environmental data in a harmonised way. Amongst the thematic data sets specified in INSPIRE is "geology". A fundamental question arising from this is: what is meant by the term "geology"? The question must be answered, and in some detail, if the intentions of the INSPIRE Directive to provide consistency of access are to be realised.

The Directive itself provides very little constraint on this definition. In it "geology" is described as

*"Geology characterised according to composition and structure. Includes bedrock, aquifers and geomorphology". (*Directive 2007/2/EC, Annex II).

The challenge for the EC and its Member States – more specifically for the geological survey community – is to convert these few words into a precise and practical specification that will deliver the outcomes intended by INSPIRE. The geological survey community is attempting to develop this specification through two complementary routes. Through a Theme Working Group – a generic procedure adopted by the EC that will start in May 2009 for a group of INSPIRE themes that will very probably include "Geology" - and a new EC eContentplus project, OneGeology-Europe. These groups do have pre-existing pan-European experience to build from – for the geoinformation system of the 1 : 5 Million International Geological Map of Europe and Adjacent Areas classifications and hierarchies for the geology of Europe (IGME 5000) were developed (ASCH, 2003), and while this project worked at a smaller scale than the specification now required, it provides an considerable understanding of the scientific, technical and cultural problems and potential solutions.

Within OneGeology-Europe Work Package 3 includes the task to deliver a specification of "geology" at 1:1 million scale for the attributes "rock age" and "lithology". While the initial reaction of some would be to question whether defining geology with these attributes at this scale can pose any significant challenges at all, the reality is somewhat different. Some fundamental questions must be considered:

- What are we specifying; the geology at the surface or the "bedrock" geology ie below the "superficial (Quaternary) deposits;
- Do we attempt to define the rocks by their age, or by their lithology, by lithostratigraphy or by their genesis, or all of them?
- To what extent do we include tectonic features?

Figure 1 – The aim of OneGeology-Europe: The geology of Europe on-line on the base of interoperable geological specifications (source: the IGME 5000 coverage projected via Google Earh)

These are merely the high level questions – the devil will be in the detail:

- How should metamorphic rocks be described? According to the rock name, and if so according to which classification? Will the age of their orogeny be included? The metamorphic grade? P/T conditions ?
- How should the classification of the Pre-Cambrian be tackled? The standard classification is too general for the Pre-Cambrian rocks dominant in Fennoscandia.

- What approach should we adopt to hypabyssal rocks? To ophiolite complexes, to dykes?

There are many other difficult questions and issues to be confronted and of course existing vocabularies, definitions and classifications, such the IUGS standards and the developments by the CGI GeoSciML vocabulary group need to be taken into account. Compounding these questions is the fact that few international standards exist in geoscience and almost every national geological survey has adopted different standards, standards which they are reluctant to concede.

Establishing a specification for spatial geological data for a continent, which has for almost two centuries developed disparate individual national approaches, is a major challenge. In creating a shared standard for basic geological data at a scale of 1:1 million OneGeology-Europe is taking an essential first pragmatic step in what may prove to be a long and arduous journey.

ACKNOWLEDGEMENTS

I would like to acknowledge the work of the INSPIRE Drafting Team "Data Specifications", the EuroGeoSurveys INSPIRE Working Group and the OneGeology-Europe Workpackage 3 core team. They are all in various ways working to constructively achieve the best possible data specification of "geology" for Europe.

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ONEGEOLOGY-EUROPE web site: http://www.onegeology-europe.eu

SGSS GEOGRAPHIC DATA CATALOGUE

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KEY WORDS: Catalogue, Spatial data, Metadata.

INTRODUCTION

The "Geological, Seismic and Soil Survey (SGSS)" of the Emilia-Romagna Region (RER) is composed by up to 60 employees and at least half of them has to work with maps and their attributes every day. The main tasks are visualization, query, layout and, for GIS specialists, analysis and modelling.

Since 2004 the SGSS build his own geographical database, composed by a lot of vectorial, raster and alphanumerical data.

The "SGSS Geographic Data Catalogue" provides a useful tool to access and manage this wealth of geographic information. Moreover, this Catalogue has been designed to satisfy the demand of intranet geographic data. In addition, most of these data have been made available for the internet users also.

The main target of this application is to make the ordinary tasks of the SGSS users easier by structuring the information, improving the access to the data directly from the ESRI ArcSDE database and connecting with the metadata stored in the RER Metadata Repository.

This application has been developed also thanks to the partnership with "Province of Bologna", a public administration of the Emilia-Romagna Region, who released the first version of the Catalogue at the beginning of 2007.

ARCHITECTURE

The "SGSS Catalogue" consists of two main applications having similar interfaces with search and browse tools based on a unique thematic classification scheme.

The schematic architecture (figure 1) is composed by four tiers and, from bottom to top, can be resumed as:

- DBMS
- SERVICES
- APPLICATIONS
- CLIENTS

DBMS:

Almost all the datasets produced by the SGSS, concerning geographic entities and linked documents, are stored into a single RDBMS environment. The database is maintained in an ORACLE DB. The schema is a hybrid model between the ESRI geo-database and the simple alphanumerical tables and views. The data structure is stable: it has been consolidated during the last 5 years and it is updated and maintained almost every day.

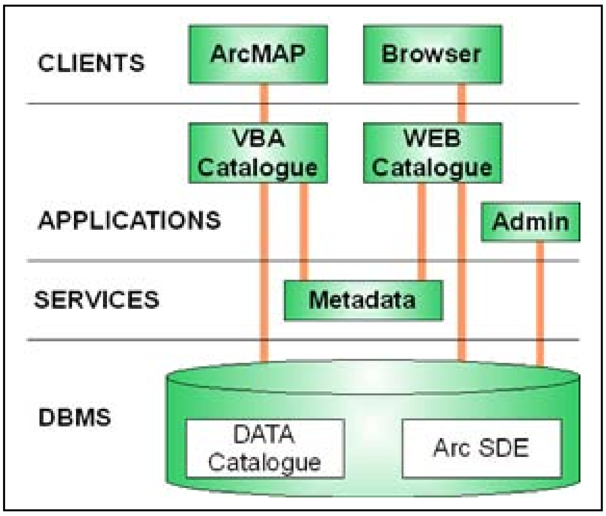

Figure 1 – Catalogue system architecture.

On the other hand, has been developed a new database, called the "Data Catalogue" in figure 1, containing the relationship between the ArcSDE database and the Catalogue structure. This database is the background of the administration panel and it is maintained by the Catalogue administrator through an user friendly interface.

SERVICES:

Regarding metadata (figure 2), the Emilia-Romagna Region provides an enterprise system, called "Metadata Manager", to store and manage the metadata in ISO 19115 format. Both Catalogue applications exploit the metadata service exposed from the Metadata Manager.

Figure 2 – Snapshot of a Metadata page.

APPLICATIONS:

The "SGSS Geographic Data Catalogue" is composed by three levels of independent applications: the Administration Application, the Intranet Application and the Internet Application.

The first one, called "Administration Panel", is focused to manage and structure the information to be published in the Catalogue. The second one, called "VBA Catalogue", is addressed to the SGSS users that work with maps. The third application is a WEB map viewer, developed in JAVA and it is focused to the Internet users.

The Administration Application component performs three basic functions:

- The synchronization between the ArcSDE database and the Data Catalogue;
- The management of the thematic classification scheme;
- The datasources link with the RER metadata service.

The "VBA Catalogue" is an interface that is loaded in ArcMAP as a new toolbar from a DLL shared in the SGSS file-server. Users login with their credentials. In this way data permissions are preserved.

The application establishes a connection with the "Data Catalogue" database and shows a hierarchical list of layers grouped in thematic sections (figure 3).

Figure 3 – ArcMAP Catalogue interface.

This structure of the tree reflects the organization and the main tasks covered by the SGSS Service. The user scrolls data in the tree view and can load multiple data sources, like Feature Classes, Dataset, Tables, etc., directly within his ArcMAP session.

On the other hand, the "WEB Catalogue" is useful for consulting through Internet most of the data managed by the SGSS. The data are available to be visualized by the Internet users, especially by to citizens, freelancers, students, researchers and enterprises. The application provides data navigation and, when allowed, data downloading.

CLIENTS:

The client tier includes ESRI ArcMAP and a generic WEB browser. ArcMAP is the main internal Desktop GIS for all the SGSS users and the Catalogue application shows all the datasets stored in the SGSS database in a more suitable and useful way than the ESRI ArcCatalog. All these data, except the reserved ones, are viewable in any WEB browser without additional plug-in.

CATALOGUE INTERFACES

A common element in both interfaces, ArcMap and Web environment, is the navigation tree view, as shown in figure 3 and 4. The data sources, listed in the tree, are symbolized with the same icons used in ArcGIS 9.x. The layers belonging to the same thematic domain are grouped in the same folder.

Both Catalogue applications share two basic functions like:

- Search: It allows to find and highlight one or more layer names based on a keyword;
- Metadata: it allows to display Metadata information of the data.

The ArcMAP interface also offers a small map preview based on the thumbnail image stored in ArcSDE database. The user can load the raw data source selected or, when present in the catalogue database, one or more representation files (.lyr).

The WEB Catalogue interface contains the Catalogue tree and two other functions. These are a quick help and a tool to search any kind of documentation related to geographic data sources. Users can visualize the Metadata information simply clicking on the selected data name. The correct compilation of the Metadata is the mandatory condition to publish data on the WEB and, at the moment, all the data sources have their own metadata.

In the WEB catalogue tree, on the left side of each data's name, there are usually two clickable icons present that give access to the map or table viewer and to the data download functions.

The map viewer consists of standard navigation tools such as: zoom in, zoom out, zoom box, full extent and pan. The map extent is preserved through the work session in the map frame, unless the user selects the full extent tool. The identify tool allows a view of the data related to the elements shown in the map. Users can type, select the view cartography scale or scroll the RER municipality areas list to zoom to the corresponding boundaries extent. Vector data are always displayed with the same simple symbol. The main purpose of this viewer is to strictly show to the user the typology and the covering area of the geographic data.

Alphanumerical data are shown in a table, including the items definition.

The download function only works with vectorial and tabular data. The tables are available in TXT and XML format optimized for MS Access, Excel and Oracle. The vectorials data are downloadable in ESRI *shapefile* format with the legend (.avl) and projection files (.prj) enclosed. All these are packaged into a single zip file.

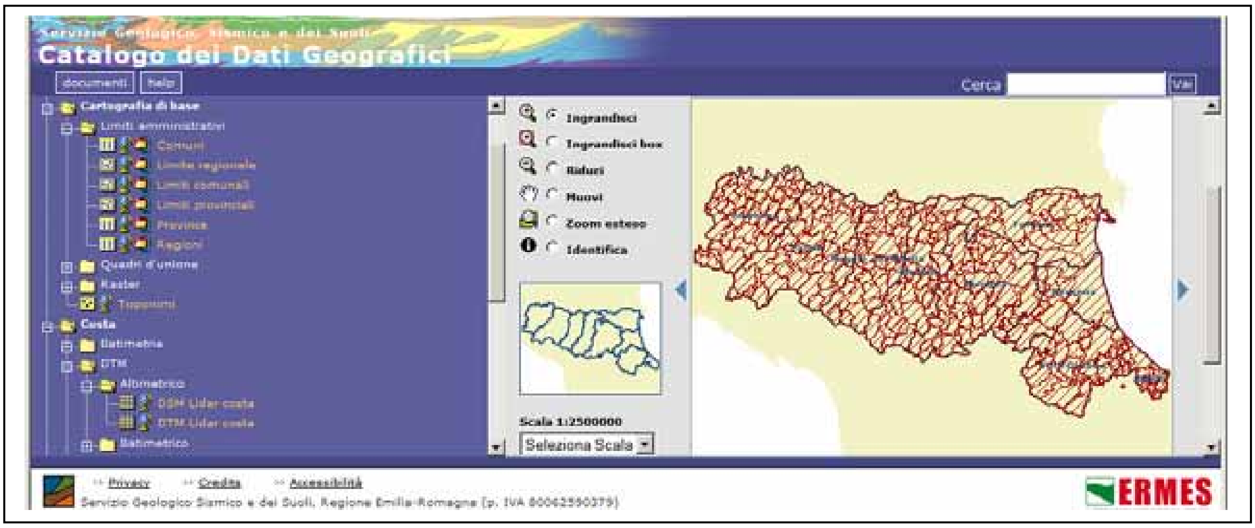

Figure 4 – WEB Catalogue interface.

CONCLUSIONS

It's always hard to realize when and if, in the end, the project targets have been achieved.

The "SGSS Catalogue" relies on the positive feedback of SGSS GIS users and a large amount of internet users which is an objective index of success. In fact, last year, the number of visitors of the SGSS web site amounted to about 240.000 units and most of them visited the SGSS WEB Catalogue. Also relevant is the collaboration with the GIS department of the Province of Bologna. In the spirit of the reuse best practices, this project is demonstrating positive results of applications, design and developing share between local and central administrations.

ACKNOWLEDGEMENTS

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GIS Service of the "Province of Bologna"

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DEVELOPMENT OF AN ADMINISTRATION-WIDE GEOGRAPHICAL INFORMATION SYSTEM FOR AGRICULTURAL APPLICATIONS

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KEY WORDS: LPIS, WMS, WFS-T, Agricultural Information System

ABSTRACT

Since 2004, an Agricultural Information System has been developed for the Bavarian Ministry for Food, Agriculture and Forestry (StMELF) for the implementation of EU and state-specific agricultural support policies to be used in the Ministry and Agricultural Offices. The presented GIS comprises a central data management with possibilities for export and import of data for on-the-spot controls and GPS-measurements. Additionally, farmers can declare their application data through a web client; these data are in turn entered into the central system by the use of standardized interfaces. In this paper, a special focus is put on system interaction and integration.

INTRODUCTION

In the course of the common EU agricultural policy (CAP-reform) of 1992 and with the introduction of subsidies for farmers, an Integrated Administrative Control System (IACS) on an alphanumerical basis was created. The system was extended in 2000 when a new policy was presented that committed the EU-member states to develop a Land Parcel Identification System (LPIS) with the goal to clearly identify agricultural parcels. Therefore, Geographical Information Systems where introduced to identify and administer the GIS-data.

In federal Germany, nearly all states have developed their own systems. In the course of this paper, the Bavarian system will be described, starting with the declaration of the farmers to the maintenance of the data by the Ministry and Agricultural Offices. The focus will be on the GIS-components of the system.

FUNCTIONAL WORKFLOW

Every year, the farmer hands in a declaration to his allotted Agricultural Office, which crops will be cultivated this year and on which parcels this will be done. The declaration not only includes information on the crops but also the area, the landscape elements that are maintained and agri-environmental measures. The declaration can be done in analogue form (paper maps of each parcel and filled in declaration forms) or digital (via the MfA Online, this is a collection of forms for alphanumerical declaration data in an internet portal of the Bavarian Ministry). Additionally, a web service is available that is hosted by the Bavarian Surveying Authority (Bayerisches Vermessungsamt, BVV). It is called BayernViewer –agrar and is linked over standardized interfaces to a transactional web-feature service which in turn is connected to the central database of the Bavarian Ministry. This database holds all geometric information on each declared farm and thus provides the basis of the GIS-System. The connection of the BayernViewer –agrar to the central database will be described further below.

Subsequently, it is the task of the editors in the Agricultural Offices to completely check the received declarations of the farmers and to enter the analogue alphanumerical data in the LPIS database BaLIS (a DB2 database application on an IBM host system). The alphanumerical data that was handed in in digital form is checked for plausibility by the host system. As a next step, the agricultural parcels have to be either newly entered or updated in the GIS-System. The parcels of a farmer have to be edited because of building and road constructions that influenced agricultural land for example or because of the transfer of a parcel to another farmer.

The client application for this task is the software LaFIS®. The LaFIS®-system developed by GAF AG will be described in more detail below.

The parcels in the GIS-system are the basis for the subsidy payments for the farmers. For Bavaria, this lies in the region of 1.4 Mrd. € / year.

The agricultural authorities are forced to assess the eligibility for subsidies of the agricultural parcels on a certain scale. It is therefore obligatory to control and measure the parcels in on-the-spot controls or by remote sensing means. At least 5% of the rd. 125000 farmers have to be controlled each year. For the on-the-spot controls, a mobile GIS-client is used called LaFIS®-VOK of the LaFIS® suite. With this client, the data of the farms can be exported from the central database and are therefore available offline for use in the field. The exchange of data for GPS-measurements is also included.

The previous explanations showed the way of a declaration from the farmer to the LPIS and GIS databases. The software, architecture and interfaces of the GIS-components, which are used for these tasks, are the topic of the following sections.

OVERVIEW OF THE SYSTEM

Figure 1 gives an overview of the system and the components and administrative authorities involved. The core system with declaration data and reference plots is maintained by the StMELF. It consists of the LaFIS®-system and the interface to the LPIS-database BaLIS. Connections exist to the BVV with the BayernViewer –agrar and the Web-Mapping Service. The WMS is used for the retrieval of raster images (digital orthophotos) for the LaFIS® clients. Therefore, standardized interfaces, like WFS-T and WMS, are used in the connection to the BVV. For the communication of LaFIS® with BaLIS customized EntireX interfaces are developed.

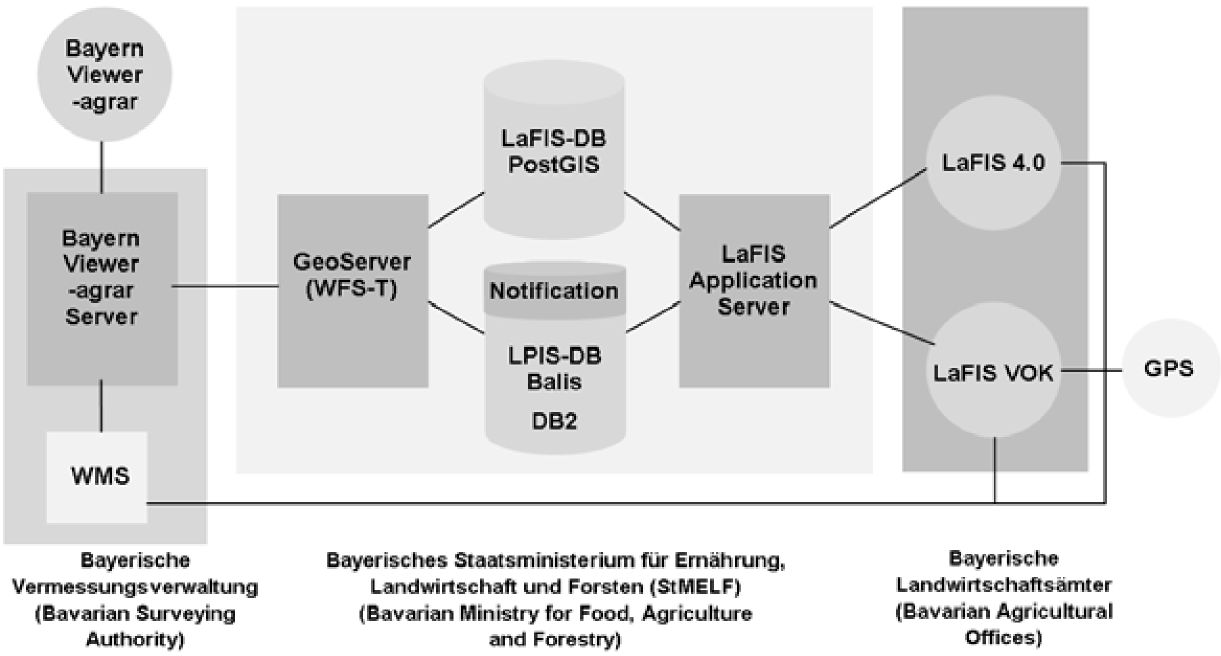

Figure 1 – Overview of the system

THE CENTRAL GIS-SYSTEM LaFIS®

The central GIS-system uses a flexible three tier architecture, consisting of a spatial database (PostGIS), an application server and the LaFIS® clients (see figure 2).

The application server communicates with two databases: a PostGIS database (LaFIS®-DB) is the main GIS-DB storing the spatial data. The alphanumerical data is maintained by the StMELF inside BaLIS. The communication between the DB2 database and the application server is managed by EntireX allowing to incorporate host based business logic written in Natural as well.

The GIS-clients LaFIS®4.0 and LaFIS®-VOK are using the application server for data exchange. The application server also manages parts of the processing and plausibility logic, like topology and data integrity checks. These functionalities are also available to other clients through customized interfaces.

During the start-up of the LaFIS®4.0 client, spatial data are loaded from the LaFIS®-DB together with the relevant declaration information from the BaLIS. Putting it all, together the application server plays an important part in the enterprise application integration keeping away the complexity from the users and allowing them to manage the integrated data in the GIS clients.

The main GIS-client is LaFIS®4.0. Using this system, the maintenance of the reference plots and landscape elements is performed and on-the-spot controls are prepared and finalised. After the preparation of the parcels, the data for the on-the-spot or remote sensing control can be exported to the mobile client LaFIS®-VOK. The data are exported to an Access DB on a mobile PC. The farms for which data are exported are locked in the central database. During export, the WMS of BVV is queried to retrieve raster images for the AOI of the exported farms. In the field, the parcels can be further exported as shapefiles to a GPS for measurements and the results re-imported to LaFIS®-VOK. At the end of the on-the-spot control, the data are transferred back to the central LaFIS®-System. In LaFIS®4.0, the results of the on-the-spot-controls can then be directly transferred to BaLIS.

To maintain data integrity while supporting online and offline editing long term transactions are used throughout the system.

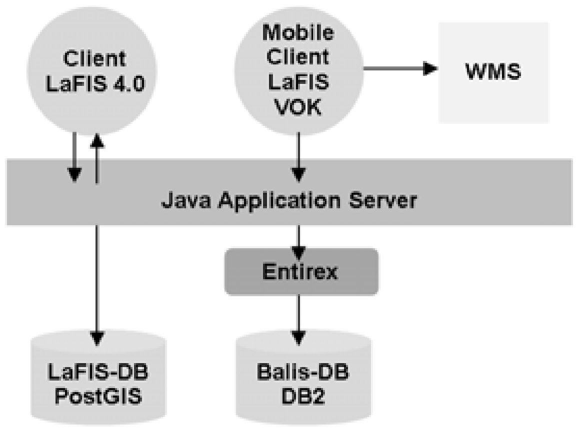

Figure 2: Overview of the central GIS-System

WFS-T AND BAYERNVIEWER -AGRAR

The main online application used by the farmers for the declaration is the MfA Online which allows to register the alphanumeric data. To tap the full potential of an online declaration, however, a WebGIS application is developed and maintained by the Bavarian Survey Administration (BVV) supporting the farmer on the one hand and giving the authorized user at the office the opportunity to directly incorporate digital geometric data into the main system. This system, called “BayernViewer -agrar”, can be started from the MfA and offers the farmer an interactive map of his agricultural parcels and related information as relevant at the moment or the last year. He can then specify parcels which will no longer belong to his farm or declare new parcels he will farm on, together with additional information.

The BayernViewer -agrar WebGIS application is hosted at the BVV. Communication and integration of the two systems is done by a OpenGeospatial Consortium standard WFS-T Geo-Webservice implemented at the StMELF site and called from BayernViewer -agrar. As transactions are supported, the farmers’ modifications are sent by a corresponding WFS-T call and handled by the StMELF LaFIS®/BaLIS system (see figure 1). Security is ensured by usage of client and server certificates.

In a more detailed view some more steps are necessary to do a complete processing of the online declared modifications. First of all, data is not directly edited in the production database but changes maintained in a separate table in a first step. This is due to security constraints as well as the workflow to review all data by an authorized user who will be informed by a notification system based on BaLIS. Therefore the WFS-T server has to fulfil two tasks. On the one hand the modified data has to be persisted and made available to the LaFIS® system and on the other hand the notification system has to be activated which is based on BaLIS.

The WFS server implementation is based on the Open Source GeoServer, supporting WFS-T in its core functionality as well as PostGIS data sources used in this case to connect to the LaFIS® system. To call the notification system in parallel to the data transaction, a GeoServer plugin was developed being called on every transaction and filtering the necessary information for notification.

In a next step concerning the functional workflow the authorized user incorporates the changes he is notified about. This is done by means of the LaFIS® client including specific tools for the completion of this task.

SUMMARY AND CONLUSION

In this paper, the Bavarian system for agricultural controls was presented. The different components and interfaces, which are used to maintain this GIS-system, have been explained.

Geoinformation systems are nowadays widely used in an enterprise context and not limited to standalone desktop solutions. Beside the integration of a variety of systems, different authorities or institutions can be incorporated to participate in such a system as was shown in this example. Thereby standards like OGC and INSPIRE play an increasing role for data exchange and system integration and can be successfully used for these kind of tasks.

ACKNOWLEDGEMENTS

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THE GEO1MDB: THE DATABASE OF THE 1:1,000,000 SCALE GEOLOGICAL MAP OF ITALY

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KEY WORDS: Geological map, lithostratigraphy, chronostratigraphy, GeoSciML, Data model.

THE FEATURES OF THE 1 MILLION GEOLOGICAL MAP OF ITALY

In 2008 the Geological Survey of Italy realized the 5th edition of 1:1,000,000 scale Geological Map of Italy, presented at the 33rd International Geological Congress that be held in Oslo.

This map has been realized using innovative criteria, representing the information for lithological and stratigraphical characterization of rocks, for the identification of depositional environments, and evidencing the Hercynian and Alpine orogenetic events.

The legend has been structured, for sedimentary rocks, based on litho- and chronostratigraphic criteria related to regional geodynamic or biological events; afterwards these units have been grouped in depositional environments and, furthermore, on the belonging to a various orogenetic cycle.

Volcanic rocks have been subdivided by petrogenetic or chemical characters; they have been successively grouped on palaeogeographic domain defined by magmatic events related to geodynamic phases.

For the intrusive rocks the main distinction has been made on the age of intrusion and distinguished in two categories (Alpine Cycle and "Triassic" and Hercinian Cycles).

The metamorphic rocks have been characterized by the age of the metamorphic event (joined to the orogenetic cycle), and further grouped on the metamorphic degree and distinct on the pressure-temperature characters.

In total, there are 104 different units of legend, to which must be added the main tectonic symbols (thrusts and faults).

The map is accompanied by a scheme that represent the main tectonostratigraphic units.

The 5th edition of the 1 million scale Geological Map of Italy introduce innovative concepts of cartography besides those traditional of litho- and chronostratigraphy.

Also being the 1:1,000,000 scale Geological Map a historical tradition of the Geological Survey of Italy, it represents the most up-to-date innovation.

This new map represent the contribution of the Geological Survey of Italy to the OneGeology international project, that has the objective to create a dynamic geological map of the World to the scale 1:1,000,000.

DATA MODEL

Based on the geological information present in the legend description and on the GeoSciML schema (IUGS-CGI) we have designed the database (figure2) of 1 million scale Geological map.

The features are polygons relate to the formation description and linear relate to the tectonic structure.

The geological tectonic events had been stored separately in a table, because could be linked to polygons and linear elements.

In the main table are allocated all the information of age (bottom and top), lithology subdivided in 5 order of litotype in important presence listed, this is due to the complexity of composition that in Italy presents an intense alternation of different type of material. Is also stored attribute concerning the orogenetic cycle, the depositional environmental and the genesis of rock, while the cartographic attribute are joined in a table using the legend number identification code.

The age in according to the International chronostratigraphic time scale (IUGS-ICS 2004 chart) have a hierarchy vocabulary structure to match the GeoSciML requests. Equally, the lithology vocabulary follow the GeoSciML schema with the ontology structure designed to match national terms with the international nomenclature.

Figure 1 – Geological Map of Italy at the scale 1:1.000.000.

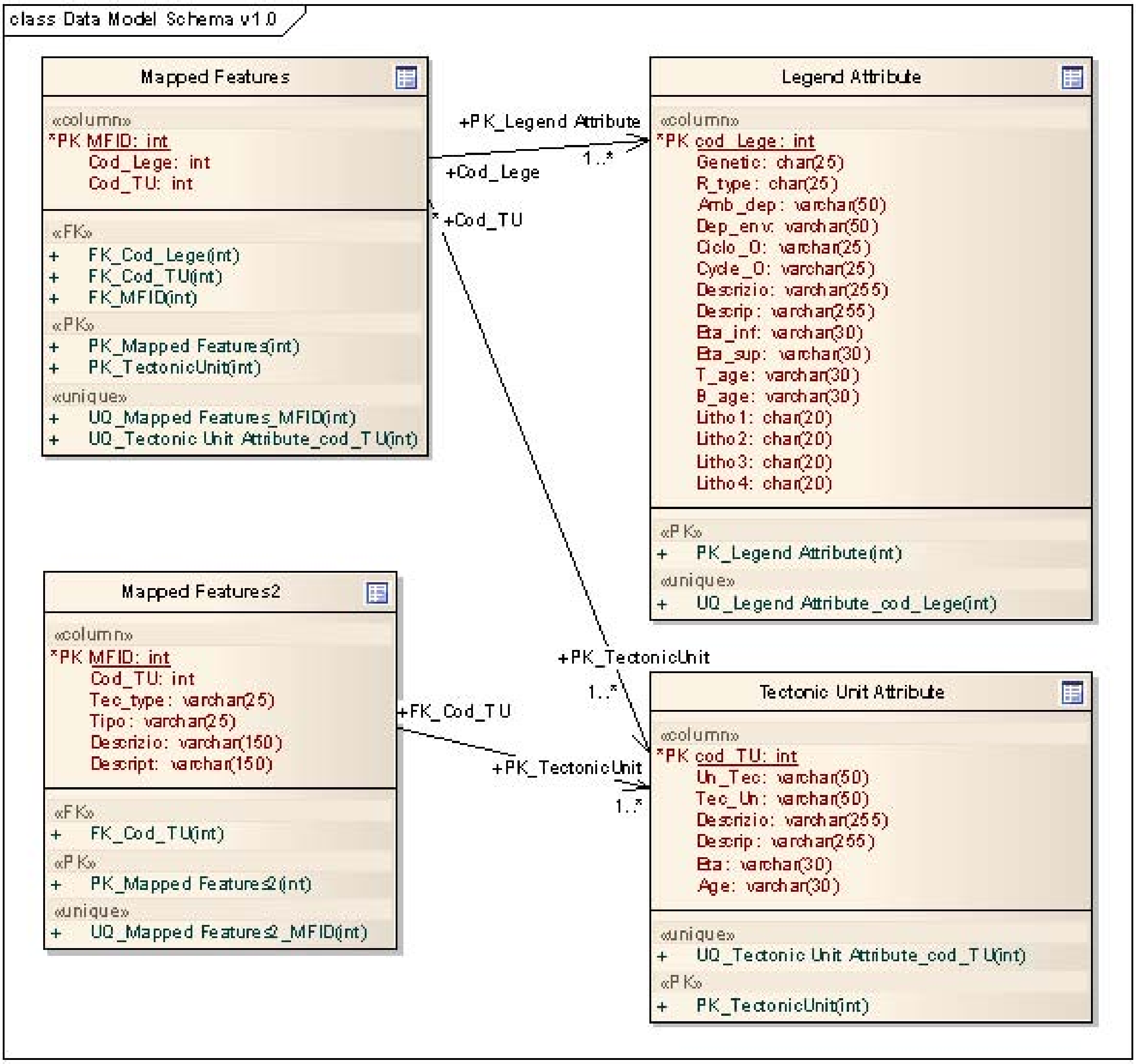

Figure 2 – Scheme of Data Model.

CONCLUSION

The database of geological map of Italy at the scale 1:1.000.000 represent an example how the new product are flexible to match an interoperable schema as GeoSciML. The database structure is designed follow the international schema but maintain the rich of national information.

This database that had been realised in two languages is also an example how the Geological Survey of Italy try to internationalise our products.

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INTEROPERABLE GEOSCIML SERVICES USING A MEDIATOR/WRAPPER ARCHITECTURE

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KEY WORDS: GeoSciML, OGC, GML, WFS, Mediator, Wrapper, XML, Geology, Map

INTRODUCTION

This paper describes the implementation of a GeoSciML (Geoscience Mark-up Language) compliant WFS (Web Feature Service) using Mediator-Wrapper technology. The work was done for GeoSciML Testbed 3, which demonstrated the recently released GeoSciML 2.0. The system described here was used by 3 of the 8 geological surveys participating in Testbed 3 (Italy, Canada and UK). The technology was originally developed at the Geological Survey of Canada (GSC) to support the Groundwater Information Network (GIN; http://www.gw-info.net). The key characteristic of this system is the use of a mediator layer between WFS clients and WFS servers using existing software. This layer enables the delivery of more complex features than possible with current WFS server software. The mediator was used with ArcIMS WFS server, MapServer, Deegree and a custom WFS service developed by the GSC.

SYSTEM REQUIREMENTS

Each survey participating in the testbed had to setup WFS's that complied with a series of requirements. These were set to highlight the capabilities of GeoSciML to deliver relevant geoscience data and demonstrate interoperability between agencies serving their data.
To achieve this goal the WFS's had to:

- deliver complex features that validated with GeoSciML (Many WFS can't be configured to create documents that validate with an arbitrary GML schema).
- support complex requests with OGC Filter statements that might contain function invocations.
- deliver documents following multiple "profiles", constrained not solely by XSD schema but also by a series of working group wide policies.
- support common vocabularies for age and lithology in requests and responses, with some dynamic term translation between common and private terms.
- support many-to-one relationships between the requested feature type and feature-valued properties.

Existing WFS software did not support many of the required features.

THE ROLE OF GIN MEDIATOR

GIN mediator is a technology that is under development at the GSC that addresses a similar problem but for groundwater data. The mediator is software that sits between a client application and one or more WFS's to intercept queries, transform them, route them to a particular WFS and finally transform the responses as shown in figure 1.
A GeoSciML query received by the GIN mediator is rewritten to target one or more WFS services.
The rewriting operation is done using a mapping file that provides a list of equivalences between GeoSciML properties and target schema properties. It can also map the values of these properties between, for example, standard vocabulary terms for the GeoSciML community and private vocabulary terms.
In cases where the private WFS service software cannot deal with functions in OGC Filter queries the mediator can sometimes be used to replace the function parts by equivalent Filter queries not using functions. For example, in the GeoSciML testbed, functions were used to support querying vocabularies with hierarchical relations. (E.g. if the user asks for sandstone, the service should also return 'wackestone', which is defined as a subtype of sandstone in the IUGS-CGI simple lithology vocabulary). The Deegree and custom GSC WFS servers could pass these functions on to call functions in the underlying database. The ArcIMS and MapServer WFS servers cannot do this but the GIN mediator could re-write the queries to list all the possible subclass values explicitly.
For example, this is an original query (namespaces declaration removed):

```
<wfs:GetFeature maxFeatures="5" service="WFS"
version="1.1.0">
  <wfs:Query typeName="gsml:MappedFeature">
    <ogc:Filter
xmlns:ogc="http://www.opengis.net/ogc">
```

```
      <ogc:PropertyIsEqualTo>
        <ogc:Function name="gsml_is_litho">
          <ogc:PropertyName>
gsml:specification/gsml:GeologicUnit/gsml:comp
osition/gsml:CompositionPart/gsml:lithology/gs
ml:ControlledConcept/
gml:name[@codeSpace='http://www.cgi-
iugs.org/uri']"
          </ogc:PropertyName>
        <ogc:Literal>
urn:cgi:classifier:CGI:SimpleLithology:2008:sa
ndstone
        </ogc:Literal>
        </ogc:Function>
        <ogc:Literal>1</ogc:Literal>
      </ogc:PropertyIsEqualTo>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

This is the original query translated to a request to an ArcIMS based WFS service:

```
<wfs:GetFeature
  maxFeatures="5"
  service="WFS"
  version="1.1.0">
  <wfs:Query
    xmlns:esri="http://www.esri.com/esri"
typeName="esri:ITA_APATSGI_EN_500k_Geologicfor
mation-ITA_APATSGI_EN_500k_Geologicformation">
    <ogc:Filter>
    <ogc:Or>
       <ogc:Or>
      <ogc:PropertyIsEqualTo>
<ogc:PropertyName>esri:cartobase.geo.geology50
0k.litho1</ogc:PropertyName>
        <ogc:Literal>sandstone</ogc:Literal>
      </ogc:PropertyIsEqualTo>
      <ogc:PropertyIsEqualTo>
<ogc:PropertyName>esri:cartobase.geo.geology50
0k.litho2</ogc:PropertyName>
        <ogc:Literal>sandstone</ogc:Literal>
      </ogc:PropertyIsEqualTo>
    </Or>
      <ogc:Or>
      <ogc:PropertyIsEqualTo>
<ogc:PropertyName>esri:cartobase.geo.geology50
0k.litho1</ogc:PropertyName>
        <ogc:Literal>wackestone</ogc:Literal>
      </ogc:PropertyIsEqualTo>
      <ogc:PropertyIsEqualTo>
       <ogc:PropertyName>esri:cartobase.geo.ge
ology500k.litho2</ogc:PropertyName>
        <ogc:Literal>wackestone</ogc:Literal>
      </ogc:PropertyIsEqualTo>
    </ogc:Or>
    </ogc:Or>
    </ogc:Filter>
  </wfs:Query>
</wfs:GetFeature>
```

The original query contained a complex path to a property

```
gsml:specification/gsml:GeologicUnit/gsml:comp
osition/gsml:CompositionPart/gsml:lithology/gs
ml:ControlledConcept/
gml:name[@codeSpace='http://www.cgi-
iugs.org/uri']"
```

that has been resolved to ISPRA fields

```
esri:cartobase.geo.geology500k.litho1
OR
esri:cartobase.geo.geology500k.litho2
```

since the lithology description may be found in either field.
The IUGS-CGI simple lithology term "urn:cgi:classifier:CGI:SimpleLithology:2008:sandstone" has been translated to the ISPRA term "sandstone" and the function 'gsml_is_litho' replaced with a list of subtype terms such as "wackestone" that should also be returned for a sandstone query.
The mediator then waits for a response document and it then applies a XSLT (W3C, 2007) , or an equivalent technology called STX (Streaming Transformation for XML : STX,2007) to transform the document into GeoSciML.

IMPLEMENTATION

The application developed by GSC is essentially a collection of custom java components and XSLT files tied together in a XML processing framework (Apache Cocoon). Cocoon organises processes into "pipelines" which chain XML manipulating components to perform a task. We implemented the WFS mediation using a series of pipelines with out-of-the-box cocoon components and a few custom reusable components we developed in Java. An overview of the application is shown in figure 1.

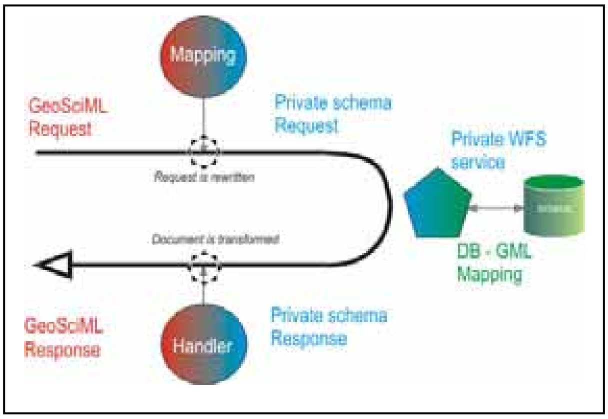

Figure 1 – Overall design of the wrapper / mediator. The curved arrow is the cocoon pipeline, which also show the sequence of processing.

The application is composed of two major components; the request mapping component that translates a GeoSciML query into a query that the private WFS can understand, and the response handler which converts the response of the private WFS into GeoSciML. "Profiles" are just different collections of mapping and transformation files that can be invoked by using a different path for the service address. The path of the service actually contains the name of a specific profile which configures the service. The mapping is an annotated XML file similar to a GeoSciML (or any other schema) instance document which is used to support XPath resolution of properties. It is not a formal GeoSciML document, as it will not validate against GeoSciML XSD schema. OGC Filter expresses properties using XPaths relative to the requested feature type name (`gsml:MappedFeature` in our example). To resolve a property like

```
<ogc:PropertyName>
gsml:specification/gsml:GeologicUnit/gsml:composition/gsml:CompositionPart/gsml:lithology/gsml:ControlledConcept/
gml:name[@codeSpace='http://www.cgi-iugs.org/uri']"
</ogc:PropertyName>
```

the mediator applies this XPath to the mapping file. The context node is **`gsml:MappedFeature`**, which is the root of the mapping document and the reader can see on figure 2 that this XPath leads to the target properties ;

`esri:cartobase.geo.geology500k.litho1`
and
`esri:cartobase.geo.geology500k.litho2`.

Since the mapping provides two targets to replace a single GeoSciML property in the original request, the mediator expands the query to an OR clause.

Several other mechanisms are provided by the mediator file to trigger specific actions. For example, external processors can be provided to address specific problems. The proc:resolver section of the mapping file (Fig 2) is an example of such special tag to invoke an external processor to translate vocabulary on the fly.

The final step is the translation of the result document generated by the WFS. The instance document is of course structured in the private schema and it must be restructured into GeoSciML. XSLT (or STX) is the mechanism that deals with the fine grain translation required to validate against the GeoSciML schema and comply with the defined Testbed profiles. The drawback is the complexity of XSLT, which is a full programming language, and therefore requires some good technical knowledge.

Discussion

Other systems (such as Deegree and GeoServer) provide a declarative language or a configuration file for the mapping. In those implementations, a single configuration file is needed to handle both the query and the response translation (although Deegree allows XSLT processing to be added). We found that in the systems we tested that provided such mapping capabilities that a lot of translation can be done easily by simple mappings but the systems fall short when it comes to fine grain adjustments for complex schema and complex logic must be used to decide how the result document should look like. This required us often to change the database structure and content to meet the requirements. To avoid changing the database we adopted an XSLT-based solution. Although XSLT is more complex, it's far more powerful, and maybe reflects the fact that on the fly translation is indeed a complex task.

CONCLUSION

GeoSciML is a complex schema where many properties are optional and the same information can be presented in different ways and the same feature type can be described to different levels of detail. Most standard WFS software deals with relatively simple feature type definitions which follow a fixed schema. With GeoSciML the XML Schema is not sufficient on its own to specify what should be returned in response to a feature query. Instead use case profiles both for the allowed queries and the responses need to be agreed. The GIN mediator allows multiple complex profiles to be served from simpler underlying WFS software. It could also be used to transform multiple existing WFS's that use their own schemas into common community schema versions.

ACKNOWLEDGEMENTS

Although the GIN mediator has been developed at the GSC, we must give credit to BGS for a significant portion of the documentation available in the GeoSciML WFS Server Cookbook at http://www.geosciml.org/geosciml/2.0/cookbook/.

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OPEN GEOSPATIAL CONSORTIUM. OpenGIS Web Feature Service Implementation Specification. <http://www.opengeospatial.org/standards/wfs>

OPEN GEOSPATIAL CONSORTIUM. OpenGIS Filter Encoding Implementation Specification. <http://www.opengeospatial.org/standards/filter>

OPEN GEOSPATIAL CONSORTIUM. OpenGIS Geography Mark-up Language (GML) Encoding Standard. <http://www.opengeospatial.org/standards/gml>

IUGS-CGI GeoSciML. GeoSciML URL http://www.cgi-iugs.org/tech_collaboration/data_model/downloads.html

```
<?xml version="1.0" encoding="UTF-8"?>
<gsml:MappedFeature "
  mappedType="esri:ITA_APATSGI_EN_500k_Geologicformation-ITA_APATSGI_EN_500k_Geologicformation">
</proc:namespaces>
<proc:targetVersion>1.0.0</proc:targetVersion>
<gml:name codeSpace="http://www.cgi-iugs.org/uri">esri:cartobase.geo.geology500k.formation_1</gml:name>
<gsml:composition>
<gsml:CompositionPart>
   <gsml:lithology>
    <gsml:ControlledConcept>
      <gsml:name codeSpace="http://www.cgi-iugs.org/uri">esri:cartobase.geo.geology500k.litho1</gsml:name>
      <gsml:name codeSpace="http://www.cgi-iugs.org/uri">>esri:cartobase.geo.geology500k.litho2</gsml:name>
</gsml:ControlledConcept>
</gsml:lithology>
</gsml:CompositionPart>
</gsml:composition>
<gsml:preferredAge> (deleted to simplify ) </gsml:preferredAge>
<gsml:occurence><gsml:MappedFeature><gsml:shape>esri:_shape_</gsml:shape></gsml:MappedFeature></gsml:occure
nce>
<proc:resolvers>
 <proc:replace name="gsml_is_pref_age" type="function"
pipeline="http://sgi.apat.it/cocoon/geosciml/mediator/gsml_is_pref_age"/>
 <proc:vocab name="age_vocab" ontology="cocoon:/mediator/ontomap/apat_mapping"
property="esri:cartobase.geo.geology500k.etasup">
 <proc:parameter name="mode" value="all"/>
 </proc:vocab>
 </proc:resolvers>
</gsml:MappedFeature>
```

Figure 2 – Mapping file (partial). The file provides instructions for the mediator on how to translate public query into private query. The mapping file is a mixture of configuration parameters (proc: prefix) and GeoSciML and related tags.

VECTORISATION OF GEOLOGICAL MAPS – LINKING THE GRAPHICS TO THE GIS

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KEY WORDS: ToolMap, GIS, Adobe Illustrator, data model

INTRODUCTION

The Swiss Geological Survey (SGS) has been producing geological maps for more than 75 years. In recent years the demand for vector data strongly increased even though the quality requirement for printed maps remained high. GIS-based tools offer many advantages such as flexibility and an enhanced rate of data update. However, printed maps still are of higher quality when produced with specialised graphic programs such as Adobe Illustrator.

Therefore, a technique was developed to permit the digitalisation of geological maps using graphic programs as well as GIS-based tools. We here present two coordinated methods:

ToolMap

Elements are drawn and attributed using a GIS-compatible software package (ToolMap), developed in cooperation with the Research centre on alpine environment (CREALP). This package was built using multiplatform open-source software.

During the procedure, lines are split into segments. Multiple attributes can be assigned to each segment. The attribution of polygons is achieved using index points, which contain the information for the surface. These attributes permit a selective extraction of elements into themes (such as bedrock, hydrogeology, tectonics, etc.).

Adobe Illustrator

Elements are drawn and attributed graphically using Adobe Illustrator. This method is being further developed in collaboration with the Swiss Geotechnical Commission.

As in ToolMap, lines are split into segments which are assigned to different graphic styles or brushes. To be compatible with GIS systems, surfaces are attributed with special symbols containing the information (e.g. the index points in ToolMap).

Linking the methods – the data model

Since both methods strictly follow the geological data model for attribution, consistent data translation is assured.

Avenza-MaPublisher is used to convert data between the two methods. A system of rules links the graphic information with the defined themes and classes. In this way, graphic attributions issuing from Illustrator documents can easily be translated into database attributes and vice versa.

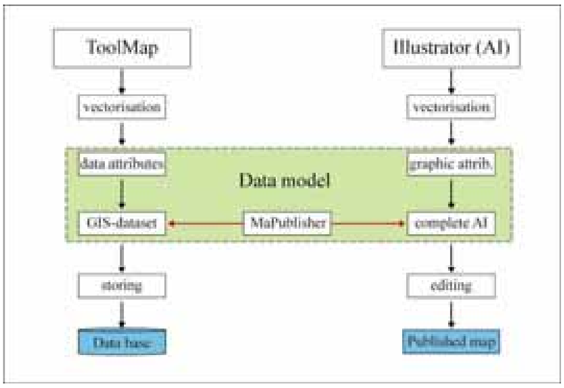

Figure 1 – Methodology

With ToolMap and Illustrator compatibility both printable and GIS-versions can be produced, offering the advantages of high quality maps with an enhanced rate of updating.

THE GEWÄSSERATLAS BAYERN – THE EVOLUTION OF AN OLD STORY

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KEY WORDS: Atlas of Bavarian Waters, Soil Information System of Bavaria, environmental information Systems, enterprise applications, dynamic segmentation, linear reference

Introduction

The Atlas of Bavarian Waters (Water Atlas) will be a new environmental enterprise information system, filling a long existing gap at the Environment Agency of Bavaria. The new application will provide an integrated access to data relevant to water management. This data includes the official water course directory and many of the technical installations related to it. Additionally, the system will hold information about water protection areas, flood risks and flood detention buildings, as well as data for the management of the European Water Framework Directive.

At the time of writing, the application is still under development. The initial operation is scheduled for July 1st 2009.

This paper explains the subject matter of the Water Atlas, its technical background, and the benefits for the environment agency in the process of consolidating its (too) huge application portfolio.

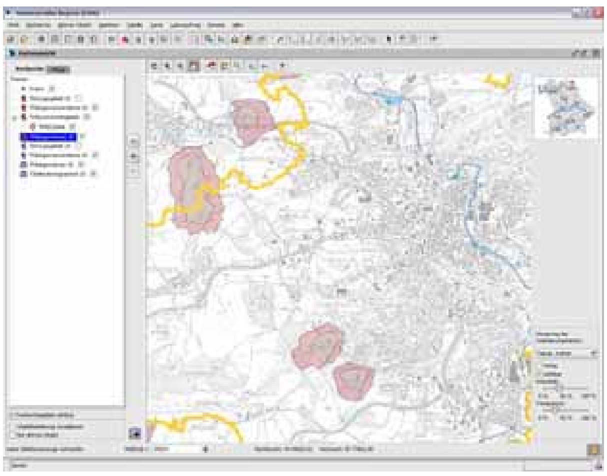

Figure 1 – Screenshot of the Water Atlas, showing waters and water protection areas with zonation

Which Information is included?

The Water Atlas reference data is the watercourse directory 1:25,000 (DWGN25), which is currently under reconstruction. This data set contains more than 700,000 individual spatial objects with attributive data. Most of the other content of the Water Atlas is referenced to the water course directory.

Apart from this reference data set, the Water Atlas provides information about the many types of installations and buildings related to a water course, including weirs, barriers, falls, and sills. The other important domain of the Water Atlas deals with flood risks and their containment. At the end of development, the system will include spatial data sets about flood risk areas (based on various flood scenarios), stream profiles and overflow depths, dikes and water detention areas.

The third objective is to document and manage the protection of water bodies, which includes all datasets mandatory for the European Waterframe Directive, which includes information about the state of water bodies and the distribution of water protection areas. In total, it is estimated that the Water Atlas will contain much more than 100 object types and thematic layers.

One important objective for the stakeholders of the system is to determine the cost of the maintenance of the state-owned water course installations and to direct the maintenance activities.

Functional Aspects of the Water Atlas

The Water Atlas requires special geospatial feature sets, which are probably (to the knowledge of the author) implemented in a central multi-tier enterprise application for the first time. These feature sets contain the following principles:

Object relationships: In order to represent the complexity of the water course systems and its installations, it is very important for the system to support the relationships of the various themes and object types involved. This includes the utilization of relationships in the process of information retrieval as well as the navigation from one object to its related objects.

Linear referencing: As opposed to conventional positioning of objects via pairs of coordinates, the Water Atlas' content relies heavily on the principle of linear referencing. Herein the location of an object is determined relative to a base route system, being, for example, either a water course or a dike building. The location of an object is determined by its so called "m-value", which is the position of the object along its parent route relative to the start of the route. The position of weirs, barriers, and other water course installments is entirely relative to its related water course.

Dynamic Segmentation: A large amount of properties of linear entities of the Water Atlas is not attributable to a single point of interest, but to sections ("segments") of an object. The principle of dynamic segmentation is to determine the beginning and the end of a property value and to let the geospatial engine take care for a correct spatial visualization of the property.

The Water Atlas provides special dialogs for exploring and editing segmented properties of linear objects.

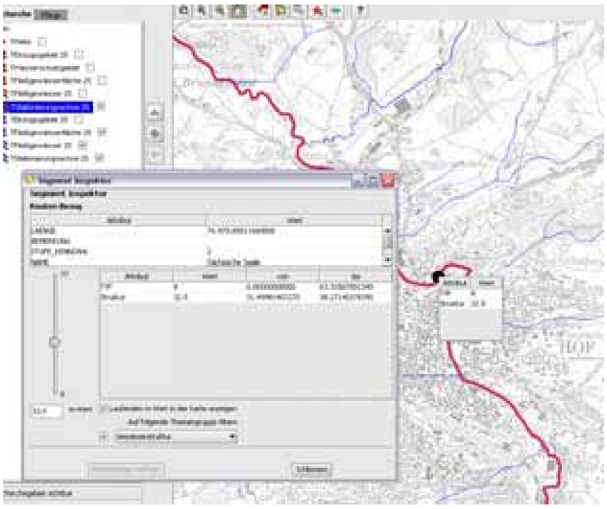

Figure 2 – Segment Inspector (water structure test data of the river Saale in the area of Hof, Northern Bavaria

Technical Aspects of the Water Atlas

The idea of developing a central information system for the Bavarian water network and its related objects dates back to the nineties. Those times saw the production of several conceptual papers, but no progress was made towards an implementation of the envisioned system. The technologies and costs at that time did not seem favourable for such an ambitious undertaking.

Now, about a decade later, new technologies emerged that made the project realistically possible, and the Bavarian State Ministry of the Environment and Public Health (StMUG) was able to provide the necessary funding.

Because of its success of five years of operation with its already existing feature set, the platform, on which the Bavarian Soil Information System was built - the GABY[1]-Platform - is utilized as a base for the new Water Atlas. GABY already provides a very high integration of geospatial and attributive data, several tools for data editing, and a comprehensive backbone for data validation, data protection, and other services. It was estimated, that GABY fulfilled already about 70 percent of the Water Atlas' requirements. Nevertheless, several aspects still need to be added to its rich feature set, most importantly the aforementioned features of object relationships, linear referencing, and dynamic segmentation.

The Water Atlas also follows the principle of GABY to provide all functionality in a generic, configurable, and reusable way. The new three principles, for example, are all described and configured by technical metadata, and are thus applicable to other environmental domains as well.

In the development process, the different tasks of engineering the technological base and of configuring the system for a particular business domain are clearly separated between the external development partners and the project team of the LfU. The LfU team concentrates on what it can do best: the design of the physical and logical data models, the implementation of data forms and data validation logic, and the definition of all aspects of the geographic visualization. This clear separation of responsibilities reduces costs and time of development considerably, given the system's large diversity.

Further technological vertices are: Oracle 10g database, ESRI server technologies (ArcSDE, ArcIMS), a multi-tier Java 6 application with CORBA middleware, and a Java Swing desktop client.

Consolidation Aspects

The 2005-founded new LfU was confronted with the IT-heritage of the three formerly independant state agencies of Environmental Protection, Water, and Geology. It is not difficult to guess, that the IT-development of these former institutions was conducted independently and mostly without much coordination. As a result, the LfU hosts about 150+ different applications, based on a large number of technologies and platforms. Obviously, there is room for consolidation.

In 2007, a study was conducted with focus on what and how such consolidation could be undertaken. One of the results was to reduce the number of platforms and concentrate on one (Java) and to reuse existing platforms, wherever possible. Thus, the GABY-platform was chosen for the realisation of the Water Atlas.

However, this does not only imply advantages on the technological aspects, but big improvements on the user side as well. Because the Water Atlas and the Soil Information System of Bavaria are essentially the same, their data becomes totally interoperable. For example, hydrogeological and water protection data will be simultaneously visible, which brings an increased value to both data sets.

[1] GABY stands for **G**eneric **A**pplication Platform for Environmental Information Systems of **Bay**ern

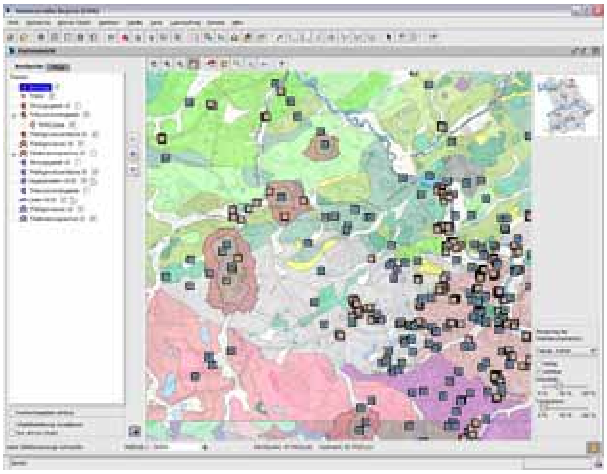

Figure 3 – Screenshot showing content of the BIS-BY and Water Atlas test data (background: geology)

The new Water Atlas therefore reflects the political decision to merge the aforementioned, formerly independant agencies into one large institution, which should stimulate the interdisciplinary collaboration in environmental affairs.

To enhance the interoperability further, the Water Atlas will be an integral part of the Bavarian SDI[2] by using and providing geospatial services via the standard WMS, WFS, and CS-W interfaces.

During the enhancement of GABY, synergetic effects became a reality. Geoediting features implemented for the Water Atlas are already reused in the context of the Soil Information System and facilities to support the usage of PDF documents were realised with funds of the Soil departement, but could be used in the context of the Water Atlas as well.

The European Water Framework Directive mandated the development of a central data set for the planning of measurements on water bodies. Because the realisation of this task could not wait until the planned production date of the Water Atlas, the required data and feature sets were already implemented within the current version of the Soil Information System.

In summary, the decision to implement the Soil Information System in a generic, reusable way finally pays *really* off (it did so before), so the Old Story becomes true.

[2] SDI: Spatial Data Infrastructure

ONEGEOLOGY – MAKING GEOLOGY ACCESSIBLE

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KEY WORDS: accessibility, web services, global, geological surveys, IYPE, GeoSciML

A VERY SHORT HISTORY

On 6 August 2008, at the opening of the 33rd International Geological Congress in Oslo, Simon Winchester, author of the best-selling book about the English geologist, William Smith and his "Map that changed the world", launched the web portal of a global project called OneGeology. Had you used the term OneGeology 32 months earlier – or typed it into Google - you would have registered a blank. The project and its name did not exist. So what is this project that appeared from nowhere in 2006 and took centre stage at the IGC in 2008?

Figure 1. Geological data from across the world in real time

At the beginning of 2006 and with the potential stimulus of the UN International Year of Planet Earth (IYPE) very much in mind, an embryonic idea was presented at short notice to the General Assembly of the Commission for the Geological Map of the World (CGMW) in Paris. Could we use this UN Year to begin the creation of an interoperable digital geological dataset of the planet at 1:1 million scale? Would it be possible to design and initiate a multi-lateral and multi-national project that mobilised geological surveys, as part of an ongoing contribution, to act as the drivers and sustainable data providers of this global dataset? Could we synergistically use this vehicle of creating a tangible geological map to accelerate progress of an emerging global geoscience data model and interchange standard? Finally, could we use the project to transfer know-how to developing countries and reduce the length and expense of their learning curve, while at the same time allow them to serve maps and data that could attract interest and investment? These aspirations, plus the chance to generate a global digital geological dataset to assist in the understanding of global environmental problems and the opportunity to raise the profile of geoscience as part of IYPE, seemed more than enough reasons to take the proposal forward.

Throughout 2006 geologists and geological surveys around the world were canvassed for their views on this proposition and in the autumn of 2006 it was apparent that the concept was proving attractive to more than enough geological surveys and international bodies to organise a meeting to kick-off the initiative; an initiative which had by now adopted the name "OneGeology". This kick-off meeting took place in March 2007, in Brighton, UK. Eighty-one participants from forty-three nations and fifty-three national and international bodies discussed the OneGeology aims and how best to achieve them. The workshop was a success and participants unanimously agreed a "Brighton Accord". This Accord gave the OneGeology initiative the international backing it needed but just as importantly, OneGeology through the Brighton meeting and Accord, captured the imagination of the world's press and media and the story was taken up across the globe, increasing the profile of IYPE, the relevance of geoscience and placing OneGeology very much in the public eye.The goals that the Brighton meeting agreed for OneGeology were deceptively simple. They were to:

- improve the accessibility of geological map data
- exchange know-how and skills so that all nations could participate
- accelerate interoperability in the geosciences and the take up of a new "standard" (GeoSciML)

EXCEEDING EXPECTATIONS

The international project coordination and technical teams began work on these goals immediately and in less than 18 months made astounding progress. They made significant amounts of geological map data accessible – currently 94 nations are participating and up to 40 of these are serving data. They delivered a web map portal and the protocols, registries and technology to "harvest" and serve data from around the world. They exchanged know-how and produced guidance ("cookbooks") and provided support so that any geological survey can participate and serve their data. They moved forward and raised the profile of a crucial data model and interoperability standard – GeoSciML.

The technology to achieve OneGeology is not complex, but it in terms of the scale of the deployment it is world leading. A basic principle of OneGeology is that it must be open to all geological surveys to participate, regardless of development status and the project has devised protocols and systems to ensure this. OneGeology is thus open to those who currently possess only traditional paper geological maps, and to those operating sophisticated web mapping systems. The end-user does not require specialist software, only access to the Internet via a web browser. In this first phase OneGeology is delivering digital geological map data from participating nations using Web Map Services (WMS). This is a distributed, dynamic and sustainable model, which leaves the data where it is best looked after and updated; that is with the provider nations. Each survey either registers its web service with the OneGeology Portal or works with a partner survey (a "buddy") to serve that data. OneGeology technology is compliant with the international Open Geospatial Consortium (OGC) Web Map Service standard. Geological surveys may use a variety of software (e.g. MapServer) to serve their data. The Portal displays the map data served by each country and provides users with the ability to zoom, pan, switch map data on and off, change its opacity and even transfer it to Google Earth.

The deliverables above are not the limit of the project achievements. In delivering its portal and technical protocols OneGeology has progressed something major global and regional bodies (including the United Nations and the European Union) have been advocating for some years – the creation of a spatial data infrastructure for planning and policy-making. The project has now been unanimously endorsed by the Directors of the geological surveys of the world meeting in Oslo and is providing a tangible catalyst for future collective and coherent action by surveys. Google references to OneGeology grew from 4000 on 1 August 2008 to over 220 000 in mid-August; it is not the size of this number alone that excites; when you look more closely at some of these web pages you see the way that "liberating" the data has allowed others to innovate and use their imaginations – from new teaching resources for geography students, to animated mash-ups and fly-throughs of Mount Fuji. The outreach has not stopped at the science and academic community; media interest in OneGeology has been extraordinary – over 700 articles and broadcasts worldwide in 4 weeks, from Nature to Vatican Radio, each in its own way presenting an opportunity to describe to audiences, who we would usually never reach, why geology is important to society - and never more important at a time of intense interest in energy needs and the impact of climate change.

The OneGeology initiative has made progress in other areas too. The European Commission, under its eContent*plus* programme, has agreed to fund a 2-year, €3.25 million, 19 nation project known as OneGeology-Europe. This will move OneGeology forward faster and allow developments in higher resolution and applied data too. In the USA the National Science Foundation is providing almost $700 000 for a similar initiative in the 50 US states – a Geoscience Information Network. These and other continental initiatives will be well linked to ensure complementarity of development and maximum synergy and benefit globally.

WHY AND WHAT NEXT?

For the OneGeology team – geoscientists, informatics experts, managers and communicators - the experience of the last year has been exhilarating. OneGeology is, in many ways, unlike most other international geological projects that have gone before. It is, in every sense, a child of its time – an open Internet paradigm, a project whose technical interoperability (sharing) goals are in reality its whole ethos. The project has been allowed to grow and extend as just as fast and as wide as its actors agree to take it, for the most part free from the territoriality and bureaucracy that frequently inhibit such initiatives. That it has been allowed this freedom is a credit to those who run geological surveys around the world because it is absolutely beyond doubt that a conventionally run (and thus constrained) OneGeology project would not have achieved its goals so spectacularly and in such a short space of time.

Where does OneGeology go next and how can we sustain the progress made? The team are now taking steps to put in place a robust, and yet still flexible, governance and operational structure. They are also continuing the technical progress, increasing the number of nations serving data and moving towards Web Feature Service technology which will provide significantly more functionality. Some difficult questions remain however: how to fund and provide continuity for a growing and thus more demanding infrastructure and user base? Whether to expand the portal to include map data from academia, commerce and the public (and how to maintain authentication if that happens)? Should OneGeology serve more downstream geoscience data – and try to spread the best practice in advanced applied or thematic information delivery in national geological surveys, for example geohazards, or carbon capture sites?

These are big challenges but with the same open and determined approach that OneGeology has adopted in its short life to date, none of them are insoluble.

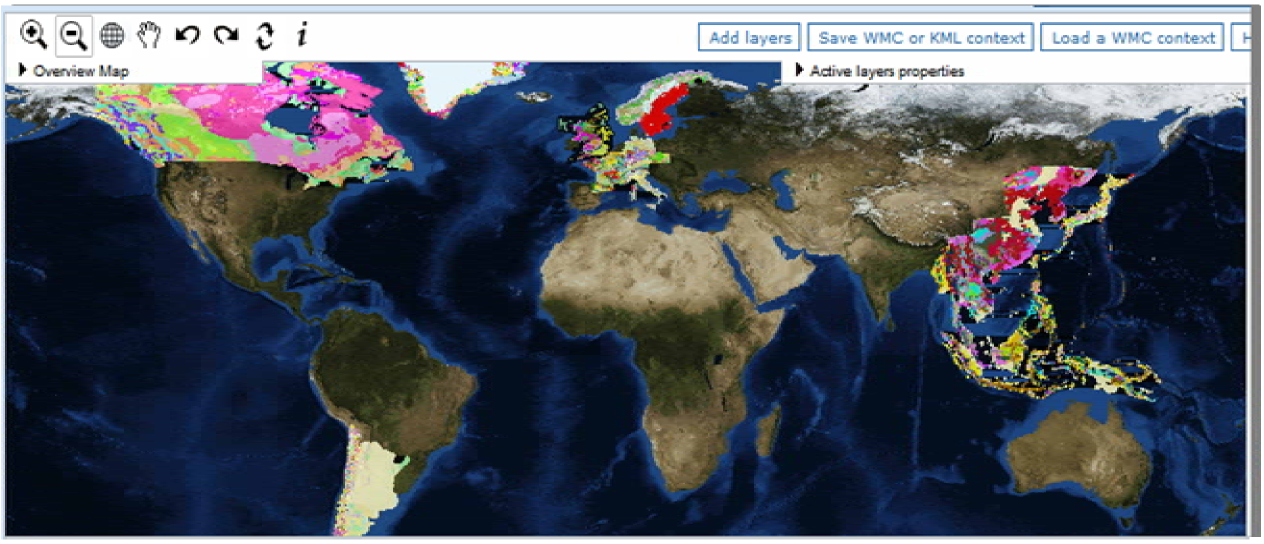

Figure 2 – A screen shot from of the OneGeology web portal

ACKNOWLEDGEMENTS

I would like to acknowledge the work of scientists, informatics experts and managers in geological surveys and global and regional organisations around the world. Without their effort, commitment and goodwill OneGeology would still be a concept.

ONEGEOLOGY-EUROPE: LEGAL ASPECTS OF MAKING GEOLOGICAL DATA AVAILABLE

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KEY WORDS: Legal aspects, INSPIRE, access

Introduction

The OneGeology-Europe project aims to make geological spatial data held by the European Geological Surveys discoverable and accessible for public authorities, citizens and businesses. In order to achieve this, a number of legal requirements need to be taken into account. This legal framework includes INSPIRE, re-use of public sector information and access to environmental information.

This contribution will take a short look at these European directives and how the OneGeology-Europe project can contribute to a better availability of geological spatial data.

THE INSPIRE DIRECTIVE

Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) was adopted on 14 March 2007 after a negotiation procedure between the European Commission, the European Parliament and the Council of Ministers of almost three years. The directive aims to promote data sharing between the Member States and the public authorities for the purpose of environmental policy and policies or activities that may have an impact on the environment.

Under article 17 of the INSPIRE directive, the Member States have to adopt measures to facilitate the sharing of data for the purposes of public tasks that may have an impact on the environment. Those measures have to preclude any restrictions likely to create obstacles at the point of use. Such restrictions can be procedural, legal, financial, etc. The Member States or the public authorities are allowed to charge for providing their data sets or services, on the condition that these charges are fully compatible with the general aim of facilitating the sharing of spatial data sets and services between public authorities. They have to be kept to the minimum required to ensure the necessary quality and supply of spatial data sets and services together with a reasonable return on investment, while respecting the self-financing requirements of the public authorities supplying the data sets and services.

Next to taking measures for data sharing, the Member States also have to establish a network of services for spatial data sets, including discovery services, view services, download services and transformation services. While the data sharing arrangements that were discussed in the previous paragraph only address data sharing between public authorities, the network services should also be available to the public (article 11 INSPIRE directive).

Public access to these services can be limited for a number of reasons. Access to the discovery services can only be limited in case this would adversely affect international relations, public security or national defence. For the other services, the list of possible reasons to refuse access is longer and includes the protection of the confidentiality of personal data, the course of justice, and the confidentiality of commercial or industrial information. Another reason why public access can be limited is intellectual property rights. This caused many discussions between the European institutions and the Member States during the negotiation procedure of the INSPIRE directive. We will address the topic of intellectual property rights later on. However, we should already indicate that the grounds for limiting access should be interpreted in a restrictive way and in each particular case, the public interest served by providing access and the interest that is being protected by the refusal of access should be weighed (art. 13.2 of the INSPIRE directive).

Public authorities can charge for providing access to the network services, with the exception of the discovery services. However, with regard to the view services charges can only be levied if they secure the maintenance of spatial data sets and services, especially in cases involving very large volumes of frequently updated data. The meteorological sector was mostly kept in mind with this latter specification. However, one could wonder what exactly is meant with “securing the maintenance” of data sets and services. We can assume that it entails that without the funds coming from these charges, the data could no longer be collected or maintained, or the service could no longer be provided. In any case, when charges are levied, e-commerce services should be available. If this entails that the entire process from the request for data through the delivery to the final payment should be possible on line, or just parts of this process can be done on line, is not clear.

THE ACCESS DIRECTIVE

Directive 2003/4/EC on public access to environmental information aims to guarantee the right of access to environmental information held by or for public authorities and to ensure that environmental information is progressively made available to the public. Hence, it provides rules to the public authorities for allowing access to environmental information on request and for disseminating information of their own motion. Due to the broad definition of environmental information, the Access directive is also applicable to geological spatial data.

The Access directive requires that on-site viewing of environmental information is free, while reasonable charges can be made for supplying the information, as a general rule not exceeding the actual costs of production. However, when public authorities make their environmental information available commercially in order to guarantee continued collection and publication of such information, market rate charges are allowed. How does this relate to the requirement of the INSPIRE directive that the download services can be charged for, and view services only when securing the maintenance of spatial data sets and services? Should view services under the INSPIRE directive be considered as a form of consultation under the Access directive, or do they involve the supply of information? What are the limits on the charges for information that falls under both the definitions of spatial data and environmental information (Janssen & Dumortier 2007, 237)?

The Access directive also requires the public authorities to make information available under article 7.1. The Member States have to take the necessary measures to ensure that the public authorities organise the environmental information which is relevant to their functions and which is held by or for them, with a view to its active and systematic dissemination to the public, in particular by means of computer telecommunications and/or electronic technology, where available. Information that has to be disseminated includes texts of international treaties and Conventions and Community, national, regional or local legislation; policies and plans relating to the environment, and periodic reports on the state of the environment. Such reports have to be provided by the Member States at least once every four years.

THE PSI DIRECTIVE

Geological spatial data is not only relevant for policy making, but also for commercial and non-commercial users outside the public sector, such as insurance companies, mining companies, universities, research centres, etc. The availability of data for these users is regulated by Directive 2003/98/EC on the re-use of public sector information (PSI directive).

The PSI directive lays down a minimum set of rules for public sector bodies to make their documents available for re-use for all commercial and non-commercial purposes that fall outside of the public task. The Directive does not intend to impose any obligation on Member States to allow re-use. They can choose freely to do so or not. If they do allow re-use, they have to comply with the conditions of the directive. These conditions include time limits, available formats, transparency and non-discrimination. With regard to charging, the PSI directive encourages the public sector bodies to apply marginal cost charging, but allows that where charges are made, “the total income from supplying and allowing re-use of documents shall not exceed the cost of collection, production, reproduction and dissemination, together with a reasonable return on investment”.

The directive also makes sure that public sector bodies comply with the rules of competition law. When a public sector body creates its own value-added products or services that fall outside of the scope of its public task, it has to apply the same charges and conditions to its own re-use as it does to its competitors from the private sector. This should avoid cross-subsidisation or dumping prices. In practice, this will not be easy to maintain and will sometimes lead to the separation of a public sector body’s public task activities and other activities into two different bodies, as was done by the Dutch Meteorological Service, for instance.

THE ONEGEOLOGY-EUROPE PROJECT

The OneGeology-Europe takes these three directives as a starting point for its research on access and licensing policies. These three directives are applicable to most of the geological spatial data held by the Geological Surveys that participate in the project, and their relationship and consequences for the access policies of these Surveys needs to be examined. Each of the directives specifies conditions for the availability of information and it needs to be clear which rules are applicable to a specific situation. For instance, public research institutions have to provide access to environmental information under the Access directive, but they are outside the scope of the PSI directive. Sometimes the distinction is not so clear. For instance, if an NGO using an environmental report of a local authority in its annual report, is it doing so on the basis of the Access directive, or is it re-using information (albeit for a non-commercial purpose) under the PSI directive? Do public sector bodies provide their added-value services as a part of their public task (e.g. predictions of floodings) or is it a commercial services that can also be done by private companies on the market? In the first case, the INSPIRE directive will be applicable, in the second case the PSI directive.

An important issue that needs to be examined in relation to these three directives, is the protection of intellectual property rights. As was mentioned above, the INSPIRE directive and the Access directive make it possible to refuse public access to information on the basis of potential harm to intellectual property rights (IPR). The PSI directive on the other hand ensures that the IPR of the public sector bodies remains intact, but encourages them to use their IPR in a way that "facilitates re-use" (recital 22 of the PSI directive).

This raises the question when geological spatial data is protected by IPR. Two types of IPR come into play. First, spatial data can be protected by copyright if they fulfil the national standard of originality. However, as spatial databases should be accurate, and avoid discrepancies between the real world and depictions of it (Cho 2005, 139), originality will not be easily obtained. The continued search for interoperability and the increased use of standards will severely limit the scope for creativity and originality (Janssen and Dumortier 2006, 211). Second, spatial databases can be eligible for protection by the sui generis database right, which was introduced by Directive 1996/9/EC on the legal protection of databases. This database right was introduced to protect databases that had taken a lot of money and effort to create and maintain, but were not original. For a database to be eligible for protection, the rightholder has to make a substantial investment in the obtaining, verification or presentation of its contents, and not in the creation of such contents. This may cause difficulties for spatial databases, as a large part of the investment will lie in obtaining the data, rather than in incorporating these data in a database.

The OneGeology-Europe project will attempt to clarify these legal issues, as a starting point for preparing access and licensing policies. These access and licensing policies should try to find a balance between the needs of all the stakeholders and be transparent and user-friendly.

ACKNOWLEDGEMENT

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OBJECT ORIENTED DESIGN AND OGC GEOMETRIES APPLIED TO SPANISH GEOLOGICAL CARTOGRAPHY

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KEY WORDS: object-oriented, geological cartography, OGC standards, complex geometries, Spain.

INTRODUCTION

Official Spanish Geological Cartography represented by 1:50.000 maps of MAGNA plan has been digitized since early 90´s. Conceptual models and physical implementations of digital formats follow traditional Entity-Relationship (ER) design. Commercial relational or geospatial databases act as support of those designs. But due to complex geologic symbols, relational design is not enough to represent properly geologic features drawn on maps. Mapping of landslides, metamorphic aureoles and other geological processes involve polygons, lines and points combinations that have to be splitted into different layers. Commercial formats force to keep a unique geometry per layer. Also E-R diagrams and relational database use implies an one-to-one relationship between graphical features and registers. In many cases, relational design breaks down the author's original information. A fault affected by a later tectonic phase is usually a group of lines with no conceptual link.

The term "*impedance mismatch*" is used in literature (Worboys and Duckham, 2004) to describe upsets between abstraction and implementation levels. Applying a relational model leads to a digital information hard to manage, basically for non-specialist users. Proper queries to show complex features and relationships entail fragile applications close linked with database structure. Each change on database structure or information affects programmed queries. A better solution is to enclose geometry collections and relationships in the geological features definition. As a result object-oriented approach provides a methodological framework to cope with the impedance mismatch

The objective of the present work is to systematize such features in order to make a "requirements list" as a conceptual model's starting point. *Unified Model Language* (UML) is used as notation to sketch conceptual model diagrams. Open Geospatial Consortium (OGC) features are the basis of MAGNA map classes diagrams.

Commercial and free software have been evaluated to match requirements. With this purpose, a short concept proof is carried out with the aim of testing the model and reaching the implementation level.

CONCEPTUAL DESIGN

Four information levels in geological symbology have been specified in order to help objects design: *Class, Type, Case and Fragment* (fig. 1).

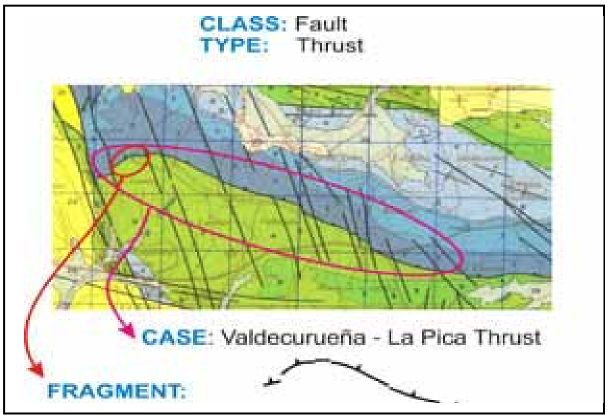

Figure 1 – Information levels.

Any combination of these levels might occur. *Geodatabase* use can theoretically solve with all of these combos. As a matter of fact, two pitfalls ,from strict object-orientation point of view (Egenhofer and Frank, 1992), can occur: geometry element duplication and the need of an outer program application or query that doesn't take part of the geometric element definition. Geometry duplication reveals a great system dependence on primitive graphic types (point, line and polygon). Those two scenarios lead to well-known graphic information maintenance problems (Haugerud, 1998).

For example a granitic pluton outcrop crossed by a dike (fig. 2) represents, by means of the information level, a *Case* including two *Fragments*. Relational tables model *Fragments* and *Class* (unit number). But modelling isolated plutons (*Cases*) of the same *Class* need an extra field to represent them. Real object-oriented approach should not require an extra field because each pluton is a multipolygon object.

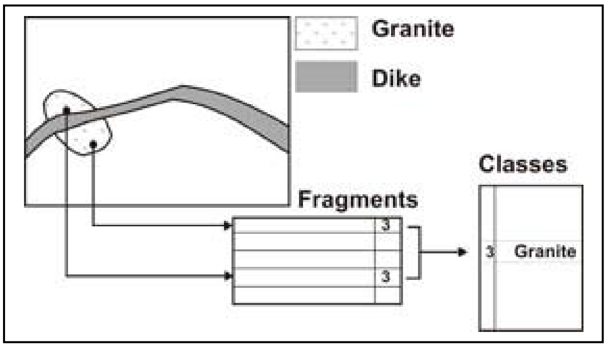

Figure 2 – A "Case" with two "Fragments".

Using level information combinations, a list of non-solved cases has been made. Those situations set up the "requirements list" for the new design. A common used geometry specification is the Simple Access feature from *Open Gis Consortium* (OGC, 2005) based on *Spatial Schema Standard* (ISO19107, 2003). It provides a good starting point to build new classes: they are implemented in many open-source heavy clients *(uDig, OpenJump*, etc) and includes several complex geometries classes. Most important class is *MAGNA Cartographic Unit* (*UCM*) related with the units drawn on maps. As *UCM* Class diagram shows (fig. 3), it aggregates *Lineal Entity* and *Outcrop* classes. An *UCM* can aggregate others units: facies changes, inclusions, etc. These special features are regarded as separate ones by the author map and usually remain isolated in a relational model. Several classes have been designed using UML notation. They are:

- *MAGNA Cartographic Unit (UCM).*
- *Outcrop UCM*
- *LinealEntity UCM.*
- *UCM Boundary*
- *Fold*
- *StructureObservation.*
- *UCM Annotation*

CONCEPT PROOF

Complex geometries and topology are the two key points to solve in order to match requirements list and conceptual model implementation.

Complex geometries are combinations of graphical primitives. Their development is related with object-relational databases. Although OGC provides a standard definition, many software vendors offer non-standard proprietary ones (Lo and Yeung, 2007).

Topology eases relationships between classes. For example, unit limits in geological maps play a main role compared with other thematic cartographies (Wahl, 2004). Object-relational databases such as Geodatabases can manage complex geometries, but not all are compatible with OGC Standards. Topology usually is an application proprietary issue and in many cases need to be defined out of the classes.

A complex structure such as Soria Fault is the chosen to make trials. Digitized fault graphical elements are initially scattered in four *shape* files from a relational design model (Pérez-Cerdán et al., 2006). Three GIS clients were tested: *Smallworld, ArcGis and OpenJump*.

Software analysis has been made taking into account several parameters (table 1). A model proof has been made with *Smallworld* and *OpenJump.* They represent the two extremes of a proprietary-open source line.

	Software		
Requirements	*Smallworld*	*ArcGis*	*OpenJump*
Complex Geometries	yes	yes	yes
OGC Standards	no	no	no
Program. Language	Magik	C#	Java
SGDB	VMDS	Access Oracle Spatial	PostGis
Topology	yes	yes	Must be implemented
Ease importing original info.	low	high	high

Table 1. Software analysis.

CONCLUSIONS

OGC and ISO1907 Standards helped complex geometries tests. But their implementation degree varies in the analyzed tools. It ranges between simple database assignations to C++ programming. Standard Topologies described in ISO1907 are not still included.

OO approach applied to graphical elements drawn on the geological map requires more effort to understand the complexities of the information than a relational approach. The latter only needs point-line-polygon assignation. But OO needs to define each object (Soria Fault) and which graphical elements belong to that object. So, auxiliary information must be looked up. In contrast, that effort provides better information structure especially intended to non-expert readers.

Conceptual diagrams point further research work. Theoretical Object-oriented (OO) concepts such as "multiple inheritance" that should solve duplication of geometries need to be developed.

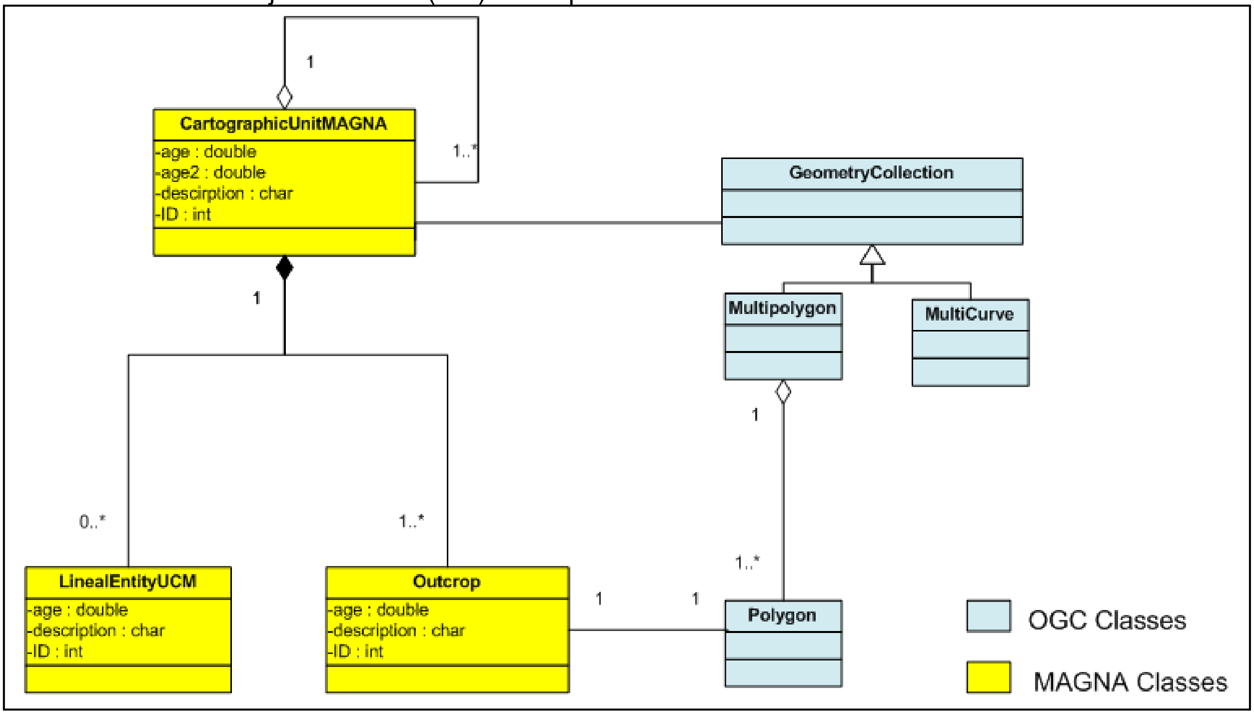

Figure 3. Cartographic Unit MAGNA (UCM) diagram Class.

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THE GEOLOGICAL INFORMATION SYSTEM SWITZERLAND

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KEY WORDS: Geological Information System, GIS, WebGIS, WebServices, NSDI, Web2.0

IMPORTANCE OF GEOLOGICAL INFORMATION

Geological information is of great importance for society because it is implied in a large number of products of our everyday life. Traffic constructions like roads and railway tunnels and the supply with fossil energy resources are only the most obvious products for which geological know-how is crucial. But even common products like toothpaste and cat litter would not exist without geological information and knowledge.

For a wide range of disciplines in the geo-sciences geological information is an important basis for decision-making processes. For instance, information on the stability of bedrock and superficial deposits is essential for choosing specific building sites for houses, tunnels, etc. Questions concerning the search for radioactive waste disposal sites can only be answered with the help of geological data and information. Furthermore geological data supply basic information for the preparation of natural hazard maps, a topic, which is becoming increasingly import in recent years (e.g. extreme flooding of Swiss rivers in the summer of 2005 and rock fall directly striking a car on the Gotthard Highway (A6) in 2006).

SUPPLYING GEOLOGICAL INFORMATION

To be able to address the challenges of the modern society described above, it is essential that geological information is easy accessible. Recent developments and advancements of IT-technologies like the Internet, GIS, Web-Services, etc. enables us to distribute and exchange the required information in an interoperable way, so that everyone who needs information can use it easily.

Like some other Geological Surveys, the British Geological Survey (BGS) for instance, gives numerous examples for applications of their geological data, its respective importance and how data and services can be presented and distributed via the internet (cf. http://www.bgs.ac.uk/britainbeneath/; http://www.bgs.ac.uk/ services/home.html). The accessibility of data is easy and in many cases free of charge and the relevance and importance of such data is easy understandable for professionals and laymen.

SWISS CHALLENGES

Compared to the UK, geological information in Switzerland is only poorly accessible. This is on the one hand, because complete geological coverage of Switzerland on the detail scale is not achieved yet, and on the other hand, because geological investigations and its coordination in Switzerland are carried out by a large number of institutions (e.g. Platform Geosciences of the Swiss Academy of Natural Sciences (sc|nat), Swiss Geological Survey (SGS), Swiss Geotechnical Commission (SGTK), Swiss Geophysical Commission (SGPK), Geological Institutes of Swiss universities, Swiss Association of Geologists (CHGeol) and different other organisations). As a consequence tasks and responsibilities of the different institutions are often not clearly visible and access to existing geological data and services is difficult. Restricted communication between the players of the “Geo-Community” and missing coordination of activities enhances this problem.

To overcome these problems is the major challenge for the SGS in the future.

MEETING THE CHALLENGE

In order to meet this challenge and to create a tool for solving the problems mentioned above, the development of an information system for geological purposes in Switzerland is intended. Such a centralised, web-based information system not just makes the existing geological and geo-scientific datasets and services available, but also gives an overview of the Swiss Geo-Community and its national and international organisational integration. Furthermore, geological terms and selected sites of the Swiss geology (e.g. Glarner Hauptüberschiebung, UNESCO world heritage) are described and presented for non-professionals.

As part of the National Spatial Data Infrastructure (NSDI) of Switzerland the Geological Information System is thought to be the gateway to geo-sciences in general and to geological sciences in Switzerland in particular.

AIMS OF THE GEOLOGICAL INFORMATION SYSTEM

The primary aims of such an information system are:

- Make existing geological data available and web-accessible
- Visualise the organisational integration of the players of the Swiss Geo-Community
- Develop a centralised information-platform for professionals, semi-professionals and laymen
- Strengthen the public awareness of geology and geo-sciences in Switzerland

Related on these aims the following target groups of the Geological Information System can be derived:

- Professional geologists
- Semi-professionals, e.g. teachers
- Laymen from a broad public

A FIRST SKETCH

The content of the intended information system already exists to a large extent on the web-presences of the members of the Swiss Geo-Community. Assembling this content the following components of the Geological Information System may be proposed (Fig. 1):

- Dataviewer
- Geological and geo-thematic datasets
- Web-services (e.g. WMS, WFS, but also Geo-RSS and non geospatial services)
- Geology-Glossary (geological terms explained easy understandable) or Geology "Wiki"-site
- Easy understandable description of "key-sites" of the Swiss geology
- (Geo-) Graphical presentation of the Swiss Geo-Community and description of tasks and responsibilities of its members
- Adress-database of the members of the Geo-Community
- Geology discussion-forum
- Job exchange
- Calender of events
- Web-application for creating user-generated geological content (Users can comment on existing geological maps or create their own geological maps)

Especially the last component listed above is based on Web2.0 technology. But also in a geology discussion-forum or a calender of geological events users may generate content by themselves. The interactive character of this technology might attract and tie users to the geology portal and thus enhance publicity of geology. However, although web-sites based on Web2.0-technology (e.g. www.facebook.com and others) are very popular, the potential for enhancing the perception of geology in society by such “geological social-networking” components have to evaluated.

APROACH

In order to built-up the Geological Information System Switzerland and to achieve the aims mentioned above the following approach is envisaged:

- Clairfy the needs and requirements of the Swiss Geo-community (in progress)
- Initiate a working-group containing representatives of the members of the Swiss Geo-community (to be performed)
- Develop a concept for the built-up of the system (in progress)
- Develop a prototype-system (to be performed)
- Develop the final Geological Information System (to be performed)

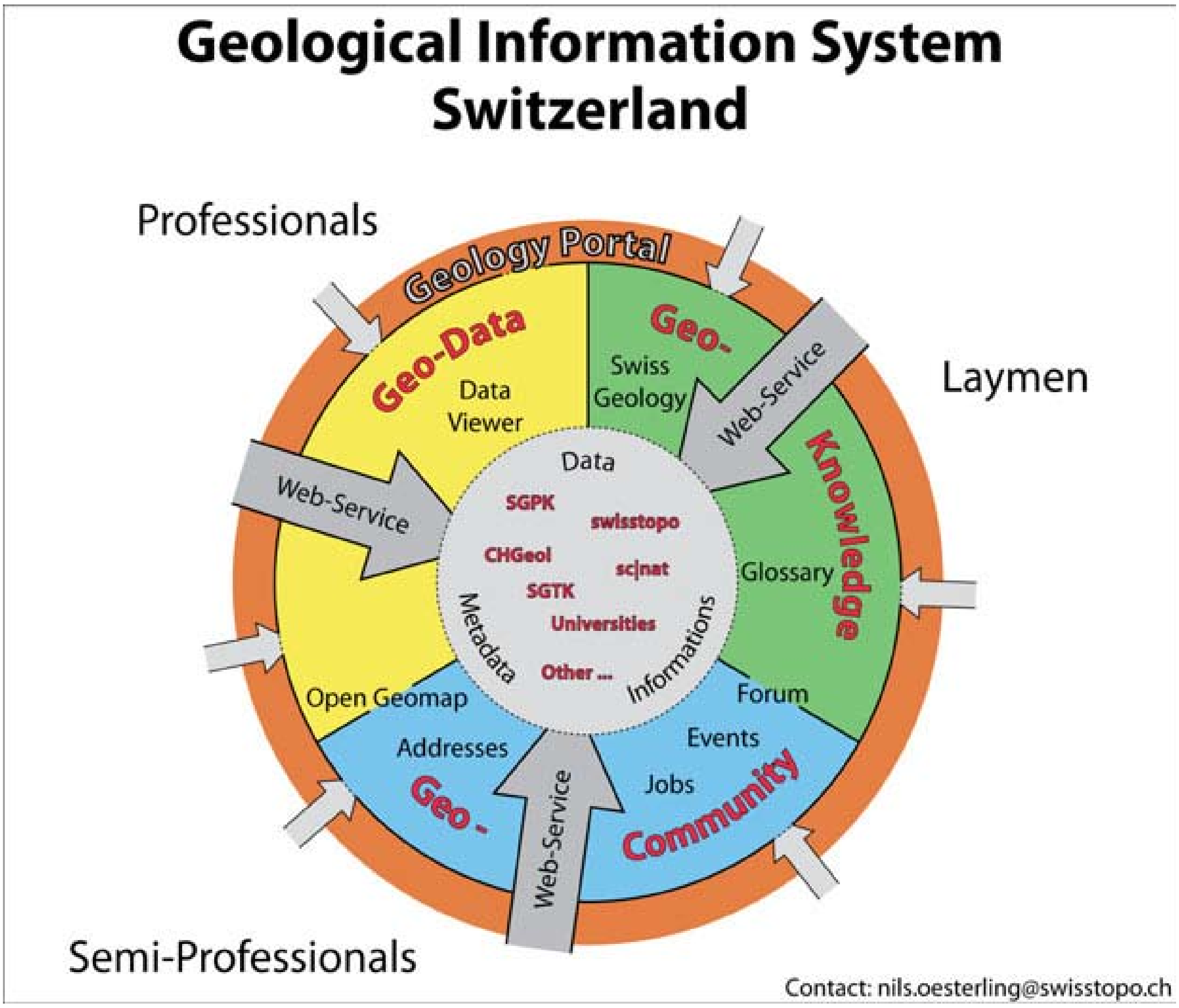

Figure 1 – Schematic overview the the structure of the Geological Information System Switzerland. The core of the system is built on the available geological data and information. Access to the data is provided via a web-portal or dircetly via web-services. The entire system is divided into three sectors covering issues related to geo-data, geo-knowledge and the geo-community. Each sector contains different components, e.g. a data viewer for visulising geological data or a discussion-forum for the communication between professionals and laymen. The target groups are professional geologist, the semi-professional sector (e.g. teachers) as well as laymen from a broad public.

THE NEW INSTITUT GEOLÒGIC DE CATALUNYA: THE GEOWORKS PROGRAMME OF THE YOUNGEST GEOLOGICAL INSTITUTE OF EUROPE

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KEY WORDS: ten words as a maximum.

The Institut Geologic de Catalunya

Through the Law 19/2005 of the Catalan Parliament, the Catalan Government created the Geological Institute as a new instrument to contribute to the availability of basic and updated geological, pedological and geothematic information. The Law relates the activity of the Geological Institute to "the research, advice and production of information relative to the ground and the subsoil, which constitute indispensable tools to promote the several policies, both public and private, that have their operative axes in the ground and the subsoil, and also to establish the necessary preventive or corrective measures for situations of risk. For the exercise of these functions, the geological map of Catalonia is configured as a fundamental instrument".

The GeoTreballs, a new concept of geological map

The geological works, both in their theoretical and applied aspects, have a long tradition in Catalonia, which precedents go back to the last decades of the 19th century. However, because of some historical vicissitudes, there is still an important lack concerning modern, basic geological, pedological and geothematic information, necessary for land and urban planning. The availability of this information and the subsequent generated knowledge about the soil and the subsoil, are essential items for the right management of these natural, limited and non renewable resources.

What we call GeoTreballs (the Catalan word for "Geo-Works") is a set of programs through which the several layers of information that constitute the Geological Map of Catalonia have to be completed. The GeoTreballs are organized through six programs aimed to acquiring, elaborating, integrating and publishing the basic geological, pedological and geothematic information concerning the whole of the territory, in the suitable scales for the land and urban planning, to be produced in a period of time estimated in about fifteen years.

In this way, the Geological Map of Catalonia results from the integration of the results produced by the completion of six *GeoTreballs*, each of which generating a complete cartographic series and the corresponding systems of associated data bases. Namely, the six *GeoTreballs* are:

- Geological Map 1:25000.
- Geological Map of the Active and Recent Processes
- and of the Anthropic Activity 1:25000 (GeoAntròpic 25).
- Geological Map of Urban Areas 1:5000.
- Soil Map 1:25000.
- Hydrogeological Map 1:25000.
- Map for the Prevention of Geological Risks 1:25000.

The concepts, contents, covered areas, and uses and applications of the informations resulting from the completion of each of the GeoTreballs are sumarized as follows:

- **The Geological Map 1:25000** is the basic, general geological map. It reaches the whole area of Catalonia (31.895 Km2), divided into 304 sheets. From a conceptual point of view, it is the general geological framework for the other GeoTreballs, and provides them with the necessary, basic geological information. As other classical geological maps, the Geological Map 1:25.000 summarizes the basic geological knowledge of the Region. It is produced from specific field and laboratory reserach supported by the available subsurface and remote sensing data. It informs about the lithology, the stratigraphy, the age, the structure and other geological characteristics of the materials that form the basement, about the surficial and recent deposits, and about those of antrhopogenic origin.

- **The Geological Map of the Active and Recent Processes and of the Anthropic Activity 1:25000** is an applied geothematic map produced to the suitable scale for the land planning. As its name is a so long title, we call it GeoAntròpic 25. The map covers the whole area of Catalunya divided into 304 sheets, and informs about the basic lithology and structure of the geological basement, about the lithology and the processes that have generated the surficial deposits and about the human actions that have resulted in modificatons of the land's original geometry and/or its natural attributes (Fig. 1). As in other geothematic maps occur, the basic information partially derives from the analysis of that contained in the general geological map, completed with specific field research, geotechnical and subsurface data, and from the analysis and interpretation of old and recent topographic maps and aerial photographs, as well as other documents produced using remote sensing techniques. To summarize, the GeoAntròpic 25 deals with the constraints that the geological environment imposes to the development of the human activity, and about the effects that the human activity produces in the geological environment. Moreover, the information contained in this map is essential for the realization of the Map for the Prevention of Geological Risks 1:25 000, and for the implementation of its related Information System.

- **The Geological Map of Urban Areas 1:5000** is also an applied geothematic map, produced at the suitable scale for the urban planning. It covers an area of 2109 Km2, corresponding to that of all cities and towns of more than 10.000 inhabitants, and the county capital towns of Catalonia of less than 10.000 inhabitants. Conceptually, the information contained in this map is of the same type than that of the GeoAntròpic 25, but the methodology for data capture is strongly conditioned by the scale and very especially by the physical particularities which characterize the highly anthropised zones (Fig. 2).

- **The Soil Map 1:25000** is a map of pedological content, produced at the suitable scale for the agricultural and general land planning. It covers the whole area of Catalonia, and it is also divided into 304 sheets. The availability of information about the physical constitution and chemistry of the soils, as limited and non renewable resources, is essential for the management of the agricultural land as well as for the general and environmental planning in the widest sense of the term. The soil maps are the minimum that is required to manage the edaphic resources and to carry out national and European strategies of sustainable development. The information included in the Soil Map is also essential to complete the Information System of geological risks.

- **The Hydrogeological Map 1:25000** is an applied geothematic map especially designed for the management of the groundwater resources and for the policies of protection of other environmental issues. The information that it contains allows reducing the costs of constructive projects. Its scale also allows to a detailed delimitation of the water resources in the subsurface, both spatially and temporarily, resulting in a useful administrative instrument.

- **The Map for the Prevention of Geological Risks 1:25.000** is an applied, multi – risk map that forms part of the policy of prevention of natural risks in Catalonia. The treatment of the data concerning the several geological risks (risk of movement of the terrain, seismic risk, risk of avalanches or risk of floods, among other) allow to make a zoning of the territory, which is necessary for the general land planning, and is the basis for the development of local analyses related to urban planning (Fig. 3).

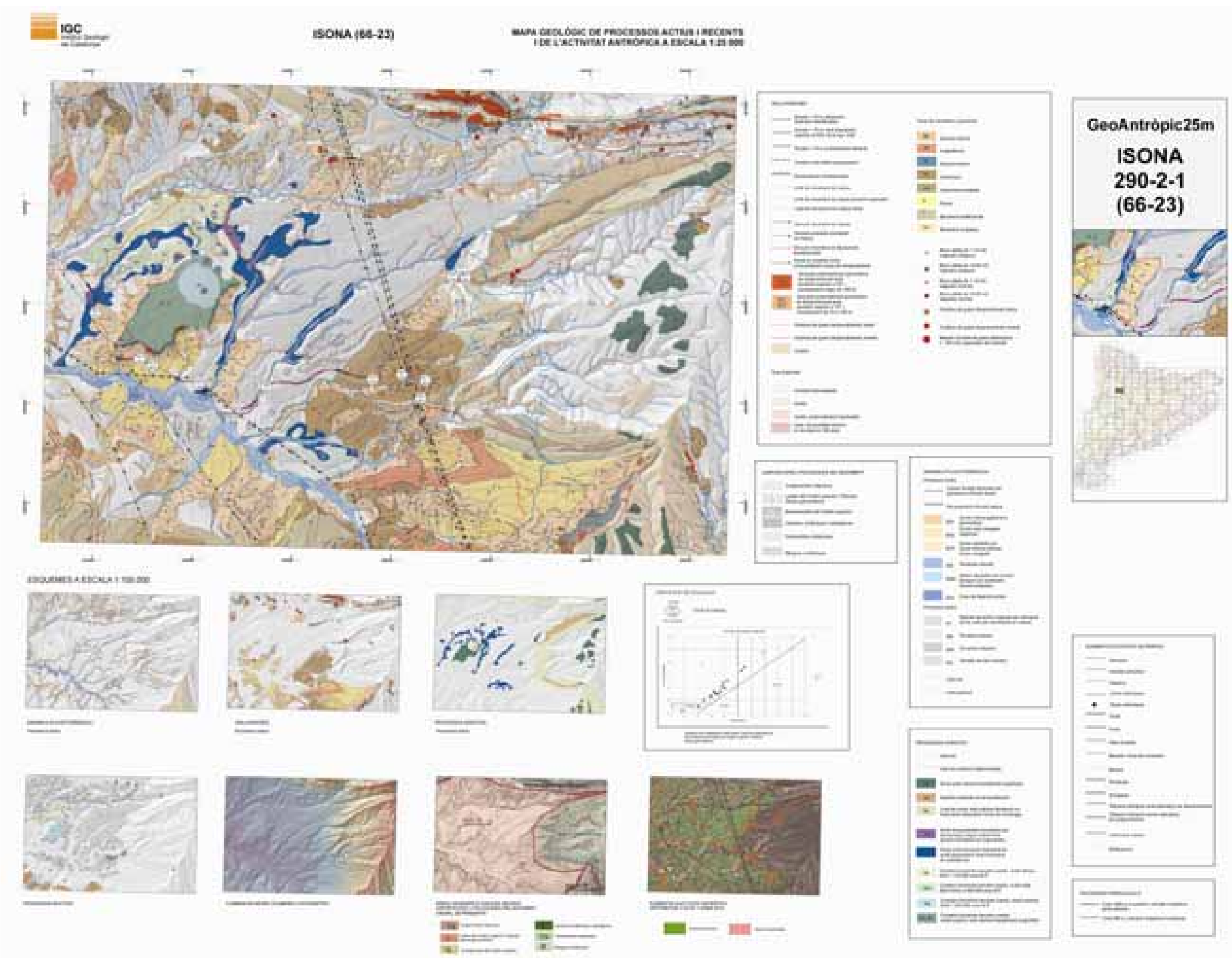

Fig.1- Example of a GeoAnthropic map

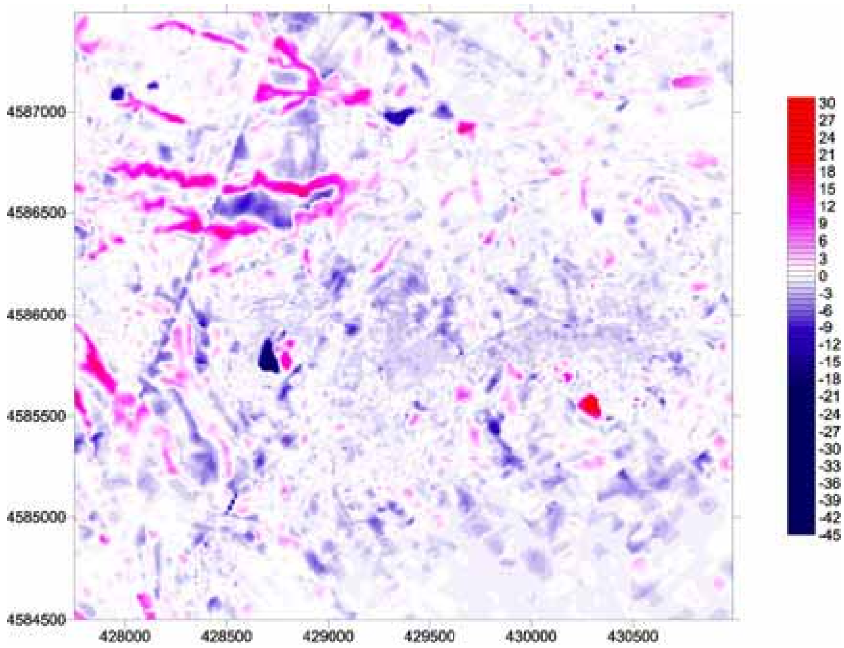

Fig.2. Model of infill and excavation obtained through a digitations and restitution process of present and ancient aerial photography.

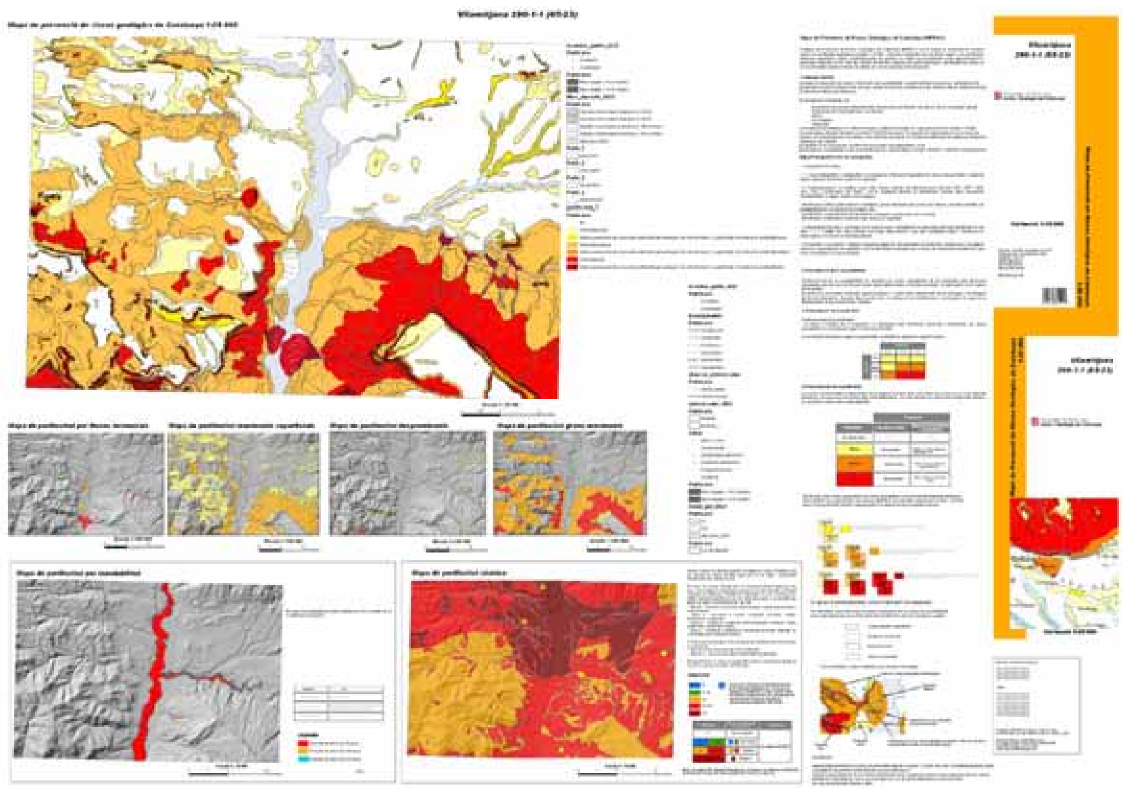

Figure 3 – Example of a geological hazar map.

INFORMATIONAL INTERDISCIPLINARY DATABASE FOR THE CONSTRUCTION OF THE GEODYNAMIC MODELS OF THE ACTIVE CONTINENTAL MARGINS OF THE EARTH

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KEY WORDS database, geodynamic model, continental margins, Sakhalin, Neftegorsk earthquake, subduction zone, deep structure, lithosphere.

The present stage of geosciences is characterized by a special attention to researches in the field of deep structure of the Earth which are caused by a need to decide theoretical problems of geodynamics, to prospect effectively for mineral deposits hidden in depth, to research a problem of seismic hazard, to forecast and reduce a damage from natural disasters, in particular what are caused by earthquakes and volcano eruptions, and also to solve an environmental problems.
Of particular risk are continental margins which represent a danger to the people living there. Continental margins are characterized by high seismicity, volcanic eruptions and other natural cataclysms. In this connection continental margins are object of detailed study under the international and national geophysical projects (Cruise Reports, 2000; Rodnikov et al, 2002; 2008
The obtained results under projects are a basis for creating the Information interdisciplinary database, which can be used for constructing geodynamic models of a deep structure of active continental margins of the Earth. The Information interdisciplinary database includes geologic-geophysical parameters in a digital form and with geographical coordinate references.
The database embraces data on bathymetry, seismology, deep seismic sounding, gravity, heat flow, magnetic, geology, petrology, the results of geophysical survey, deep drilling of the seafloor, dredging, the location of deep faults, rift and paleorift structures, ancient and recent subduction zones, magmatic formations and volcanoes, mineralization zones and areas for oil and gas formation, asthenospheric diapirs and partial melting zones in the upper mantle and other data.
Geodynamic models of a deep structure for active continental margins in the Okhotsk, Japanese and Philippine Sea regions are created on a basis of complex analysis of all this data. Detailed descriptions of models are available.
An application of the Information interdisciplinary database for construction of a deep structure model of the lithosphere in the region of Neftegorsk earthquake which has occurred with magnitude Ms=7.1 on May 27, 1995 at 13:03:49.2 GMT in the northern part of Sakhalin, in the Sea of Okhotsk caused victims and destructions is examined.
The Okhotsk Sea plate is characterized by high seismicity (figure 1).

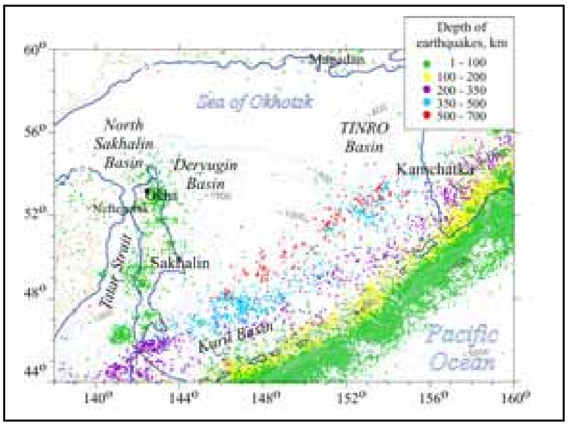

Figure 1 – Seismicity in the Okhotsk sea region. (source: Geophysical service, RAS)

The vast majority of earthquakes are confined to Kuril island arc. The Pacific plate there subducts under the continent forming a seismic focal zone, which is traced to a depth of 700 km. In the west, the Okhotsk Sea plate is bounded with deep faults extending along Sakhalin where earthquakes are localized in the crust (Yunga, Rogozhin, 2000).
The Neftegorsk earthquake has occurred on the North Sakhalin consisted of Neogene and Quaternary sandy-argillaceous sediments with thickness about 6 km (Figure 2). The location of the earthquake was 52.6^0 N, 142.8^0 E.

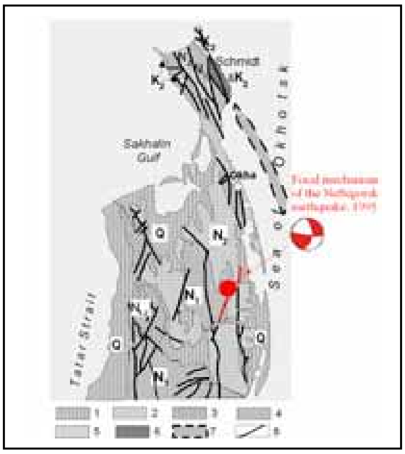

Figure 2 - Geological map of North Sakhalin. 1-Quaternary ; 2-Pliocene; 3-Neogene; 4- Miocene; 5-Upper Cretaceous; 6-Ophiolite complex on Schmidt Peninsula;7- Ophiolite complex along the eastern shore of Sakhalin; 8-Faults

The hypocentre of Neftegorsk earthquake was found on a depth of 18 km. As a result of this disastrous earthquake seismic rupture of north-northeast strike of an overall length of 35 km appeared which caused right-lateral strike-slip fault displacement with amplitude of the horizontal shift component up to 8 m and vertical upthrust component up to 2 m (Rogozhin, 1996; Yunga, Rogozhin, 2000.

As may be seen from the constructed model of a deep structure of the lithosphere under Neftegorsk earthquake region, North Sakhalin comprise the North Sakhalin sedimentary basin, the West Deryugin basin and the ophiolite complex located between them (Rodnikov et al, 2002; 2008; figure 3).

The Deryugin Basin was formed in an ancient deep trench after the subduction of the Okhotsk

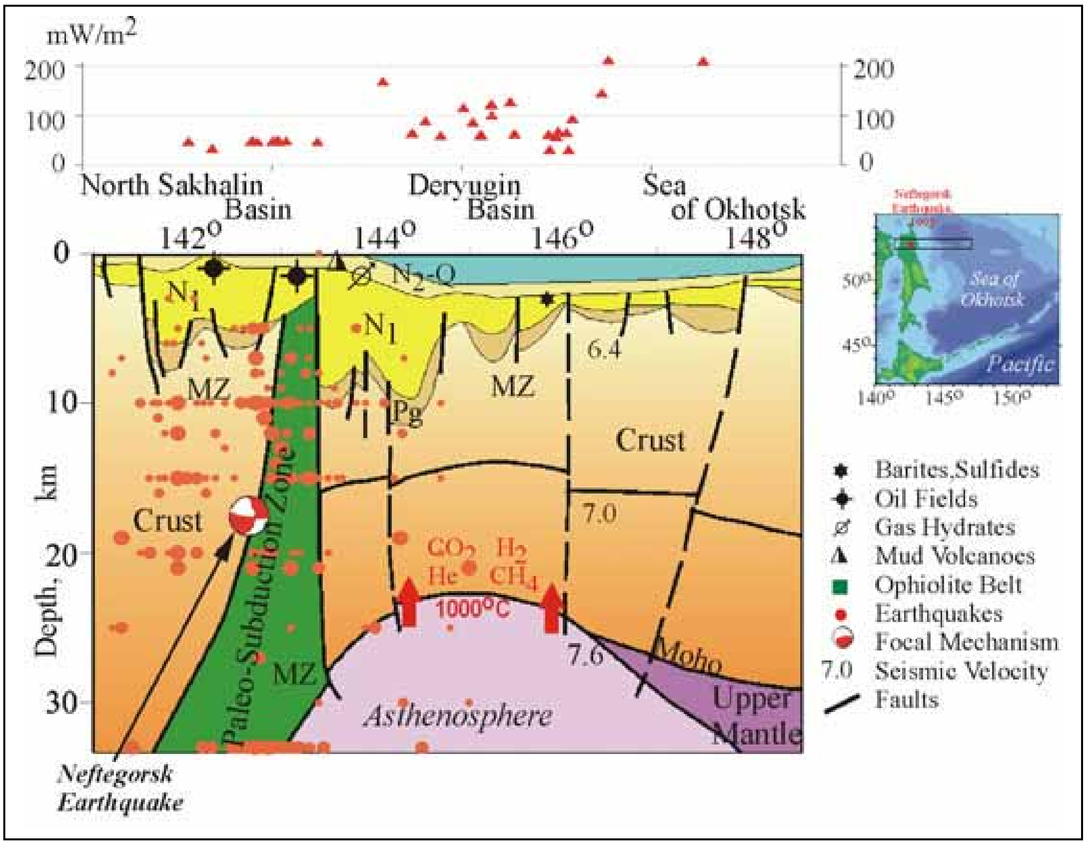

Figure 3 – The geodynamic model of the deep structure of the lithosphere in the Neftegorsk earthquake region.

sea plate under Sakhalin was completed in the Early Paleogene. In the Late Cretaceous-Early Paleogene in the Northern Sakhalin region a back-arc basin was located and filled with sand-clayey oil and gas bearing deposits. The ophiolite complex fixes the position of the ancient seismofocal zone, i.e. the Mesozoic zone of

subduction of the oceanic crust of the Sea of Okhotsk under Sakhalin (Granik, 1999).
On a surface the subduction zone is shown as deep faults stretched along Sakhalin. It is probable that the manifestation of the Neftegorsk earthquake was a result of activization of this

SUMMARY

The Informational interdisciplinary database can be considered as a modern information system for constructing various geodynamic models of a deep structure of active continental margins of the Earth.
Constructed on the basis of complex interpretation of the geologic-geophysical data the geodynamic models of active continental margins give the chance
- to study a deep structure of the Earth under seismic dangerous zones, volcanic areas, mineralization regions and sedimentary basins;
- to investigate a role of the deep processes in mantle which have an influence on formation of crust structures;
- to present dynamics of development of continental margins;
- to spend correlation between the geological features, tectonomagmatic, hydrothermal activity and the processes in the upper mantle.

ACKNOWLEDGMENT

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ONEGEOLOGY-EUROPE: ARCHITECTURE, DATA MODEL, AND WEB SERVICES.

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(3) Czech Geological Survey (CGS).

KEY WORDS:
Geology, Interoperability, INSPIRE, Metadata, Catalogue, Web services, GeoSciML, Geoportal.

OneGeology-Europe: the project

OneGeology-Europe is a large ambitious project to make geological spatial data further known and accessible.
Geological data are essential to the prediction and mitigation of landslides, subsidence, earthquakes, flooding and pollution. Geology is the keyword for planning the future of Europe
Health and environment protection, and the development of modern societies go across geology. The study of medicines and diseases, the research and extraction of drinking water, infrastructure engineering, use of several forms of energy deriving from methane, oil, coal, hydroelectric, nuclear or geothermal, raw materials supply, as well as food need the intervention of geology.
Land management, identification, assessment and management of geo-resources (such as groundwater and energy sources), prevention and mitigation of natural hazards (such as landslides, floods, volcanic eruptions, earthquakes), prevention of cultural and environmental degradation are possible only through the set up of a geological database and of methodologies which help human beings in improving their relationships with the natural environment. Harmonisation of information becomes vital for a proper use and respect of the crucial resources, and to guarantee a sustainable development

The OneGeology-Europe project develops an integrated system of data to create and make accessible for the first time through the internet the geological map of the whole of Europe.
The elaboration of several data sets owned by the national European geological survey is carried out in accordance with the requirements of INSPIRE (Infrastructure for Spatial Information in Europe), the recent European Directive which sets guidelines for the elaboration of territorial data.
Since geological data are elaborated differently from country to country, they are difficult to share. OneGeology-Europe, while providing more detailed and complete information, will foster even beyond the geological community an easier exchange of data within Europe and globally.
An extremely wide range of organisations in commercial and public sector domains uses geological information. It is also used by many citizens through their leisure pursuits or education. Moreover, geological data is used also by the resource and civil engineering and by planning and environmental sectors.
The information will be useful for broad spectrum of purposes such as educational, hazard mitigation, mineral and energy resource exploration, groundwater protection, civil engineering, land and property development, planning and policy making and insurance.
Geological data held by national geological surveys is generally described in national language of the country. The project also defines and implements a multilingual metadata profile for the geosciences. The initial list of languages that will be available are: English, French, German, Italian, Spanish, Swedish, Czech and Norwegian.
Intrinsically linked to OneGeology, OneGeology-Europe is characterised by the high technological capacity of the EU Member States, and has the final goal to achieve the harmonisation of European geological survey data according to common standards. As a direct consequence Europe will make a further step in terms of innovation and information dissemination, continuing to play a world leading role in the development of geosciences information.

The project started September 2008 for two years, with 29 partners from 20 countries (20 partners are Geological Surveys). The budget is 3.25 M€, with a European Commission contribution of 2.6 M€.

Objectives

Several objectives are assigned to this project:

- It will bring together a web-accessible, interoperable geological spatial dataset for the whole of Europe at 1:1 million scale based on existing data held by the pan-European Geological Surveys.
- It will develop a harmonised specification for basic geological map data and make significant progress towards harmonising the dataset (an

essential first step to addressing harmonisation at higher data resolutions).

- It will accelerate the development and deployment of a nascent international interchange standard for geological data – GeoSciML , which will enable the sharing and exchange of the data within and beyond the geological community within Europe and globally.
- It will facilitate re-use and addition of value by a wide spectrum of users in the public and private sector and identify, document and disseminate strategies for the reduction of technical and business barriers to re-use.
- It will address the multilingual aspects of access through a multilingual discovery portal. In identifying and raising awareness in the user and provider communities it will move geological knowledge closer to the end-user where it will have greater societal impact and ensure fuller exploitation of a key data resource gathered at huge public expense

The project will be strongly interlinked with the INSPIRE directive and IUGS Commission for the Management and Application of Geoscience Information (CGI).

Expected results

OneGeology-Europe will provide the following results:

- an interoperable geology spatial dataset at 1:1 million scale for all onshore EU
- scientific and informatics specifications for the harmonisation of geological data at this resolution; progress towards a harmonised dataset
- view service providing access to best practice high resolution geological spatial data services for 6 Member States
- 2-4 pilot and case studies on cross-border delivery of harmonised high resolution data access
- multilingual discovery metadata for all participants' geological and applied map data
- robust data model, schema and mark-up language for the geosciences
- web portal providing easy multilingual access to the above data and examples of user-focused web services
- best practice examples of the delivery of geological data to a range of users
- guidance and code of practice on licencing and clearing arrangements facilitating re-use of geological spatial data
- exchange of science, technology, informatics and communication skills and experience across the EU and globally.

OneGeology Architecture

The technical team has defined a draft architecture with the following main components:

- a common data model to exchange geological data; each data provider has to map its own data to the common language
- a set of web services to view, access, and process geological data,
- a metadata catologue with its metadata editor to register metadata of datasets and services,
- a geoportal to provide the user with a user-friendly way to discover, view and access geological data.

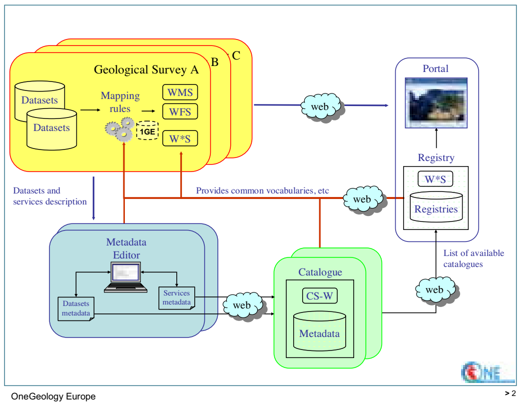

Figure 1 – Draft OneGeology-Europe architecture.

Metadata and Catalogue service

A Multilingual Geological Metadata Profile based on ISO standards (ISO 19115/19119, and 19139 for XML encoding) will be defined. This profile will take into account INSPIRE Implementing Rules for metadata.

To manage these metadata and to enable searching references to available geological datasets and services, a Catalogue Service will be setup, based on OGC standard (CSW – Catalogue Service for the Web, with an ISO Application Profile). The OneGeology Portal will use this CSW interface to access the catalogue.

The metadata catalogue will be provided at a minimum in 8 European languages (English, French, German, Italian, Spanish, Swedish, Czech, Norwegian), with the possibility to extend to other languages.

The GeoSciML data model and vocabularies

To share and exchange geological data, a common data model must be defined. The project will re-use the GeoSciML data model, developed since 2006 by a group of Geological Surveys. This data model, built as a data transfer standard for geoscience, is based on ISO and OGC standards (as the ISO General Feature Model and GML - Geography Markup Language).
To improve interoperability of geological data, the GeoSciML data model is completed by agreed vocabularies related to rock type or other properties. This agreement on geological concepts across Europe is the main scientific part of the project.

Web services for viewing and accessing data

Once the user discovered datasets relevant to his purpose, web services are provided to view and access data. These web services will be based on ISO and OGC standards: WMS (Web Map Service) for the view service, and WFS (Web Feature Service) for the access data service.
For their implementation, OneGeology-Europe will take into account, as much as possible, rules defined by the INSPIRE Implementing Rules for Network Services.

Conclusion

The OneGeology-Europe project benefits from several international initiatives as OneGeology Global (http://www.onegeology.org), GeoSciML, from standard specifications for web services from ISO and OGC to improve interoperability.
The European directive INSPIRE defining a legal framework and technical rules to develop the European infrastructure provides also a favourable context.
The project is not finished and, from a technical point of view, the main tasks are to set up, test and make all components running for all partners, to connect them at this European scale (20 Geological Surveys), dealing with an open architecture.

The technical aspect presented in this paper must not hide the scientific challenge of harmonising geological concepts across Geological Surveys in Europe. Informatics and science are both necessary to deliver an interoperable geology spatial dataset at 1:1 million scale for all onshore EU.

More information is available

OneGeolgy-Europe web site:
http://www.onegeology-europe.eu/

GeoSciML documentation:
http://www.geosciml.org/

GeoSciML twiki:
https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/WebHome

THE EUROPEAN SOIL DATA CENTRE, THE EUROPEAN SOIL BUREAU NETWORK AND INSPIRE DATA SPECIFICATIONS FOR SOIL

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KEY WORDS:

ESDAC, European Soil Data Centre, ESBN, European Soil Bureau Network, INSPIRE, data specifications, soil

Abstract

The European Soil Bureau Network (ESBN) [ESBN] is a network of main soil data providers in Europe, under the secretariat of the European Commission's Joint Research Centre (JRC) and operates through Working Groups oriented at day-actual topics. The "Working Group on INSPIRE and ESDAC", established in August 2008, for a working period of 2 years, has set the task of assisting the legal and formal INSPIRE process of data specification for Soil at European level, as a theme of Annex III of the INSPIRE Directive. The European Soil Data Centre (ESDAC), considered as a focal point for soil data in Europe specifically at the service of the European Commission's DG ENV and established at the JRC is conceived as a decentralized system of soil data and services and will benefit from specifications that are jointly developed with national and regional soil data stakeholders; therefore it intends to participate in the INSPIRE Soil data specification through chairing the ESBN Working Group. The ultimate goal is that spatial data infrastructures for soil that legally need to be developed by the Member States under the INSPIRE Directive will be able to inter-operate smoothly with ESDAC through a series of network services, and thus give to DG ENV, as primary user of ESDAC at European level, a tool to access soil data without the need to manage them centrally. This paper will report on the achievements so far.

The European Soil Data Centre and the Soil Thematic Strategy

During the last years the need for a coherent approach to soil protection has come on the political agenda in Europe; it was introduced as one of the thematic strategies within the Community's 6th Environment Action Programme. In this context of a European Soil Thematic Strategy (STS) [STS], the European policy makers require access to European soil data and information of various types to assess the state of soils at European level. Also, as part of the newly proposed Soil Framework Directive (SFD) [SFD], Member States would need to communicate to the European Commission soil data, in particular so-called "risk areas" which are areas at risk to major soil threats (soil erosion, lack of organic matter, etc.). The way to do this practically in terms of data specification would need to be discussed between Member States and EC once the Directive will be into force.

As part of this need to collect and assess soil data and information, the European Commission (EC) and the European Environment Agency (EEA) decided to establish a European Soil Data Centre (ESDAC), located at the EC's Joint Research Centre (JRC), as one of ten environmental data centres in Europe. Each environmental data centre acts as the primary data contact point for the EC's DG ENV in order to fulfill its information needs. ESDAC operates under the scheme illustrated by figure 1.

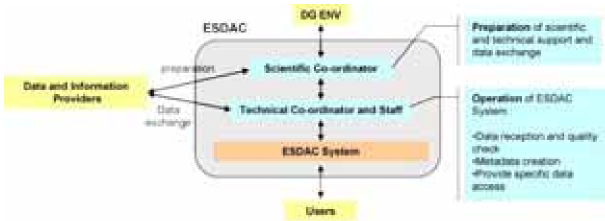

Figure 1. Operational ESDAC

The sources of soil information that currently reside at the ESDAC are JRC in-house and commissioned soil research activities, results from activities within the European Soil Bureau Network (the major scientific network for soil in Europe), results from EU funded soil related projects and results from collaborations with other organizations in the area of soils (e.g. EuroGeoSurveys). In the future, ESDAC would also need to prepare for the receipt, processing and making available reporting data coming from Member States in the context of the SFD.

The European Soil Bureau Network

The European Soil Bureau Network (ESBN) is a scientific network of important soil data providers in Europe, under the secretariat of the European Commission's Joint Research Centre (JRC) and operates through Working Groups oriented at day-actual topics. The "Working Group on INSPIRE and ESDAC", established in August 2008, for a working period of 2 years, has set the task of assisting the legal and formal INSPIRE process of data specification for Soil at European level, as a theme of Annex III of the INSPIRE Directive. It was also recognized that ESDAC, conceived as a distributed system of soil data and services, would benefit from soil data specifications, jointly developed with soil data stakeholders. Therefore, ESDAC was asked to lead the efforts of this working group. This work should also be linked to developments at the ISO/TC190 (on soil quality) that seeks to set-up an international standard for soil data recording and exchange.

INSPIRE

The INSPIRE Directive [INSPIRE], aiming at the establishment of an Infrastructure for Spatial Information in the European Community (INSPIRE), entered into force in May 2007. This directive recognizes that the general situation on spatial information for environmental purposes in Europe is one of fragmentation of datasets and sources, gaps in availability, lack of harmonization between datasets at different geographical scales and duplication of information collection. The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. Policy-makers at European and national level are among the main targeted users who would need access to a number of services that include the visualization of information layers, overlay of information from different sources, spatial and temporal analysis, etc.

INSPIRE and soil data

Soil data are regarded as spatial data in the INSPIRE Directive (Annex III) and therefore Member States have to take them into account when setting up or adapting their national spatial data infrastructures. **A common European data specification for soil** will need to be set up in order to make data interoperability between soil data services possible. Given the heterogeneity of soil data specifications and models in the Member States of the EU as revealed by the recent work in the EU-funded ENVASSO project [ENVASSO], together with the vast experience within the European scientific soil data community of data harmonization during the set-up of the European Soil Database (ESDB) [ESDB], this will not be an easy task, even if assisted by the highly structured INSPIRE approach.

INSPIRE and ESDAC

The INSPIRE Directive addresses Member States only and it is their task to come to a common position concerning soil data through collaborative work between so-called Legally Mandated Organizations (LMO) and the soil Spatial Data Interest Community (SDIC). The European Commission, and therefore the ESDAC, is not formally required to take part in this process. However, if ESDAC wants to consolidate its role as a compiler and provider of European datasets, it is only natural that it will interact with soil data players at Member State level and try to influence any decisions on European soil data representation. Therefore, ESDAC, as leader of the ESBN Working Group on INSPIRE, is candidate for participation in and contribution to the Implementing Rules that will need to come out of the INSPIRE Thematic Working Group (TWG) for Annex-III theme "soil", which will be composed of soil and IT/GIS experts.
Figure 2 illustrates the interrelation between the elements previously described.

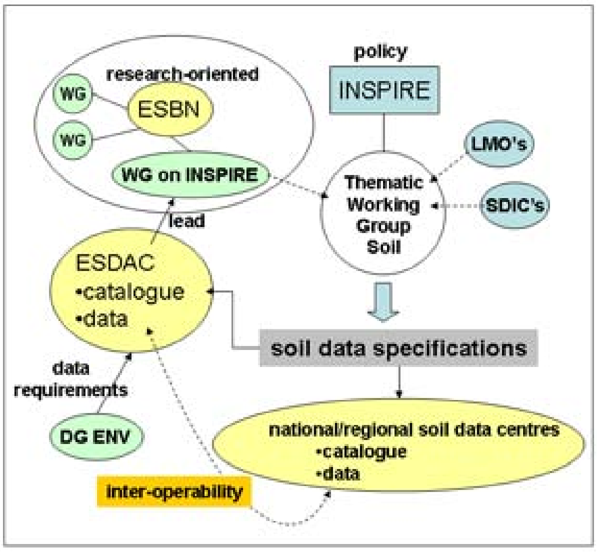

Figure 2. Interrelation ESBN, ESDAC, INSPIRE

The road ahead to INSPIRE soil data specifications

The development of INSPIRE Implementing rules for the interoperability and and, where practicable, harmonisation of soil spatial data sets and services is following a two-step approach. In a first phase a conceptual framework and specification methodology was developed. In a second phase, based on these, data specifications for each data theme will take place, along a road of tasks that is clearly specified and will require three years:

- Task 1: User requirements and use cases
- Task 2: Analysis of the relevant reference material
- Task 3: “As-is” analysis
- Task 4: Gap analysis
- Task 5: Drafting data specification
- Task 6: Testing of draft data specifications for the soil theme in the soil data community
- Task 7: Preparation and adoption of IR for the based on draft and testing (legal text)

At this moment, all Scientific and Technical Coordination of INSPIRE is entrusted to the JRC for the preparation of the technical rules that will facilitate a coherent implementation of INSPIRE across Europe. This work includes the selection and setting-up of the TWG on Soil and guidance in the process of data specification.

Ideally, it is envisaged that, after the data process specification and after proper adoption of the implementing rules , ESDAC will be able to exchange soil data (possibly harmonized) with external organizations at national and regional level, through suitable network services.

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[ENVASSO]: http://www.envasso.com/

[ESBN] : http://eusoils.jrc.ec.europa.eu/esbn/Esbn_overview.html

[ESDB]: “The European Soil Database distribution version 2.0, European Commission and the European Soil Bureau Network, CD-ROM, EUR 19945 EN, 2004" (http://eusoils.jrc.it/ESDB_Archive/ESDB_Data_Distribution/ESDB_data.html)

[INSPIRE]: “Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)”, published in the official Journal on the 25th April 2007, entering into force on the 15th May 2007. (http://www.ec-gis.org/inspire/)

[SFD]: http://ec.europa.eu/environment/soil/three_en.htm

[STS]: http://ec.europa.eu/environment/soil/index_en.htm

GEOLOGICAL, HYDROGEOLOGICAL AND SOIL SURVEY OF BAVARIA: PROSPECTS FOR A COUNTRYWIDE SURVEY

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KEY WORDS: geological hydrogeological and soil survey, general legend, information system, 3D-modeling, geodata infrastructure

INTRODUCTION

In order to provide a good planning basis for the whole country, in Bavaria in the 90ies the political will was declared to complete a statewide detailed geological, hydrogeological and soil survey until 2015. Activities started in 1996, when the first integrated geoscientific mapping project was launched in the planning region of Ingolstadt (WROBEL, 2000). Several large projects followed, which were partly supported by regional development stocks of the EU. Since beginning of the year 2008, activities have been continued with the project "Information Offensive Shallow Geothermal Energy" which runs in two subprojects until 2015. With these projects, full coverage of Bavaria will be achieved as planned.

The contents of the maps, the requirements for the data and special features of the maps are described in the following.

GEOLOGICAL SURVEY

The geological survey in Bavaria collects and evaluates data about the distribution and properties of rocks, such as e.g. field, lithological, structural and geochemical data.

One of the main products derived from the wealth of data is the printed geological map at a scale of 1:25,000 ("Geologische Karte von Bayern 1:25.000"). The geological map provides information about the different geological units, their stratigraphic classifications, structural elements and stratification; it includes selected drilling locations and outcrops. Furthermore, a cross-section illustrates the stratification of rock units in depth. Detailed descriptions of the geological units, their lithology and geochemical composition as well as their structure are provided in additional booklets. For overview purposes the geological outline map 1:500,000 ("Geologische Karte von Bayern 1:500.000") was produced together with a description booklet. For a geological outline of Bavaria see figure 1.

From the beginning in the 1950´s until now about 70 % of the Bavarian expanse has been mapped at the 1:25,000 scale. Since 1996 geological mapping in Bavaria has been intensified by multi-disciplinary projects involving temporary engagements of geologists as well as cooperation with universities and other contractors.

Figure 1 – Geological outline map of Bavaria

From 2002 to 2007 the focus for geological mapping was in Eastern Bavaria and the Landshut region.

Starting in 2008, geological mapping was intensified in Southern Bavaria (Molasse area and Alps), in Northwest Bavaria and in Central Bavaria north of Regensburg in order to fill the remaining gaps in geological knowledge. One of the objectives of the present project is to map more than 130 geological maps at a scale of 1:25,000, most of them covering about 140 km², until the year 2015.

Because of the ambitious time schedule and the large number of geological maps to be produced, in some areas only preliminary geological maps can be made. Nevertheless, the project is a great challenge for the geological survey!

HYDROGEOLOGICAL SURVEY

The hydrogeological survey of Bavaria is being carried out by a consecutive mapping of whole political planning regions. The 18 planning regions of Bavaria are shown in red lines in figure 2. This concept was started in 1996 and since then 3 planning regions have been published and 2 other planning regions are in the finishing stage. In the present project, another six planning regions are being worked out until 2011. From 2012 until 2015 the seven planning regions remaining will be finished (figure 2).

Figure 2 – Present state of the hydrogeological survey: green: survey finished, dark blue: survey in finishing stage, blue: survey in progress (2008–2011), light blue: survey 2012–2015

The aim of the hydrogeological survey is to develop a consistent hydrogeological conceptual model based on a comprehensive knowledge of the geology and visualize it in hydrogeological maps.

In order to accomplish this, the staff recherches all (hydro-)geological information and important input data available, such as borehole data or groundwater studies at water authorities, planning bureaus or drilling companies as well as available mapping projects, diploma theses or manuscript maps. The evaluated data is entered into the Bavarian Soil Information System (BIS). Supplemented by additional field surveys, e.g. intensive hydrogeochemical sampling of wells and springs, pumping tests or groundwater measurement campaigns, the scientists produce full scale maps.

Routinely the geological survey produces hydrogeological base maps, cross-sections and maps of the protective effectiveness of the groundwater cover in the scale of 1:50 000 (HK50) and 1:100 000 (HK100). They are available as printed hardcopies as well as digitally in form of scans and vector data (e.g. for the direct use in numerical groundwater models).

Elements of the hydrogeological base maps are:

- propagation and hydrogeological classification of the upper aquifer and covering layers
- groundwater contour lines and measuring points
- hydraulically critical areas e.g. artesian groundwater basins
- isolines of confining layers of aquifers/aquitards
- geological buildup of aquifers/aquitards
- tectonical elements of hydrogeological relevance
- location of productive and observation wells, springs, extraction/injection wells

The map of the protective effectiveness of the groundwater cover contains:

- classification of the protective effectiveness of the groundwater cover (HÖLTING et al. 1995)
- hydrogeological buildup and tectonical elements
- confining layers of aquifers/aquitards
- groundwater protection zones

The hydrogeological cross-sections contain:

- hydrogeological sections through the hydrogeological units (stratigraphical and/or lithological information)
- groundwater storeys and groundwater bodies
- water table, potentiometric surface

These data are the basis to address topics such as:

- determination of groundwater catchments and drinking water protection zones
- drinking water exploration and development
- flooding protection measures
- treatment of toxic waste sites
- avoiding conflicts between groundwater protection, nature protection and mining of mineral deposits close to the surface
- planning of traffic routes and building projects
- exploitation of deposits
- enforcement of the EU water framework directive
- ecological questions in nature protection

Since 2008 the hydrogeolocal survey supports a new key aspect: the production of maps for applications of shallow geothermal energy such as ground heat exchangers or ground water extraction/injection wells for heating or cooling purposes of buildings.

All information gathered by the hydrogeological survey will be available for the users online through the Bavarian Soil Information System as far as data protection regulations allow.

SOIL SURVEY

In order to complete a first countrywide soil survey of Bavaria in a reasonable time period, the compilation of an outline soil map ("Übersichtsbodenkarte") 1:25 000 (ÜBK 25) started in the early 90ies. This is a conceptual map, which is verified in the field. At present about 80 % of the territory of Bavaria has been mapped and is available in digital form. Closing the remaining gaps in Northwest and Southern Bavaria will be accelerated in the running project "Information Offensive Shallow Geothermal Energy".

As most of the mapping has to be carried out in Northwest Bavaria, the entire project team was deployed there. Additionally external companies are engaged to support the mapping.

According to the specific structures of the different landscapes there are different approaches to develop applicable mapping units and a corresponding map legend. But three particulars must be content of every mapping unit:

1) soil type(s) inclusive spatial ratio
2) texture
3) parent material.

The mapping units represent the so called "Bodenform" (soil body) which combines soil type and substrate in one term.

The structure of the general legend as basis for a seamless cartography has already been implemented.

In addition to the map it is intended to offer corresponding soil parameters through a spatial data base. This data set provides every soil mapping unit with representative soil profiles and enables a wide range of applications.

3D-MODELING

Progress in computers and new software made it possible, to shift from the classical 2D-paper mapping to digital mapping and then to 3D-modeling of the underground. A number of geological surveys in Germany have started the 3D modelling process in the last years (ELFERS et al., 2004). In Bavaria 3D-modelling has begun in the first integrated mapping project in the planning region of Ingolstadt. The model was accomplished in 2002. Parallel to the 2D mapping process regional 3D-models are now routinely being developed for all planning regions using the software GOCAD. The models are the basis for groundwater vulnerability maps and serve as input for numerical process modelling e.g. groundwater models.

It is planned to integrate the 3D-models into the Bavarian soil information system.

SPECIFIC FEATURES OF THE MAPS

In order to make the maps usable in the internet, it is essential, that certain requirements are being met. Most important is, that all the mapping units used are based on a general legend (WAGNER et al., 2006). The general legend is contained in a database, where properties can be attributed to the legend units such as rock type, hydraulic conductivity or porosity. Through the geometries of the legend units these properties can be related to the maps.

Another important point is seamless geometries. Especially the existing older maps were oftenly not well correlated with the geometries of the neighbouring maps. In the present countrywide mapping project it is therefore a major task to revise the existing maps with respect to seamless geometries. Also applying the general legend to older maps requires a lot of resources.

In the internet the maps will be made available as web map service (WMS) also. Thus the maps will be integrated in the national geodata infrastructure and will be compatible following the requirements the new European INSPIRE initiative. Therefore it will also be possible to view the maps together with maps provided by neighbouring countries – which is a main purpose of the INSPIRE initiative of the EU.

FUTURE CHALLENGES

With a detailed countrywide geoscientific map of Bavaria available the Geological Survey will be able to answer societies needs in a much more effective way, than it is possible at present.

The key to this is the availability of the maps in the internet on the basis of a general legend of mapping units. In order to reach more users, it will be necessary to transfer the scientific information of the maps into text information understandable to the non scientific user. One first application will be the new internet portal of the geological survey of Bavaria for the use of shallow geothermal energy (SCHULZE et al., 2009). The user may choose a location of interest on the map and then all information that can be drawn from the existing maps at this location will be provided in the form of understandable texts.

More thematic layers shall follow later on, such as engineering geology, geological hazards or local drilling conditions.

3D-modeling will gain great relevance as future applications will use the deeper ground more intensively than at present. Examples are deep geothermal plants, storage of carbon dioxide (CCS), storage of gas and exploration and exploitation of natural resources.

3D-models in various resolutions will be needed in order to contain conflicting uses of these appplications.

ACKNOWLEDGEMENTS

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EVOLUTIVE ANALYSIS OF CHANNEL CHANGES THROUGH MAP COMPARISONS: FIRST RESULTS PERTAINING TO THE TARO RIVER BASIN (PARMA PROVINCE, NORTHERN ITALY)

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KEY WORDS: alluvial morphology, maps, GIS, geostatistics

FOREWORD

Maps published over the last two centuries are nowadays available, providing us with an opportunity to study morphological changes brought about by processes linked to fluvial dynamics; in particular, we can look at spatial variations affecting the active river bed[1].

The elements derived from the various maps are compared using GIS programmes which allow convenient application of mathematical-statistical methods to quantify (calculating parameters) changes that have occurred over suitable time intervals. Width and surface of alluvial channels, meander ratio and channel adjustment of rivers are all analyzed. A new development is the use of cadastral sheets in this type of spatial analysis; although not originally compiled “purely” to represent geographic elements, this cartographic base is interesting as it can be used to identify areas of so-called “public water bodies” within the active river beds of watercourses for the years 1940-1950 (last available update).

THE STUDY AREA

The study area comprises the catchment basin of the River Taro, one of the major rivers in Emilia-Romagna and a left tributary of the River Po. The basin’s longest axis is south west – north east oriented and the basin itself encompasses an area of approximately 2,072 Km² which includes around two thirds of Parma province. The mountain sector of the study area, which lies within the Apennine chain, reaches its peak altitude at Mount Maggiorasca (1799 m) near the region’s southernmost boundary. The reliefs are formed by geological units comprising a sequences of sandstones, pelites, calcareous marls and, in a lower concentration, ophiolitic rocks; these formations are (largely) tectonically superimposed on chaotic clayey units. The substrate of quaternary deposits, formed by debris slope accumulations (largely, landslides) and gravels and sands of intramontane alluvial deposits. Thicker, more extensive alluvial deposits form the plain section of the basin, with outcropping gravels (covering an area of approx. 57 Km²) and sands with varying clay content.

METHODS

The original data, subsequent processing, analyses and results are purely of cartographic interest, since it is impossible to verify the actual ground attitude at the time the map was compiled and printed. This drawback, which does not apply to aerial and satellite photographs, is true for all maps, especially those predating air photogrammetric.

The source materials used for this project were aerial photos and maps, produced over the last 200 years and digitalized from the ‘90s, available from various departments and institutes of Emilia-Romagna regional authority; when necessary, the original documents were scanned and subsequently georeferenced using the ED50 – UTM32∗[2] cartographic reference system.

Each of these raster bases was digitalized with two types of vector layers: a polygon vector layer which relates to the active river bed in its entirety, and a linear layer which represents the watercourse and its channels within the active river bed (figure 1). For the older maps, compiled without recourse to air photogrammetry techniques, the data collected can be considered reliable only from a cartographic point of view, while it is impossible to verify the actual attitude of channels and the boundaries of the active river bed.

[1] Areas affected by current and previous fluvial activity, active in recent times and, in some cases, still affected by the morphogenetic action of the watercourse in spate.

[2] The parameters of this reference system are equivalent to those of ED50-UTM, but with a false northing of 4,000,000 Km.

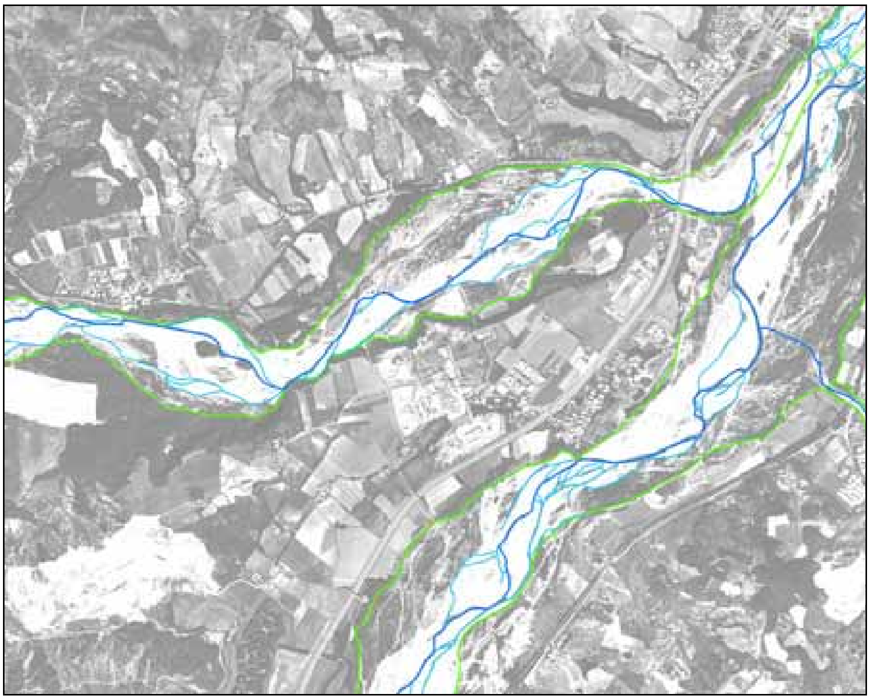

Figure 1 – example of digitalization of polygons and lines.

A list of some of the maps used:

- Historical pre-unification map , 1801-1859 (scale 1:50.000)
- Topographic map of the Kingdom of Italy, IGMI 1st edition (Bessell), circa 1890 (scale 1:50.000)
- Topographic map of Italy, IGMI 2nd edition (Hyford), circa 1930-'40 (scale 1:25.000)
- Cadastral maps, circa 1940-1950 (scale 1:2.000)
- GAI flight: aerial survey, 1954 (scale 1:30.000 circa)
- Regional Technical Map, years 1971-1978 (scale 1:10.000)
- AIMA digital orthophotos, 1996 (scale 1:10.000)
- Editions of the Land Use Map, from 1976 to 2003 (scale 1:25.000)

Linear layers pertaining to the course of rivers obtained through comparison feature the following fields in the associated table:

- channel (value 1 or 2): in the event of braided morphology, indicates whether the watercourse is the main one (1) or, if it is a secondary channel (2) which is longitudinal or transversal to the river course
- name: name of the watercourse
- length: length of the individual section calculated automatically by the GIS software

The following parameters were calculated

Sinuosity index

SI = Corridor length ÷ Downvalley length. The length of the river corridor divided by the actual downvalley length of the main watercourse (value 1 in the "channel" field) produces the sinuosity index, also termed the **meander ratio**. An SI ratio that tends to the value of 0 indicates that the fluvial channel is far longer than the river corridor and that the river takes a meandering course within the active river bed. A ratio tending to 1 indicates that the length of the river is akin to that of the river corridor, meaning the river follows a straight course. The mean river corridor was obtained by taking into account an "envelope" of the (digitalized) courses of active river beds, obtained from various maps, approximating the straightest course possible. This point in the study requires further refinement since we need a mathematical-statistical method[3] for "automatically" producing the best approximation of the river corridor.

Calculating channel density

By applying the "density" function and taking into account the numerical value entered in the "channel" field, we can generate a raster density map, which expresses the presence of "braided" sections, namely those with a higher number of secondary channels, for each data set utilized. Thus, we can estimate local variations in river morphology over time.

Calculating parameters based on the width of the active river bed (using polygon vector layers), on suitably identified river sections. These parameters enable a semi-quantitative study of the evolutive phases of the

[3] A method has been developed and is being trialled using available data.

watercourse, identifying and differentiating, spatially and temporally, those sections susceptible to erosion and channeling.

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AGRICULTURAL AND ENVIRONMENTAL DATA FROM SCHLESWIG-HOLSTEIN FOR THE GEO DATA INFRASTRUCTURE

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KEY WORDS: agriculture, environment, geo data, web mapping, web service, geo data infrastructure.

Introduction

Under the authority of the Ministry of Agriculture, the Environment and Rural Areas of Schleswig-Holstein there has been developed an internet platform for geographic data. This "**Agricultural and Environmental Atlas of Land Schleswig-Holstein**" is based on the web mapping open source product UMN Mapserver of the University of Minnesota. In the following it is referenced as **AE-Atlas**.

Since the year 2005 Schleswig-Holstein (SH) officially cooperates with Mecklenburg-Western Pomerania (MV), since the year 2006 also with Rhineland-Palatinate (RP).

Description of the platform

The development around the UMN Mapserver started in the year 2001. In the meantime there has been built a powerful wrapper application concerning the aspects

- configuration management for different interactive entries into the portal,
- theme management for convenient administration extending the UMN Mapserver Facilities,
- access management for users, roles and themes,
- multi language support,
- web services and
- geo data infrastructure.

The complete wrapper application is written in PHP using the mapscript interface of DM Solutions in Canada.

Used operating systems are Windows 2003 Server (SH) and Open SuSE Linux 10.x (MV, RP).

A significant part of the platform is held in a database. Supported database systems are Oracle (SH, MV) and PostgreSQL (RP).

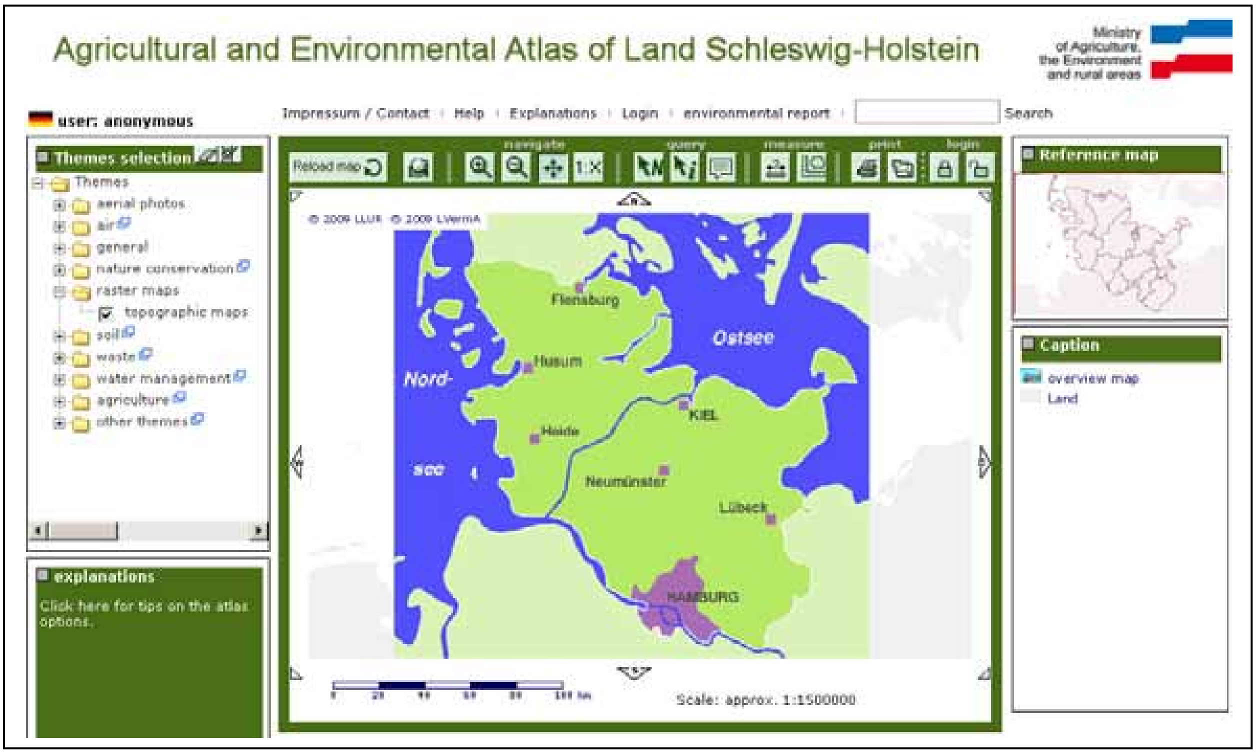

Figure 1 –Interactive English version of the Agricultural and Environmental Atlas Schleswig-Holstein.

The platform provides geo data in three ways:

- It can be used for interactive access with a standard web browser.
- It provides a web service for name and number based search.
- It is part of the machine geo data infrastructure.

Use case 1: Interactive access with a standard web browser

The interactive user interface is accessible by www.umweltatlas.schleswig-holstein.de or www.agraratlas.schleswig-holstein.de. Figure 1 shows the start screen after switching to English language. The anonymous user may zoom in and out, pan, print, measure and query themes in different ways. A wide variety of about 100 themes is provided.

Named users may have more or different themes and rights. Some sophisticated rights are a download feature, the ability to mark points on the map and describe or comment them, store and reload views and an attribute based search facility.

Use case 2: As a web service

For each theme one attribute may be marked as name field and one as number field in the theme administration.

Themes can be queried by name and by number. The results are optionally returned as HTML, XML, Image or are directly presented in the atlas.

The search form in figure 2 (available at http//www.umweltdaten.landsh.de/atlas/script/ns_maske_en.php) gives a good visual impression about the possible parameters allowed for the query-url. The selected example results to the request http://www.umweltdaten.landsh.de/atlas/script/lanuns.php?function=namesearch&return=atlas&zoom=yes&ignorecase=yes&match=exact&relation=or&ns_form_lang=en&string=Selenter%20See&number=&themes=topo&searchthemes=seen.

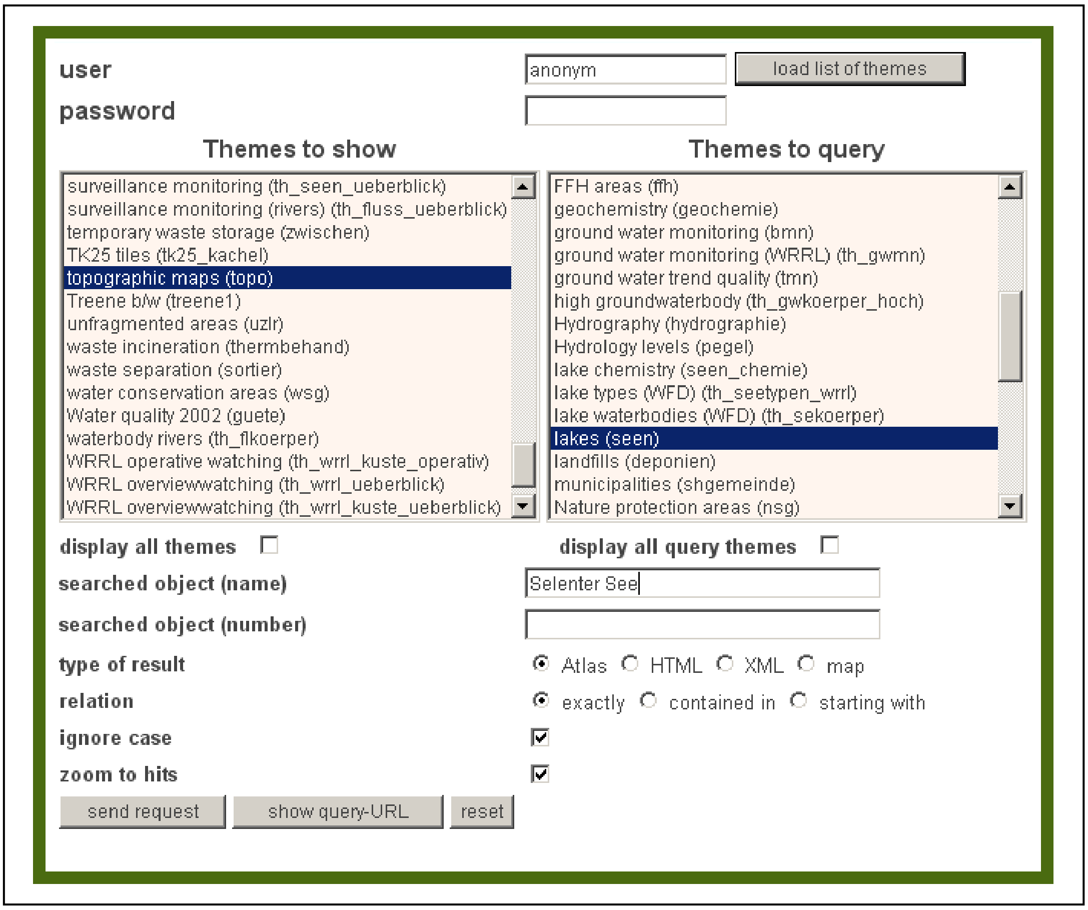

Figure 2 – Search Form for the Name and Number Search Web Service.

Use case 3: In the machine geo data infrastructure

In this context the platform is part of a machine network exchanging maps and geo object information with well defined protocols. The protocols are based on the Open Geospatial Consortium (OGC) standards. In Germany they are put into concreter terms by the German Geo Data Infrastructure (GDI-DE) committees.

The AE-Atlas is official data provider for agricultural and environmental themes in the geo data infrastructure of Schleswig-Holstein (GDI-SH, figure 3).

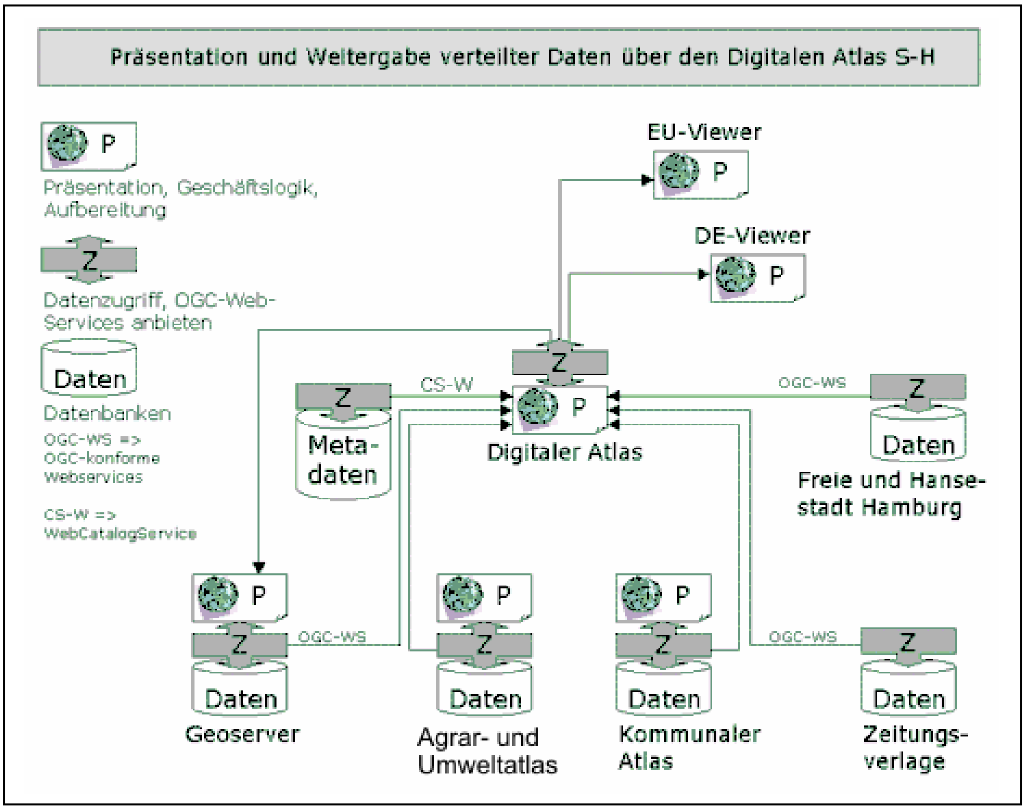

Figure 3 – Machine geo data infrastructure for Schleswig-Holstein.

On the german federal level a working group develops guidelines to bring together the protected areas of the federal states:

- nature protection areas,
- EU bird protection areas,
- FFH areas,
- National parks,
- Biosphere reserves,
- Natural parks,
- Protected landscapes and
- Water conservation areas.

The realization step 2 has been taken. Almost all federal states provide GDI-DE compliant protected areas by means of WMS. Styled layer descriptors are used to get a uniform visualization.

In realization step 3 the focus is on more sophisticated infrastructure technique and fine tuning. To be named are

- more performant WMS services,
- the use of Web Feature Service (WFS) instead of WMS,
- the development of a web service registry.

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RESULTS AND DISSEMINATION OF THE CARG PROJECT - THE ITALIAN CARTOGRAPHY PROJECT FOR THE NEW GEOLOGICAL MAP OF ITALY AT 1:50,000 SCALE

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KEY WORDS: CARG Project, Geological map, Geological Survey of Italy

THE CARG PROJECT

The project of realization of the new geological map of Italy at 1:50,000 scale - CARG Project – whose goal is the realization of 652 geological and geothematical sheets at 1:50,000 scale, started at the end of 80s; the CARG Project is managed by Geological Survey of Italy (SGI) now ISPRA (Institute for Environmental Protection and Research) and involves about 60 structures including territorial organizations (Regions and Autonomous Provinces), C.N.R. (National Research Council), University Departments and Institutes.
The Project has been funded during the period 1988/2004 with 81.259.000,00 euro for the realization and informatization of 255 geological maps and 14 geothematical maps at 1:50,000 scale, 7 marine geology maps at 1:250,000 scale of Adriatic coastal areas, 1 morphobathymetric map of the Tyrrhenian Sea, part of the CROP Project (Deep Crust Project), the organization and implementation of the geological database certification of methodologies and prescriptions, update of the Italian geological formations catalogue. 40% of the Italian territory has been analysed and studied with the valuable contributions of experts of Earth Sciences over the past 20 years (*Tab.1*).
Maps describe in detail the main geological elements of italian territory highlighting the presence of potential hazard risks.

The CARG Project provides official guidelines and cartographic representation standards, written by SGI in cooperation with experts, to realize geological mapping at 1:50,000 scale, and published in the series of 'Quaderni del Servizio Geologico' (*Fig. 1*). These guidelines are the reference for the survey, mapping and infomatization of geological and geothematical sheets in order to obtain an homogeneous mapping production all over the Country.
Further information about thematical issues can be retried on the ISPRA web site.
www.apat.gov.it/site/it-IT/Progetti/Progetto_CARG_-_Cartografia_geologica_e_geotematica/

Figure 1 – The CARG Project guidelines.

Year	*€*	*Geological sheets financed*
1988	*10.330.000*	*66*
1989-90 -91	*41.317.000*	*85*
1996	*5.165.000*	*16*
1999	*26.658.275,96*	*80*
2004	*3.790.000,00*	*8*

Table 1 – The CARG Project: funding distribution.

THE PROJECT PECULIARITY

Geological mapping of Italy at 1:50,000 scale represents in two dimensions the three-dimensional stratigraphic and depositional units cropping out; it defines their correlations and distribution, their lithological and sedimentological characteristics, and the environments in which

they originated. It includes also the survey of continental platform in front of Italy's coasts, recognising their importance for the protection and proper management of the coastal area.
The detailed study of plio-quaternary continental deposits is an other innovative feature of the Project; they are considered at par with the substratum, not merely covering up the underlying rocks.
14 geothematical sheets (like geomorphology, hydrogeology, slope stability) are founded by the Project and they take on an "experimental" character like the 7 marine geology maps at 1:250,000 scale of Adriatic sea.

CARG DATABASE

The Project provides also the realization of a geological database at 1:25,000 scale including biostratigraphic, petrographic, structural and sedimentological data derived from geological mapping and analyses of samples.
This database allows to store and to process a large amount of data which can be update in real time. The print of a geological sheet at 1:50,000 scale is, actually, only one of the target of the project but the data contained in the printed sheet are available before publishing.
Print files production is carried out by means of the informatization process.

THE CARG PROJECT: STATE OF ART

Of about the 255 GEOLOGICAL MAPS FINANCED 131 have been completed so far (both printed and in press) and 124 are still in progress (*Fig.2*).
More in detail the state of art of CARG project is:
47 sheets printed;
84 sheets on printing;
68 sheets completed survey;
56 sheets survey in progress;

156 maps can be consulted at the ISPRA web site address:
http://www.apat.gov.it/Media/carg/index.html.
Besides printed sheets about 1000 maps at 1:25,000 scale and 1200 maps at 1:10,000 scale could be already consulted and used by territorial organizations (Regions and Autonomous Provinces) in order to realize detailed maps for applied purpose.

The CARG Project achieved widespread success by University Departments and Institutes because financial resources allowed to realize detailed studies in the field of Earth Sciences and to edit maps with scientifical high-level.

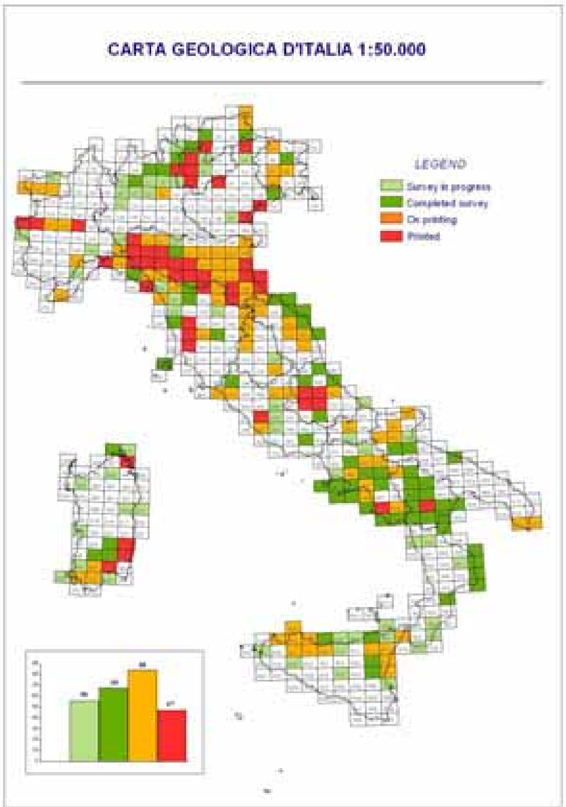

Figure 2 – The CARG Project: state of the art.

The SGI periodically publishes official data related of the CARG Project state of art in a document called RIP (Periodical Informative Report). This document is directed to a large number of CARG users and beneficiaries.

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Topic – Use of geophysical and remote sensing methods an technology

RING AND LINEAR STRUCTURES: REMOTE SENSING, GEOPHYSICAL, GEOLOGICAL DATA AND PROGNOSIS OF PGE-NI-CU DEPOSITS

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KEYWORDS: geophysical survey, linear tectonic structures, Ni-Cu-PGE deposits, nucleus, remote sensing, ring tectonic structures

INTRODUCTION

High world demand for Ni and PGE, rare and occasional discoveries of economic deposits and lowering tenors of their ores (Dummet, 2000) require new approaches to prognosis, prospecting and assessment of their hosting structures, ore-bearing basic-ultrabasic magmatic complexes and deposits themselves.

Monitoring of geological and remote sensing data on PGE-Ni-Cu deposits, their host magmatic complexes and structural settings revealed remarkable regularities. Most of PGE-Ni-Cu deposits and their magmatic hosts are localized in a wide range of combined linear and circular platform and orogenic tectonic structures (tens m – > 1000 km) in various tectonic settings of Wilson's cycle geodynamic regimes (Windley, 1995).

METHODS

Geological, geomorphological and geophysical data, coupled with remote sensing data (multi scale space, aerial maps and plans), have been analyzed and correlated to each other to reveal and interpret giant, large, intermediate and small reference and potential PGE-Ni-Cu hosting structures. Results of the monitoring are illustrated with typical examples. Instrumental techniques are necessary for detailed prognostical work.

RING AND LINEAR STRUCTURES AND THEIR ORE MINERALIZATION

Giant structures (> 1000 km) comprise Archean cratons as a whole, often consisting of nuclei clusters filled by complexes of granite-greenstone belts with Ni-Cu-PGE deposits. They may be intersected with giant lineaments hosting basic-ultrabsic intrusive complexes with PGE deposits (Great Dyke complex, Rhodesian craton) (Fig.1), Other examples are Binneringie and Jimberlane Dykes with PGE mineralization in Yilgarn craton, Australia, Koillismaa-Penicat-Oulanca cluster of discontinuous Ni-Cu-PGE deposits on dislocated margin of East-European (or Ladoga) nucleus consisted of ring and radial-convergence tectonic systems (Fig. 2). Finnish federal exploration program resulted in discoveries of these deposits.

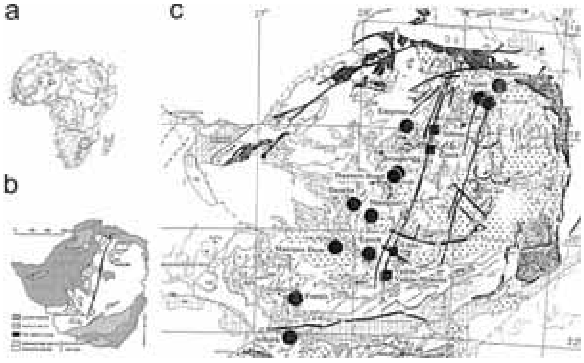

Fig. 1. Rhodesian Craton – giant nucleus (a), its greenstone belts (b), linear, arched, circular tectonic structures, Ni-Cu (circles) and PGE (squares) deposits (c) (Prendergast, 1989; et al.)

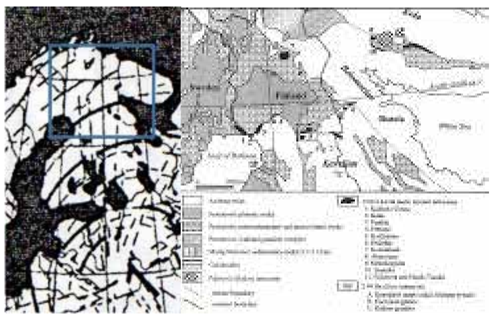

Fig. 2. Tectonic elements of East-European dislocated nucleus (a) and associated Ni-Cu-PGE deposits (Serokourov et al., 2001; Alapieti et al., 1990)

Large structures (100s km) comprise groups of old circular nuclei, radial, arched and transecting linear structures and their magmatic and ore content within cratons.

Small-scale satellite maps and plans, gravity surveys and morphometric data indicate the existence of large continental ring structures (Michigan-Guronian, Ohio, Missouri-Illinois a.o. basins, 500-750 km diameter, on the east of US and Canada, such as Superior lake system), and other structural elements. All of them crosscut to each other and form intersecting zones of Midcontinent Rift and west continental extension of Atlantis transform fault (branch of Mesozoic McKenzie rift). They comprise world giant PGE-Ni-Cu Sudbury (1,85 Ga), Duluth (1,1 Ga) complexes, a number of smaller mineralized intrusive bodies and dyke swarms. Both giant intrusive complexes and their PGE-Ni-Cu deposits are localized within interfered multi size ring, arched and linear structure combinations (Fig. 3, 4).

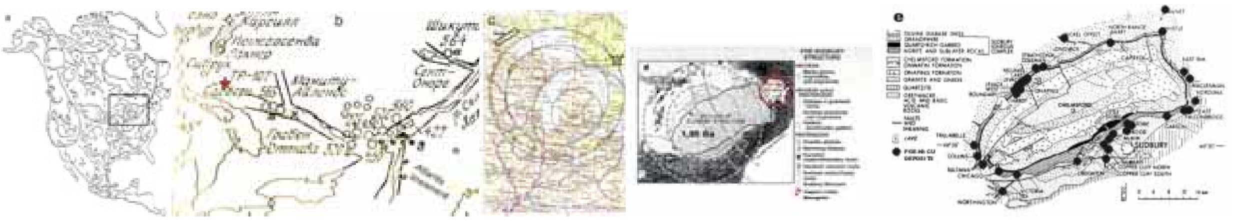

Fig. 3. Position of Sudbury magmatic complex in linear regional and local structures of NW old continental extension of Atlantis transform (a) and complicated combination of Proterozoic circular structures and branches of Mesozoic McKenzie rift system (b, c, d), and its PGE-Ni-Cu deposits (Pye et al., 1984) (e).

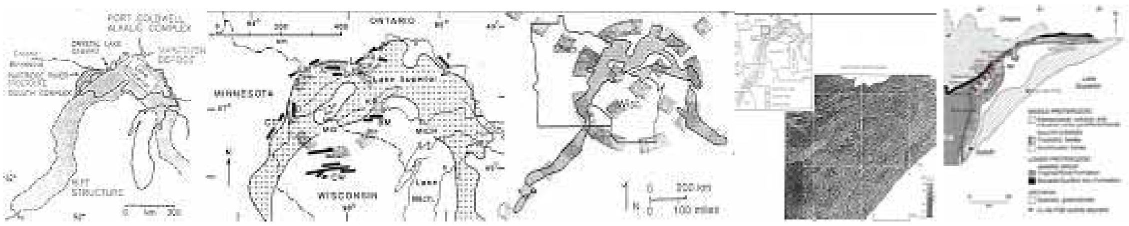

Fig. 4. The mapping of combination of Midcontinent rift and west continental extension of Atlantis transform fault zone and associated linear and ring morphostructures (a, b), gravity high (c) and its details (d) and Ni-Cu-PGE deposits within Duluth basic-ultrabasic complex (Norman, 1977; et al.).

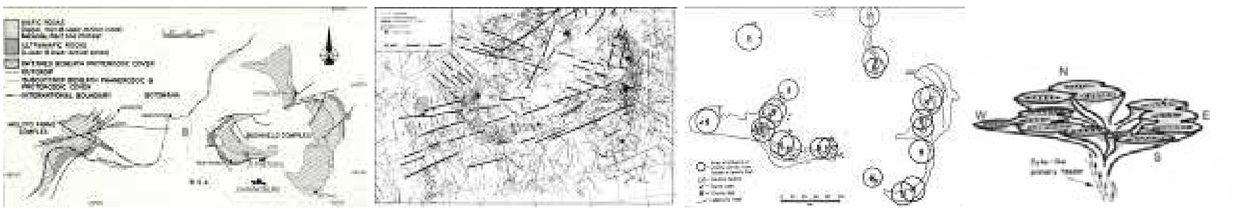

Fig. 5. The mapping of Bushveld complex in intersection of transafrican longitudinal "Vail" (Vail, 1978) and ENE Murchison lineaments (a) as a combination ("bouquet") of differ scale PGE-bearing ring magmatic funnels and pipes (b, c, d) (von Gruenewaldt et al., 1989) and pipe-like (Vlakfontein, west flank) and ribbon-like linear intrusives (Uitkomst, Nkomati) Ni-Cu deposits to ESE of the complex (Maier, et al., 2004).

The other famous example is Bushveld intrusive complex – a giant PGE depository at the intersection of Murchison ENE lineament and NNE transafrican tectonic line (Vail, 1978) within Kaapvaal craton. This complex is a multi rooted cluster of stratified funnel-type intrusive bodies and pipes in interfered combinations of multi size cone-type structures. (Fig. 5). Ribbon-like Uitcomst intrusive to SE of Bushveld (Nkomati PGE-Ni-Cu deposit) in crosscutting Laersdrift fault system is believed (Mayer et al., 2004) to be linked with Bushveld complex.

Intermediate structures (10s km) usually are satellites or constituents of large and giant structures. All the PGE-Ni-Cu deposits and occurrences in the Norilsk area associated with funnel-like gently sloped oval platobasalt volcanic basins ("muldas") in the periphery of a nuclei consisted of ring and radial-convergence tectonic systems. Ribbon-like ore-bearing intrusives are radially oriented in bottom surfaces of basins on a border of basalts and underlying sediments (Fig. 6).

Basins, linear tectonic elements and intrusives and margins of basins displayed in low scale aerial and space photos and are available for study and predictive work with multi scale remote sensing methods.

Small structures (1-10 km). Geological and geomorphologic data revealed some ring structures in the vicinity of new Ni-Cu

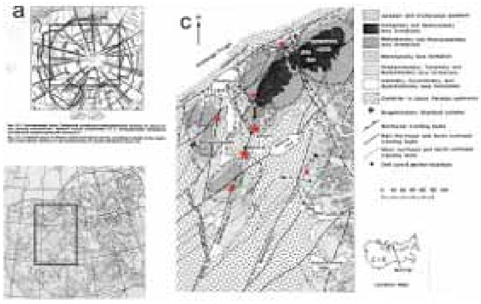

Fig. 6. Links between regional (a) and local circular structures of Siberian platform (b) and Ni-Cu-PGE deposits within Norilsk area on its NW margin (c).

Voisey's Bay deposit in Arctic Canada. Their surface configuration coupled with exploration drilling data display structural control of nickeliferous intrusive localization, funnel-like configuration and show intrusive and ore hosting successively formed ring structures. Ore-bearing intrusive have been following tectonic surfaces of the interfering tectonic funnels during intrusion of magma (Fig. 7). Such fingerprints require to reveal and careful examine combinations of crosscutting ring structures in the area of Nain Cu-Ni province (Labrador, Canada).

a b c

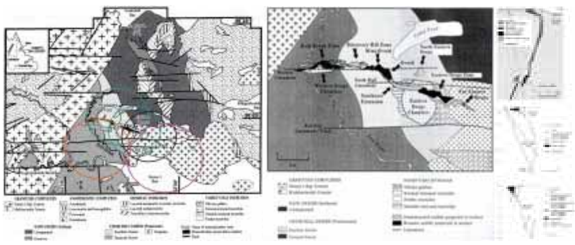

Fig. 7. Ring structure control of intrusive (a) and ore localization (b, c), Voisey's Bay deposit, Labrador, Canada (Evans-Lamswood et al., 2000; Li et al., 2000; Naldrett et al., 2000).

Very small pipe-like (100s m - first kilomeners) pipe-type platform *structures* are typical for alkali-basic-ultrabasic (dunite-peridotite-pyroxenite-gabbro-monzonite) comp-lexes in activated platform margins. They are sources of Au-PGE placers all over the world (Kondyor, Inagly, Chad, Aldansky shield), in volcano-plutonic belts of old and young orogens (Goodnews Bay, Alaska, Coldwell Complex, Ontario, Canada; some of Urals complexes). Aerial photo and plans are using for reveal single and clastered small ring structures and complexes. Instrumental techniques are using structures. Instrumental techniques are using for detail remote sensing on tracing of Au-PGE placers (Fig. 8).

Other examples comprise small sized orogene nickeliferous gabbro-granie complexes in Norvay, PGE-Ni-Cu occurrences in gabbroids of Bohemian Massif, new nickeliferous complexes in Junggarian (Xingjiang) and other mineralized circular structures.

CONCLUSIONS

Geomorphological, surface and aerial mapping,
surface and aerial geophysical surveys, space

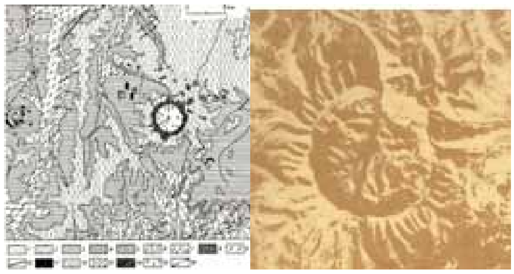

Fig. 8. Geological map (a) and aerial image (b) of Kondyor massif area: 1-3 – Upper PR; 4-5 – Lower PR; 6-8 – AR; 9 – granite, diorite (AR); 10 – diabase (D_2); 11-14 – granitoids (J-K); 15 – dunite, pyroxenite, gabbro, diorite, syenite, pegmatite (Lower MZ), 16 – fault (Nekrasov et al., 1994).

and aerial zone spectral cartographic data on all famous world Ni-Cu and PGE mining areas have revealed interrelations between location of deposits and combinations of linear and circular (arched) structures in large structures. Sites of intersecting tectonic elements usually are channels for ascending magmas and their ore components.

In some new ore mining areas it was determined that location of nickeliferous and platiniferous intrusives and their ores are governed by funnel contours of circular structures (Norilsk camp) or complex intersections of interfered multi size structures (Voisey's Bay). Such fingerprints are guides to potential mining targets.

Reviewed examples of combinations of different scale linear and circular structures, associated basic-ultrabasic magmatism and Ni-Cu-PGE deposits display possibilities of their using as fingerprints for prognosis (in combination with other prospecting methods of remote sensing – digital photography, zone spectral, radar, a.o. methods, geomorphology, geophysical, geochemical surveys coupled with modern apparatus) of Ni-Cu-PGE-bearing magmatic complexes within local areas of wildcat metallogenic taxons (ore provinces and ore regions).

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USE OF REMOTE SENSING DATA IN SEARCHING FOR HYDROCARBON DEPOSITS AND IN PROVIDING INDUSTRIAL SAFETY OF OIL-AND-GAS FIELDS

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KEY WORDS: Remote sensing, interferometry, oil-gas deposits, multilayered GIS models

INTRODUCTION

For an oil-and-gas company, providing the right of use of the interiors is preceded by great efforts on economical substantiation of licencing's expediency. Lack of studies of new regions and limited access to the existing information result in a serious problem when substantiating the expediency of licencing of a new territory.

Estimates of presence of oil and gas in a new region can be performed on the base of complex analysis of available geological, geophysical and especially space (remote sensing) data [De Mers, 2009; Alexeev et al., 1988; Baranov et al., 1989].

THE CONCEPT OF REMOTE SENSING

The advantage of using remote sensing data is that they permit to obtain the unique information that cannot be retrieved by any other methods (Kronberg, 1985). Yet, they provide essential benefits in costs while searching for liquid hydrocarbons, ensuring, at the same time, efficient production of geological prospecting due to the use of innovative high-end technologies. Since remote sensing methods, especially the landscape indicative ones, determine hydrocarbon geochemical anomalies observed in space images rather than the deposits themselves, they can be applied to any type of accumulations, including unstructured fields (Fig. 1). Aside from these, other methods such as analysis of spectral characteristics of images, determination of particular anomalies in the infrared diapason, lineament analysis, as well as photogrammetric methods are also employed [Baranov et al., 2002].

The use of remote sensing data substantially reduces the costs of geological prospecting, in particular due to the localization of potentially perspective areas. Yet, it is an extremely powerful instrument for ecological monitoring and providing industrial safety of licenced areas, objects of development, and hydrocarbon transport.

EXAMPLE: INTERFEROMETRY

Let us provide a descriptive example on industrial safety. For that, the monitoring of the Earth's surface displacements on the entire area of a deposit (or a group of deposits) is carried out by means of an innovative technique of satellite-based differential radar interferometry [Kantemirov et al., 2008a; Kantemirov et al., 2008b]. This technique allows measuring displacements of the reflective surface by means of interferometric processing of time series of radar images for the area to be analysed. The specific character of interferometric processing of radar images requires the phase noise to be removed from the resulting interferogramma; upon this, the radar satellite orbit has to be refined. These problems can be solved using data acquired from GPS stations equipped by corner reflectors of the radio-signal. Only a finite number of corner reflectors has to be installed in the deposit area to provide a uniformly spaced net of ground control points for satellite radar imaging. On these reflectors differential GPS measurements should be regularly executed. Temporal intervals between the radar images in the time series and the type of radar are chosen separately and individually for each deposit, taking into account the tectonic activity of the region, the geodynamic situation, the intensity of hydrocarbon production, etc.

The output of the differential interferometric processing is a map of ground displacements for a given territory [Kantemirov et al., 2008b]. It is a highly accurate technology that allows determining ground movements up to several millimetres in the vertical direction (in case of multi-pass method of persistent scatterers). The displacements map is calibrated by ground control points (GPS stations with corner reflectors and separate corner reflectors), and it can be renewed with a required time interval. The displacements map is comparatively analysed with geological, geophysical and field-geological information to separate natural and human-caused components of the displacements.

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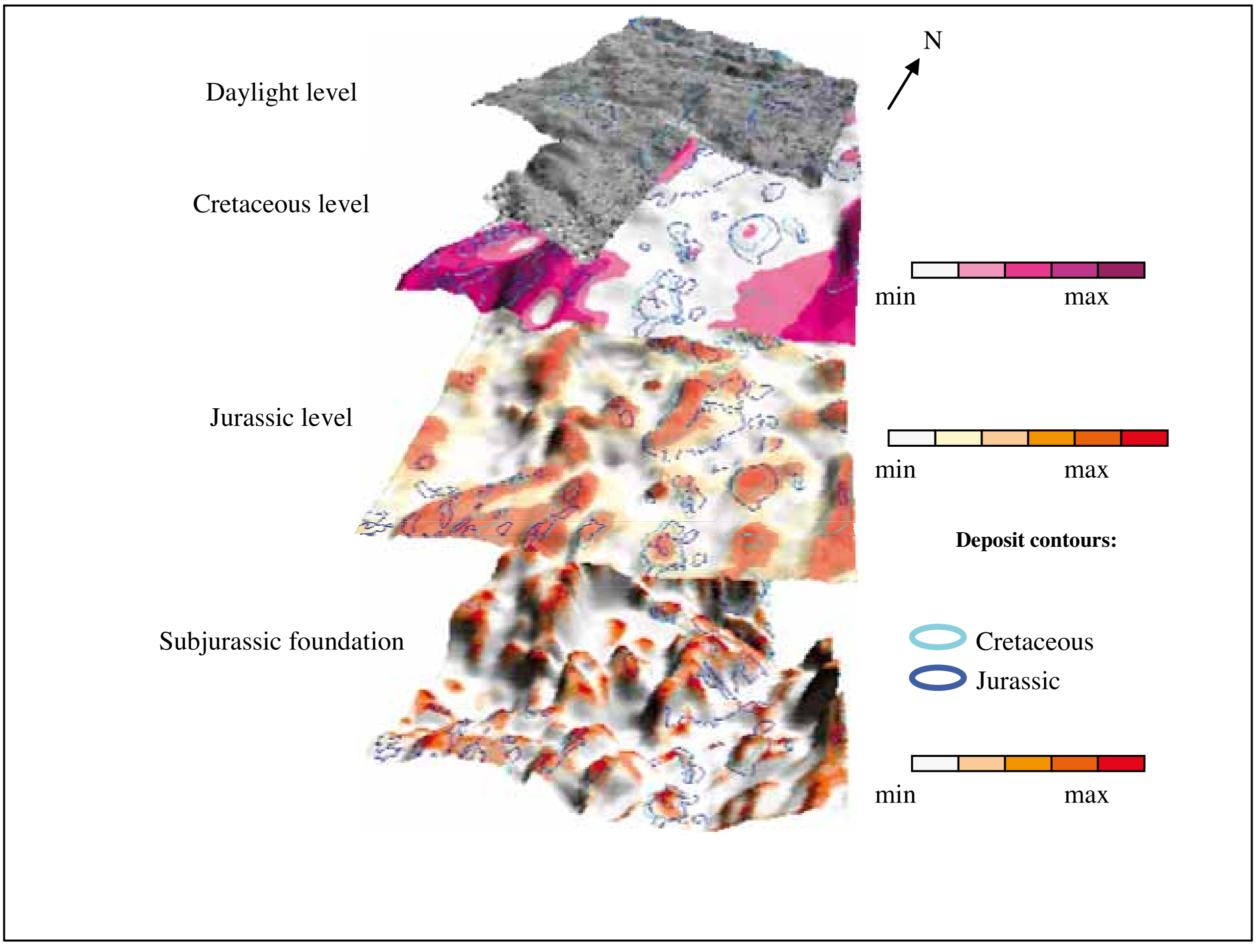

Figure 1 – A multilayered GIS model based on the complex analysis of geological, geophysical and space data

HIGH RESOLUTION LIDAR DATA AS A FUTURE TOOL FOR GEOSCIENTIFIC ANALYSIS

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KEY WORDS: DTM, LIDAR, stream burning, slope degree, military training area, JMRC Hohenfels, sinkhole remedy, geological mapping, contour lines, horse shoe structures

High resolution DTM (LIDAR) and its practical application

The Environmental Division of the Department of Public Works of the USAG Hohenfels has been using several DTMs for many years. Since the year 2007 a new generation of data is available in the raster size of 1x1 meter. A very distinct advantage of these LIDAR data is the exact illustration of the land surface in decimeter detail and simultaneously the complete elimination of any vegetation cover. The areas of use for these extreme high resolution DTMs and DSMs are countless for the Hohenfels Training Area. They range from supporting activities for surface water management (hydrology and erosion areas) to mapping/ field surveys of geo-risks such as sinkholes or rock cliffs in remote areas, to military 3D-simulations of training scenarios in open terrain or urban areas (MOUT Training).
Since the year 2006 there has been an active international cooperation between the US Army and the LfU, Geological Service, regarding geological issues, covered by an EU-cofinanced project called "Informations-offensive Oberflächen-nahe Geothermie".
The Hohenfels Training area is mainly formed by upper jurassic dolomite- and limestones with significant karstic phenomena and its related problems.
The practical application in such areas will be shown using three examples.

DTM as a planning tool for sustainable use of active karst areas

In areas of high intense military use there is a potential danger of contaminant input into ground water through sinkholes and ponors as pathways. Therefore the Environmental Division works on solutions for an optimized surface water management in order to gain a priority groundwater protection.
The selected case area is located in a region with an extremely high number of historically known sinkholes. A high contamination potential is given by the intense military use of this area (live fire). Using tracer studies and mobile surface water monitoring it was shown that sinkholes lead large volumes of surface water into the surrounding subsurface drainage with extremely high flow velocities (up to 9 km per day).
The goal of this task was to calculate the actual hydrology of the area by use of the high resolution terrain model and to develop proposals for applied protection measures.
The terrain model solely reflects the terrain surface. Therefore hidden pathways such as culverts are not considered, leading to errors in the hydrologies. In a first step these parameters were mapped in the field and integrated into the original DTM using the process of "streamburning". This procedure allows the lowering of the pixels for a calculated depth to allow the waterflow into the correct direction and therefore to replicate the modeled pathways with the real drainagelines. Figure 1a shows that a total of 310 ha directly drain into the known sinkholes.
By using of the spacial exact topography, management measures were developed to support a complete deviation of the surface water into areas of low threat to groundwater contamination. Figure 1b illustrates the design (2005) including 2 drainage ditches 2 road detours and 3 earthern berms around the active sinkholes.
Using the 2007 DTM data (figure 1c) the executed protection measures are already visible. The added culverts were burned into the DTM and the new calculated hydrology was remodeled. The figure illustrates, how the surface water is directed away from the sinkholes by the new channels. The drainage area of the concerned sinkholes shrunk from about 310 ha to less than 3 ha (only 1 % of the former area). Thus, the threat potential was significantly reduced.

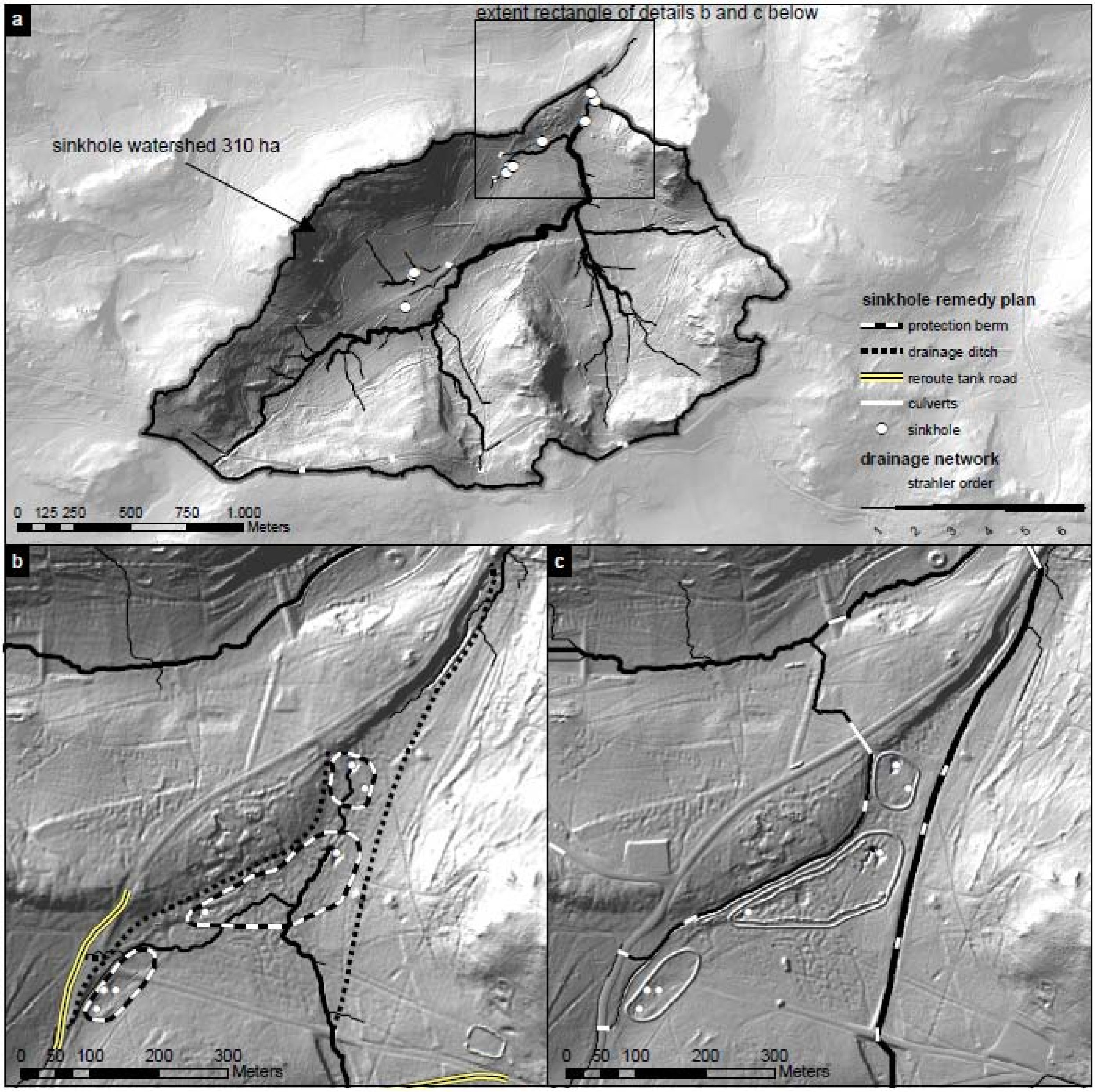

Figure 1 – High resolution DTM and calculated water-regime in environmental management of sinkhole areas.

DTMs as a mapping tool for FFH biotope types

A large portion of Hohenfels Training Area is reported as FFH area (Flora Fauna Habitat) in accordance with EU-regulation “Natura 2000”. Rock outcrops with steep cliffs are of a special importance serving as a home for threatened and endangered biotopes, such as special rock cliff vegetation, bat quarters, nesting birds, etc. There was the request for a spacial mapping of these formations, sometimes being only a few square meters in dimension. In order to reduce the mapping effort on a total area of 160 km² the LIDAR-DTMs served as a mapping basis for this event. By use of GIS a DTM slope grid was calculated and the classification of the slope was developed. This allowed a highly improved and detailed map compared to regular isohypse or so called “hillshade” illustrations being used in other projects. The exact delineation of the rock cliffs has allowed enormous time savings compared to a regular mapping campaign and the data quality was significantly improved.

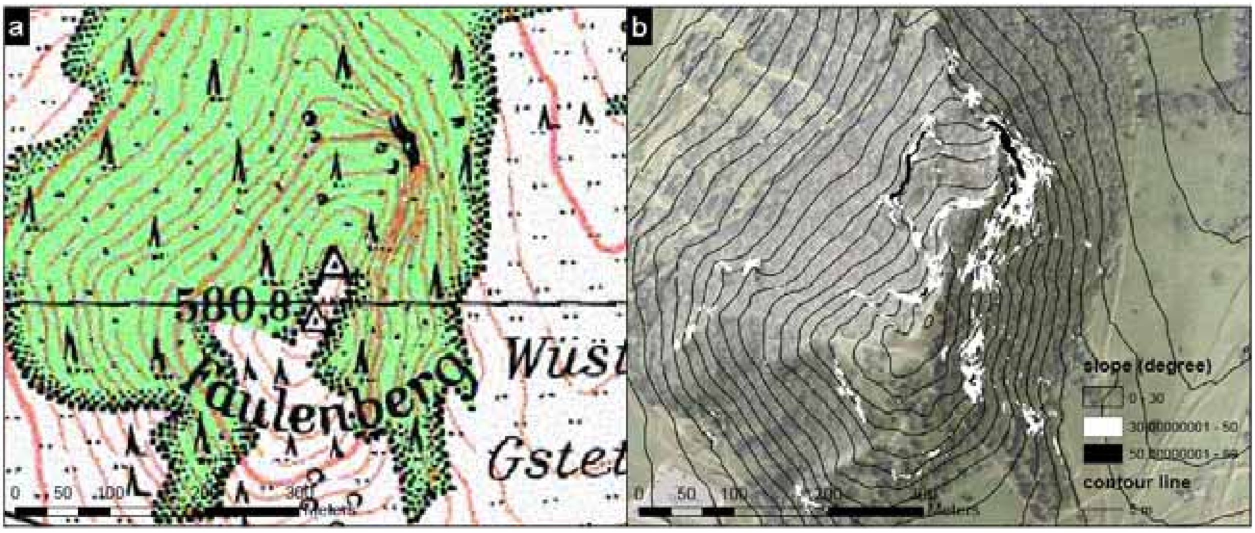

Figure 2 – Slope degree grid calculated from high resolution DTM as basis for targeted mapping of FFH base data.

High resolution DTM (LIDAR) and its practical application

By looking at the Hillshade-model of the training area the user will identify horseshoe structures in the Schwammriff – areas and at the edges towards the Vils-valley. These structures cannot be retrieved in the isoline image of the topographic map.

The existence of these structures has a significant impact on the geological maps and the resulting analysis of models being related to these structures. This will be shown on the sample of the geological map GK 25 on the sheet 6736 Velburg.

The isohypse (figure 3a) show the peak of the Faulenberg as a compact broad plateau. The formations of the upper Kimmeridgian reflect a horizontal cover in the peak region with distinct strata being parallel to the isohypse (figure 3b).

The Hillshade-model (figure 3c) depicts the significant horseshoe formation. The edges of this 100 m broad structure are massive dolomites of the Upper Kimmeridgians showing a few meter thick “wall” in the field. As an ancient fill of the horseshoe structure basin sediments such as “Plattendolomite” (thin layered dolomite) could be expected. A field verification was not conducted yet.

The southern top area is a small cliff and it is not a uniform rounded cap.

The generated isohypse model (figure 3d) of the LIDAR-DTM is significantly distinct from the topographic map isoline model. The LIDAR-DTM shows the real conditions in a highly detailed and more realistic extend. The overlay of the geological information of the existing map with the new LIDAR-model data proofs that the geology is not correctly shown in the geological map.

Figure 3f shows the corrected Upper Kimmeridgian delineation based on the LIDAR data.

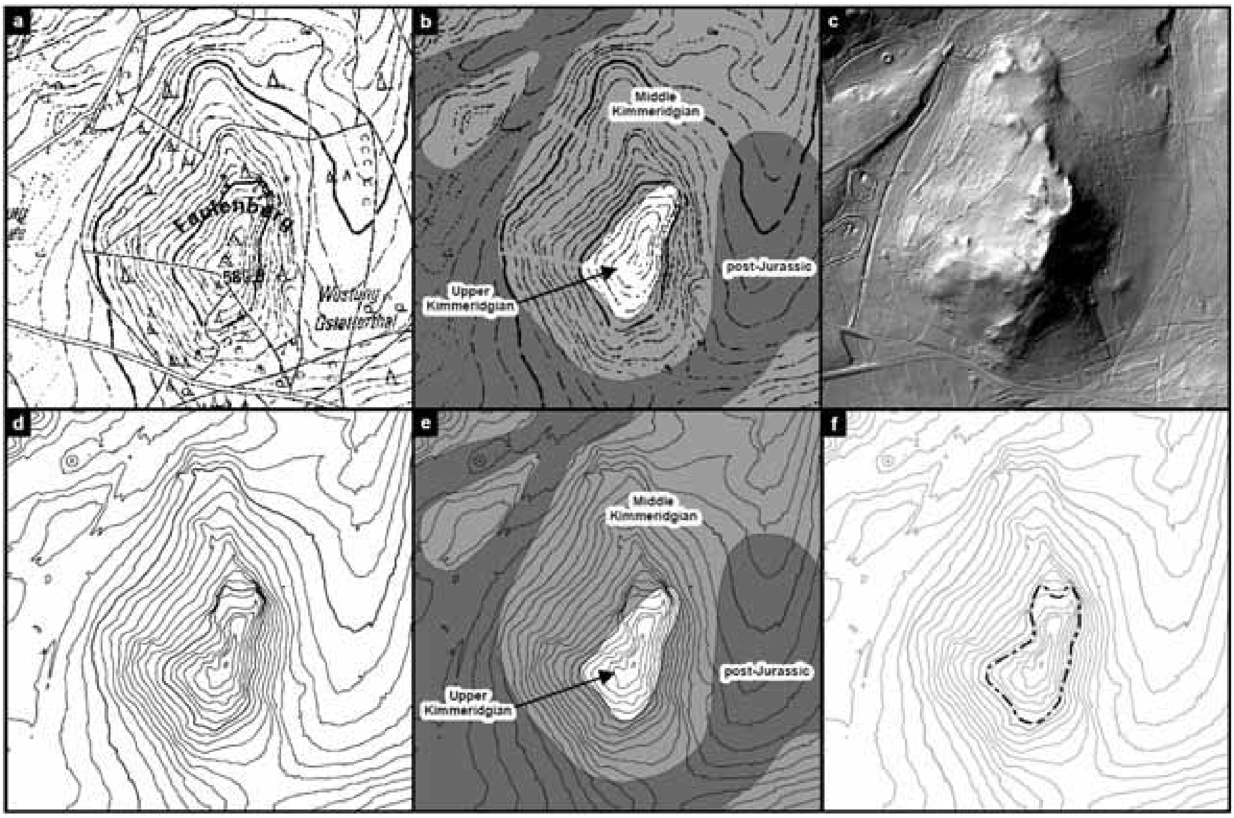

Figure 3 – High resolution DTM and its use for updating geological maps.

Conclusion

Similar to the success story of the GPS since the 1990s, LIDAR geodata show a great potential to improve the daily use of geodata in the future. The high resolution in conjunction with the elimination of the vegetation/ forest cover allows the recognition of topographical/ geological details and its interrelationships far above the existing framework. Therefore it can already provide important hints and information for upcoming field work, on the computer screen.

The shown case studies are a small threshold of the possibilities for this tool within the broad area of military, geoscientific and environmental applications.

Interdisciplinary cooperation and exchange of know-how will definitely lead to further applications of higher resolution DTMs and its secondary by-products such as isohypse in 0.5 m intervals, delineation of drainage areas, calculation of slopes and expositions, hydrology lines.

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COMPUTER TECHNOLOGY FOR INTEGRATED ANALYSIS AND INTERPRETATION OF GEOLOGICAL AND GEOPHYSICAL DATA FOR REGIONAL PROFILES

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Abstracts

The computer technology is designed for integrated analysis and interpretation of geological and geophysical data acquired at regional profiles and building a physical-geological model of the Earth's crust complying with all geophysical fields. The main element of a technique is independence of processing and interpretation of the data of each method with their subsequent integration in integrated model. The computer technology was applied to processing and interpretation of geophysical data acquired along profiles in the different regions of Russia.

A system of deep geological and geophysical survey is aimed at study of the geological structure and geodynamic situation in mineragenetic provinces and regions, and global and regional geological structures. Survey is performed along regional profiles using a combination of geophysical methods including gravity, magnetic, electric (magneto-telluric sounding - MTS), seismic (reflection survey – CMP) surveys and deep seismic sounding (refracted survey).

The technique and technology of integrated analysis and interpretation of geological and geophysical data include the following stages:

1) Building an a priori model – it is performed based on the analysis of all available regional geological, petrophysical, deep drilling data and etc.

2) Processing and interpretation of specific geophysical data including as follows:

- making use of gravity and magnetic data to draw structure-tectonic maps of the area under study, map of the basement relief, 3D models of density and magnetic parameters distribution in the studied area which are compiled from the 1:1 000 000 maps in order to find a spatial distribution of sources and enhance the investigation depth (particularly, down to Moho for the gravity survey);

- making use of the seismic data to draw time and depth seismic energy sections, and depth sections along profiles;

3) Integrated analysis and interpretation .

2D models of magnetic and density parameters distribution along the profile sections are found as cut-out from the resulting 3D models.

Specific models built for individual geophysical methods – seismic, electric, magnetic, and density are correlated with each other in space (often they are not complying spatially) and projected to the same profile and tied by depth parameters.

Next, these spatially tied models are correlated by geometrical and physical parameters. At this stage, common features of seismic, electric, magnetic and density images of the section under study are found. Geometrization of the Earth's crust is performed as well as identification of subhorizontal compartments, the most contrast in physical properties, and subvertical heterogeneous zones within the limits of specific crust layers and throughout the whole crust. Within the limits of a generalized geometrical framework produced by the correlation of individual geophysical models it is possible to switch to a physical description of identified blocks using a combination of various physical parameters – velocity, density, magnetic susceptibility, and electric resistivity. Based on the results of analysis of identified blocks of the Earth's crust and resulting geophysical characteristics forecasted are the origin of these blocks and characterization of their material composition. A resulting qualitative integrated model is used as a basis for a more detailed integrated analysis using the analytical methods of complex data processing.

Al the above-mentioned stages are implemented using technological and analytical tools of GIS INTEGRO – GEOPHYSICS software system which includes modules providing for processing and interpretation of potential geophysical fields, seismic data, electric survey data, and module supporting the integrated processing and interpretation. Functional capabilities of potential field processing and interpretation module allows compute various characteristics of potential fields – statistical and structural, perform analytical transformations, filtration, build 3D models based on the analytical and correlation sounding, solve direct and inverse problems. Electric survey processing and interpretation module provides the analysis and preprocessing of magneto-telluric sounding data (MTS), and solution of direct and inverse problems. Seismic survey module provides for the integrated interpretation of well logging data (deep well logs) and seismic data, it also allows build depth sections of various types. Resulting individual geophysical models are saved using the same geoinformation software shell providing visualization, spatial tying and editing of these models. The integrated processing and interpretation module allows perform zoning by a combination of indicators, and solve direct and inverse problems for integrated models.

To provide the spatial tying of above-mentioned models the software system has tools allowing project the models to the same profile, rescale the models by Z-coordinate, and correlate the models with each other and with the base map.

The software system includes tools for integrating spatially-correlated models allowing visualize and superimpose the models, produced a vector layer enclosing point, linear and areal targets and assign the attribute information (physical parameters) to these targets. Parameters of these targets can be forwarded to the modules of individual data processing and interpretation and can be used, for example, to verify a compatibility of resulting individual geophysical model with the source data by solving a direct problem. Parameters of a resulting integrated model can be delivered to the integrated processing module to adjust the values of these parameters by solving an integrated problem.

The above-mentioned software tools were applied to processing and interpretation of geophysical data acquired along profiles in the European part of Russia (2 500 km) and Siberia (2 000 km) and integrated models describing the deep structure of the studied areas along the profiles swaths were produced.

URANIUM AND THORIUM CARTOGRAPHY IN THE SOUTH OF THE STAVELOT-VENN MASSIF (BELGIUM): A GIS-CASE STUDY.

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KEY WORDS: Uranium, Thorium, Airborne Gamma Ray, AGRS, Belgium,Stavelot.

INTRODUCTION

In 1994 and 1995, the geological surveys of Belgium and Grand Duchy of Luxembourg conducted an airborne survey of the natural radiometry (gamma radiometry) emitted by the radioactive isotopes of uranium, thorium and potassium to study the distribution of these natural radioactive elements related to the surface geology. Flight lines are N-S oriented and separated by one kilometre with a measure each second, approximately one data each 70 m. Raw data were then treated by correcting them of various factors affecting the effective radioactive emission of the ground: attenuation of the gamma rays according to altitude and the atmospheric presence of radon being able to intervene up to 50% in the measured sizes. The values out of U, Th and K are calculated for each point. The results are then displayed in a geographical information system (GIS) and superposed with various cartographic information sources. In order to obtain continuity between the lines of flights, the values out of U, Th and K were interpolated by kriging.

GEOLOGY

The Caledonian Stavelot-Venn Massif is the best-exposed Lower Paleozoic inlier in the Variscan Ardennes Allochton (previously also called Dinant Nappe) in Belgium. The Ardennes in southern Belgium consists of an allochtonous domain thrusted onto an autochtonous unit during the Variscan orogeny. Rocks from the Early Cambrian up to the top of the Middle Ordovician in age correspond to the oldest rocks present in this allochton. They have been deformed during the Caledonian and the Late Carboniferous Variscan orogenies and affected by the Hercynian metamorphism (Ferket, Muchez, Schroyen & Sintubin, 1998). The Lower Paleozoic is a complex structure composed of a thick siliciclastic sequence with sedimentary (slates, siltstones, sandstones, black shales) and rare magmatic rocks (rhyolites and dacites) (Lamens & Geukens,1984; Lamens, 1986; Verniers *et al*., 2001).

The Lower Cambrian deposits is represented by the Deville Group (disused stage named Devillian), constituted by greenish, purplish and grey coloured slates and quartzites, subdivided into the Bellevaux (>150m thick, old Dva of the published Belgian geological maps) and the Hours formations (150m thick, old Dvb). It is followed by the Revin Group (disused stage named Revinian), Middle and Upper Cambrian in age, constituted by dark and light grey coloured slates and quartzites, subdivided in the Wanne (old Rv1-2, 550-650m thick), La Venne (old Rv3-4, 500m thick) and La Gleize (old Rv5, 300m thick in the north of the Stavelot-Venn Massif) formations. The Ordovician corresponds to the Salm Group (disused stage named Salmian) subdivided into three stratigraphical formations (respectively, from base to top, Jalhay, Ottré and Bihain Formations). The Jalhay Formation (old Sm1) is constituted by bleu-green slates, sandstones and silty slates ("quartzophyllades"). The Ottré Formation (old Sm2) is composed of purplish slates and silty slates, while the Bihain Formation (old Sm3) contains black and silty slates and greenish sandstones (Verniers *et al*., 2001).

RESULTS

The radiometric data concerning the south of the Caledonian Stavelot-Venn Massif were compared with the geological map drawn up by Geukens (1986) and with U and Rn measurements carried out on samples. It is characterized by several zones with high U contains and drawing lengthened bodies (Figure 1) which one can easily superimpose on geology. Both Groups of Revin (Upper Cambrian) and Salm (Lower and Middle Ordovician) are difficult to separate on the radiometric point of view, on the other hand, the richest zones in uranium underline both the La Gleize Formation and the Jalhay Formation. This relation confirms the specific fields studies undertaken concerning the behaviour of radon and thus of uranium with geology. Three zones are distinguished particularly for their high percentages of U: a) a rather broad and intense zone of Vielsalm city, b) a band between Vauchavanne and Arbrefontaine, and c) a weaker zone between Regné and Ottré decreasing towards Salmchâteau. The underground and aerial quarries of slate and coticule (manganesiferous garnet rich razor hones) have median U content. The spring of Thier de Justice (Vielsalm), rich in radon, coincides with the zone of maximum anomaly out of uranium (Goemaere, 2008).

K and Th present a similar geographical distribution, indicating a parallel behaviour and highlighting the areas belonging to the Group of Salm, richer in K and Th. The geographical extension of the richest zone is equivalent roughly to the southern part of the Stavelot Massif, from Bra to Petit-Thier, in the north and from Bihain to Regné, in the south. More precisely, slates of Sm1 and Sm2 (Ottré Formation) are particularly well highlighted. These two formations are mainly made up of “quartzophyllades” (regular alternation of thin layers of slates and quartzites) rich in K-micas with some black slates beds, rich in organic matter. K and Th thus mark the rocks made up of argillaceous minerals. Th is associated with the organic matter present in abundance in the black slates of Sm1 and Sm2. The exploitations of slate and coticule are all in the zone at high percentage of K and Th (Goemaere, 2008).

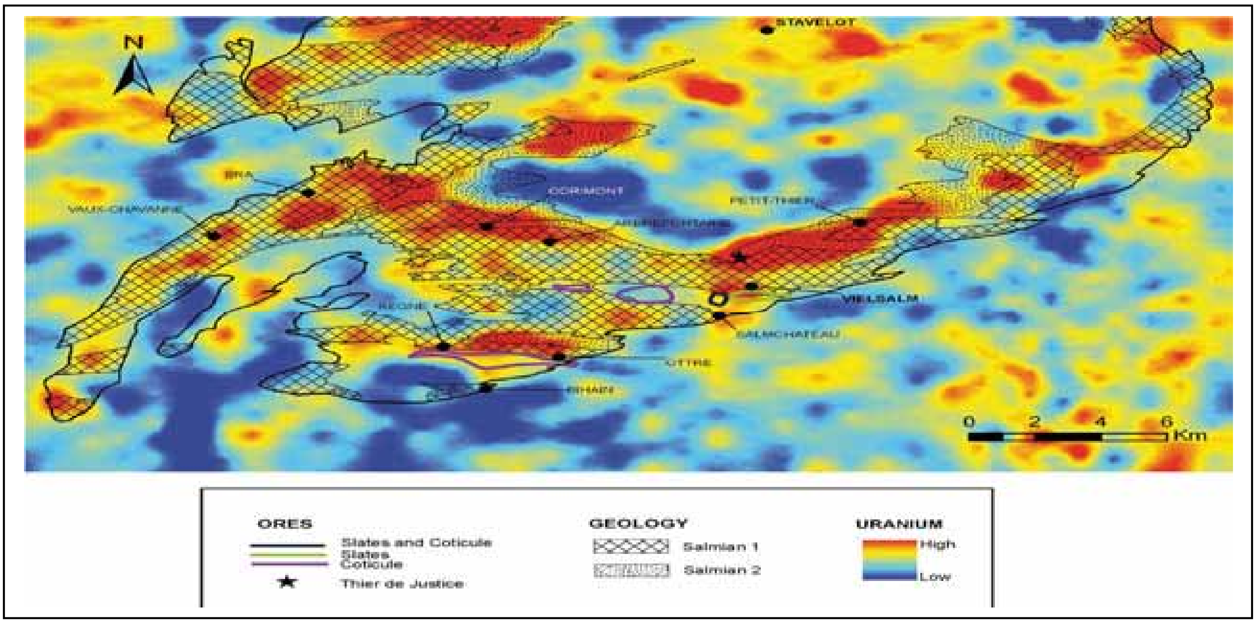

Figure 1 – Geological map of the Stavelot Massif and Uranium.

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INTEGRATED ANALYSIS OF GROUND DISPLACEMENT DATA, SEISMIC ACTIVITY AND MORPHOMETRIC DATA OF THE CAMPI FLEGREI (CAMPANIA, SOUTHERN ITALY) 2000-2006 RECENT BRADYSEISMIC CRISES, IN GIS ENVIRONMENT.

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KEY WORDS: Campi Flegrei, bradyseismic crises, ground displacement, tiltmetric data, morphometric analysis, GIS.

GEODYNAMIC BACKGROUND OF THE CAMPI FLEGREI AREA

In this paper the results of an integrated analysis of ground displacement data, local seismic activity and DEM image analysis, in GIS environment, which has been performed for the Campi Flegrei volcanic area, are presented and discussed. The study has been carried out for the recent bradyseismic crises of 2000-2006, with the aim of working out a preliminary interpretation of the recent dynamics of the area.

The Campi Flegrei volcanic district formed as a consequence of the lithospheric stretching in the central Tyrrhenian sea and Apennine Belt-parallel extension, in Quaternary time (Malinverno and Ryan, 1986). The Phlegraean caldera, the most relevant tectonic element of the volcanic district, is an active volcanic area located to the west of the town of Naples, and, due to its very intense urbanization, is characterized by high volcanic risk (Orsi et al., 1999).

The morphological features of this caldera are due to the combined action of both volcanism and regional tectonics; in fact the caldera is a nested structure which originated through two major collapses related to the major eruptions of the Campanian Ignimbrite (39 ky) and the Neapolitan Yellow Tuff (15 ky) (De Vivo et al., 2001, Deino et al, 2004). After the Yellow Tuff eruption, volcanic activity and ground deformation have been very intense, with many different eruptive episodes. The last eruption took place in 1538 and formed the Mt. Nuovo cone (Di Vito et al., 1987; Di Vito et al., 1999). The magmatic system of the caldera is still active with low energy seismicity, slight ground deformation and quite intense fumarolic activity (Chiodini, 2009).

GROUND DISPLACEMENT FROM LEVELLING DATA

The deformation history of the Campi Flegrei whole area has been recorded in detail by high precision levelling measurements carried out since the end of the sixties. At the present times, the levelling network extends over an area of about 160 km^2 and consists of 350 benchmarks (bm) covering a circuit of 135 km, with a mean spacing of 400 m, and it is organized into 14 interconnected loops for minimizing errors (fig. 1).

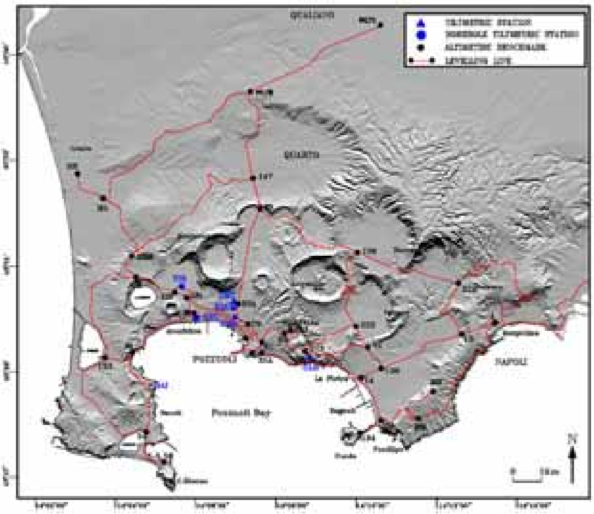

Figure 1 – High precision levelling and tiltmetric network of the Campi Flegrei.

A peculiar behaviour of Campi Flegrei since historical times has been the phenomenon known as the 'bradyseism', characterized by alternating intense ground uplift and slow subsidence episodes. The Campi Flegrei major recent bradyseismic crises, which were characterized by remarkable ground uplift and intense seismic activity, occurred in 1969-1972 with a maximum ground uplift of about 177 cm, and in 1982-1984 with a maximum ground uplift of about 179 cm (Berrino et al., 1984; Del Gaudio et al., 2007; Del Gaudio et al., 2009). As regards both crises the geometry of deformation was about bell-shaped and covered an almost circular area centred in the town of Pozzuoli with a radius of 6 km (Orsi et al., 1999). Minor crises were observed more recently with low seismicity, characterized by seismic swarms, and slight ground deformation (fig. 2). Particularly, significant uplift episodes were recorded in 1989, (7.3 cm of uplift), 1994 (1.2 cm of uplift), March-August 2000 (4 cm of uplift) and from June 2004 to October 2006 (5.5 cm of uplift).

The detailed study of these last uplift events, from both geodetic and seismotectonic point of view is the object of this paper.

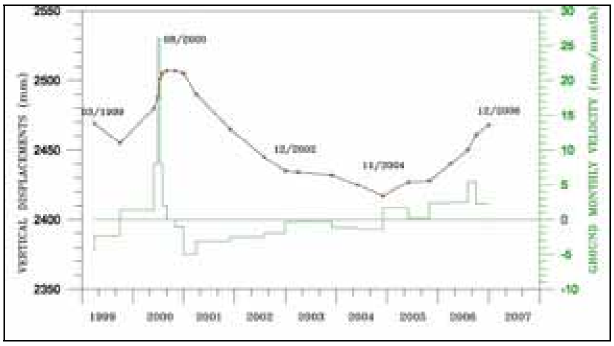

Figure 2 – Vertical displacements, March 1999 - December 2006, measured at Benchmark n. 25A (Pozzuoli Corso Umberto); in green the monthly velocity of the ground.

GROUND INCLINATION FROM TILTMETRIC DATA

Since the last ten years, the Campi Flegrei tiltmetric monitoring network has provided additional information related to the angular component of strain in the different station sites and has allowed to follow in better detail the evolution of the deformation pattern of the area.

The Campi Flegrei tiltmetric network consists of 7 stations, 5 of which equipped with surface sensors (DMA, DMB, DMC, BAI and OLB) and 2 boreholes (TOI and ARC) (fig.1). With respect to the bm n.25A of the levelling route (located in the town of Pozzuoli), the tilt stations are respectively located: DMA 1.6 km NNW, DMB 1.8 km NNW, BAI 4 km WSW, TOI 3.6 km NW, ARC 2.7 km NW and OLB 1.5 km ESE (Aquino et al., 2006).

Beginning from year 2000, the deformation field has appeared to be more asymmetrical relatively to past years, when it had radial symmetry around the maximum uplift area, close to Rione Terra in Pozzuoli. In order to work out a quantitative estimate of the deformation unhomogeneity in the eastern sector compared to the western sector of the area, in this paper two profiles WSW-ENE (benchmark 22-72) and SE-NW (benchmark 25A–81) respectively oriented, which are convergent towards the town of Pozzuoli, have been extracted from the altimetric network. For both profiles, the vertical displacements of a benchmark closer to this town with respect to that one more distant have been divided by their horizontal distance; the obtained derivatives represent the mean ground tilt along each profile.

In the period 3/1999-8/2000 (which included an uplift episode, fig. 2) a tilt of 6 µradians (in modulus) was observed along both profiles. In the following period 8/2000-11/2004 (when a deflation episode occurred, fig. 2) the tilt value measured along the profile WSW-ENE resulted 1.6 times greater than the value observed along the SE-NW profile (25.3/15.7 µradians), showing higher deformation to the east of the town of Pozzuoli during deflation. In the last period 11/2004-12/2006, along the WSW-ENE profile it was observed a tilt value of 9.4 µradians, about half the value of 13 µradians computed along the SE-NW profile; since the last period included an uplift episode (see fig. 2), it seems that in this sector (east of Pozzuoli) it is necessary a greater force in order to reverse the sense of movement from deflation to uplift.

The ground inclinations above reported refer to distances of some km (the previous profiles have respective lengths of 1.654 km and 2.331 km); investigating on smaller sections it can be found further evidence of the displacement field unhomogeneity. Indeed, on the section 20-19A (444 m long) of the first profile and on the section 81-82B of the second profile (102 m long), located near the tilt stations OLB and DMB respectively, tilt values of 24.8 and 9.8 µradians have been measured in the last of the three time intervals considered (11/2004-12/2006). The higher gradient near OLB is confirmed by the signals acquired by this tilt station (and decorrelated from soil temperature effects through a statistic procedure applied to the original tiltmetric series) between July 25 and November 2, 2006 (fig. 3), during a phase of slow unrest, when a significant rotation of the tilt vector with 39 µradians in N55E direction has been observed (Ricco et al, 2007).

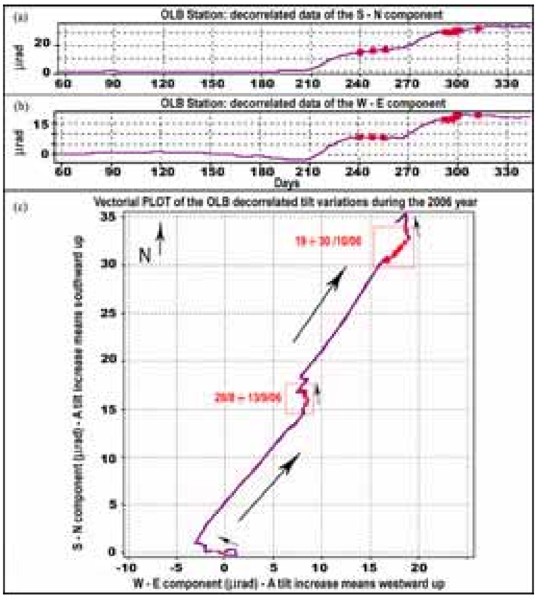

Figure 3 –(a/b) the decorrelated signals of the SN and WE tilt components recorded at OLB in 2006.
(c) the vectorial plot of the tilt variations; black arrows indicate tilt vectors while red squares represent seismic events recorded at STH seismic station (near Solfatara).

This value is about 15 times greater than the value of DMB, DMA and ARC tilt stations, all placed to the west of the maximum uplift area (Pozzuoli). Such high ratio can be due to the location of the OLB station, placed on a site which shows much higher tilt gradient. The observed anomaly could be explained through the presence of a structural discontinuity whose near-field effect can induce a greater deformation (fig. 4).

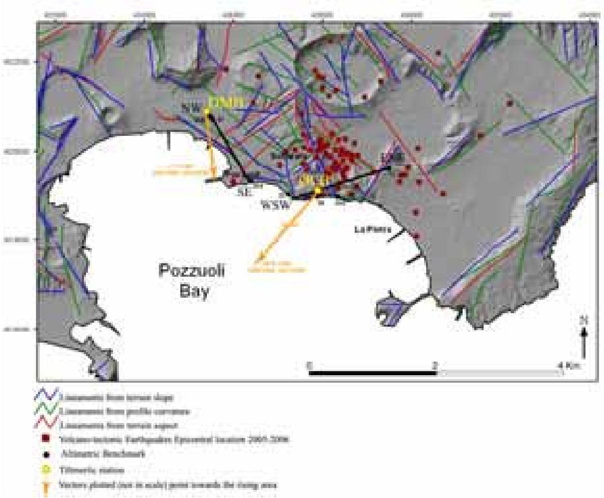

Figure 4 - The map shows three different thematic layers overlapped: instrumental seismic events (VT 2005-2006) with red squares, shaded relief and structural lineaments from image analysis. The two black lines indicate the profiles considered in this paper, respectively close to DMB and OLB tilt stations. The orange arrows show the uplift recorded by DMB and OLB tilt stations during the 2006 deformation episode.

SEISMICITY

The major bradyseismic episodes of Campi Flegrei have always been accompanied by subsequent seismic crises. The 1969-1972 episode has been the first one to be recorded instrumentally, it consisted of about 4000 earthquakes of moderate energy (maximum magnitude M=2.5), which were located along the Pozzuoli coast and near Solfatara. The following significant unrest episode, the 1982-1984 bradyseismic crisis, was characterized by about 15000 earthquakes, well located by modern seismic networks (Osservatorio Vesuviano O.V. and others) mostly in the central area of maximum deformation. Important seismic swarms have been recorded, like the 1984 1st April swarm (500 events in 6 hours) and located near the harbour of Pozzuoli, as well as many high energy events occurred, mostly located on the eastern side of the Solfatara crater, with maximum magnitude M=4.2 in December 1984.

In this paper we have not considered the Long Period (LP) seismic events, occurred in 2000 and 2006 mostly, but we have focused our analysis on the Volcano-Tectonic (VT) seismic events associated with the 2004-2006 bradyseismic episodes, in order to identify which sector of the Caldera could have been activated during such episodes, from a seismotectonic point a view. In Fig. 4 we have plotted the epicentral locations of about 90 well located VT events (courtesy of M. Castellano) that have been recorded from 2005 to 2006 by both the permanent and temporary I.N.G.V.-O.V. seismic networks (Saccorotti et al., 2007). The magnitude of the events were not greater than 1.4 , while their hypocentral depths had values between 0.5 and 4 km approximately. Most of these earthquakes have occurred as seismic swarms, and their epicentral locations cluster in the eastern side of the Solfatara crater and towards south-east, a zone quite close to the deformation anomaly detected by the OLB tilt station, and associable to many coincident morphometric lineaments with NNW-SSE direction, identified on the eastern border of Solfatara, as it can be seen in Fig.4. For this reason, the above lineaments can be considered responsible for the observed 2005-2006 VT seismicity.

MORPHOMETRIC DATA FROM IMAGE ANALYSIS

The tectonic elements outcropping in the area are mainly correlated with a circular geometry of deformation, and could also have been inherited by the regional NW-SE and NE-SW normal faults; likely, such faults acted as preferential magma rise conduits feeding the active Campanian volcanoes.

In order to identify the important structural lineaments of the area under study, which could have been responsible for the observed VT seismicity, the high resolution DEM (5x5 pixel m) of the Campi Flegrei area (Vilardo et al., 2008) has been used in this paper first of all for calculating the morphometric parameters as the terrain slope, terrain aspect, and profile curvature.

The image processing techniques (Math et al., 1995) are among the most used methods for locating and mapping structural lineaments. The criteria of lineament extraction is based on the identification of linear topographic surface features, such as valleys, ridges, breaks in slope, boundaries of elevated areas aligned in a rectilinear or slightly curvilinear shape and that distinctly differ from the patterns of adjacent features (Jordan et al., 2005).

We have identified significant structural lineaments extracting the linear continuity of the morphostructural features observed on the DEM (Mitasowa and Hofierka, 1993), examining their spatial and statistical coherence, and carrying out the comparison and correlation with the structural lineaments already known from literature (Orsi et al., 1999) The aim of our analysis has been validation of the lineaments extracted from DEM (Nappi et al., 2008), for constraining and correlating the active structural lineaments with the recent local seismic swarms as well as with the local displacements data. Accordingly, as a final step of our work, all the geodetic, seismological and morphotectonic data collected and analysed in this paper have been geo-referred into the UTM-WGS84 reference system in GIS environment, so that their cartographic restitution and multi-layers representation have allowed us to analyse the whole dataset jointly and carry out mutual correlations and new interpretations. In fig. 4 it is shown the integrated multi-layer map obtained, which has given us new seismotectonic insights for this sector of the Campi Flegrei area.

CONCLUSIONS

In conclusion, the obtained results have allowed us to hypothesize a remarkable change as regards the deformation pattern active in the Campi Flegrei area in 2000-2006, respect to the previous periods. In detail, the eastern sector of the Campi Flegrei caldera, east to the town of Pozzuoli, seems to be affected by a different and complex kinematic behaviour, compared to the other sectors. These results are strongly supported by high precision levelling and tiltmetric new data, which together with the seismic data and new morphotectonic lineaments identified through image analysis, allow us to hypothesize significant structural discontinuities NNW-SSE oriented and located in the M. Olibano zone (near OLB tilt station), probably responsible for seismic activity and for the anomalous deformation field observed.

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GEOLOGICAL INTERPRETATION OF THE AIRBORNE GAMMA RAY SPECTROMETRY MAPS OF BELGIUM

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KEY WORDS: Geology, Belgium, Airborne Gamma Ray, AGRS, Uranium, Thorium, and Potassium.

INTRODUCTION

An airborne geophysical survey was carried out over Belgium and Luxembourg in 1994, from an aircraft flying at 120 m altitude above ground level, measuring natural magnetism and natural radioactivity or spectrometry. A total of 49,400 line-km were flown. A new Quaternary map of Flanders (northern Belgium) has recently become available, allowing a formal geological interpretation of the spectrometric results for the whole country, which is the focus of the present paper. Airborne Gamma Ray Spectrometry (AGRS) records the gamma rays emitted by the elements potassium (K), uranium (U) and thorium (Th) contained in the top layer of the soil, to a depth of less than a meter. The spectrometric patterns are thus related to the geochemical composition of the superficial geology and to its pedological evolution. For potassium, the ^{40}K isotope is radioactive. For uranium and thorium, the gamma rays emitted by some daughter elements are stronger than those emitted by U and Th themselves, so it is customary to use ^{214}Bi for U, and ^{208}Tl for Th. The concentrations of potassium, uranium equivalent and thorium equivalent can be calculated from the airborne measurements, provided some calibration takes place on the ground.

Radiometric acquisition and processing

The on-shore survey was flown with a fixed wing aircraft, Rockwell Shrike Aerocommander 500S, flying at a constant speed of 250 km/h. The survey progressed from east to west. A gamma ray spectrometer of the model Exploranium GR820 (self calibrating airborne spectrometer) was used, containing 8 NaI crystals and 256 channels, with a total volume of 33.5 litres. The following energy windows were recorded (CGG, 1995):
Total Count:0.4 to 3.0 MeV (Mega-electronVolt)
K, potassium:1.35 to 1.57 MeV, using the spectral line of ^{40}K
U, uranium:1.63 to 1.89 MeV, centered around the spectral line of ^{214}Bi
Th, thorium:2.42 to 2.81 MeV, centered around the spectral line of ^{208}Tl
Cosmic background:3.01 to 6.00 MeV.
The sample interval was 1 second, corresponding to a linear resolution of about 70 m at the flying speed of 250 km/h.

The radiometric data processing started with corrections for spectrometer dead time, cosmic background, ambient air temperature and pressure, compton stripping, and height attenuation.
As these are the only corrections that have to be carried out for the potassium (K) counts, a regular square grid was calculated at this stage at 100 m intervals for K, from which contour maps were drawn.
For thorium (Th), some slight mislevelling between adjacent lines appeared on the screen displays of the thorium colour image obtained through ER-Mapper. This was corrected by cross-correlation of each line with the two adjacent lines. After this correction, the Th grid was calculated at 100 m intervals as for K.
For uranium (U), a radon correction has to be applied. ^{238}U decays to stable lead ^{206}Pb through a series of daughter isotopes including ^{222}Rn which is a gas with a half-life of about 4 days. It escapes from soil into groundwater and on into the atmosphere, and causes weather-related enrichment, which is corrected using cross-correlation with Th and K (CGG, 1995).

RESULTS

After processing by the Compagnie Générale de Géophysique, four maps (U, Th, K and Total count) were interpolated by kriging and with the help of GIS compared with geological maps. Several large geological entities are highlighted by their high or low U-Th-K contents. The Campine region situated in northeastern Belgium is characterised by a very low response for the three elements due to its sandy Neogene and Quaternary subsoil and overlying soils (Figure 1). The Holocene mudstones of the Polders area near the North Sea coastline and the Scheldt estuary in NW Belgium show a higher response especially for K and Th. A sand dune belt with low K-Th response separates the Polders from the sea. South of the Polders, Pleistocene fluviatile

sediments of the Flemish Valley are poor in K and Th. These thick sandy sediments were deposited during the Pleistocene glacial periods, when a major river system ran from east to west just south of the continental glaciers covering northern Europe; more to the south, fine-grained loess was deposited by winds blowing over the glaciated continent. The central area of the country, north of the axis Meuse-Sambre, represents this loess belt consisting of Pleistocene eolian sediments characterised by relatively high values of K, Th and U.
To the southwest of the Flemish Valley, Paleogene Ypresian clay is responsible for a slightly higher K-Th signal.

South of the axis Meuse-Sambre, the synclinorium of Dinant shows parallel strokes corresponding to K-Th sandstones and shales alternating with K-Th poor limestones, all belonging to the folded Middle to Upper-Devonian and Carboniferous.
The high Ardenne area generally shows high K-Th corresponding to the Lower Devonian shales. However, the Hautes Fagnes region has very low concentrations of these elements at the surface, due to a thick layer of water-saturated vegetation which absorbs radiation from the underlying rocks. In the southeast, Jurassic sandstone outcropping in a wide W-E oriented belt shows a very weak K-Th-U signal, but more to the south Cretaceous shales and marls again exhibit a stronger signal.

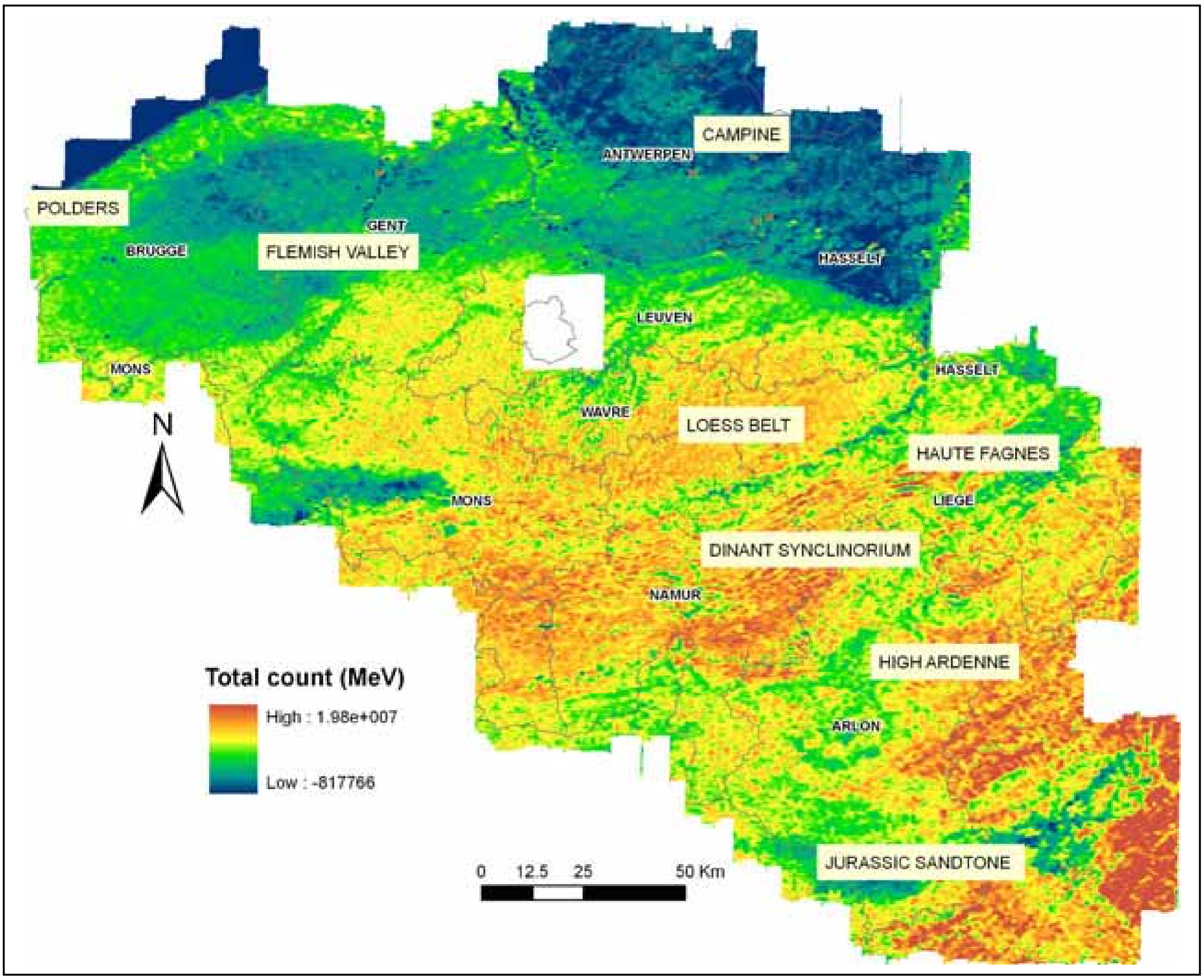

Figure 1 – Total count (MeV)and localisation of the demonstrative areas.

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EVALUATION OF THE LAND RESOURCES IN THE TOCANTINS RIVER VALLEY-BRAZIL USING SATELLITE DATA AND GIS

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KEY WORDS: Satellite data, optical and digital interpretation, land use map, soil map, supervised and unsupervised classification, 3-D perspective, geographical information system.

MAIN CHARACTERISTICS OF THE STUDY AREA:

- Location: Central northeast of Brazil, between the states of Maranhão and Tocantins
- Climate: Transition between the humid climate of the Amazon and semi-arid climate of the northeast
- Soils: Slight to moderate fertile
- Vegetation: Semievergreen seasonal forest and Semievergreen seasonal forest with Cerrado and Babaçu

OBJECTIVES OF THE RESEARCH PROJECT:

- Mapping of the land use of the area using remote sensing techniques
- Mapping of the soil type of the area using remote sensing techniques
- Optical and digital interpretation of satellite imagery
- Elaboration of a 3-D perspective of the study area
- Study of the topography of the area and its implication in reflectance variation, soil and land use
- Evaluation of the land resources for future development of an irrigation project in the area

METHODOLOGY:

- Satellite image analysis, bands 2-green, 3-red, 4-NIR, best bands for resources enhancement
- Optical interpretation: ground cover 185km by 185km
- Digital interpretation: ground cover 90km by 90km, top left quadrant of the optical image
- OPTICAL + DIGITAL, a dual approach of image interpretation is used i.e., they; complement each other
- Optical interpretation-general classification of the area, boundary definition and information extraction
- Digital interpretation-automated analysis and greater level of detail

OPTICAL INTERPRETATION:

For the optical interpretation a color composite image is projected onto a white sheet of paper on the scale 1:250.000. The identification of the map units were based on:

- Spectral (color and tone) and spatial features
- Comparison with published reports and maps
- Inferential analysis and deductive reasoning

RESULTS:

- <u>Land Use Map</u> with four broad categories: vegetation type, bares soil, water bodies and man-made features and seventeen detailed classes.
- <u>Soil Map</u> - The delineation of the soil boundaries was done through the assessment of land-form, geology, vegetation type and land use, resulting in seven soil type units

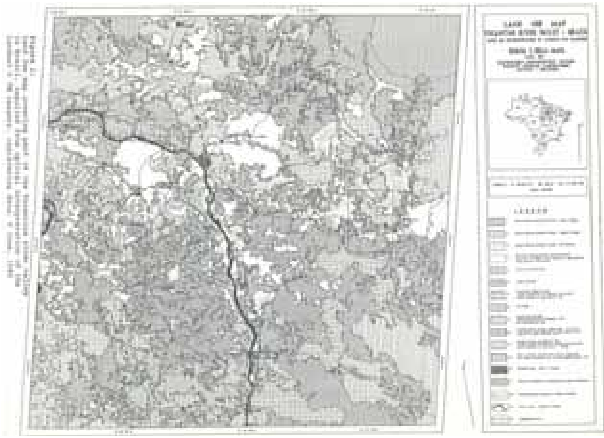

Fig. 1: Optical interpretation – Land use map - Tocantins river valley

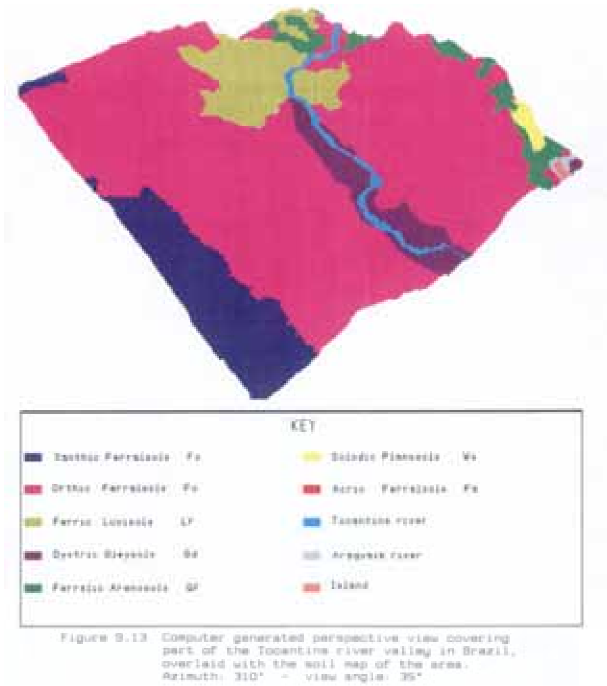

Fig. 2: Optical interpretation: Soil map - Tocantins river valley

DIGITAL INTERPRETATION:

For the digital interpretation twenty five areas of 3km by 3km were depicted from the entire image, having in mind the full spectral nature of the region, composing a mosaic of the study area. The identification of the map units was then carried out in the mosaic image using the International Imaging system software. Two methods of pattern recognition techniques were performed:

Supervised classification-training areas

Unsupervised classification-clustering techniques

Results:

Land use map-mosaic of the study area-supervised classification

Land use map-mosaic of the study area-unsupervised classification

DRM – digital relief model merging DEM and the satellite image data

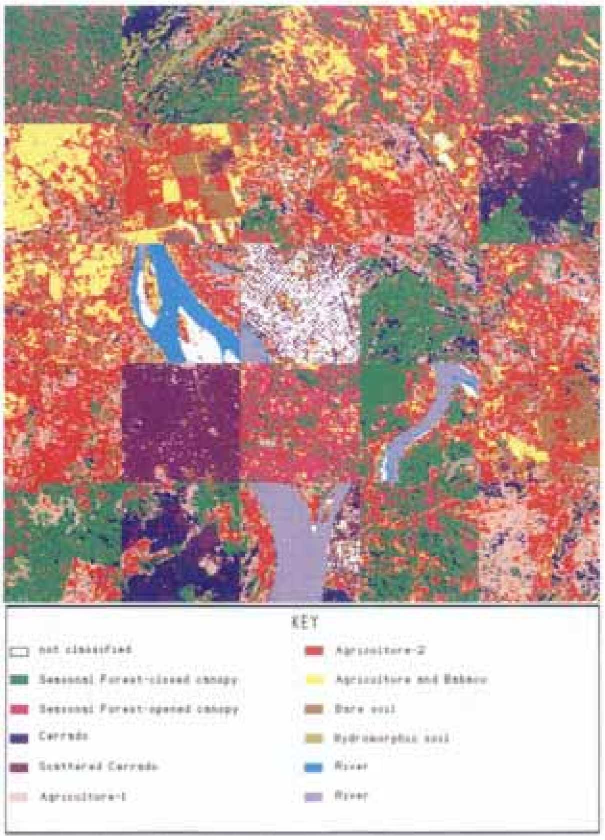

Fig. 3: Land Use Map-mosaic of the study area-supervised classification

The differences between the supervised and unsupervised classification lies on the fact that in the supervised classification an homogeneous class of the unsupervised classification was split up generating a more reliable map of the study area.

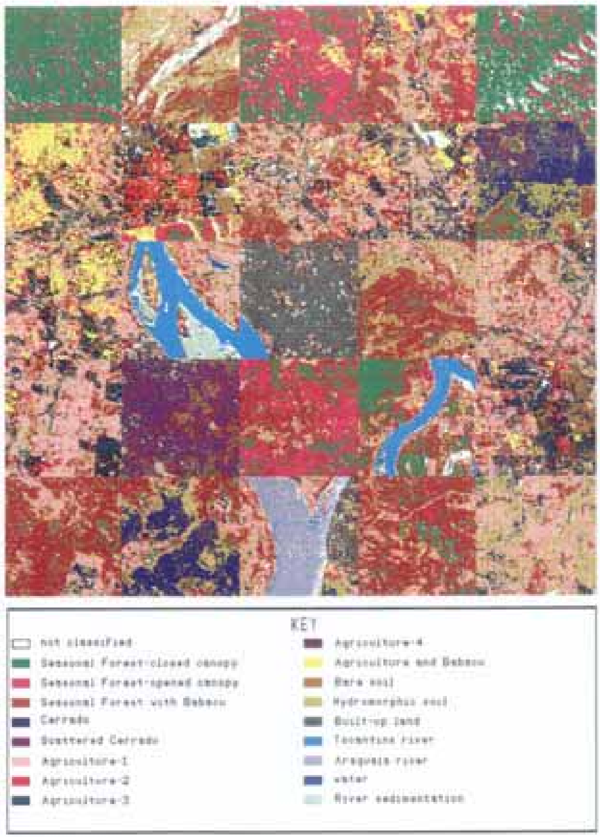

Fig. 4: Land Use Map-mosaic of the study area-unsupervised classification

For the elaboration of the digital relief model (DRM) a topographic map of the area was used. Interpolation between the contours was performed and then converted to altitudes generating the digital elevation model (DEM) which was overlaid by the geometrically corrected satellite data generating the DRM as shown below:

APPLICATIONS OF THE DRM:

Information of the relief of the area for computation of slope and aspect useful for the estimation of:

- run-off and erosion
- Derive more accurate Land Use and Soil map based on land topography
- Analysis of Spectral reflectance differences based on topography

CONCLUSIONS:

- Optical and digital interpretation of satellite data are complimentary and provide up to date information for land use and soils in the Tocantins river valley in Brazil
- Optical interpretation gives a s general view of the area, synoptic mapping
- Digital interpretation gives detailed assessment of the data
- The development of a DRM and GIS to merge satellite data, soil, topography and land use data is very useful tool for management decision

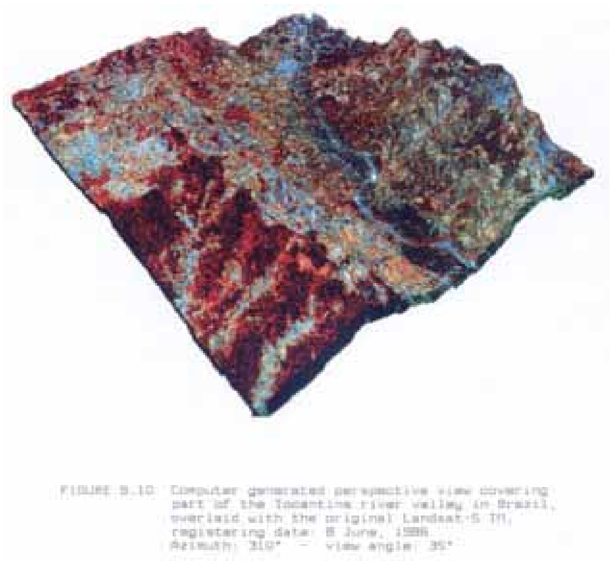

Fig. 5: DRM-Digital elevation model overlaid by satellite data – Tocantins river valley

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COMPARISON OF AIRBORNE GAMMA-RAY SPECTROMETRY AND GROUNDWATER BASED RADON ACTIVITY MEASUREMENTS – A CASE STUDY

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KEY WORDS: airborne radiometry, radon in groundwater, hard rock weathering, Bavaria.

INTRODUCTION

Comprehensive hydrogeological investigations were carried out in the crystalline rocks of eastern Bavaria – the western part of the Bohemian massif – and adjacent Cenozoic sediments from 2002 to 2007. Mapping was accompanied by extensive hydrogeochemical sampling comprising radon measurements using liquid scintillation counter (LSC) technique. In addition, airborne geophysical measurements including magnetics, electromagnetics and gamma-ray spectrometry were performed in a 315 km^2 large test area on the southwestern rim of the hard rock terrain.

In this contribution airborne radiometric data considering the radioelements potassium, thorium and uranium are compared with radon activity measurements in groundwater outcrops in order to derive general geological implications. Other results of this airborne geophysics campaign accomplished by the Federal Institute for Geosciences and Natural Resources on behalf of the Geological Survey of the Bavarian Environment Agency, e.g. structural inferences, are described in Rohrmüller *et al.*, (2009, this volume).

Figure 1 – Hard rock terrains in Bavaria (grey) and the airborne survey area at the SW rim of Bohemian massif

GEOLOGIC / HYDROGEOLOGIC FRAMEWORK

The hard rocks of eastern Bavaria build up a low mountain range between 250 and 1450 m a.s.l. which is part of the basement rocks formed in the Variscan orogeny in Devonian and Carboniferous times. All rocks have undergone intensive mechanical and chemical weathering culminating under (sub-) tropical conditions in Tertiary. The metamorphic and igneous rock suits are thus covered by a zone of regolith, debris and/or associated Quarternary deposits reaching a thickness up to several tens of meters. These weathering products, the overlying (peri)glacial deposits and the fissured zone of the bedrock form the principal regionally extended aquifer, which is characterized by an anisotropic groundwater flow regime, attributed to the orientations and physical properties of fracture systems. The upper horizons of the weathering zone may be characterized by a high clay content which is crucial for groundwater protection and potentially favourable in terms of groundwater retention.

AIRBORNE RADIOMETRIC DATA

Airborne radiometry detects the natural gamma-ray radiation of soil and rocks to about 0.5 m depth. The measured gamma particle energy allows retrieving the concentration of the source radionuclide or daughter elements of potassium (^{40}K), thorium$_{eq}$ (^{208}Tl) and uranium$_{eq}$ (^{214}Bi).

The high-resolution helicopter survey (Siemon *et al.*, 2007) was flown in a rectangular area of 22.5 km by 14 km in a compact one-week-campaign in July 2007. It was performed along 66 flight lines and 11 perpendicular control flight lines spaced 200-400 m and 2000 m, respectively, at an average terrain clearance of 115 m for the onboard gamma-ray detector. An Exploranium spectrometer equipped with a 16.8 l NaI crystal pack was used at an energy range 0.41 – 2.81 MeV. One record per second at a survey speed of about 150 km/h resulted in measurement intervals of 40 m. Original data were interpolated to 100 m resolution grids and counts per second of each channel were converted into concentrations by use of calibration factors. Cosmic background radiation was corrected; absorption of biomass (forests), however, was neglected, as band ratios are used in interpretation which shrinks the effect of environmental factors on radiometric response, such as soil moisture, vegetation and topography (IAEA, 2003).

RADON MEASUREMENTS IN GROUNDWATER

Radon activity measurements at springs and wells have been integral part of the hydrogeochemical investigations in Bavaria since 2002. Additional samples were taken within the area of the airborne survey to ensure a high information density.

For the determination of Rn activities a Triathler liquid scintillation counter was used, featuring an alpha-/beta-separation based on pulse shape analysis utilizing a multichannel analyser. In routine operation the extraction method was applied, where radon is extracted into a water immiscible cocktail and measured after a minimum latency of three hours, but within the first decay interval. This procedure results in a detection limit of 5.2 Bq / L for the usual 300 s test time. Multiple measurements and round robin tests revealed a standard deviation < 5 % for samples > 30 Bq / L.

VERTICAL DISTRIBUTION OF RADIO-ELEMENTS IN THE WEATHERING ZONE

Under the impact of weathering, driven by infiltration and percolation of water, certain elements are depleted or relatively enriched, due to the global loss of material. Within the uppermost portion of the weathered zone, detectable by airborne survey, this compositional redistribution, regarding the radioelements considered, can be summarized as follows: (i) potassium is mobilized in solution and thus strongly depleted, (ii) thorium, lacking soluble ions, is relatively concentrated towards the top of the profile, whereas (iii) the behaviour of uranium is indistinct (e.g. Butt and Zeegers, 1992; Wilford *et al.*, 1997). The latter, chiefly, is a function of the changing solubility of uranium with varying redox conditions and the escape of radon gas, the immediate precursor of ^{214}Bi in the ^{238}U decay series.

Consequently, K/eTh ratios are particularly appropriate for qualifying the intensity of weathering in the shallow subsurface horizons.

DISTRIBUTION OF RADON IN GROUNDWATER

Radon is a naturally occurring radioactive gas, highly soluble in water and essentially chemically inert. Three natural isotopes are known, derived from three different radioactive decay chains, commencing with ^{238}U, ^{232}Th and ^{235}U. Of these, ^{222}Rn, member of the ^{238}U decay series, half-life $T_{1/2}$ = 3,825 d, is by far the most abundant and the only one discussed here. – Equilibrium measurements show (cf. Diepolder and Herold, 2007) that ^{222}Rn activities in groundwater are far in excess of those from an equilibrium decay of dissolved radium (the rather insoluble immediate precursor to radon in the ^{238}U decay chain, $T_{1/2}$ = 1600 a). Thus, radon in groundwater is dominantly directly released from the mineral matrix in aquifer grains or wall rock of fractures: Radon activities in groundwater are controlled by primary lithology and mineralogy of the aquifer host rock, the intensity of alteration or weathering (allowing the radon to emanate out of the crystal lattice), the aperture of fractures and fissures, and hydrodynamic factors. Hence, radon in groundwater is more a geological parameter measured in groundwater than it is an inherent hydrogeological feature.

Measuring Rn activities in groundwater thus provides average values valid for a certain section of the catchment area, depending on the flow velocity. Two major constraints, however, strongly curtail the areal interpretation of radon resp. uranium distribution: (i) the irregular array of the observational network due to the heterogeneous distribution of outcrops and (ii) significant time-dependent variations of the Rn activities as a result of the varying influence of superficial water and/or interflow (Fig. 2).

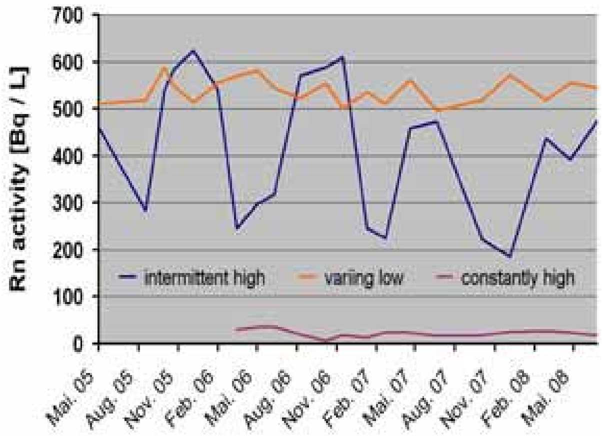

Figure 2 – Time series of Rn activity measurements at springs in the same high-Rn environment, illustrating the seasonal variations in superficial water / interflow impact

Considering these limitations typical ^{222}Rn-activity ranges of groundwater in certain areas or lithological units can be established (Diepolder, 2007) reflecting the bulk uranium contents of the aquifer host rocks. Based on these compositional ranges radon measurements can provide important information about the regional provenance of groundwater and allow to distinguish between interflow and surficial water as opposed to “real” groundwater. Dense sampling also may help to delineate intrusions (bearing ^{238}U and/or daughter nuclides) at a deeper level and to map inhomogeneities with respect to radon, such as faults or late magmatic veins.

INTERPRETATION OF AERIAL RADIOMETRY

Amongst the synoptic displays of the airborne gamma-ray spectrometry band ratios Th/U distribution (Fig. 3) is the most ambiguous, presumably due to the indistinct behaviour of uranium on weathering. The only conspicuous major feature in figure 3 is the Fürstenstein granite complex in the north, where areas of probably enhanced weathering and pedogenesis can be delineated.

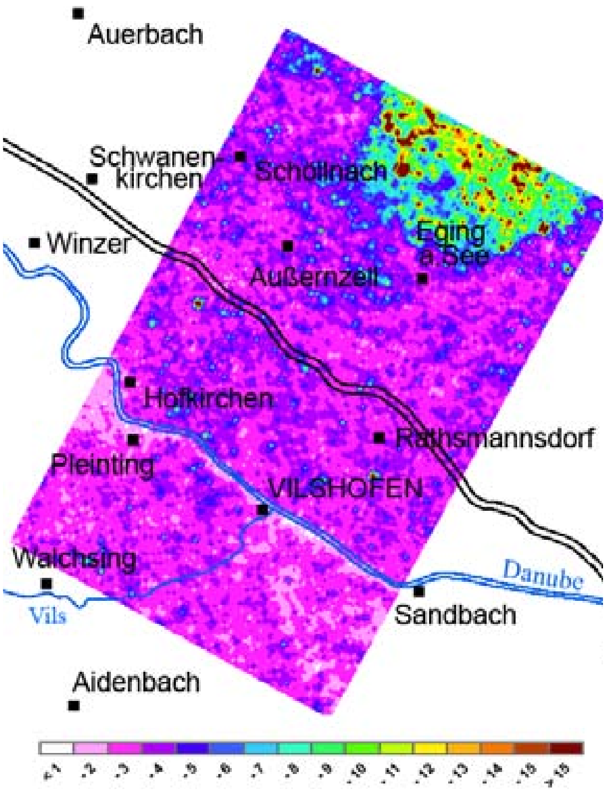

Figure 3 – eTh/eU ratio distribution in the airborne survey area. High ratios signify a more intense weathering of felsic rocks.

K/eTh ratios (Fig. 4), by contrast, clearly reveal patterns which must be attributed to the varying thickness of the regolith, i.e. the varying effect of weathering. The most striking example however, the SSE–NNW trending lineament north of Vilshofen, can not be conclusively explained by less intense weathering, and must therefore be related to deviant bedrock lithology or a major fault system.

Generally, when cross-checking relevant drilling profiles and areas revealing low K/eTh ratios, thus suggesting an intense weathering, quite some areas could be identified where the data do not match. Thus it is evident, that not all K/eTh distribution pattern can be solely attributed to the thickness of the regolith. For an overall interpretation of K/eTh ratios a distinction has to be made between the different bedrocks considering their radioelement contents. Furthermore, primary weathering effects are interfered from differences in geomorphology and may be concealed by clay eluviation, transport and (re-)sedimentation processes or by periglacial processes, such as solifluction (Dickson and Scott, 1997; IAEA, 2003).

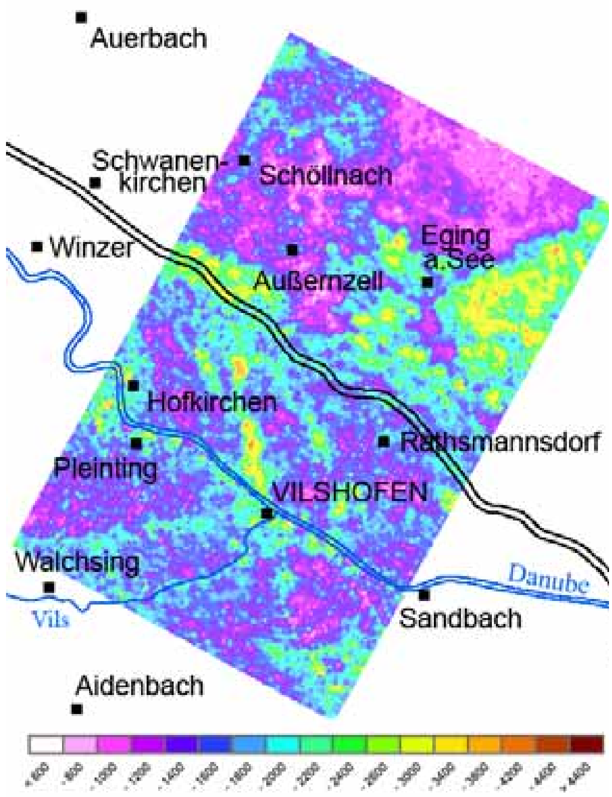

Figure 4 – K/eTh distribution in the airborne survey area. High K/eTh ratios signify a less intense weathering.

RESULTS OF RADON MEASUREMENTS IN GROUNDWATER AND COMPARISON WITH URANIUM DISTRIBUTION

Radon concentrations in groundwater within the airborne reconnaissance area range from less than 10 Bq/L in regions with a thick cover of Tertiary sediments up to 430 Bq/L in the Fürstenstein granite complex. Considering only the higher values of distinct areas (presumably unaffected by surficial influence), the radon concentrations can be related to different classes of aquifer host rocks featuring different average radioelement contents. However, due to the heterogeneous distribution of groundwater outcrops a gapless area-wide statement on radon distribution is not feasible.

Comparing the results of the ^{222}Rn activity measurements in groundwater and the uranium$_{eq}$ concentration distribution derived by aerial gamma-ray spectrometry (Fig. 5), little conformity can be perceived, neither on a large nor on a small scale. One reason for this poor correlation of the almost immediate precursor/successor (^{222}Rn vs. ^{218}Bi) in the ^{238}U decay chain seems to be the fact that different horizons of the weathering profile are surveyed by the two methods: the uppermost 0.5 meter by airborne radiometry, and deeper levels of the aquifer host rock by radon measurements. As a consequence of the varying physicochemical conditions within the soil / regolith profile and the changing solubility of uranium with varying redox conditions, uranium is irregularly distributed with depth (e.g. Dickson and Scott, 1997). In addition, radon and its soluble precursors in the decay chain are affected by redistribution due to groundwater flow.

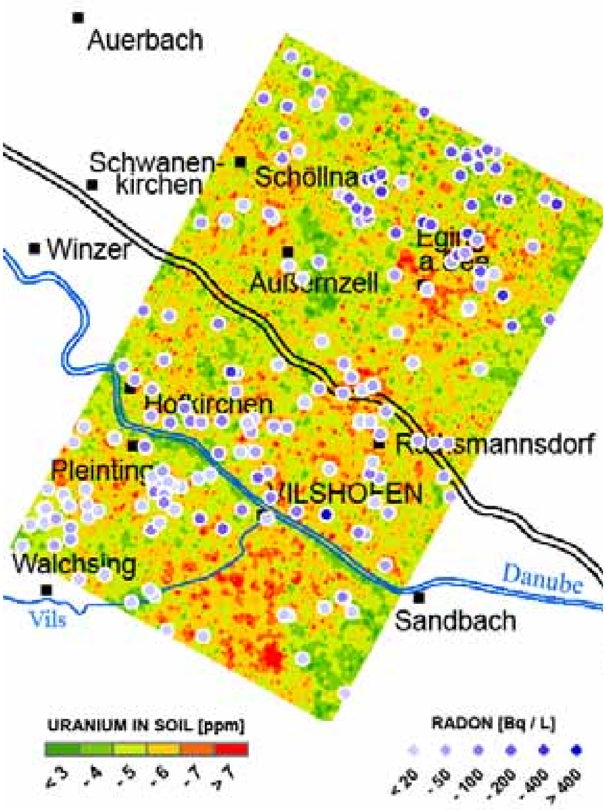

Figure 5 – Uranium$_{eq}$ concentration in near surface horizons as derived from airborne radiometry survey vs. radon activity measurements in groundwater.

The synoptic display of uranium$_{eq}$ as derived by airborne survey generally shows an ambiguous and scattered distribution which can not be correlated with the distribution pattern of any other radioelement or band ratio. Nor can the pattern in figure 5 be attributed to compositional variations in primary uranium contents as expected from bulk composition of the bedrock. Thus it is evident that uranium underwent a complex manifold re-distribution on alteration, weathering and pedogenesis which makes it the least interpretable radioelement with respect to its lateral distribution.

CONCLUSIONS

Application of airborne gamma-ray spectrometry in soil mapping and regolith studies, as described by many authors, only seems rewarding in areas with a ± homogeneous bedrock geology and superficial deposits weathered in-situ. The interpretation of radioelement concentrations in areas with a heterogeneous bedrock geology and/or dislocation of weathering products requires a thorough understanding of the local processes in radionuclide distribution on alteration and weathering, and hence small scale studies. The indistinct uranium distribution and, inter alia, the mobility of radon inhibits plausible results by comparing of the two related radioelements.

Nevertheless, the 2007 gamma-ray aerial survey provided some valuable new information to the knowledge of regional geology. Some of the results still have to be approved utilizing other airborne geophysical data. This multi-method approach is beyond the scope of this contribution and subject to further evaluations.

ACKNOWLEDGEMENT

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A SYNOPTIC VIEW OF THE NEW LUNAR CONTROL, ULCN 2005, AS AN AFFINE DEFORMATION OF THE OLD UNIFIED LUNAR CONTROL NETWORKS

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KEY WORDS: Lunar Control Network, ULCN 2005, Lunar Topography, Reference Frame Transformation

Abstract

As in the case of the Earth, Lunar mapping activities require a reference network for the selenodetic control. The recent Lunar control networks include the Unified Lunar Control Network (ULCN 1994) and the Clementine Lunar Control Network (CLCN), both derived at RAND, and ULCN 2005 at USGS. The ULCN 1994 was based on the images from the Apollo, Mariner 10, and Galileo missions, and Earth-based photographs, whereas the CLCN was derived from Clementine images and measurements on Clementine 750-nm images. The ULCN 2005 consists of 272,931 *control points* with an average of one point for approximately every 46 km^2. The new ULCN 2005 is the fusion of the ULCN 1994 and the CLCN networks and improves greatly upon the accuracy of the CLCN. The primary significant feature of the ULCN 2005 in comparison to the previous ones is that it is also solved for the radii of the control points. Consequently, the resulting ULCN 2005 is a unified *three dimensional* photogrammetrically determined network as opposed the two earlier 2D (selenocentric latitudes and longitudes) control network solutions. Comparison by Archinal et al 2006 showed that the radii derived from the images exhibit no systematic difference between the Clementine LIDAR values, which are accurate to a few hundred meters. The horizontal accuracy of the ULCN 2005 is also reported to be a few hundred meters. This study compares the new ULCN 2005 solution with the earlier ULCN 1994 solution in two stages. First the parameters of a *global* reference frame transformation between the two solutions with global rigid body motions (rotations and translations) and deformations (normal strains and shears). In the second stage, their differences are modelled as *local* deformations and rigid body motion of quadrangles that are formed on the surface of the lunar sphere by the old network control points (ULCN 1994 and CLCN) and tetrahedrons (fundamental 3D selenodetic figures) of the colocated control points which now include information about their radii. The differences between the old and the new control points are quantified and analyzed as a function of 3D normal strains, shears, rotations and translations for each quadrangle/tetrahedron in their local topocentric coordinate systems.

BUILDING A 3D MODEL WITH GEOPHYSICAL DATA FOR A VALLEY IN SOUTH EASTERN BAVARIA

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KEY WORDS: refraction seismics, geoelectrics, quaternary valley-fill, 3D-modelling, GOCAD, GIS.

PURPOSE OF THE STUDY

The understanding of hydrogeological features of the shallow subsurface is a crucial point for statements about the groundwater flow. This project is intended as a feasibility study for modelling quaternary valley-fills in the Alps regarding hydrogeological aspects. It demonstrates the preparation of geophysical data recorded in an alpine valley (fig.1) named "Wimbachtal" in south eastern Bavaria to create a 3D model. The intention is to reconstruct the bedrock boundary and to differentiate the unconsolidated quaternary material and its thickness. Furthermore information shall be obtained about the groundwater table to better understand the present hydrogeological conditions.

INVESTIGATION AREA

The Wimbach valley is located in south eastern Bavaria in the centre of the Berchtesgadener Alps. It is the residual of a former arch now separated into the Watzmann in the east and the Hochkalter in the northwest of the investigation area. The Wimbach valley in between shows significant glacial modifications. In the upper part it is shaped as a characteristically cirque followed by a glacial trough with steep walls. The valley bottom as well as parts of the valley flanks are covered by thick debris layers.

The bedrock underlying the debris changes close to the Wimbachschloss from Dachsteinkalk in the lower part to dolomite in the upper part of the valley. Particularly the physical weathering of dolomite is responsible for the enormous amount of debris in the valley.

RECORDING AND EVALUATION METHODS

Hydrogeological aspects of the valley were already analysed by a combination of schlumberger resistivity sounding and refraction seismic from 1977 till 2008 (BADER 1988).

For the refraction seismic measurements a 24-channel equipment from Geometrics named Strata View was used. The seismic signal is generated by an explosion in a depth of 1 to 2 m. The lengths of the recording lines vary between 460 and 680 m. The depth of penetration reached at least 200 m, depending on the distance of the offset shot. Since the first measurements in the Wimbach valley in 1977 the progress of software and computer capability now allows a more detailed interpretation, e.g. of the refraction signals. Currently the refraction signals are reinterpreted with ReflexW, a software designed for processing and interpretation of refraction data and developed by K. J. Sandmeier. Also new measurements are carried out to create a high data density for the 3D modelling.

The evaluation with ReflexW is divided into the verification of the intercept-delay, the wavefront-inversion and the network raytracing (SANDMEIER 2005, SANDMEIER & LIEBHARDT 2005). The result is a 2D layer model with boundaries of characteristic changes in travel times.

For measuring geoelectric resistivity a 4-point DC system from the former state authority "Niedersächsisches Landesamt für Bodenforschung Hannover" is used. The maximum distance between the electrodes of each profile ranges from 400 to 1.000 m. Therefore it is possible to detect the groundwater table as well as the bedrock boundary. The analysis of the measured resistivities has originally been carried out with a curve atlas, but a software-controlled re-evaluation is in process. The result are 1D vertical profiles differentiated in layers with significant resistivity contrasts.

The results of the interpretation of both the seismic and the geoelectric measurements are exported as ASCII files and prepared for usage in 3D geomodelling.

DATA PREPARATION IN ARCGIS

The geophysical profiles exported from ReflexW contain no information about location and elevation of the data. So the geophysical data of the profiles has to be merged with the spatial information. This was done by using the ArcGIS Modelbuilder. First the geophysical profiles were converted into a dBase database and imported into ArcGIS. There is also a georeferenced ArcGIS polyline shape containing the location of every geophysical profile interpreted. The database containing the geophysical data and the polyline shape with the spatial information are used as input data for a model in the ArcGIS toolbox. This

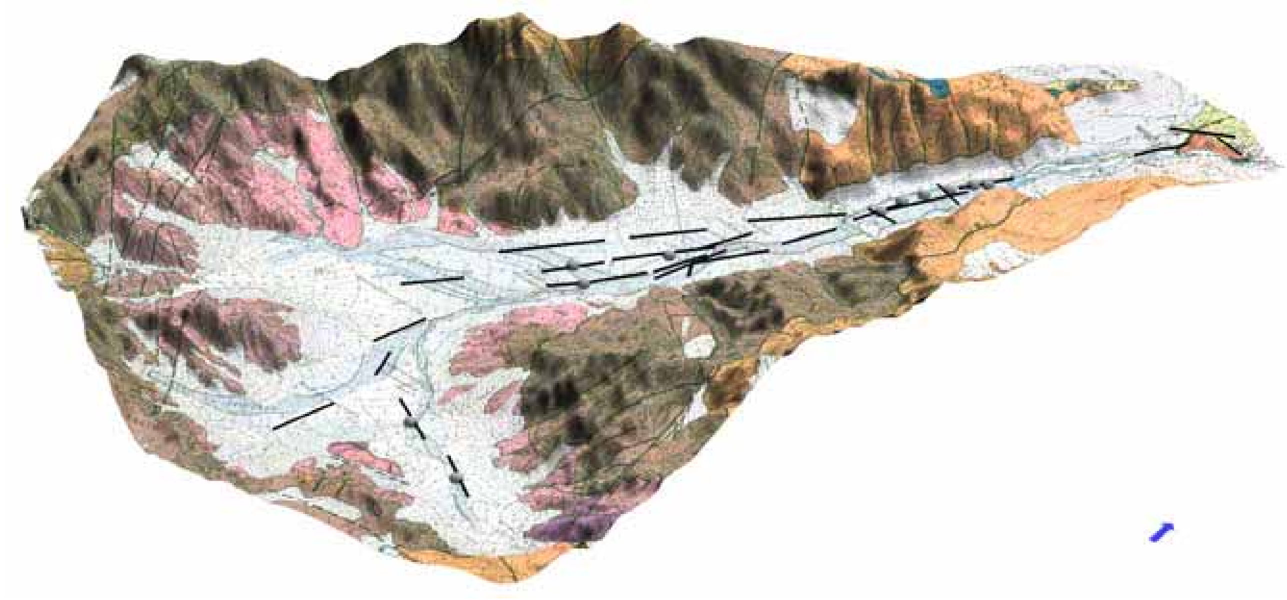

Figure 1 – The Wimbach valley and the location of the seismic profils (lines) and the geoelectric soundings (spheres).

model was developed with ArcGIS modelbuilder especially for these data sets to perform the following steps automatically. Through an identifier field the geophysical data sets are linked to the appropriate polylines and thus georeferenced. Afterwards elevation data is added to the georeferenced data sets by deriving elevation values for each data point from a raster data set containing the digital elevation model. Now the resulting data sets contain all the necessary information for usage in 3D modelling. The geophysical profile data sets are exported as an ASCII file and imported into 3D geomodelling software GOCAD via a curve import function.

The data sets derived from the geoelectric measurements already contain spatial information and can be imported directly into GOCAD through a point set import function.

AN APPROACH FOR THE 3D MODEL

The objective of the planned 3D model is to derive information about the bedrock boundary, the unconsolidated sediments and the groundwater table from the geophysical measurements.

In addition to the geophysical data outcrop data is derived from the geological map “Berchtesgadener Land” with a scale of 1 : 25.000 (LANGENSCHEIDT et al. 1998). Basis for the model is a digital elevation model with a resolution of 50 meters, already used for the spatial adjustment of the geophysical data in ArcGIS.

Visualizing all the data in 3D space is a first way to draw initial hydrogeological conclusions.

The data is distributed rather evenly over the model area. Especially in the lower part of the Wimbach valley with a high data density it should be possible to create a quite accurate surface for the bedrock boundary. To differentiate the unconsolidated quaternary sediments and to make statements about the groundwater table is more difficult and relies a lot on the density and level of detail of the input data. An approach to verify and enhance the model can be to carry out additional measurements in selected areas.

ACKNOWLEDGEMENTS

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SUBSURFACE MODELLING USING SCANNED 2D-SEISMICS

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KEY WORDS: German Molasse Basin, Bavaria, geothermal energy, 3D-modelling, GIS, seismic.

GEOTHERMAL POTENTIAL IN SOUTHERN BAVARIA

The German Molasse basin, herein the area around the city of Munich, provides an excellent setting for the usage of geothermal energy from depth (BayStMWIVT 2004). The aquifer of main interest is within the carbonate succession of the Upper Jurassic (Malm), it shows significant productivity and with respect to its depth also very elevated temperatures. Groundwater flow is mainly via fractures and permeability is even higher in zones around major faults where high rates of extraction are to be expected (BayStMWIVT 2004).

In order to design a successful and economic drilling and production it is crucial to identify and map fault-geometries and depth of aquifer as well as its facies (bedded versus reef-facies).

Due to extensive exploration by the petroleum-industry within the region from the early 1960ies on (Lemke, 1988), the Bavarian Environment Agency holds seismic sections with a total length of more than 2600km (figure 1) which are classified by the industry's rights of ownership. Unfortunately, most of these non-migrated time sections are available only as paper plots of sometimes rather poor quality.

Additionally, many drillholes were logged with vertical seismic profiles (VSP) that allow a correlation between seismic sections and well-stratigraphy. These data also provide a good overview of seismic velocities within the whole molasse basin in general and the working area in particular.

INTERPRETATION OF SEISMIC DATA

Within the area under study the succession of main geothermal interest is widely marked by the top of the Lithothamnium-limestone (Upper Eocene). It appears as a reliable and prominent double-reflection in most of the seismic sections. Its area of deposition covers nearly 80% of the working area (Lemke, 1988, Zweigel, 1998). In places of absence or non-deposition a certain

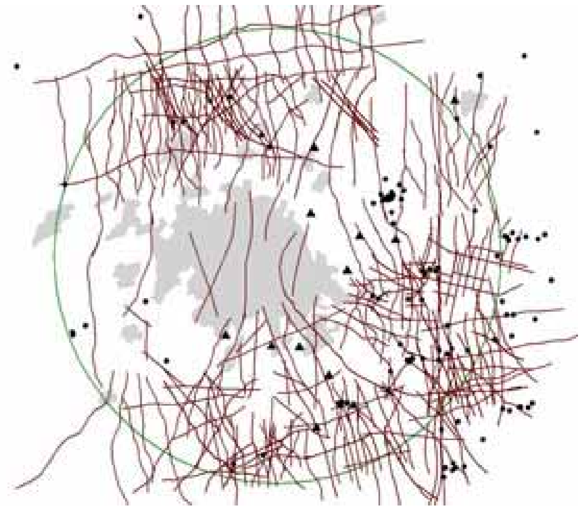

Figure 1 – Working area (circle) around Munich with seismic lines, drillholes from petroleum exploration (dots) and from geothermal drilling (triangles).

reflector of another carbonate strata (Purbeck) can be used instead. On some few sections of very good quality certain patterns of seismic reflections (Thomas and Schulz, 2005) can be used to distinguish bedding - from reef facies within the Upper Jurassic (Malm), the latter offering significantly higher permeability.

Interpretation is performed with two approaches: Data from seismic sections are handled in a 2D-GIS in a classic way and it is transferred into 3D-software GOCAD (by Paradigm) with its capacity of 3D-visualisation and analysis.

INTERPRETATION WITH 2D-GIS

2D-interpretation is done with ArcGIS by ESRI. This includes seismic traces and point-sets with TWT-depth of those reflections which are traced at distances of 400 to 500m (CDP). Special attention is set on the appearance of faults (syn- and antithetic). These are marked on the traces within the GIS and are correlated between several traces towards complex fault-networks (figure 2).

Pointsets are interpolated into surfaces with GIS or SURFER by GoldenSoftware with limited respect of faults / discontinuities.

This method is hampered by sometimes poor image quality of these ‚analogue' seismic plots. Sometimes the signals' travel time can't be read exactly and the faults' correct position is ambiguous. In highly fractured zones the interpolation of surfaces has to be done in parts which are manually re-assembled afterwards.

At last, VSP-data of appropriate drillholes allow for depth conversion with an average error of +/- 50m.

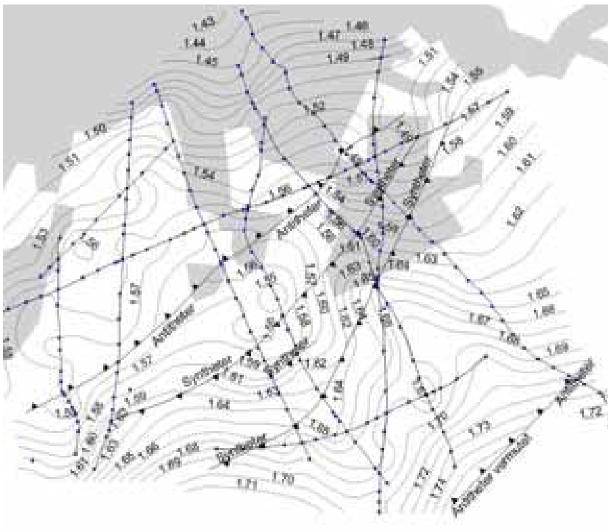

Figure 2 – Detail SE of Munich. Possible interpretation of Lithothamnium-limestone (dots) on seismic lines together with correlation of faults (syn- and anthithetic) by 2D-interpretation, still under discussion. Contours are two-way-time (s) for top of Lithothamnium-limestone.

different versions of fault networks imply the complete re-construction of a model. These various networks are difficult to manage within most 3D-packages, so this task is better done with GIS. The finalization of a fault-network is one of the biggest challenges in modelling (figure 4).

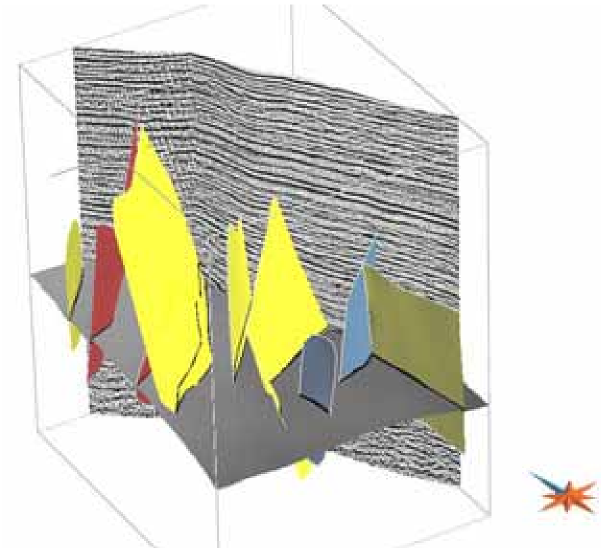

Figure 3 – Detail SE of Munich (same as in fig.2). Interpretation in GOCAD (view from SW, time-domain, 3fold vertical exagg.). Scanned (non-migrated) b/w seismic plot allows for ambigous fault correlation.

INTERPRETATION IN 3D

In order to allow interpretation in 3D with GOCAD all of the seismic paper plots had to be scanned and trimmed. With GIS the seismic traces are attributed with the TWT-depth of the corresponding section. A geoprocessing-model in ArcGIS automatically constructs 3D-datasets for further surface construction in GOCAD. Scanned seismic images are draped on these surfaces by batch-scripting.

There are some advantages by the interpretation in GOCAD which is also performed in time-domain: 3D-sections can be vertically exaggerated that pronounces optically areas of discontinuities (like faults, onlaps, erosions). New digital seismic can be visualized and interpreted simultaneously. Structural correlation between seismic sections is very detailed because of the exact 3D-projection and the access to all neighbouring sections (there is a common interpretation of all relevant data). However, since most of the sections are non-migrated, artefacts and flexures can easily be misinterpreted as faults as well (figure 3).

Software for 3D-modeling normally postulate the exact definition of a certain fault network before surfaces can be fault-modelled. Thus,

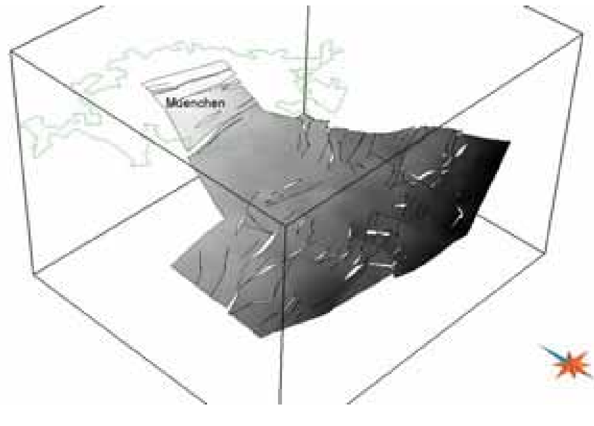

Figure 4 – Current state of fault-network modelling S of Munich. Preliminary version neglecting possible strike-slip faults. Faults trend roughly W-E, top of Lithothamnium-limestone dipping S (view from SW, time-domain, 3fold vertical exag´g.).

Stacking-velocities are provided with most seismic plots and are digitized as 3D-pointset. These are volume-interpolated together with the VSP-data by kriging as well as by GOCAD's built-in interpolation DSI to produce a preliminary velocity model for the conversion of well stratigraphy into time-domain which is preferred during interpretation. After establishing of a structural model the velocity model can be adjusted to stratigraphy and the whole geological model can be depth-converted.

CONCLUSION

General drawback of 2D-interpretation is the huge effort in time for the manual interpretation of hundreds of seismic sections and their digitisation. On the other side, main structures and tectonically relevant fault-systems can be identified and focused on. With GIS several versions of fault-correlations can be managed and easily be modified.
In comparison, 3D-visualization and -interpretation is preferred for its capability of taking all available and relevant data simultaneously into account at a very high level of detail. Surfaces can be rebuilt fairly fast when interpretation has changed. However, the need for early commitment on a specific definition of fault-network during model building still keeps 3D-modelling from being flexible.
The most simple model in a structural sense is achieved by the combination of classic 2D-interpretation with its focus on simple correlations and 3D-visualisation with its graphical strength and real-3D level of detail. Tectonic inconsistencies are highlighted only in 3D.

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MONITORING AIR POLLUTION EFFECT ON THE DETERIORATION OF VEGETATION COVER, USING STATISTICAL METHODS AND TM AND ETM+ IMAGERIES, SARCHESHMEH COPPER COMPLEX, CENTRAL IRAN

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KEY WORDS: Air pollution, NDVI, Statistical evaluation, Vegetation cover deterioration, Iran.

INTRODUCTION

A major cause of vegetation cover deterioration is air pollution. Smelting industry is a well-known air pollutant worldwide. The inflicted damage to vegetation cover is usually monitored using satellite imagery. While it is necessary to characterize the nature of the problem and the ranges of magnitude of effects on the vegetation through field samples it is difficult to determine the geographic extent and locations of the areas affected using conventional methods (woodcock et al. 2000). It is already shown that stress and reduced vitality have some effect on the spectral signature of green plants, generally manifestsed as a decrease in near infrared (NIR) and increase in the visible wavelengths (Jensen 1996). According to Gupta (1991) healthy vegetation normally reflects strongly in the NIR region. The most widely used vegetation index for ecological applications is the Normalized Difference Vegetation Index (NDVI) (Giannico 2007). NDVI is generally expressed by the following formula (Rouse et al. 1974):

$$NDVI = (\rho NIR - \rho R) / (\rho NIR + \rho R)$$

The higher the NDVI values the higher the probability that the corresponding area on the ground has a dense coverage of healthy green vegetation (Campbell 1996).
The main purpose of this paper is to present a method based on simple statistical approaches on NDVI values and bands 3 and 4 data, for investigating the effect of air pollution on vegetation, in Sarcheshmeh sparsely vegetated area. In order to serve this purpose, image descriptive statistics, and modified soil brightness line plot (Richardson and Wiegand 1977) are used.

STUDY AREA

Iran ranks 16th among the world's major copper producers. Sarcheshmeh copper deposit, the largest porphyry copper deposit in Iran is located 160km SW of Kerman city in Kerman Province (Figure 1).

Vegetation cover reflects the climatic conditions of the region ؛ i.e., in low-lying plains vegetation cover is mainly bush and desert plants, while wild almond and pistachio flourish in mountainous areas (Shafiei 2000). According to Shahidi et al. (2007), the region's vegetation density varies between 58.4 and 126.6 bushes per 25 square meters. Although the overall, natural vegetation is relatively sparse, it is fairy concentrated along stream courses and orchards.
Prevailing wind directions based on available meteorological data in the period 1987 to 2000 are NE and N (Sarcheshmeh meteorological station).

SATELLITE DATA

A cloud-free Landsat ETM$^+$ subscene from August 2000 and a somewhat cloudy subscene of TM Landsat from August 1987 over the study area were chosen. The partial cloudiness of TM data did not have any effect on the image processing, as the clouds were covering less than 10 percent of the subscene, mostly south of the open pit. The reason for choosing August imageries was to avoid snow cover and represent the peak of the growing season. Although it was not possible to use anniversary dates to minimize or remove the seasonal sun angle and plant phonological differences (Jensen 1996), the images are close enough to justify the results (table 1). Prior to statistical analysis satellite data were geometrically and atmospherically corrected.

Landsat Mission	Path/Row	Day/month/year
5	160/39	07/08/2000
7	160/39	28/08/1987

Table 1. Landsat TM and ETM imagery acquired

METHODOLIGY

In order to evaluate air pollution effects on vegetation cover in a 14-years period (1987-2000), six windows (50 × 50 pixels each) were selected in different geographical directions (figure 1). Three of the selected windows with varying distances from the smelting plant stacks, were chosen in the direction of the prevailing wind, i.e. North and Northeast. Only one window was selected in the North direction**.**
The reason is acid drainage of the mine which also flows in this direction, making it impossible to differentiate acid mine drainage and polluting emission effects on vegetation.

The fourth window was also selected west of the smelting plant, where the copper city is located. The remaining two windows are selected in SW and E directions.
In order to show NDVI variations in the selected windows, statistical parameters i.e., maximum, minimum, mean, median, standard deviation, first (Q_1) and third (Q_3) quartiles were determined (table 2). All statistical calculations were carried out by S-plus. 6.1.2, and SPSS.10 softwares.

Table 2 presents the calculated statistical parameters for the years 1987 and 2000. All values (except maximums) are negative and close to zero indicating that most pixels display unvegetated surface.
The data for the year 2000 are more negative compared with 1987 data, probably reflecting vegetation loss in the 14 years interval.
Standard deviation (SD) is generally used as a criterion for homogeneity; in this case the smaller the SD, the more homogenous, the NDVI values.
Comparison of windows SD and mean values for the year 1987 and 2000 (table 3) shows that the greatest difference in SD values occurs in N window, where the SD in 2000 is smaller and the mean value is more negative.
First and third quartiles (Q_1 and Q_3) may also be used to compare NDVI values in 1987 and 2000 to avoid comparison of the extreme values, i.e. maximum and minimum.
Table 3 shows that all Q_1 and Q_3 values in 1987 and 2000 are negative and near zero indicating that most NDVI values represent barren soil or rock.
The more negative Q3 values in the year 2000 compared with Q_1 in 1987 emphasizes the fact that vegetation cover (Positive NDVI values) is much reduced in the 14 years interval. The reduced vegetation is more prominent in N, NE_1, and NE_2 windows.

window	Year	Mean	First quartile (Q_1)	Median (Q_2)	Third quartile (Q_3)	Standard deviation (SD)	Max.	Min.
N1	1987	-0.054	-0.098	-0.077	-0.049	0.089	0.503	-0.163
	2000	-0.116	-0.135	-0.12	-0.104	0.029	0.090	-0.190
NE1	1987	-0.58	-0.097	-0.062	-0.044	0.035	0.348	-0.12
	2000	-0.97	-0.116	-0.104	-0.088	0.034	0.261	-0.176
NE2	1987	-0.083	-0.111	-0.102	-0.088	0.064	0.369	-0.151
	2000	-0.117	-0.141	-0.132	-0.119	0.052	0.265	-0.178
W	1987	-0.053	-0.092	-0.076	-0.044	0.080	0.638	-0.191
	2000	-0.071	-0.119	-0.103	-0.070	0.10	0.658	-0.218
SW	1987	-0.064	-0.107	-0.095	-0.078	0.101	0.463	-0.142
	2000	-0.084	-0.123	-0.112	-0.097	0.095	0.503	-0.176
E	1987	-0.062	-0.085	-0.064	-0.048	0.040	0.489	-0.164
	2000	-0.098	-0.121	-0.103	-0.087	0.048	0.428	-0.232

Table 2. Descriptive statistics for selected windows

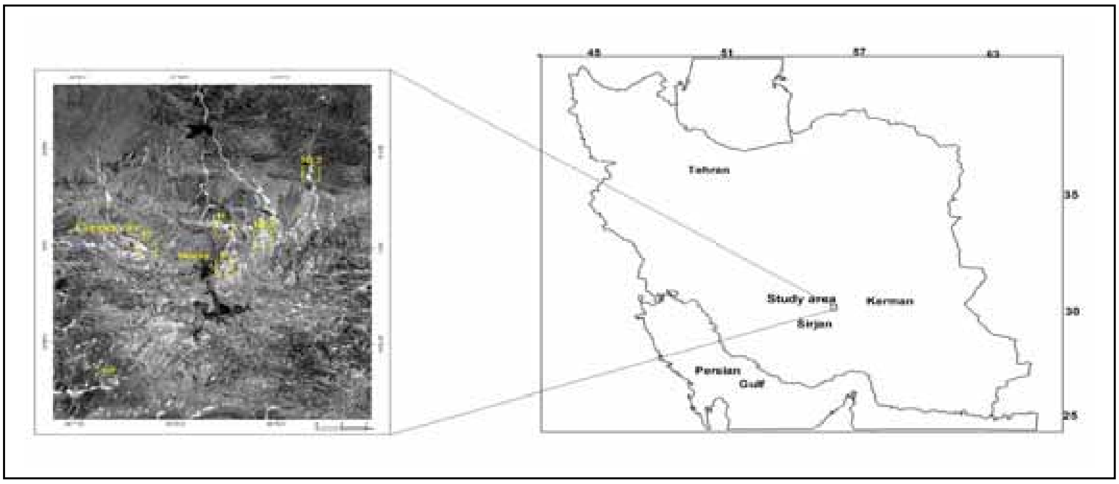

Figure 1. Study area location and selected windows on NDVI image for the year 1987.

Measured reflectance by a sensor often contains soil and vegetation components (Gibson and Power 2000). On a scatter diagram of near-infrared and red band values, soil response will form a more or less straight line. This is the soil brightness line which was first devised by Richardson and Wiegand (1977). The perpendicular distance to the soil line is an indicator of plant development (Jensen 1996). The goal in cluster analysis is to find an optimal grouping for which the observations within each cluster are similar but the clusters are dissimilar.

Plotting bands 3 and 4 data for N-1987 window on a scatter diagram reveals two separate clusters of soil and vegetation (Figure 2). If soil is further divided into wet and dry, then a third cluster will also appear on the scatter plot. Therefore, k-means cluster analysis with 3 clusters on bands 3 and 4 values of selected windows were carried out.

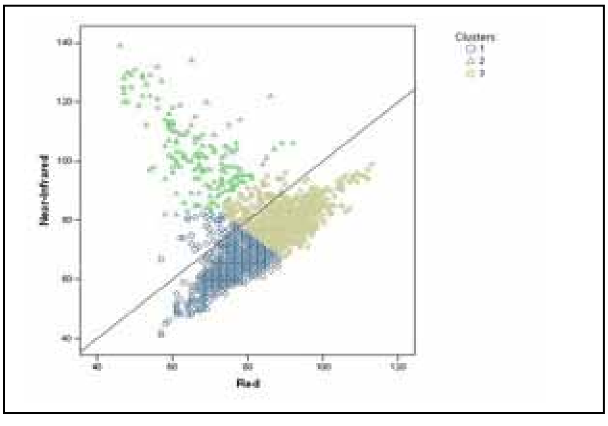

Figure2. Results of k-means cluster analysis using 3 clusters on N window (1987).

Clustering data for different windows showed different results, depend on the status of vegetation and location of windows; i.e. in downwind or upwind direction. For example for NE_1 (1987 and 2000) there are 3 mixed clusters of vegetation and soil data (Figure 3 a-b). The reason is probably lack of dense vegetation in these two years to produce distinct clusters.

Apparently whenever the vegetation cover is healthy and dense, cluster analysis divides the pixel values into three clusters with a distinct vegetation cluster. Hence, in our experience, pixels of healthy vegetation with high spectral reflectance in near-infrared band (high value) and low value in red, and high perpendicular distance to the soil line, form a separate cluster. Thus k-means cluster analysis is a good means of monitoring overall vegetation status.

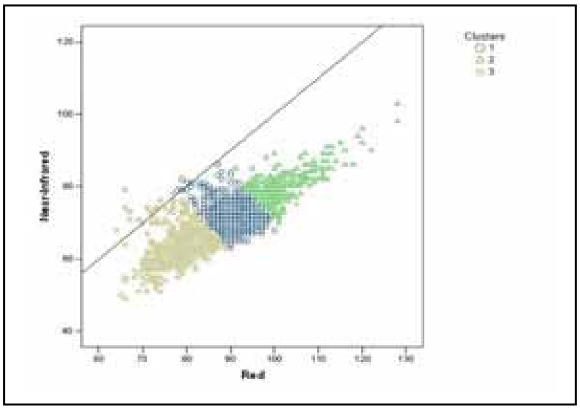

Figure 3a. Results of k-means cluster analysis using 3 clusters on NE1 window (1987).

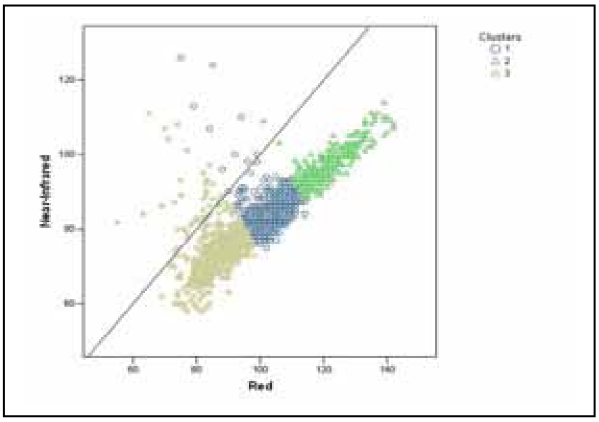

Figure 3b. Results of k-means cluster analysis using 3 clusters on NE1 window (2000).

CONCLUDING REMARKS

NDVI images for the selected windows showed that vegetation deterioration is evident especially in N, NE1, and NE2 windows in the year 2000. This is in agreement with the statistical data and indicates the impact of prevailing wind direction. The coincidence of the inflicted vegetation damage and the prevailing wind direction emphasizes the role played by air pollution than other causes such as draught conditions. A recent study carried out by Lotfian (2007) on lichens in the vicinity of Sarcheshmeh copper complex indicate reduced lichen's chlorophyll contents due to air pollution. The reduction is also more sever northeast of the complex. This study showed that simple statistical methods can be used as a monitoring tool to indicate vegetation cover deterioration even in a region of sparse vegetation, using relatively coarse resolution TM and ETM data. Finally despite many possible perturbing factors upon the NDVI, it remains a valuable quantitative vegetation monitoring tool.

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AIRBORNE GEOPHYSICAL REMOTE SENSING VS. FIELD MAPPING: A STRUCTURAL CASE STUDY FROM THE VILSHOFEN AREA (BAVARIA)

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KEY WORDS: crystalline rocks, Bavarian Forest, Cenozoic sediments, airborne geophysics, structural geology, Danube Fault Zone.

INTRODUCTION

From 2002 to 2007 an intensive geological mapping campaign was carried out in Eastern Bavaria (Fig. 1). These activities were part of an integrated geoscientific mapping project with a detailed geological, hydrogeological and soil survey which was partly supported by regional development funds of the EU.

In the Bavarian Forest more than 20 geological maps at a scale of 1:25,000 were mapped. New information about the different geological units, their stratigraphic classifications, structural elements and stratifications were collected.

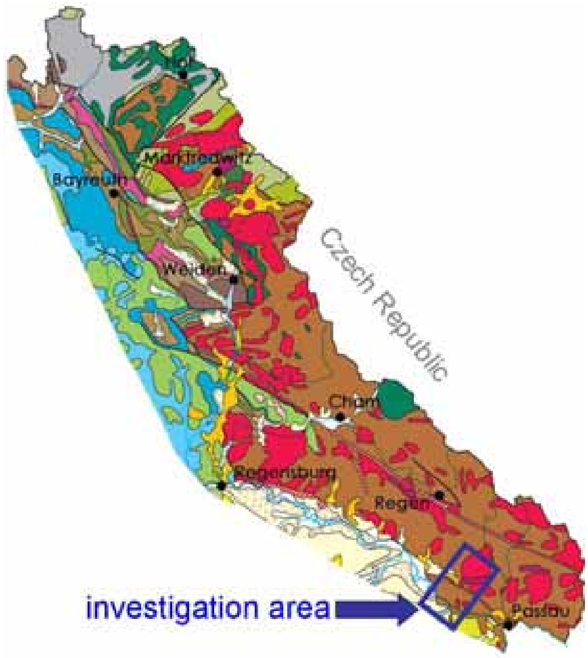

Figure 1 – Target area of the integrated geoscientific mapping project - geological map of East Bavaria with the investigation area for airborne geophysics near Vilshofen (blue rectangle).

In the southern Bavarian Forest the crystalline rocks have partly undergone intensive mechanical and chemical weathering culminating under (sub-) tropical conditions in Mesozoic and Tertiary time. Furthermore, in some areas they were covered by Tertiary sediments.

The area around Vilshofen is characterized by an extensive variegated geology with Quaternary deposits, Tertiary sediments, some small relicts of Jurassic and Cretaceous sediments as well as metamorphic and igneous crystalline rocks. In addition this region has a multistage tectonic history. Therefore it was selected for airborne geophysical measurements. In a 315 km^2 large test area electromagnetics, magnetics, and gamma-ray spectrometry were performed in summer 2007.

In this contribution geological field data are compared with airborne electromagnetic and magnetic data in order to get information about structural implications.

Other results of this airborne geophysical survey accomplished by the Federal Institute for Geosciences and Natural Resources on behalf of the Geological Survey of the Bavarian Environment Agency, e.g. gamma-ray spectroscopy and groundwater based radon activity measurements are described in *Diepolder et al.*, (2009, this volume).

GEOLOGIC OUTLINE

The eastern Bavaria crystalline rocks belong to the western part of the Bohemian Massif. They were formed in the Variscan orogeny in Devonian and Carboniferous times. The migmatic and metamorphic rocks are intruded in Carboniferous time with mainly granitic and subordinately dioritic igneous rocks like the Fürstenstein Pluton in the northern part of the investigation area and further small granitic bodies in the southern area. The precursors of the metamorphic and migmatic rock suites are predominantly metasedimentary rocks like greywackes and pelitic greywackes. In the Vilshofen area there are also a few small marble occurrences. The northwest trending Danube Fault Zone (DFZ) crosscuts the investigation area south of the Fürstenstein Pluton and south of the Hengersberg Tertiary depression. The DFZ is characterized by Variscan mylonitic and Variscan and younger (in Mesozoic and Tertiary times formed) cataclastic rocks. In this area the DFZ is situated several km in the north of the river Danube valley. Southeast of Vilshofen there are small outcrops of Jurassic and Cretaceous rocks which mostly are confined by faults. The Tertiary sediments belong to the Molasse basin and its peripheral zone. The dominant Cenozoic structural elements are north-northwest to north trending and northwest trending faults (Fig. 2).

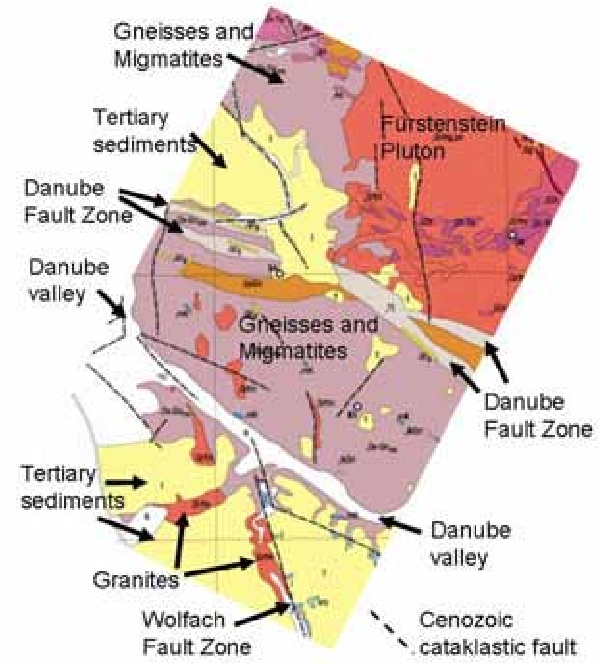

Figure 2 – Geological map of the investigation area (Teipel et al., 2008).

AIRBORNE ELECTROMAGNETIC AND MAGNETIC DATA

The high-resolution helicopter survey was flown in a rectangular area of 22.5 km by 14 km in a compact one-week campaign in July 2007. It was performed along 66 flight lines and 11 tie lines spaced 200-400 m and 2000 m, respectively.

The electromagnetic survey was performed with an active electromagnetic system (RESOLVE) manufactured by Fugro Airborne Surveys that operates at six frequencies ranging from 387 Hz to 133400 Hz. A Geometrics G-822A caesium magnetometer was used to record the total magnetic field intensity. Both systems are housed by a 10 m long tube ("bird") towed about 40 m beneath the helicopter (Fig. 3). Due to safety reasons, the average terrain clearance of the bird was rather high (75 m) in that hilly survey area. Ten records per second at a survey speed of about 150 km/h resulted in measurement intervals of 4 m. Details on the survey system and the data processing are described by Siemon *et al.* (2007).

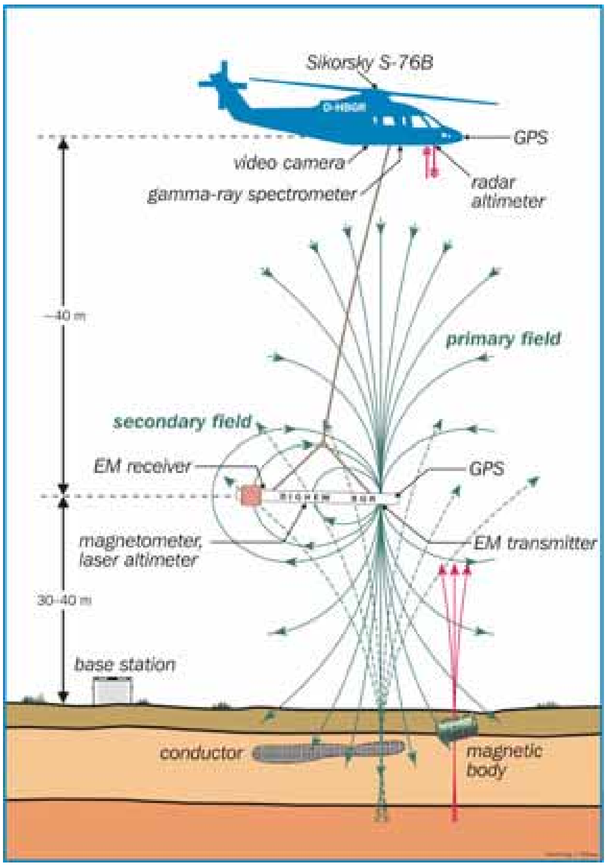

Figure 3 – Helicopter-borne geophysical system.

RESULTS OF AIRBORNE ELECTROMAGNETIC AND MAGNETIC MEASUREMENTS IN COMPARISON WITH FIELD GEOLOGY

For the near-surface lithological differentiation the results of the highest frequency (133400 Hz) electromagnetic data are used (Fig. 4). Generally, the Tertiary sediments and zones of in-situ weathered crystalline rocks are well detected. The sediments of the Hengersberg depression west of the Fürstenstein Pluton, some small Tertiary units north of the Danube and the large Tertiary units south of the Danube can be identified, whereas the identification of structural elements like the DFZ and younger cataclastic zones as well as a differentiation in the crystalline area might not be possible.

Up to now no investigations have been made about the occurrence of graphite (which is interesting for the interpretation of electromagnetic investigations) and magnetic minerals in the different rock units and in the fault zones of this investigation area.

The airborne magnetic survey presents the results for the complex structural signature of this area (Fig. 5). Simple lithological differentiation in the basement units is not possible. The DFZ as mapped in the field is not visible in this dataset. However, the structure should be more complex in the western section of the investigation area than shown on this map. In this zone the anomaly includes the west trending partly metablastic biotite-plagioclase gneisses. Furthermore, the anomalies north of the Danube and south of the DFZ are conspicuous. In this area with gneisses and migmatites, a few small marble bodies are intercalated.

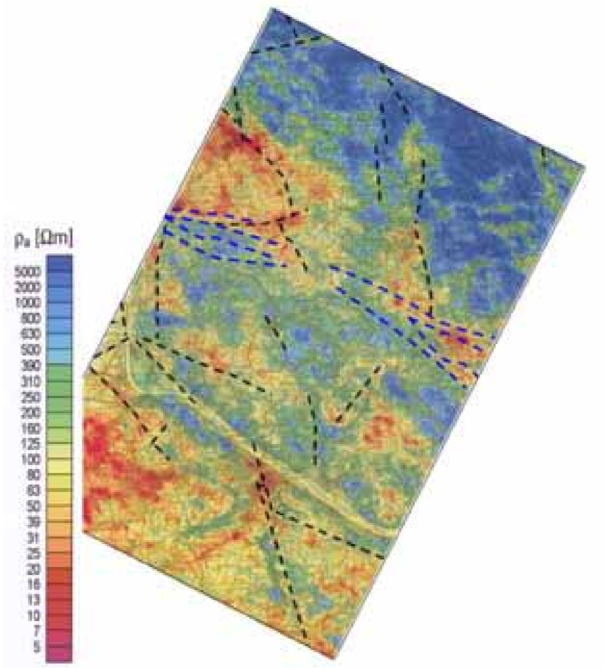

Figure 4 – Results of the airborne electromagnetic survey, frequency: 133400 Hz – near-surface elements, with tectonic elements.

Southeast of Vilshofen a magnetic anomaly occurs in a zone of marble intercalations in gneisses with little magnetite content. For the interpretation of the Cenozoic cataclastic fault network, however, the magnetic survey is not very supportive.

CONCLUSIONS

The geophysical data sets outline structures known from field mapping, as well as cryptic structures which are not easily recognised by simple methods. The pattern in airborne magnetic data shows a complex structure in the crystalline zone around the Danube Fault Zone. Possibly, there are crosscutting northwest and west trending deformation structures, which are well known in other ductile shear zones in the Bavarian Forest.

The electromagnetic and magnetic survey provides new information for the interpretation of the regional field mapping geology. Especially the electromagnetic survey at 133400 Hz provides some valuable new information to the occurrence of Tertiary sediments and in-situ weathered crystalline rocks.

Although further investigations have to be done for detailed interpretation, this investigation shows that additional information about the regional geology can be provided by the airborne gamma-ray data set (Diepolder *et al.*, 2009, this volume) that was simultaneously acquired with the electromagnetic and magnetic data sets.

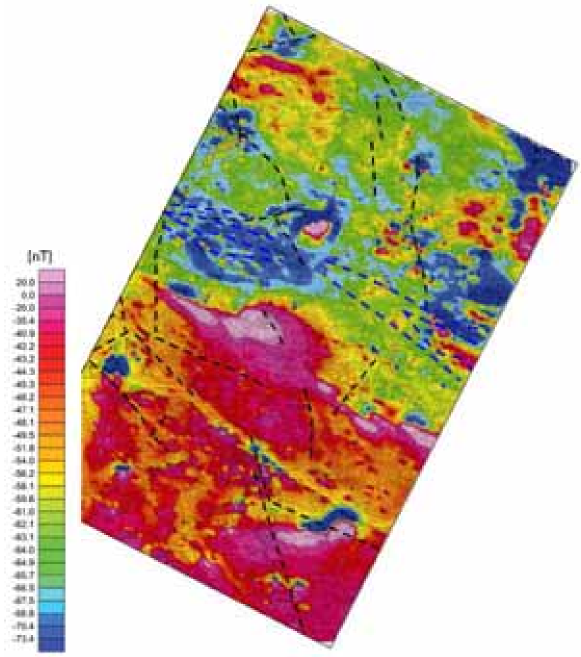

Figure 5 – Results of the airborne magnetic survey with tectonic elements.

ACKNOWLEDGEMENT

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HYDRODYNAMIC AND MIGRATION PARAMETERS OF GRANITE FRACTURES AND INJECTION GROUT AT LABORATORY SCALE

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KEY WORDS: granite, fractures, grouting mixtures.

INTRODUCTION

This work is the part of the research task "Methods and instruments of engineering barriers influence evaluation on remote interactions in the environment of an underground disposal site", which aiming on proposal and verification of the methodical procedures for valuation and prediction of the engineering barrier effectiveness. The basic task of this project is to verify the mathematical model applying ability for the analyses of the processes in fractured hard rock and the prediction of the changes of these processes cost by the application of engineering barrier, based on the clay mixture, into the fractures. Within the wide scope of methods laboratory hydraulic and migration test in granite fractured rock samples are used. The results of these tests yield input data for numerical simulation and at the same time serves to calibrate and verify the model solution.

This contribution is aimed on:

- Basic parameters of the grouting mixtures used to injection of the granite fractures.
- Change of hydrodynamic and migration parameters of granite fractures at laboratory blocks due to injection grout.

BASIC PARAMETERS OF THE GROUTING MIXTURES

During the testing program there were tested some grouting mixtures such as chemical dual-component materials on silica gel basis, dual-component polyurethane organic-mineral resins and clay-cement suspension. There were tested some basic parameters of the grouting mixtures such as viscosity, decantation, bulk density, uniaxial compressive strength and coefficient of hydraulic conductivity.

There were chosen clay-cement suspension to grout the granite fractures. The main reason were its higher hydraulic conductivity and volume stability.

There were tested four different prescriptions of the clay-cement suspensions. The parameters of the different clay-cement suspensions are given in table 1.

Figure 1 – Clay-cement suspensions.

Mixture	Viscosity (min:sec)	Decantation (%)	Bulk density ($kg.m^{-3}$)
3:1	2:07	<5	1221
2:1	0:45	<5	1231
1:1	0:38	<5	1222
1:2	0:31	<5	1227

Table 1 – Parameters of clay-cement suspensions.

The uniaxial compressive strength of the clay-cement suspensions was measured after 7, 14, 28 and 120 days of the ageing process. It rises almost constantly from 0,1 MPa up to 0,7 MPa.

The coefficient of hydraulic conductivity varies from 1×10^{-7} $m.s^{-1}$ (mixture 1:2) up to 1×10^{-9} $m.s^{-1}$ (mixture 3:1).

The clay-cement suspension 1:2 due to its higher coefficient of hydraulic conductivity and higher volume stability was chosen to grout the granite blocks.

HYDRODYNAMIC AND MIGRATION PARAMETERS OF GRANITE FRACTURES

Two blocks of rock with dimensions of 800 × 600 × 300 mm and with the artificial fracture and one cube with dimensions of 600 × 600 × 600 mm and with the natural fracture were tested in the laboratory. Inside artificial fractures the movement of the liquid media was physically simulated in conditions of unfilled fracture or fracture filled with breccia.

In the first step of the laboratory tests the physical and hydrodynamical properties of the fresh rock bore cores without fractures were ascertained.

The second step was to determine hydraulic properties of the tested fracture with the assistance of hydrodynamic and migration tests in the steady state water flow condition. Conservative tracers of NaCl and uranin were used. The tests provided the volumetric flow quantity through these fractures for different sizes of the hydraulic gradient and the complete break-through curves for the tracers with this gradient.

The third step was to measure the hydrodynamic and migration properties after partial grouting of the granite blocks.

RESULTS

The coefficient of hydraulic conductivity of fresh bore cores moves around the 1×10^{-12} $m.s^{-1}$.

The relation between the volumetric flow and hydraulic gradient of the granite fractures before and after grouting was determined.

There were measured and evaluated the break-through curves of different tracers before and after grouting.

The applicability of the use of the fluorescein uranin was ascertained after the grouting of the blocks.

ACKNOWLEDGEMENT

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AUTOMATIC ANALYSIS OF TERRESTRIAL LASER DATA: THE APPLICATION TO A ROCK CLIFFS INSTABILITY IN THE DOLOMITES (EASTERN ALPS- ITALY)

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KEY WORDS: terrestrial laser scanner, rock instabilities, segmentation approach, dip angle, dip direction, plane equation

1. Introduction

Terrestrial laser scanner (TLS) techniques are nowadays a powerful tool to acquire accurate geometrical models of discontinuous rock masses and to detect relative displacements of unstable zones through the use of multi-temporal images. The TLS can be used for deformation and structural analysis, as shown by Teza et al. (2007), and many others. Respect to topographical methods and the traditional “Scan-line” this approach shows higher accuracy and its remote acquisition allows fast and safe surveys. The acquired data are represented by a point cloud, made up by millions of points, each characterized by x, y, z values and by intensity scalars or mapped RGB colourization via photo coupling.

This study concerns the analysis of the geomechanical behaviour of the instable rock cliffs formed by the Cinque Torri group in the Dolomites (Italy). The geomorphology of the area is strongly influenced by the tectonic structures that resulted from the Alpine orogenesis and the geotechnical contrast between lithologies. Several rock cliffs collapses occurred in the area. The most recent one is the fall of the Torre Trephor that happened in June 2004. Among the various pinnacles, the most hazardous is represented by the Torre Inglese, an unstable rock tower of about 7800 m^3 made up by Dolomia Principale, which reaches up to an altitude of about 2275 m a.s.l.

The applied methodology is based on TLS data processing by means of the experimental software Point Cloud Mapper (PCM), (Vosselman, 2004), that allowed automated structural discontinuity analysis of the Torre Inglese.

2. Rock discontinuities evaluation

The method, as explained by Vosselmann (2005) and Slob (2005) has its mathematical basis in the 3D Hough Transform in combination with a Least-Squares evaluation. Its objective consist in the determination of the main geometrical properties of the rock discontinuities, the dip angle and the dip direction. Besides, through the interactive post-processing proposed by Slob (2005), it is possible to obtain other information such as plane dimension and plane equation parameters. This method does not require any surface reconstruction since it uses only the original point cloud data. Therefore it results in a fast – automated analysis, only marginally influenced by vegetation and other sources of error (Slob, 2005).

More specifically, to detect geometrical objects inside the unorganized point cloud a region growing strategy is obtained through the following steps. Firstly, a spatial organization of the original point cloud data is provided through a (Kd) tree-based structure which allows a quick spatial search in the point cloud and therefore the efficiency of the *direct segmentation approach*.

In PCM the 3-D Hough transform is used to select a good set of seed points from the point cloud that forms part of the plane. The seed plane is then “grown” interactively using a spatial search and then the new plane is every time optimized with Least Square (LS) estimation. The product of the segmentation process is a labelled point cloud, where points with the same label are part of the same discontinuity plane.

The LS method operates with a region-growing strategy to assign the equation to mathematically determine each plane. This step provides orientation data of all the planes thus allowing the identification of the main discontinuity sets.

3. Case study

In June 2008 the pinnacle Torre Inglese was surveyed by a Riegl LMS Z420i terrestrial laser scanner, through six acquisitions of about 4 million of points each (Fig. 1).

The average spatial resolution related to the points of the cloud is in the order of 11 cm at 200 m distance.

The TLS point cloud enabled a structural characterization of the rock pinnacle using the PCM software (Fig.2). Five discontinuity sets were discovered, (Fig. 3) among which are the discontinuity sets directly linking to the regional tectonic and the fragmentation of the Cinque Torri

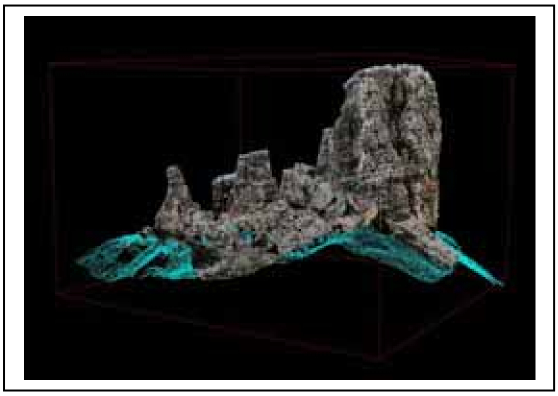

Figure 1. The point cloud data set with the associated RGB values of Cinque Torri (Dolomites, Italy). The Torre Inglese pinnacle is the external one on the left.

group (78°/83°, 258°/49°) and a local systems of fractures that cross almost perpendicularly the stratification(251°/6°).
Moreover, the plane parameters provided by the post -processing of the segmented point cloud allowed a geometrical characterization of each joint family, in terms of normal set spacing, plane centroid and the maximum extends of x, y and z coordinates.

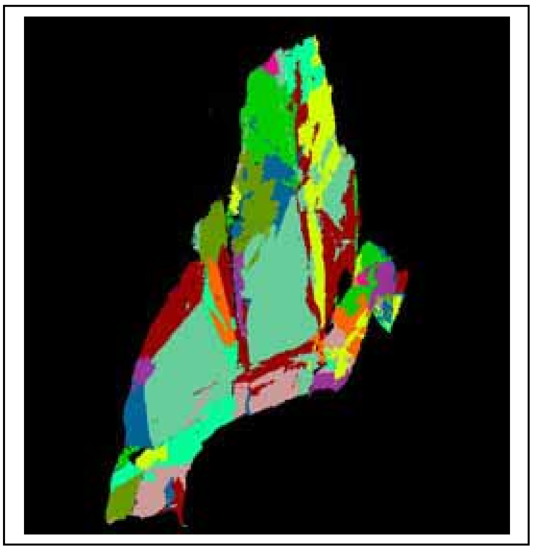

Figure 2. A render view with PCM of the Western side of the Torre Inglese point cloud (Cinque Torri, Italy).

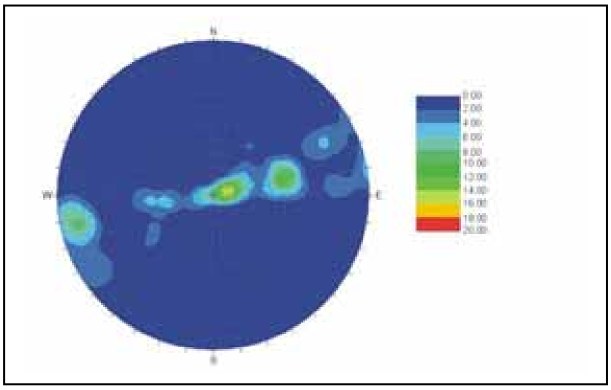

Figure 3. Stereo polar density plot of the segmented point cloud.

4. Conclusions

The approach of this study for accurate structural analysis of an unstable rock body provides the specific parameters needed in rock stability analysis. The TLS methodology combined with the PCM processing and the LS estimation represents a very fast and accurate acquisition of geometrical pattern of the fractured rock tower.
A reliable representation of the potential instability phenomena in terms both of cinematic and geometries is mainly evidenced by a detailed characterization of the rock body discontinuities.
Moreover, the availability of laser scanner data and an almost automated method for their elaboration, results in fast and safe surveys, especially in case of inaccessible and hazardous areas such as the Cinque Torri group.

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Topic – Geohazards

BAVARIA'S SEISMICITY IN HISTORICAL DOCUMENTS

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KEY WORDS: earthquake, historical data, natural hazard, seismicity.

EARTHQUAKES IN BAVARIA

In Bavaria the recording and scientific assessment of earthquakes is principally undertaken by the Department for Geo- and Environmental Sciences at the Ludwigs-Maximilians-University of Munich and the Bavarian Environment Agency (forming together the Bavarian Seismological Service). Instrumental recording of earthquakes in Bavaria began with the Wiechert seismometer in Munich-Bogenhausen 1905. Today the Geophysical Observatory in Fürstenfeldbruck is the data centre for a modern digital seismological network in Bavaria. A list of local Bavarian earthquakes from 1390 until now has been published online under www.erdbeben-in-bayern.de, as well as a list of earthquakes from neighbouring countries, which were felt in Bavaria, from 1970 onwards.

In order to complete the existing data base of historical earthquakes in Bavaria or relevant for Bavaria, the Bavarian Environment Agency has teamed up with the Department of Geography at the University of Munich, which offers expertise in historical assessment of natural hazards (see Barnikel & Becht 2004). The project BASE (Bavaria's Seismicity in Historical Documents), which is currently running in its sixth year, deals with historical written documents and all information about earthquakes relevant for Bavaria stored in them. The first two parts of the project (BASE I and II) dealt with the inclusion of data from already published literature, the current parts (BASE-NET and BASE20) deal with the inclusion of earthquake data from original written documents (letters, postcards, etc.) and the setting up of an internet website to enable interested and informed citizens of Bavaria to contribute to the data base in the future.

EARTHQUAKE DATA BEFORE 1905

In the year 1905 a new Wiechert seismometer was installed in Munich and from that moment onwards the measuring of earthquakes in Bavaria was taken to a new level. The first step of the BASE-project between 2004 and 2006 (BASE I) was the collection and assessment of all relevant publications about earthquakes in Bavaria before 1905. A total of 27 crucial publications over the past two centuries were scrutinized (cf. Barnikel & Geiss 2008). The publications could be found in the Geophysical Observatory in Fürstenfeldbruck (run by the University of Munich), the Library of the Bavarian Geological Survey (now part of the Bavarian Environment Agency) and the State Library of Bavaria in Munich. The data were filed in a specially designed data base, which was modified from the one successfully used in the HANG-project about natural hazards in the Alps (Barnikel 2004). At the end of the assessment a total of 1111 data sets were included in the BASE data base.

A more problematic step was the inclusion of earthquakes mentioned only in *maps* of important publications (especially Sieberg 1940). Those maps are in general quite speculative and only in very few cases specific. But in order to get a complete picture of the seismic situation in Bavaria it was necessary to include events which were shown as relevant for Bavaria in these maps. This resulted in the inclusion of at least 232 different earthquakes (project BASE II).

In addition to that all existing earthquake catalogues with possible relevance for Bavaria were screened (Grünthal 1988, Leydecker 1986ff., Swiss Seismological Service 2002, Shebalin et al. 1998, ZAMG 2006) and the Kövesligethy formula ($I = I_0 - 3 \cdot \log(R/h) - 1,3 \cdot \alpha \cdot (R-h)$) was used to determine the intensity of earthquakes from neighbouring countries. Consequently all earthquakes with a calculated intensity of $I \geq 3$ (with $\alpha = 0,001$) for Bavaria were included.

That added 188 "new" events from Leydecker 1986 (30 of which also appear in Van Gils & Leydecker 1991, 3 of which also appear in Shebalin et al. 1998 and 2 of which also appear in ZAMG 2006), 91 events from Van Gils & Leydecker 1991 (6 events also in Leydecker 1986, 5 events also in ZAMG 2006, 3 events also in Shebalin et al. 1998), nine events from ZAMG 2006 (two parallel entries in Leydecker 1986) and seven events from Leydecker 1998.

In total a number of 1673 references to earthquakes in Bavaria for the time up to 1905 have been collected. For these references date, time, location, quotation, details about the quake itself, damages and other crucial information are listed in the data base. The exceptions are of course those earthquakes which have been extracted from maps, where no further information from within Bavaria could be found. These earthquakes are attributed to their origin outside Bavaria and are listed in the data base under the names of Bavarian cities and towns on the maps.

Earthquakes added from the catalogues for foreign countries or from Leydecker 1986, on the other hand, cannot be attributed to any location in Bavaria. Thus, they are only listed under the name of the Bavarian administrative district, which is closest to the epicentre. For these quakes (and for the ones taken from the maps) it is highly desirable to collect more information. Project BASE-NET (see below) is aiming at this specific problem.

Astonishing enough is the fact that about three quarters of the events themselves, which have been collected so far, could not be linked to a specific date or place from the earthquake catalogues of the surrounding areas, although quite a few quakes must be considered fakes, especially when just mentioned by a few (or only one) sources. Most of these events took place in either Switzerland or Austria, just under 10% in the German state of Baden-Württemberg, the Czech Republic or Italy respectively. The large number of uncertain epicentres for earthquakes felt in Bavaria is nevertheless puzzling, but so is the fact that both, the German and the European catalogue, list a significant different number of German quakes with the same intensity span for the time period up to 1905. The European catalogue mentions 1019 events in Germany before 1906, the German catalogue 1821. (As long as there are such grave differences between the catalogues, every user is forced to establish his own catalogue as we do for Bavaria.)

Those places where earthquakes have definitely been recorded prior to 1905 are shown in figure 1. One can easily see that some large areas in Bavaria have not recorded any earthquakes according to the assessed literature. It is also with respect to these areas that project BASE-NET attempts to collect more information about events hitherto unknown.

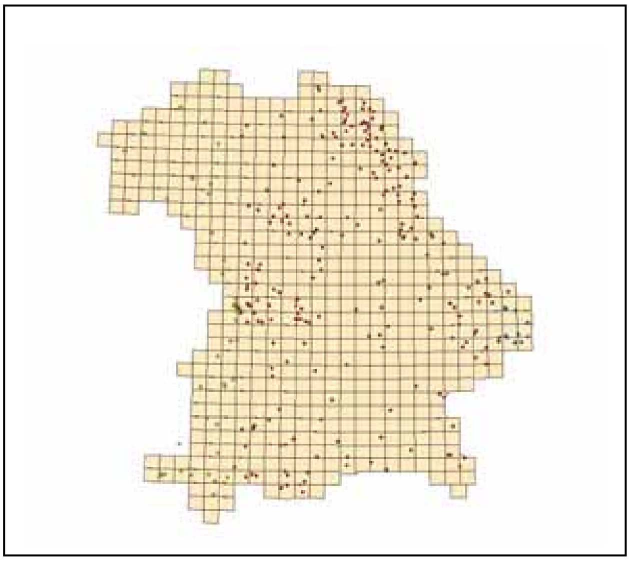

Figure 1 – Locations in Bavaria where earthquakes have been recorded prior to 1905. The coloured dots refer to the different degrees of longitude.

RESULTS FROM BASE I AND II

The old Bavarian earthquake catalogue lists four events from the 14th until the 17th century, the oldest one being the 1390 event in Bad Reichenhall. BASE adds 232 events from the 4th century until the 17th century, the oldest one being a (questionable) quake recorded in Memmingen in 369 AD. The past few centuries are of course much better represented in the data base than the older ones. The renaissance of natural sciences after the 1500s led to a more profound occupation with natural hazards. More people noted earthquakes and reported them. As a not surprising result we have more detailed information about quakes for the past few centuries than for the time before 1500. More than half of all events filed in the BASE-catalogue date back to the 18th and 19th centuries, whereas the 10th and 15th centuries are, astonishingly enough, only sparsely represented.

The next interesting finding is the difference of the geographical distribution of the earthquakes before 1905 and after. Before 1905 most earthquakes felt in Bavaria took place in either the Alps or the northern fringe of the Bohemian Forest. But a surprisingly high number of events happened all over central Europe with no exclusive connection to the more active seismic regions (figure 2). After 1905, as can be seen on www.erdbeben-in-bayern.de, most earthquake events seem to be concentrated in an area around the Alps and the Bohemian Forest respectively (cf.

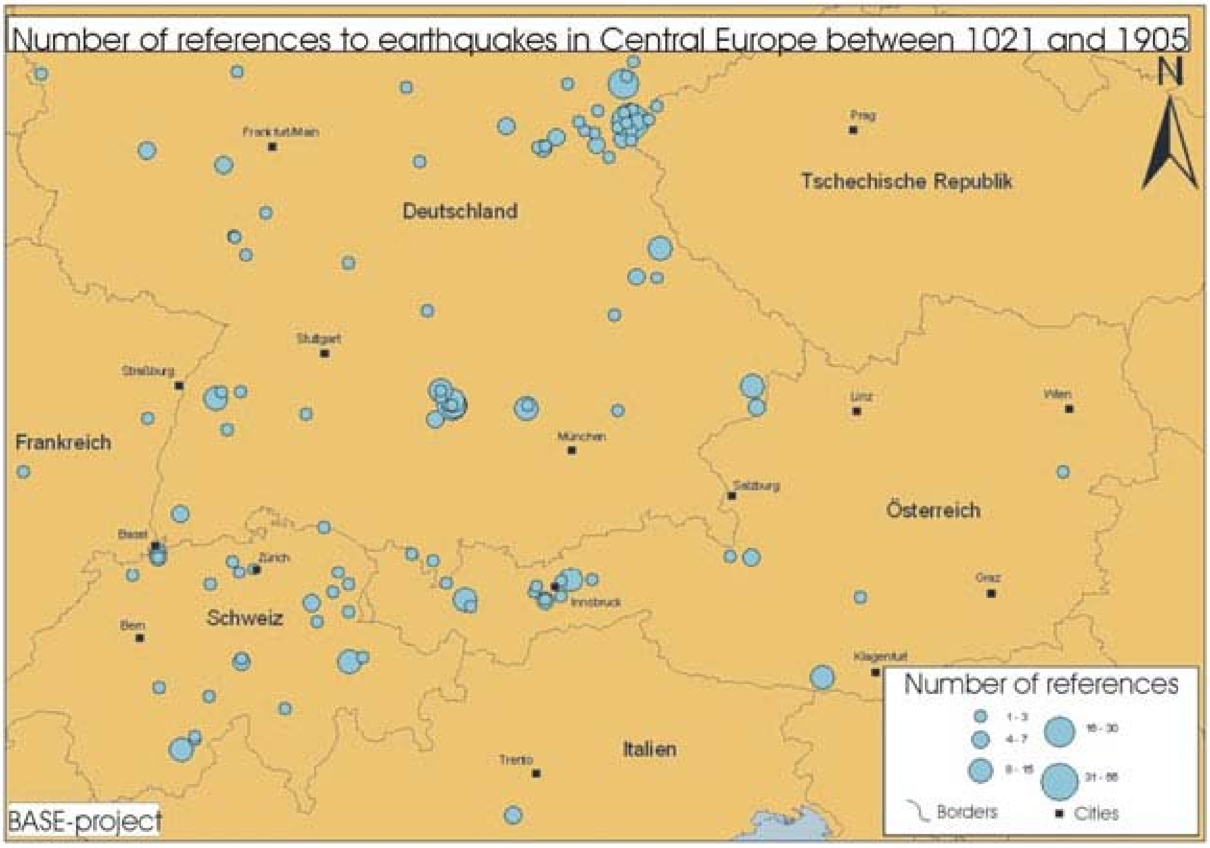

Figure 2 – Number of references to earthquakes in Central Europe between 1021 and 1905. The blue circles show the epicentres of earthquakes which were felt and recorded in Bavaria. The larger the circle diameter, the more references for the earthquake in question could be collected.

Barnikel & Geiss 2008, which compares the two periods).

DISCUSSION

As a result, data from the BASE-project are useful with regard to several aspects:

-The data is compiled in a catalogue which in the future can be accessed by every user through the internet. It is not only a valuable tool for specialists, it also helps the public understand geodynamics better.

-The catalogue can be enlarged and improved by citizens, thus including more man-power in scientific research and showing the public that everybody can contribute to the betterment of science and society, as an open-source project it will be a kind of Web 2.0-try to link science and public (project BASE-NET).

-This step will produce new pieces of information from areas which have not produced earthquake reports so far. Hopefully this will help to judge the tentative records only based on maps or mathematic calculations so far.

-The data will help us to calibrate existing catalogues, especially the Bavarian catalogue, and should serve as a model for the calibration of other existing catalogues.

-The list of known earthquakes will be prolonged significantly and so provide a basis for future risk modelling.

The figure of unknown earthquake-epicentres remains a problem that needs to be solved. The inclusion of data from local archives is, consequently, of utmost importance. The future presentation of the BASE-DB on the web (www.erdbeben-in-bayern.de) is an important step to reach this goal and serves as an example for other catalogues. The inclusion of the original text sources is crucial in this respect, because it allows later adjustment and validation. But a future assimilation of the existing catalogues from the different European countries will also be important. The BASE-project will, in addition to that, collect written data for events after 1905 in a second step (BASE20). A comparison between the written sources, which have already served for large parts of the literature dealing with Bavarian seismicity, and instrumental data from the seismometers may prove useful for the calibration of older written data. Another step should be an examination, how reliability scales could be used to classify the reliability of the historical earthquakes collected by BASE and the implementation of indicative magnitude values could be valuable. In the end the catalogue should then be ready to be used in further scientific studies about earthquakes in southern Germany.

The other step, as mentioned above, will be the inclusion of (validated) contributions made by citizens all over Bavaria who share an interest in earthquakes and have access to local publications or documents which may have been denied wider distribution in journals or other scientific publications and are, therefore, largely unknown.

ACKNOWLEDGEMENTS

We are grateful to the Bavarian Environment Agency for funding the project.

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HAZARD ASSESSMENT STRATEGIES FOR LARGE LANDSLIDES IN THE EMILIA-ROMAGNA REGION (ITALY)

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KEY WORDS: Landslide, hazard, earth flow, translational rock slide, reactivation, Emilia-Romagna, Italy .

LANDSLIDE SUSCEPTIBILITY

In a large portion of Northern Apennines, corresponding to the Emilia sector, the so-called "Argille Scagliose" Formation (mainly Cretaceous in age) represents the main source of landslides, with a high susceptibility value (Landslide Density Index from 20 to 40 %). This type of clayey rocks consists of tectonic or sedimentary melanges (i.e. "*olistostromes*"). From the structural viewpoint, they can be defined as "*bimrocks" (block-in-matrix rocks),* according to literature.

Large ancient earth flows are here quite common. They show a large crown, a relatively narrower middle "channel" -corresponding to the area of flow- and a wide basal fan reaching the valley floor, with a modest slope inclination. The 2.6 km long Morsiano landslide, with sharp hourglass shape, is a typical example (Figure 1, left).

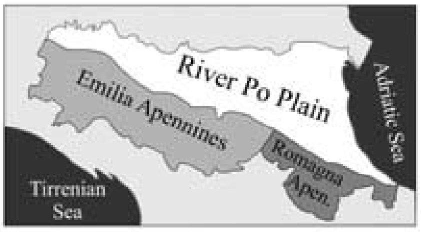

Figure 1: Different landslides such as Morsiano (left) and Roncosole (right) reflect different geological features between Emilia and Romagna Apennines.
Large, sometimes huge, earth flows prevail in the Emilia sector, where the chain is mainly formed by clayey formations (e.g. "Argille Scagliose" Auctt.). In Romagna, well stratified arenites with continuous and gently dipping bedding planes (e.g.: "Marnoso Arenacea Formation") often trigger translational rock slides.

About 10% of them show a thickness exceeding 40 m.

These landslides are the result of multi-phase events occurring over a period of thousands of years through the superimposition of new earth flow

The majority of them originated after the last glacial period and grew during the wettest periods of the Holocene, mainly from 5000 to 2000 years ago (Bertolini, 2007).

In terms of shear strength properties, these materials show a high degree of variability, both spatially and temporally, which is difficult to quantify.

As regards the relationship between morphology and susceptibility, the majority of landslides are concentrated in areas where the slope gradient ranges from 8 to 11°, which is the usual slope angle of "Argille Scagliose" and similar formations.

With the exception of the Marecchia valley, the Romagna sector shows a totally different feature, being mainly formed by arenites such as the "Marnoso Arenacea" Formation, Oligo- Miocene in age.

The Marnoso-Arenacea shows a well layered structure, with persistent bedding planes locally dipping out from the slope. In such conditions, sets of rock strata tend to translate downslope, as exemplified in Figure 1 (right). The surface of sliding develops along thin clayey or/and marly inter-strata.

In synthesis, as a consequence of the stronger bedrock, the Romagna sector is a less susceptible territory, being the Landslide Density Index comprised between 10 and 20 %.

LARGE EARTH FLOWS AS RISK FACTORS

We can consider these landslide bodies as the legacy of former, more conducive climatic periods, but, in spite of their ancient origin, they are still dangerous.

Few earth flows are perpetually active (e.g. the *Lavina di Roncovetro* (Figure 2), while the majority of them alternate periods of activity with periods of dormancy lasting from a year to a century (e.g. the Cervarezza Landslide, Figure 3). Longer periods of dormancy cannot be ruled out *a priori*, because of the lack of historical records.

A comparison of these different behaviours indicates the main problem caused by anthropogenic factors and urban management: the longer the dormancy period, the more people have erected buildings and structures upon the landslide body. If the landslide reactivation occurred more frequently, the more people were aware of the danger and avoided building.

Figure 2 – The permanently active "Lavina di Roncovetro". Photo by Bertolini G., 2006.

Figure 3 – The large, dormant Cervarezza landslide. Photo by Bertolini G., 2005.

ANCIENT EARTH-FLOWS: THE REACTIVATION MECHANISM

A recurring behaviour can be seen in the majority of reactivations of ancient earth flows that have occurred during the last decade (Figure 4).

In many documented or observed events, when a **reactivation** occurs, the movement begins in the source area and migrates through a sliding mechanism towards the toe of the ancient landslide (Bertolini & Pizziolo, 2008).

The scale of deformations and displacement velocities decrease moving from the source sector in the direction of the toe, which is generally the last section of the landslide to reactivate. In the majority of cases, deformation of the ancient landslide is limited to sliding over several or tens of metres towards the valley floor. Complete reactivation by flowing is a rare eventuality, limited to shallow landslides.

In a few cases, the movement led to a significant advancement of the toe (e.g., 28, 56 and 400 metres respectively in the Corniglio, Cerrè Sologno and Cà Lita cases)

In the great majority of cases, the movement comes to a stop in few months.

The Corniglio and Cà Lita cases are an exception: they returned to dormancy, respectively, after about six and four years of activity.

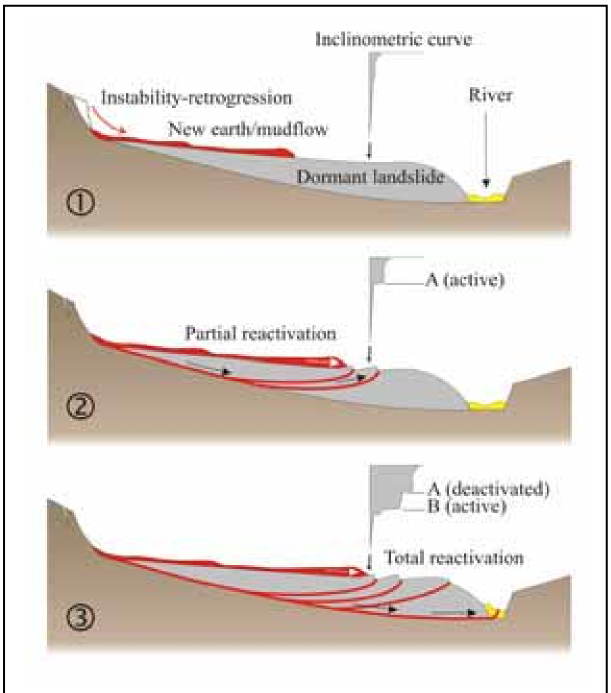

Figure 4 – Reactivation often occurs through recurring behaviour. The inclinometer curve exemplified in the figure shows a "single slip surface" in the phase 2 and a "multiple slip surface" in phase 3. "A" deactivates (relatively) after the trigger of "B"..

CAUSES OF REACTIVATION

Intense and/or prolonged precipitation plays a major role as a triggering factors in reactivating landslide bodies.

Long-lasting rainfalls are the more frequent triggering factors throughout the year, while melting snow cover has particularly effect in the months of March and April.

Seismic triggers have seldom been incontrovertibly identified, however, from a statistical point of view, precipitation is a much more important triggering factor than earthquakes.

RISK-REDUCTION STRATEGIES

Regional-scale cartography

A detailed inventory of these large landslide bodies must to be the first step in order to reduce the risk. In fact, most of them are still recognisable by their geological or morphological features, as far as by historical records.

In Emilia-Romagna, these already existing landslide bodies -and in particular ancient earth-flows- represent almost the whole source of risk: it has been demonstrated that about the 90% of damage caused by landslide activity derives from their reactivation.

A detailed Landslide Inventory Map is the most powerful means of performing ***territorial forecasting*** for urban management plans. The scale of regional survey has to be comprised between 1 to 10.000 and 1 to 5.000. The usefulness of derived thematic cartographies, such as susceptibility, hazard and risk maps, depends substantially from the quality of this source of data.

The use of GIS greatly assists the process of data analysis, but it must not to be a subsitute for the involvement of geothecnical professionals (Fell et al., 2008) and field-survey experts.

Site-specific approach

Uncertainty about geological and hydro-geological parameters minimizes the reliability of deterministic methods (such as stability analyses) for zoning and forecasting purposes.

The main obstacle is the variability in space and time of geomechanical parameters and the continuous changes in pore water pressures brought about by external (precipitation, snow melting) or internal factors (overload, local stresses, nourishment from subsoil waters).

Several studies have attempted to obtain triggering thresholds from real events. Many of these are based on the usual empirical relationship between rainfalls and landslide behaviour.

So far, because of the uncertainty of results, these findings remain of scientific interest but, at the moment, do not find any real application.

The problem is that the relationship between causes and effects is anything but simple. Hidden progressive failures can be in progress for years, withouth superficial evidencies. Internal stresses are continuously changing over time and consequently the same trigger (e.g.: a given amount of rain or snowmelt) can produce different effects from time to time.

Hazard as probability of reactivation

In principle, if a detailed knowledge of past events exists, the site-specific hazard P (related to a given landslide) may be calculated as the inverse of the "recurrence interval" T, defined as the period of time between consecutive reactivations. This can be performed on the basis of many direct and indirect methods: multiple-date aerial photos, previous ground surveys, earth observation techniques (e.g. InSAR), absolute dating (e.g. ^{14}C methods) or review of historical data.

In the regions and countries where old, long-standing administrations (governmental or/and religious) exist, historical records represent the most promising source of data.

This is particularly true in Italy where the public administration usually offers compensation for damage caused by unstable slopes and provides funds for the consolidation of the latter.

Presently, the Emilia-Romagna Region data base contains about 6,600 landslide events pertaining to 4,700 landslide bodies.

However, in practice, even with such an exhaustive data-base, calculating the reactivation frequency for a given landslide can be a frustrating task. These records are influenced by different factors, not always related to the evolution of the landslide activity.

For example, changes in legislation and availability of funds can lead to a proliferation of administrative files and maybe to a degree of exaggeration about the effects of the landslide.

Another problem is related to a natural factor: the extreme variability in time of the length of the dormancy periods for each individual landslide, which is difficult to express with a simple average value.

FINAL REMARKS

A deterministic approach including stability analyses and numerical modelling has a limited forecast function in large, ancient earth flows situated in a complex geological context, as in many Apenninic slopes.

Historical research has proved to be a very effective instrument, but with a limited function for a quantitative hazard assessment, because of the non-periodical behaviour of ancient earth flows. In addition, the time distribution of historical records is often influenced by factors not always related to the evolution of the landslide activity (eg: wars, variability in legislation, demography, financial resources).

Field experience underlines the difficulty in identifying the significant factors of reactivation with their relative importance and in quantifying their triggering thresholds.

In order to minimise the effect of the above cited uncertainties, the hazard assessment of these ancient earth flows should be reached by a site-specific multiple approach, pooling together several elements of evaluation and applying, in particular, detailed observation of field evidence (through ground survey, earth observation methods; preferably surface and sub-surface investigations and monitoring). It is necessary to define with accuracy the landslide perimeter and recognise possible indicators of present movements or situations that could lead to future movements (e.g.: local instabilities in the source area or riverbank erosion at the toe, coalescent landslides);

The landslide spatial impact has to be defined, considering the expected scenario in case of reactivation (e.g. estimation of retrogression, widening and travel distance on the basis of local conditions and previous or analogous events).

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THE ANCONA LANDSLIDE, AN EXAMPLE OF INTEGRATED EARLY WARNING SYSTEM FOR HAZARD EVALUATION

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KEY WORDS: complex composite landslide, early warning system, risk reduction

THE LANDSLIDE EVENT

A large and deep landslide interested on 13th December 1982 the northern area of the Ancona city, the "Montagnolo" hill started to slide towards the sea (Figure 1).

The event involved, about 180 millions of cubic meters of soil and rock; it damaged private houses and strategic buildings and infrastructures, about 3000 people were evacuated. The railway and the main road were blocked, the gas and water supplies were interrupted

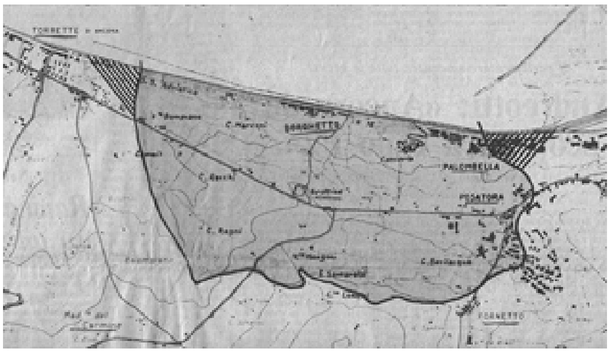

Figure 1: First field map after the event

TIPOLOGY

Taking into account all the researches and investigations during the last 25 years both in site and in laboratory, we can conclude that the Great Landslide of Ancona city is an Deep-seated landslide (complex, composite according to Cruden & Varnes 1996) reactivated after a long period of precipitation; new fractures were opened by a long period of earthquakes 10y before (6 months duration).

The landslide involves clay and silty clay layers (Pliocene-Pleistocene), fractured with different OCR parameter, alternated with thin sand levels.

Overlapped sliding zones are active (maximum depth: 100-120 m, maximum depth 1982 event is 75 m bgl).

Across all the body of the landslide, in horizontal direction, parallel to the coast, there are two natural trenches that cross the slope. These trenches are upstream of old landslides slid down and now they are filled with heterogenic and plastic soils. These soils involves clay and silty clay, mud and thin sand level with some fragments of calcarenitic layers.

These trenches together with a complex structural system of fracture and discontinuity, influenced the system of underground water.

All the geological and geotechnical analyses of the landslide mechanisms aimed at the consolidation preliminary design in the 2000; but this plan concluded that a consolidation was impossible, both due to very large expenses and to a very strong environmental impact, which would have totally changed the site appearance with a severe socio-economical impact.

Ancona Administration decided then to live with the landslide reducing nevertheless the risk for the people living there.

During the last years, some partial interventions of the total preliminary design, for the consolidation stroke, have been made. Two drainages systems were done, one deep based on trenches and wells, and a more superficial one with canals. Reinforced bulkheads were built and in some part of the area reforestations were made.

Ancona Administration decided to continue the drainages systems both superficial and deep.

EARLY WARNING SYSTEM

In 2002 the Regione Marche, promulgated a law specifically for the people living in the landslide, to give Ancona Administration the responsibility of creating an Early Warning System and an Emergency Plan for people. The whole project has the aim both to issue to the population a certification to live safely in their homes and to check the landslide moving.

It is already installed a surface monitoring system based on 7 total stations and 33 geodetic GPS (7 references and 26 monitoring points) integrated recently by a borehole in place geotechnical system based on 3 DMS multiparametric columns installed down to 95 m depth.

Surface monitoring

The surface monitoring system is based on:

• 7 Automatic Robotic Stations (of high precision)

• 230 reflector points (installed partly on the 64 inhabited houses and on the structures and infrastructures)

• 26 geodetic GPS (Global Position System – at single frequency L1 (installed on the 64 inhabited houses)

• 8 geodetic GPS at dual frequency L1+L2 (reference)

• 7 high precision clinometric sensors for the stability control of the main stations of the I and II level of the net (automatic geodetic boxes).

The combination of the different instruments: GPS, Automatic Robotic Stations and the clinometric sensors allows us to monitor in the 3D (3D, X, Y, Z) a great number of points previously identified, to keep them under supervision with different measuring technical and from different control positions. The adoption of the geodetic GPS at dual frequency assure an high quality of the GPS measures, and a greater versatility at all the system.

This monitoring system is studied to try to determine every surface movement both in the area and in the inhabited houses and to produce some alarms managed by a Control Centre H24 placed in the Town Hall, where a staff of technicians have to estimate the alarms. Only whenever the situation requires the Coordinator starts the Civil Protection Plain.

The measuring cycle is set up on 30 minutes, but in emergency or after a long rainy period, the system can operate on every points of the dual frequency GPS net also in Real Time RTK, and with the 7 Automatic Robotic Stations. (Figure 2)

Figure 2 - Surface and in place borehole systems

The surface monitoring is based on GPS system in 3 different active levels, on 7 Automatic Robotic Stations and a later control with 7 high precision clinometric sensors for the stability control of the main stations of the I and II level of the net:

A - GPS system:

1.Main Network (I level active at the moment) formed by n°3 main stations outside of the landslide area with n°3 geodetic GPS at dual frequency L1+L2 (reference) placed on two steady buildings, and a third one placed on a Geodetic box at Marina Dorica founded with a reinforced concrete pole (18 m).

2.Secondary Network (II level active at the moment), formed by n°5 main stations inside of the landslide area with n°5 geodetic GPS at dual frequency L1+L2 (reference) placed on one building and on n°4 Geodetic boxes founded with reiforced concrete poles (12-18 m).

All these geodetic GPS (n°3+n°5) form a high precision net working in the Early-warning system, on different control levels, to assure the GPS net (at single frequency L1), installed on 26 inhabited houses, a strong network; so that after an alarm it can work in real time RTK.

3.Third Network (III level active at the moment) formed by n°26 geodetic GPS at single frequency L1 installed on 26 inhabited houses inside of the landslide area.

B - Automatic Robotic Stations

The Automatic Robotic Stations (n°7 of high precision) are placed in the I and II level networks, in the same places of the geodetic GPS at dual frequency L1+L2, except for the “Collodi school” building. They control (angles and distances) of 230 reflector spots placed on the inhabited buildings left and on the consolidation structures built inside the landslide.

Geotechnical monitoring (DMS)

The in place Geotechnical Monitoring System DMS (patents and trade mark CSG srl -Italy) was installed in February 2009. It is maden by n°3 Modular Dynamic System columns positioned inside borehole 100 m depth.

Each column is formed by n°85 Biaxial Inclinometric modules (range +/-20°, resolution 0,01°), n° 2 Piezometric Sensors (range 100 psi, resolution 0,01 m), n°85 Temperature Sensors (range 0-70°C, resolution 0,1°C) for a total active length of 85 metres with instruments, while the first ten metres and the last five ones are without any instruments. Digital compasses are also on board.

DMS columns have been preassembled and installed in site (Figure 3) with DMS REELER, connecting the required number of modules, each containing one or more geotechnical-geophysical sensors and the electronic boards for data collection and transmission.

The modules are linked by special 2D/3D flexible joints that allow strong, continuous adaptability to bends and twists of the borehole, whilst maintaining rigorously the orientation with respect to a reference system defined during installation.

Figure 3 - DMS installation in place

DMS Early warning management.(Figure 4)

The data from the DMS instrumentation column are sent through RS485 protocol to the control unit, which compares them with threshold values (set by the user) and storages them in a circular buffer.

In case of movements larger than threshold values, the control unit sends a warning SMS/direct call to the staff on duty of the monitoring centre.

The same is the case of rapid change of water-table levels. Warning levels are counted from 1 to 4, in a growing order of danger.

In the monitoring centre, the control software GeoMaster takes care of downloading the data stored in the control unit memory buffer.

The DMS Early Warning is the software that visualizes the subsurface data at the monitoring centre and wherever an Internet connection is possible. The software in a compact check panel allows the contextual control of displacement (E-W, N-S, Module diagrams, on Polar and Azimuthal plots) as well as the variations of the level of the water table and temperature; time history of each multiparametric module, and displacement-velocity are also displayed at selected intervals.

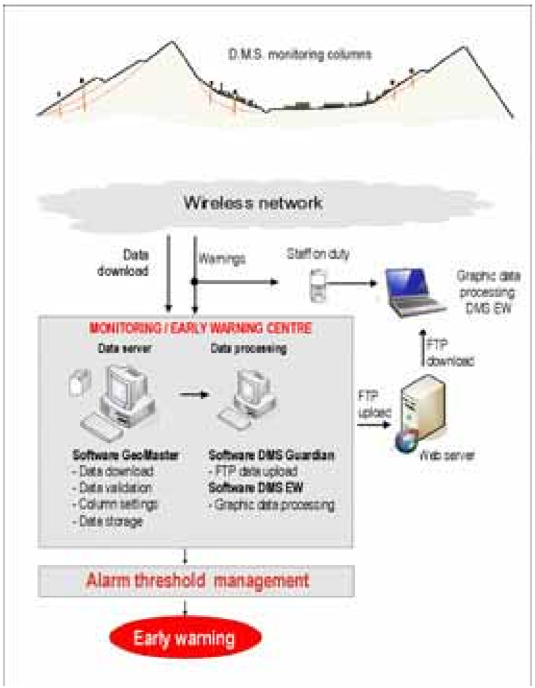

Figure 4 DMS Early Warning managment

TRANSMISSION SYSTEM

The transmitted data coming from different sensors, are collected according to the two following procedures:

a.I and II Level Net: data transmission in real time through a WiFi Standard HyperLan to the Town Monitoring Centre. The system is based on a main radio line (spot to spot) between the Automatic Robotic Stations and the Ancona Municipality Monitoring Centre. Data transmission in real time works through some free frequencies radio links of 5,4 GHz (HyperLan). It realizes a strong transmission and a low environmental impact thanks to their noise controls system.

b.III Level Net and in DMS system: data transmission through periodic GSM in CSD mode.

FIRST MONITORING DATA

After some months of observation and data analisys of the surface monitoring system, apart from any ordinary variations connected to the days and seasons, some little movements have been found.

Some geodetic GPS at single frequency L1 installed on 26 inhabited houses inside the landslide area (third network) have collected movements of 0,5-1,5 cm towards N (slope direction) (Figure 5).

The interested area is where the landslide has the maximum depth (100 – 120 m) and where lots of plastic soils into the two trenches are found.

But the movements examined don’t worry because happen in a restricted area and during seasons changes (summer-winter) when the clay soils loose their humidity and reduce their volume.

These data have permitted to verify the monitoring system sensibility also for what concerns the smallest movements in the colluvial soils.

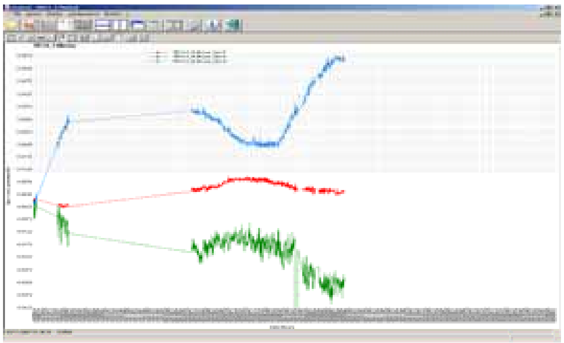

Figure 5: GPS Time history of a movement

In this way, the Ancona Administration has chosen to "live with landslide": a new philosophy that implies that the security for the population is achieved through a high-quality and comprehensive early-warning system that check in real time the landslide hazard taking into account multiple sliding surfaces and surface effects.

This in contrast with the more static concept of standard engineering remediation works, which are clearly impracticable so far, in our case.

This project is the result of the best conjunction between human resources and a more reliable technology in the Early Warning monitoring field, put in use for a best safety and peacefulness for the people living on the Ancona landslide.

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MONITORING INSTABILITY PHENOMENA AT REGIONAL AND LOCAL SCALE WITH RADAR SATELLITE DATA

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KEY WORDS: *remote sensing, landslide, subsidence, reservoir monitoring, Permanent Scatterers, SAR, interferometry.*

ABSTRACT

Permanent Scatterers Interferometry is a precise, cost-effective technology for monitoring surface deformation by means of multiple satellite radar images. Since 2003 it has been used in Emilia Romagna to monitor subsidence phenomena in the city of Bologna, landslides in the Apennines and to map more than 12,000 sqkm of the Padana plain. PSInSAR™ has become a primary tool for many government authorities involved in land management as well as for private companies. Today new satellite missions, such as TerraSAR-X and Cosmo-Skymed, are giving even more perspectives and further enhancing monitoring capabilities.

INTRODUCTION

Permanent Scatterer SAR Interferometry (PSInSAR™) provides high precision measurements of surface deformation by processing satellite radar images.

Thanks to its high resolution, and to the availability of data archives since 1992 (covering most of Europe), PSInSAR™ represents nowadays one of the most powerful techniques for land instability analysis.

PS DATA OVERVIEW

PSInSAR™ is a proprietary technology designed for satellite radar data processing. It allows the user to estimate with high accuracy the displacement occurring to "radar targets", called "Permanent Scatterers" (PS), available within the area of interest. A PS can correspond to both natural (such as rock outcrops or large boulders) and artificial targets (such as buildings, metal or concrete power poles, part of a pipeline, or of a dam) already present on the ground. They have a "constant" electromagnetic behaviour with respect to the radar signal. For all those targets, the displacement time series can be retrieved during the time span covered by satellite images. Due Due to their different nature, PS are widely distributed on the surface with a density that can vary from zero in heavily vegetated areas, to thousands of PS per square kilometres in urban areas.

PSInSAR™ is a multi-scale technology. PS are points of measurement that are singled out using radar images having 100x100km dimensions. Hence it's possible to retrieve information on a single building as well as on wide areas, as shown in the following examples.

Since satellite radar acquisitions are available since the beginning of the nineties, investigations of historical trends can be performed together with the monitoring of recent events.

PSInSAR™ analysis is complentary to conventional surveys and geological and geomorphological studies in performing landslides inventories at regional scale and in monitoring local phenomena year by year.

APPLICATIONS FROM REGIONAL TO LOCAL SCALE

Considering their characteristics, PSInSAR™ data can be successfully exploited to perform both regional and local analyses.

Landslide, subsidence and seismic activity monitoring as well as risk management and safety assessment in urban areas are the main fields of application of the PSInSAR™ technology.

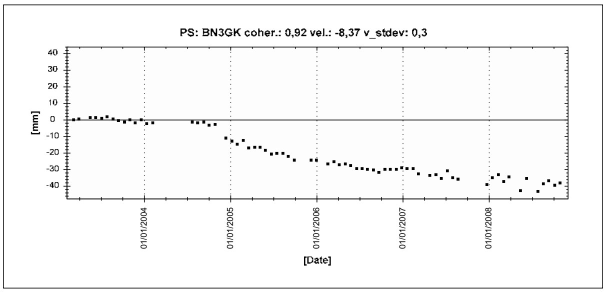

Figure 1: Time series (2003-2008) of the sudden displacement [3,5 cm] occurred to a building close to a tunnel during excavation for a subway station in late 2004.

EMILIA ROMAGNA

In Emilia Romagna, PSInSAR™ data have been used successfully since 2003 for studying urban subsidence occurring in Bologna and slow landslides in the Appennine area. The analysis has been extended later to the whole Padana plain (ca. 12,000 sqkm) in order to highlight natural and man-induced subsidence.

In the former project, the results showed a general stability of the neighbourhoods of Bologna located on the hills surrounding the city, while subsidence phenomena up to 30 [mm/yr], induced by natural compaction or by water withdrawal, occur in the plain.

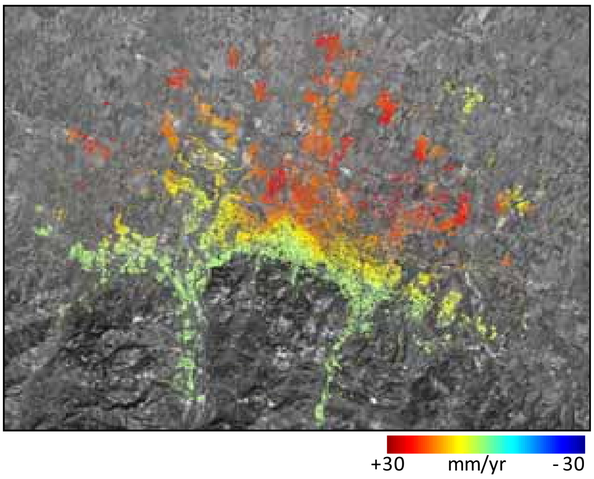

Figure 2: PSInSAR™ analysis over Bologna. Annual PS velocity rate along Line of Sight is shown [mm/yr].

In the latter project, more than 500 radar scenes have been processed. The PS analysis has been carried out at “low-resolution” (i.e. 100 m posting of the information), as the objective was to highlight mainly the regional trends. More than 250,000 PS provided a synoptic view of subsidence phenomena, in particular along the coastal areas, where subsidence is not just a natural phenomenon, but also caused by anthropogenic factors. The results have been compared with spirit levelling surveys carried out in the same period, showing a good agreement and suggesting how these two technologies can be used in synergy for future monitoring projects.

Figure 3: PS coverage of the Emilia Romagna plain using more than 500 radar scenes.

ALPINE REGION

The whole territory of Regione Piemonte (>25,000 sqkm), the Alpine area of Regione Lombardia (>6,000 sqkm) and the whole Regione Valle D’Aosta (>3,000 sqkm) are just some examples of mountainous areas that have been analyzed in order to map landslides.

PS results, compared with the Italian Inventory of Landslides (IFFI), showed that for many phenomena the state of activity can be better defined, as PSInSAR™ supplies quantitative and precise measurements of the displacement (over the sparse PS grid); some landslide boundaries have been reshaped as well as new landslides, impossible to detect with other traditional surveys, have now been detected.

Mapping landslide distribution at a regional scale is traditionally based on geo-morphological analysis, supported by aerial-photo interpretation and field surveys. However, where displacement rate is very low (millimetres to centimetres per year), assessing the activity of a landslide is generally difficult or even impossible without the help of long-term displacement data. This is the case of DGSDs (Deep-seated Gravitational Slope Deformations), which are typically characterized by a succession of long periods of quiescence and reactivation, which can result in large cumulative displacements that can seriously damage structures and infrastructures.

Such a large inventory can help geologist to quickly highlight the most active phenomena and then to plan intervention for risk mitigation using a quantitative and reliable approach.

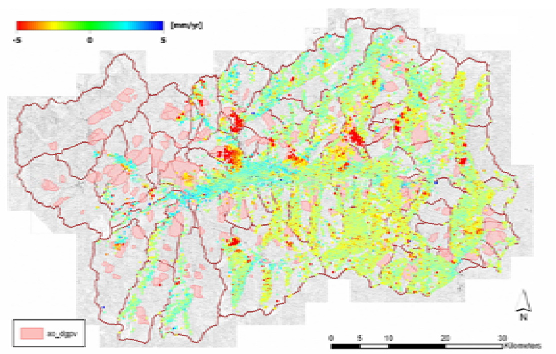

Figure 4: PS distribution and velocity map over the Valle d’Aosta Region (NW Italy). Base map: DGSD perimeters from IFFI Project (Italian Landslide Inventory).

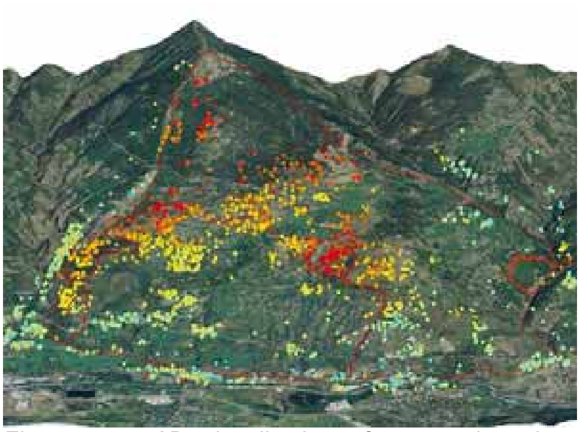

Figure 5: a 3D visualization of a complex slope instability phenomenon in the Alps monitored by PS data.

THE ITALIAN INTERFEROMETRIC DATABASE

In 2008 the Italian Ministry of Environment has awarded a 5,3 mln euro project for creating an interferometric archive of radar data over the whole Italian territory. To the authors' knowledge, this is the only example of a national database worldwide.

More than 12,000 SAR scenes acquired over Italy are being used to create the first database of interferometric information on a national level for mapping unstable areas.

More than 10,000,000 PS are expected to be identified: a unique achievement, considering the extension of the area studied, the resolution and the precision of the analysis.

The availability of such a huge amount of information will provide all the regional governments with an very powerful tool to help the detection and interpretation of natural phenomena, from regional scales to analyses and will probably create the base for new methodologies in the study of landslides and subsidence.

OIL AND GAS

One of the market sectors that is taking more advantage of space geodesy is the Oil&Gas.

For many oil and gas fields PSInSAR™ information can provide useful data about surface deformation caused by hydrocarbon extraction, or injection, and fault reactivation. Reservoir monitoring benefits from the analysis of PS results in combination with microseismic, 3D and 4D seismic, tiltmeters, GPS, and other survey approaches, as each analysis gives information at different spatial and temporal scales. Numerical models can then provide information about reservoir permeability. A better understanding of the complex phenomena occurring to a production field is crucial for both safely enhancing oil recovery and properly mitigating the risk for the environment.

Recently, PSInSAR™ has been also adopted for monitoring surface effects of CO_2 sequestration at the In Salah gas storage site in Algeria, one of the pilot and pioneer project in this field. "*Satellite SAR data has proven highly valuable to monitor subtle mm-scale surface deformation related to subsurface pressure changes caused by injection and production*" (*Ringrose et al. First Break, Jan 2009*).

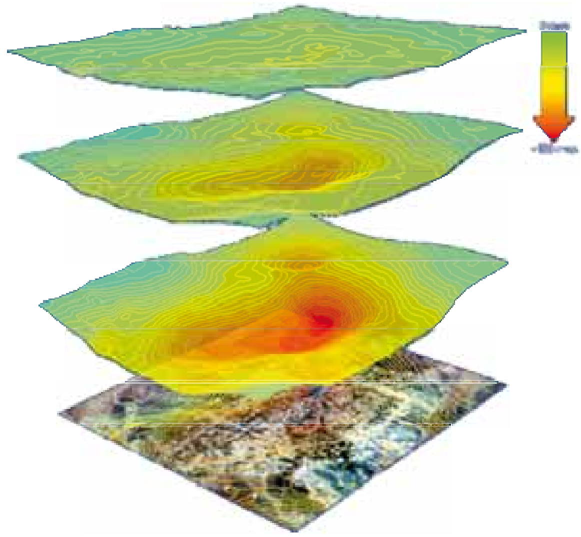

Figure 6: Subsidence effects induced by oil production in a Middel East oil & gas field. More than 100mm detected in about 2-year monitoring project.

OUTLOOK AND FUTURE DEVELOPMENT

Thanks to the results obtained during the last years, PSInSAR™ has eventually become a reliable, trustworthy technology, now commonly adopted as a standard survey tool.

New perspective in the use of radar satellite data are now open with the new SAR missions. The German Terra SAR-X satellite and the Italian constellation Cosmo Sky-Med, both launched in 2007, are now supplying data with an unprecedented density. With a resolution up to 1mx1m on the ground, the PS density in urbanized areas can easily reach values of thousands of points per square kilometres making possible even the monitoring of single parts of a building, maybe affected by differential motion with respect to the others. Moreover, with a revisiting time of 11 and 8 days respectively, new sensors allow even monthly update of the analysis.

Figure 7. Example of coverage density comparison between Radarsat-1and new TerrraSAR-X data. Each dot corresponds to a PS, hence to a point of measurement.

Still a lot has to be done both in Research and Development, as well as in training and dissemination of a risk management culture among government that have to deal with our environment. Only a preventive acquisition policy of radar data carried out today can grant monitoring capabilities in the future.

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FLOODS AND MUDFLOWS ON NOVEMBER 11, 2001 IN BAB EL OUED (ALGIERS)

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KEY WORDS: mudflow - flood - ambient vibrations - H/V - Algeria.

ABSTRACT

Natural hazards in Algeria consist mainly in seismic shakings, floods, and landslides, themselves inducing various geological, geomorphologic and geotechnical secondary hazards, which are very often amplified by the growing urbanization of the phenomena-prone areas. We present the phenomena that occurred in Algeria in the Bab El Oued November 11, 2001 mudflow which claimed several hundred lives. We briefly describe and analyze these natural disasters, and we propose the application of geophysical techniques, such as ambient noise recordings, to help evaluate their extent is proposed.

INTRODUCTION

On November 10, 2001, northern Algeria was hit by a heavy rainstorm, which has been extensively studied (Argence et al., 2006; Hegglin et al., 2004; Kästner, 2003; Santos-Munoz, et al., 2006; Thomas et al., 2003), , affecting 14 wilayas (administrative regions).Damages were reported in 252 cities and villages. However, the Bab El Oued district of Algiers (see location on figures 1) was by far the most damaged zone (figure 3). It has been devastated by sudden cataclysmic floods and mudflows, which claimed over 760 lives, 115 disappeared, 423 wounded, and caused considerable damages to the habitations and infrastructures. The consequences of this dramatic flow, caused by a very localized, heavy, and sudden rainstorm, were amplified by several uphill factors (see distribution and localizations on figures 1 and 2): (1) steep slopes covered by unconsolidated sediments and anthropogenic fillings, (2) heavy degradation of vegetal cover, (3) anarchic urbanization, and (4) the obstruction of the main Lazhar collector.

Figure 1. Detailed map of Algiers area

DESCRIPTION AND ANALYZE OF FLOODS AND MUDFLOWS

Rainfalls in Algiers during the 9-10 November period reached exceptional values at localized areas compared to nearby locations (table 1), to levels never recorded in the past (Behlouli, 2004). The Bouzareah hill, culminating at an elevation of over 400 m, dominating the very densely populated district of Bab El Oued, acted as a topographic barrier, leading to the discharge of the storm clouds on the western and northern slopes of the hill, over a 2 km radius zone only. The maximum rainfall level has been reached on the Bab El Oued watershed (Bouzareah station) with 261.6 mm in less than 24 hours, about 2.25 times the 117.1 mm November monthly average of the 1995-2004 period, while at the same time, for example, at Algiers airport, located about 18 km from the Bouzareah station, the level reached only 9.5 mm (table 1). Unfortunately, thorough information is available at Bouzareah station only. At this station, during the 1911 - 2000 period, daily rainfall over 100 mm was observed only 6 times, with a maximum of 134 mm in 1911. . From both the Galton and Gumbel laws , a return period of about 200 years is expected for a precipitation level such as in 2001 (Issaadi and Ahmane, 2003), thus illustrating the cataclysmic character of these rainfalls.

Mudflow parameters were obtained with the following, commonly used, empirical formulas:

$$Q = V . S \quad (1)$$

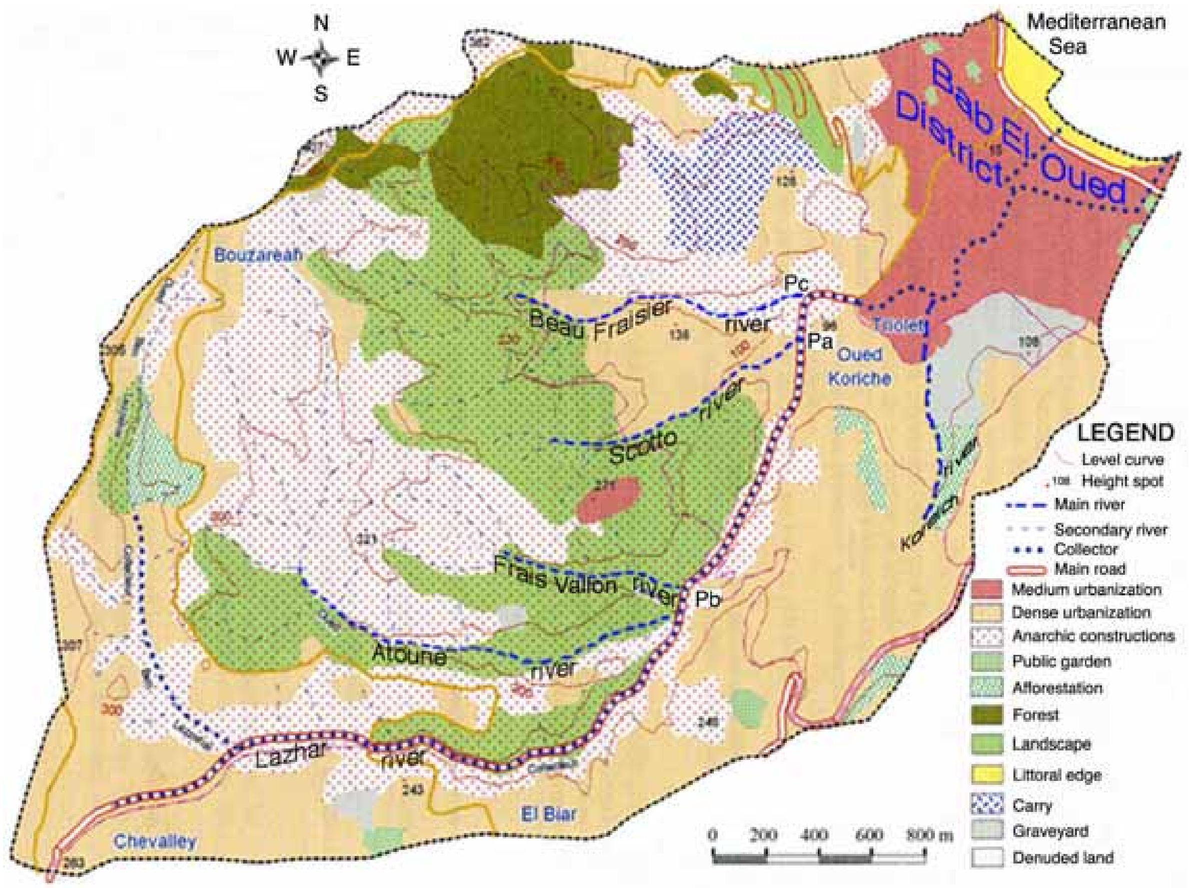

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Figure 2. Land use in the Bab El Oued watershed. Pa, Pb, and Pc symbols indicate the locations where the pictures of figures 3a, 3b, and 3c (Passerelle Scotto, Frais Vallon, and Beau Fraisier, respectively) were taken.

where Q : discharge in m3/s; V : water velocity in m/s; S : wet section in m2.

$$V = 1/n.R^{2/3}.\ I^{1/2} \quad (2)$$

Where n : Manning-Stricker roughness coefficient; R : hydraulic radius in m, with R = S/P, P being the wet perimeter; I : water line slope.

These formulas were applied on the Passerelle Scotto and Triolet sites (see location on **figure 2**) where data of water level, wet section, and slope were available, giving discharges of 143 and 730 m^3/s respectively (**table 2**). For an observed flooding duration of about 2 hours, a total volume of about 2,600,000 m^3 of water has been involved carrying along an empirically estimated 800,000 m^3 of sediments (Issaadi and Ahmane, 2003).

Station	Elevation(m)	Rainfall (mm) 2001/11/09 - 2001/11/10			November monthly average (1995-2004) (mm)
		6 pm to 6 am	6 am to 12 am	12 am to 6 pm	
Bouzareah	344	129.2	132.4	0	117.1
Algiers harbor	3	72	109		n. a.
Birmourad rais	165	78	69.4	21	130
Staoueli	122	0	135		n. a.
Algiers airport	24	8.1	1.4	0	93

Table 1. Rainfall records at stations located in the Algiers area on 9-10 November 2001 and the monthly November average records of the 1995-2004 period. Note the drastic difference between the 24 hour record at Bouzareah and the monthly average as well with the nearby station of Algiers airport.

Site	Water Level (m)	Wet section (m²)	Water Velocity (m/s)	Discharge (m^3/s)
Passerelle Scotto	2.2	37	3.87	143
Triolet	2.45	113	6.47	731

Table 2. Water level and flood discharge (obtained with the velocity and wet section values) at Passerelle

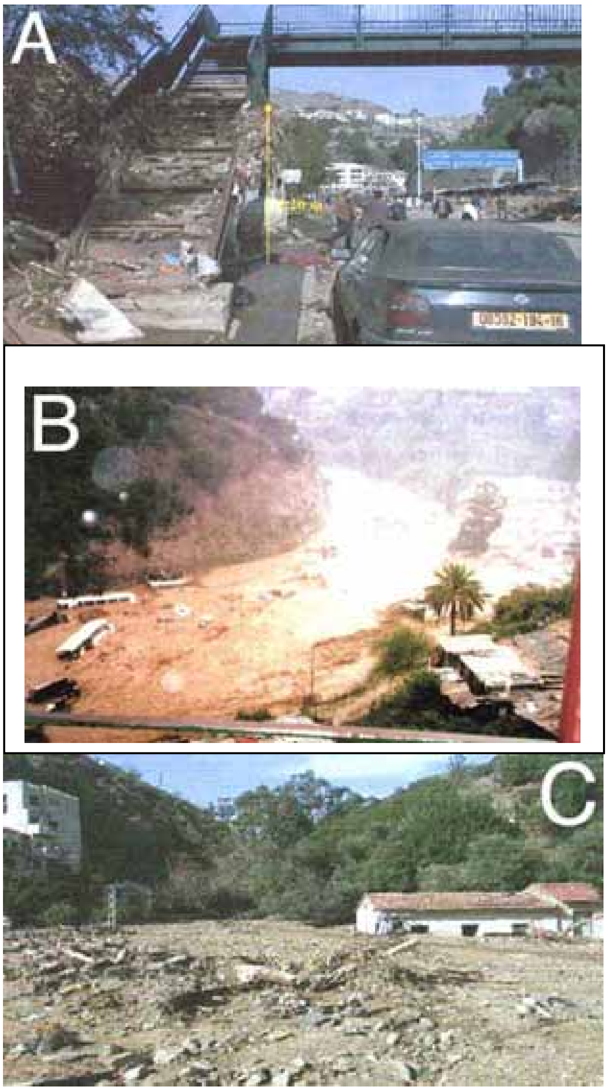

Figure 3. (a) Trace of water level at Passerelle Scotto, (b) mud torrent in Frais Vallon, (c) 5-meter thick sediment deposits at in Beau Fraisier. Locations where the pictures were taken are indicated by Pa, Pb, and Pc symbols, respectively, in figure 2.

H/V ambient vibration (noise) method test at Bab El Oued to estimate mudflow extent and mud thickness

The H/V-noise method is now widely used to estimate site effect parameters (fundamental frequency and sometimes the associated soil amplification), and many surveys using this technique have provided convincing results (see Bard, 1999, for a review; SESAME, 2004).This method is based on the recording of ambient vibrations (noise) with a 3-component (Vertical and 2 Horizontal) seismometer, during 10-15 minutes, at each point of the site under investigation. The spectral ratio of each component is calculated in 30-second time windows and then averaged over the entire record length. Finally, the averaged spectrum of the Vertical component is divided by the quadratic mean of the two Horizontal averaged spectra, hence the name of the method. At the frequency of S-waves resonance in the soil surficial layer (f0), a peak is observed on the H/V curve, which amplitude depends strongly on the impedance contrast between the surficial layer and the under-laying bedrock. For a detailed description of the method, see SESAME (2004).

Data processing was performed using the dedicated Geopsy software (for a detailed description of the procedure see www.geopsy.org)

In order to test the possibility of using this method for the determination of the side extension and thickness of mudflows, we applied it to the Bab El Oued mudflow, over which we performed ambient noise recordings at several points.

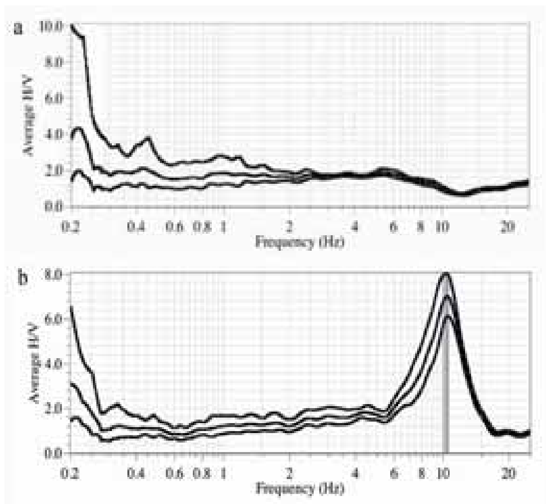

Figure 4. H/V curves obtained on a rock site next to the mud flood (a) and on top of the mud layer (b). In each graph, the central curve represents the average H/V and the upper and lower ones represent H/V plus and minus standard deviation respectively. The two greyed areas around f0 in (b) represent the central frequency standard deviation.

For example, results from two points located (1) on rock next to the mud flood and (2) on top of the mud layer (figure 4), show a flat H/V curve and a curve with a marked 10-11 Hz peak respectively. The 10-11 Hz peak is taken as representative of the mood behavior, which is agreement with the observations and results from borehole data obtained next to our recording points, giving a 5-meter mud thickness (H) with a

220 m/s S-wave velocity (Vs) (ongoing Algiers microzoning unpublished data), i.e., using the formula f0=Vs/4H, a frequency of 11 Hz. It is therefore possible to determine whether a site as been covered by mud (H/V peak) or not (flat H/V curve), which is not always obvious to observe several years after the event. Considering that Vs in the mud has a relatively stable value, by multiplying recording points over the zone affected by the flow it is expected to get varying f0 values, thus allowing a precise mapping of the extension of the flow and of the mud layer thickness. As the first tests performed over the Bab El Oued mudflow were conclusive, a complete survey of the zone is planned in the next future.

Discussion and Conclusion

The heavy precipitations that fell on the steep slopes of the Bab el Oued catchment produced a torrential flow in the discharge system and the heavily urbanized site of Bab el Oued. The damages were amplified by the large volume of torn-off sediments and anthropogenic fillings, which, among other ways, followed the main road, constructed in the former Bab el Oued (literally, door of the river) river, during the urbanization of this area at the beginning of the last century. The lessons learned from the Bab El Oued mudflow, highlight the importance of (1) precise weather forecast, (2) identification of historical events of the same type and their scale evaluation, and (3) better risk assessment, including a solid information and education of people living in disaster-prone areas, in order to prevent, or at least to minimize the consequences of such disasters. The H/V method test shows that it might be likely to be used on historical mudflows to evaluate their extent and the mud thickness. We are currently testing this method more thoroughly on the Bab El Oued mudflow.

Considerable work remains to be undertaken in Algeria in order to decrease the damages induced by natural disasters. The majority of damages due to natural disasters in Algeria are mainly due to the lack of hazards studies and the establishment of risk maps, as well as to the non-application of recommendations from existing studies. Former risk studies should be revisited, and future ones should strongly be directed towards risk management, and their application should be more thoroughly followed. Also, research works s should be much more encouraged, particularly through the use of up-to-date methods to better estimate the extend of such natural disasters.

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LARGE WATER LEVEL CHANGES AND THEIR INFLUENCE ON SLOPE STABILITY AND REACTIVATION OF LANDSLIDES IN THE THREE GORGES RESERVOIR, P. R. CHINA

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KEY WORDS: Landslides; Slope Stability; Water Level Changes; Three Gorges Reservoir; P. R. China.

INTRODUCTION

Dam sites have many advantages (especially production of power). On the other hand they also significantly influence the hydrological conditions and hence the slope stability in the reservoir area. Generally, the average ground water level in the whole reservoir area rises. Below the water table, mean normal stress is reduced by hydraulic pressure to effective normal stress (cf. Fig. 1). Thus, the reservoir water level increase decreases the stability and the factor of safety of the slopes. This can trigger new mass movements or reactivate dormant mass movements.

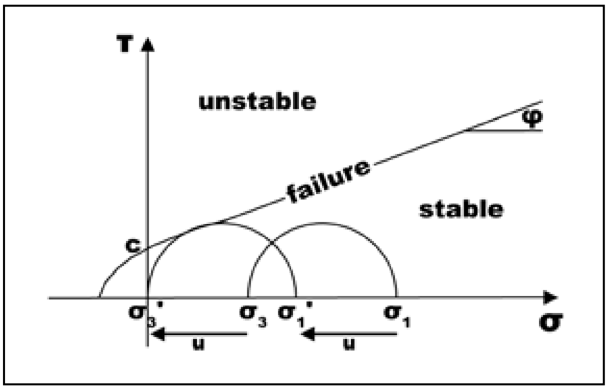

Figure 1 – Mohr-Coulomb failure criterion. The two Mohr's Circles illustrate the influence of (ground) water level and pore water pressure increase on slope stability. σ: normal stress; τ: shear stress; σ_1: maximum principal stress; σ_3: minimum principal stress; $\sigma - u = \sigma'$: effective normal stress; u: pore water pressure; c: cohesion; φ: friction angle.

Not only impoundment but also rapid draw down in the reservoir can trigger mass movements. In low permeable soil or rocks it takes long until the ground water level is adjusted to the new hydrological conditions. Until the steady state is reached the ground water level is higher and the downward water flow reduces the effective stress furthermore.

The largest newly built reservoir is the Three Gorges Reservoir (P. R. China) that almost reached its maximum design water level in November 2008. This paper summarizes and explains the main effects of reservoir water level changes on slope stability and presents some results of investigations on mass movements in the Three Gorges Area that were started in summer 2008. The objective of this German-Chinese joint project is to investigate the stability of selected dormant mass movements and other sites taking the annual reservoir water level changes into account.

MECHANICAL BACKGROUND

Simplified, the mechanical situation of the slopes near reservoirs can be divided into 4 different states (cf. Fig. 2):

a) before the impoundment: low reservoir water level and low ground water level (steady conditions): (minor) flow force parallel to the (shear) plane increases downhill force => stable;

b) after the end of the impoundment: high reservoir water level but ground water level still low and rising (transient conditions): upward directed flow force (especially at the toe of the slope) increases mainly the downhill-slope force and decreases normal force and hence frictional force => not stable;

c) before the draw down: high reservoir water level and high ground water level (steady conditions): (minor) flow force parallel to the (shear) plane increases downhill force => stable;

d) after the end of the draw down: low reservoir water level but ground water level still high and falling (transient conditions): major downward directed flow force increases mainly the downhill-slope force (and less normal force and hence frictional force) => not stable.

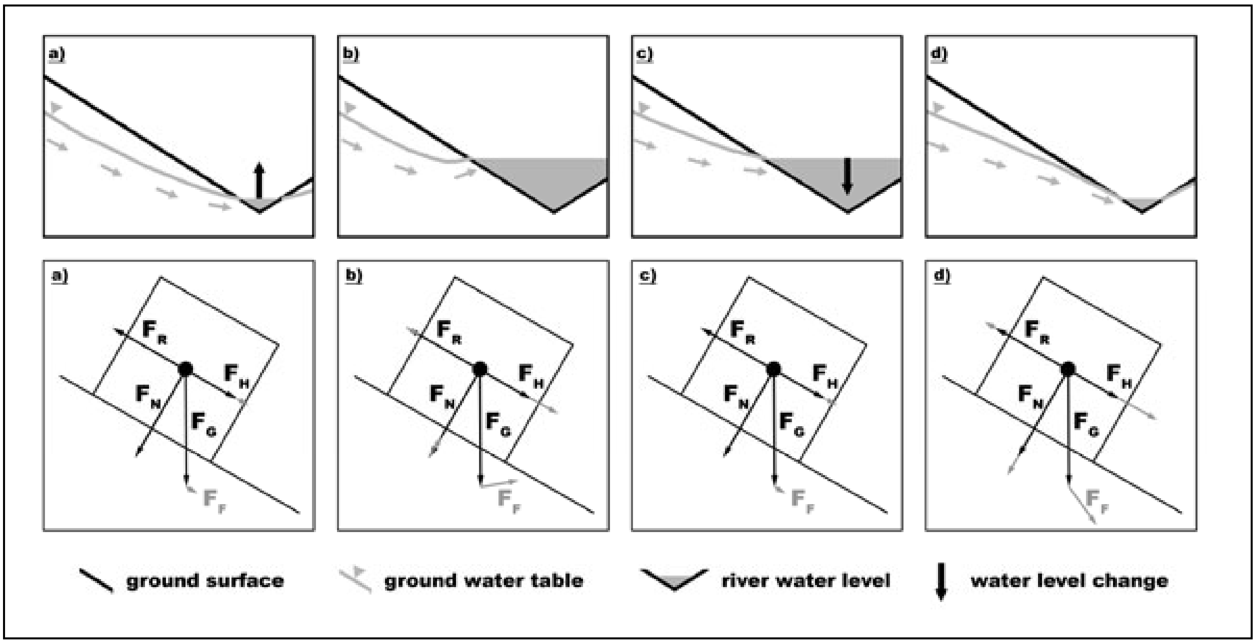

Figure 2 – Ground water flow directions and corresponding equilibrium of forces on an inclined (shear) plane for different reservoir water levels in the course of one year. F_G: Gravitational force, F_H: Downhill-slope force, F_N: Normal force perpendicular to plane, F_R: Frictional force of inclined plane (proportional to F_N), F_F: Flow force.

THREE GORGES RESERVOIR / XIANGXI CATCHMENT

The Three Gorges Reservoir (P. R. China) covers an area of about 1085 km² and has a total storage capacity of 39.3 km³. So far, the reservoir water level in November 2008 reached the first time 172.3 m above sea level, which is about 80 m higher than before the construction of the Three Gorges Dam. In the course of one year the (design) reservoir water level will vary by 30 m. The reservoir water level will reach its maximum in October/November and will be high till January, when the demand for energy increases and the amount of water that has to be discharged exceeds the amount of water supplied by the Yangtze River and its tributaries. In May and June it will be lowered further to make use of the total flood control capacity during the rainy season in summer (cf. Fig. 3).

The first impoundment took place in summer 2003 and shortly after the water level was raised by 40 m many slopes in the Three Gorges Reservoir along the Yangtze River and his tributaries began to deform and a number of mass movements occurred newly or were reactivated (e. g. Wang, Zhang et al. 2004; Wang, Wang et al. 2005). The most prominent ones are the Shuping Landslide along the Yangtze River (Wang, Zhang et al. 2008) and the Qianjiangping Landslide along the Qinghan He River (Wang, Zhang et al. 2008).

To investigate the landslide susceptibility in the Three Gorges Reservoir many studies have been carried out. Most of them focussed on the slopes of the Yangtze River but excluded the tributaries (e. g. Liu, Mason et al. 2004; Fourniadis, Liu et al. 2006; Fourniadis and Liu 2007; Wen, Aydin et al. 2007). Therefore, in our project the main focus lies on the catchment of the Xiangxi River, a northern tributary of the Yangtze River about 50 km upstream of the Three Gorges Dam (cf. Fig. 4). This area was chosen as most of the formations outcropping in the reservoir area can be found in the Xiangxi Catchment. Furthermore, the mouth of the Xiangxi River is relatively close to the Three Gorges Dam so that the impact of the impoundment is distinctive

Within the three year duration of this project that started in 2008 we map the geotechnical situation in detail (1:5.000) to produce a landslide inventory map displaying (a) distribution of the different types of hard and soft rocks, (b) location and activity of landslides, and (c) location and orientation of scarps. Furthermore, we perform geotechnical and soil mechanical analyses in the laboratory with samples from all formations.

Combined with remote sensing data (especially elevation and land use data) these data will be used as input for Neural Network Analyses to detect the areas which have a medium to high landslide susceptibility.

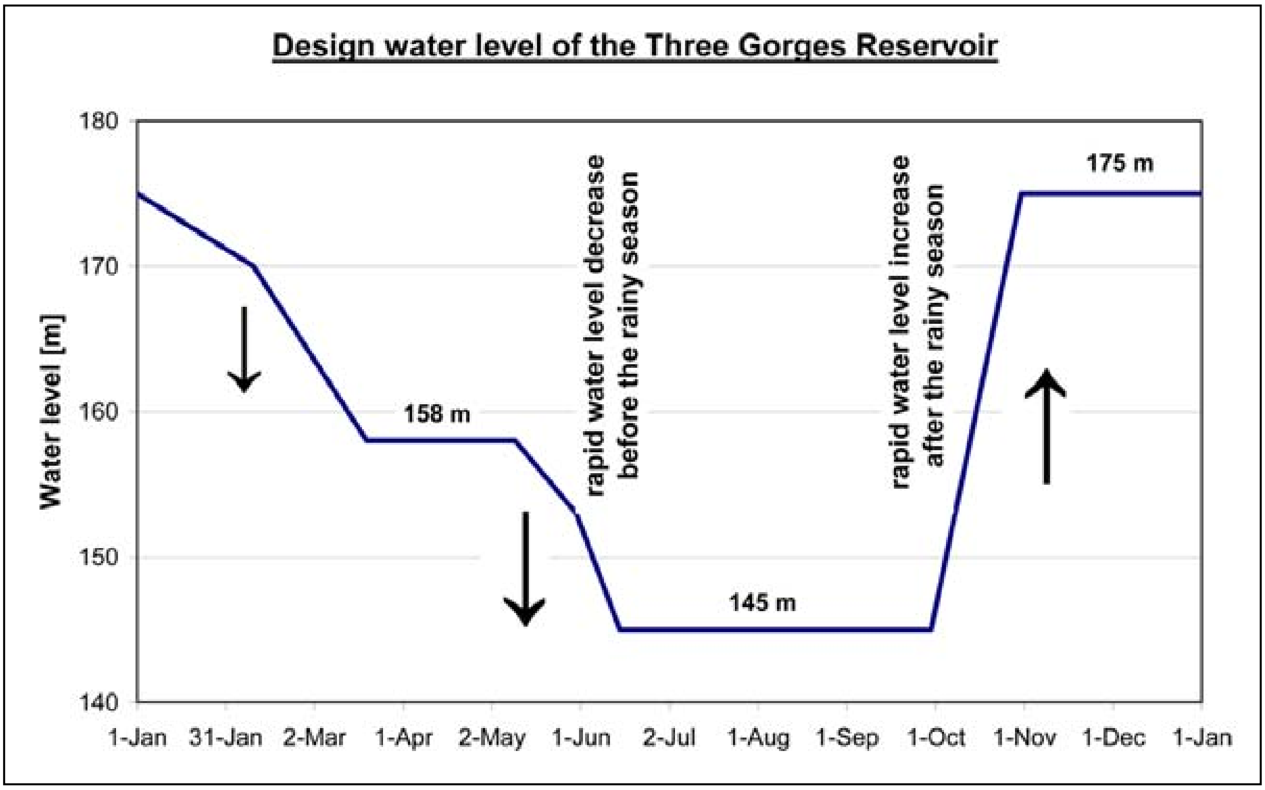

Figure 3 – Design reservoir water level of the Three Gorges Reservoir (average year). Before the construction of the Three Gorges Dam the water level was at about 95 m.

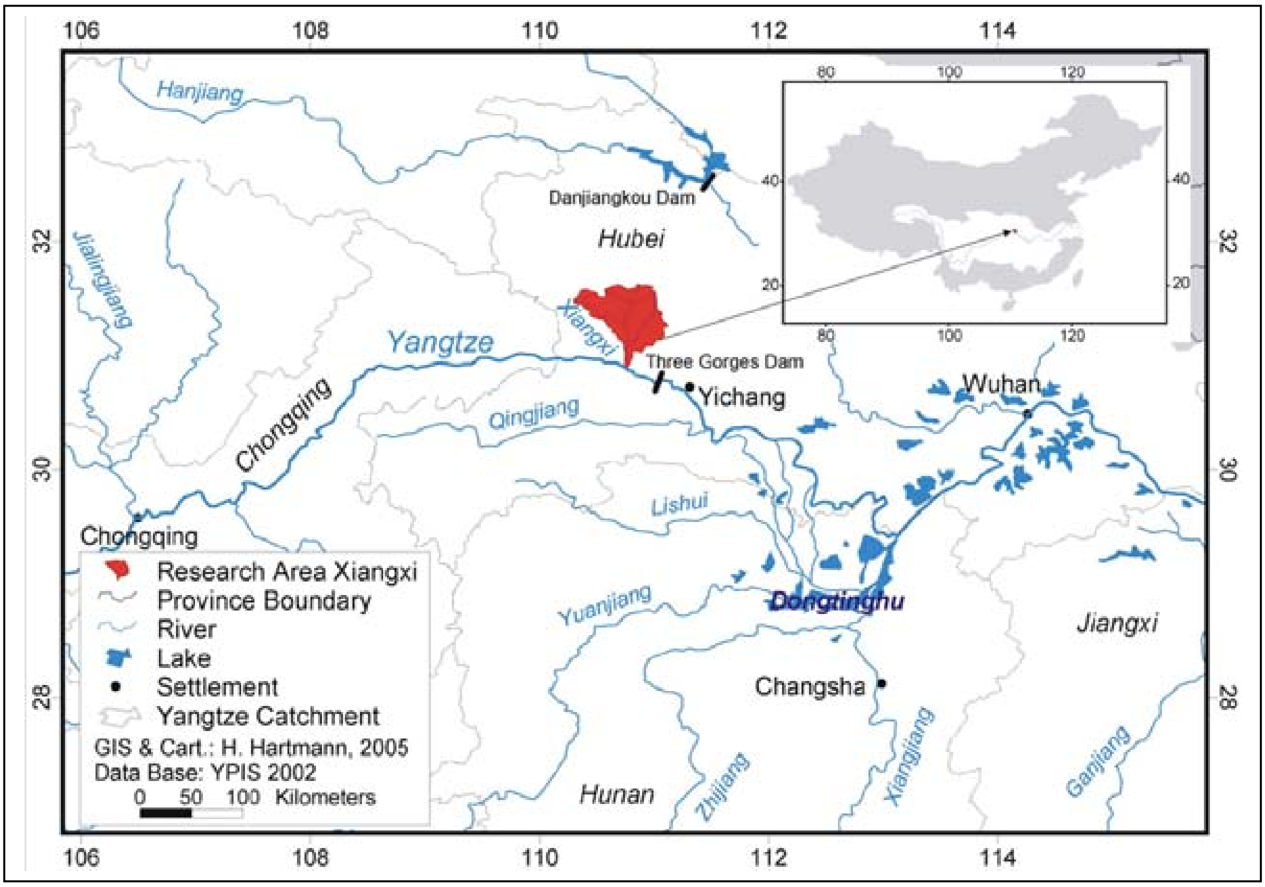

Figure 4 – Location of the Xiangxi Catchment (red), which is the research area of this project.

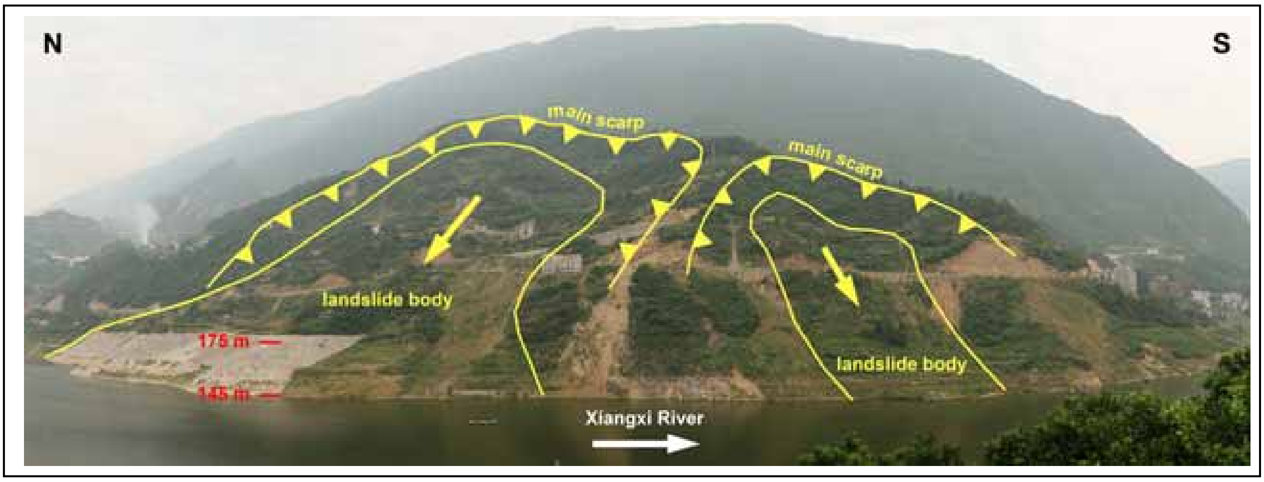

Figure 5 – Two big landslides upstream Xiakou Town. The southern landslide is inactive but can be reactivated. The northern landside is currently slowly moving and thus was partly treated to prevent bank erosion at the toe.

Figure 6 – Inactive landslide near Xiakou Town (water level 155 m). The landslide body was partly stabilised by concrete piles near the buildings.

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SINKHOLES FORMATION HAZARDS, CASE STUDY: SINKHOLES HAZARD IN HAMADAN PLAIN AND THE LAR VALLEY OF IRAN

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Abstract: The Sinkholes formation causes many problems in urban area and other region. The case study of this research is Hamadan plain and the Lar valley sinkholes. The research methodology contains review of geology, structural geology, hydrogeological conditions, study of sinkholes situation, and their characteristics. The most important characteristics of sinkholes studied in this effect on their formation and its occurred or probable hazard. There are 39 sinkholes in different size in Hamadan plain, northwest of Iran and 9 sinkholes in Lar valley north of Iran. The results of the research shows that the sinkholes are formed in carbonate bed rocks and these rocks are covered by alluvial in Hamadan plain and Lake Sediment in the Lar valley. Major hazards of sinkholes in Hamadan plain and Lar valley are farmland and irrigation system damage, groundwater pump stations damages, risk in electrical power generators; water well mud increasing, water well collapse and uncontrollable discharge of dam reservoir.

KEY WORDS: Sinkholes formation, their Hazards.

Introduction:

The scope covered by this study includes two areas in the north of Iran (Lar Valley) and the Hamedan Plain in the northwest of Iran (Fig 1), where numerous sinkholes have been formed, creating a number of problems and risks. In the Lar Valley 9 old and young sinkholes have been formed in the lake's sediments. In some areas of the Hamedan Plain, which expands over an area of 2450 km2, 33 sinkholes have taken shape during a period of 12 years.

There have been a number of research and studies on the creation of sinkholes. The results of some studies are presented below:

The sinkholes are formed in one of the two following manners (Markoo 1998):

1-Movement and discharge of surface materials from top layers along solution channels developed in basal carbonated rocks.

2-The collapse of upper rocky layers on large caves formed in the carbonated bedrock.

At least 140 sinkholes were formed from 1961 to 1986 in Orlando in USA (William 1992).

During a series of research, parameters such as depletion of ground waters, oil and gas explorations, the movement of rocks during mine Operations and the drainage of marshes are the main causes for sinkhole formation (Pewe, 1990 and Waltham, 1989). The model proposed by Waltham (1989) described the different types of sinkholes and their specifications in karstic and non-karstic soils. The different types of sinkholes according to Ford et al (1989) classification have been described and their shaping conditions have been divided in three main groups. According to Benson et al (2003)'s assessments the risk of sinkholes in each region have been divided as low risk, medium risk and high risk areas. Barry et al (1991), Colshow et al (1987) and Waltham (1989) have divided the sinkholes in 4 groups, explaining the underlying reason as the existence of carbonated rocks beneath the covering sediments. The tectonic conditions of Hamedan, their impact on sinkhole formation and the location of sinkholes along faults of carbonated rocks were described by Saadati (2003). The fault's crush zones and the high speed of carbonated rocks' decomposition in Hamedan Plain were considered by Haydari (2003) as the main causes of sinkhole formation.

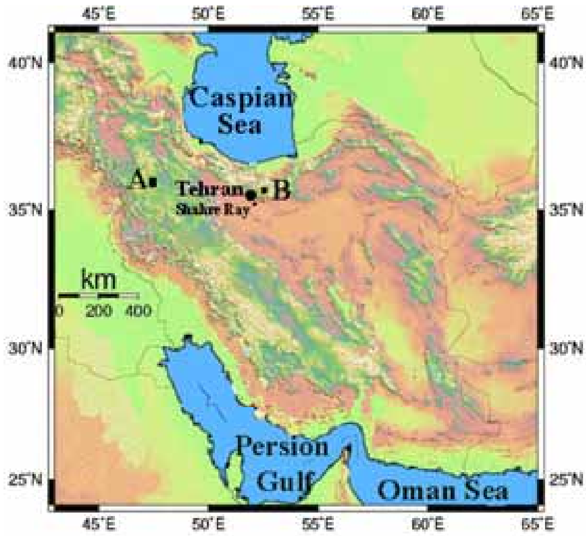

Figure1- The map of Iran and situation of Hamadan plain in northwest (A) and the Lar region in north (B).

The geological specifications of the bedrock in Hamedan Plain such as sand discharge and gas emission from the wells and rapid depletion of the ground waters point out to occurrence of sinkholes (Amiri, 2003).

The occurrence of sinkholes in the region of Lar Dam and their location in relation to the faults have

been described (Khorsandi, 2003). Moreover, studies have shown the location of the sinkhole as being the result of fault activity and a method to prove the active state of faults has been proposed based on the location of sinkholes (Khorsandi, 2007).
The zoning map of sinkholes risk in the region of the dam and their hazards were also presented in the context of enhancing the dam's safety (Amir Hosseini, 1998).
The methodology of this research includes the geologic studies of the Hamedan Plain and the Lar Dam, their geological structure, the review of hydrological conditions, the study of sinkholes and their specifications and their eventual risks.
The results show that occurrence of sinkholes in Hamedan Plain was hazardous for the following cases, sometimes resulting in damages and destructions:
Rural and urban areas
Agricultural lands
Irrigation systems
Pumping stations
Power stations
Turbid well waters
Collapse of structures and buildings
Induced earthquake
Soil instability around structures
In the region of the Lar Dam, the occurrence of sinkholes depicts the escape of water from the lake and the karstic phenomena beneath the dam's lake and body, jeopardizing the dam's stability.

Geology and geological structure:

The oldest geological formation in the margin of the Hamedan Plain includes the rotation of Jurassic – Mesozoic sandstone, shale, limestone and slate deposits with some variations showing in some areas.
The Cretaceous includes the shale and lime marl deposits, and in the basal sections bulk orbitolin limes (K1 andK2) are observed.(Fig2)
In the Cenozoic, the basal Miocene deposits include lime and marl and in some areas marl and lime marl (Qm) with abundance of nomolith fossils. In some cases these deposits form the plain's bedrock, with its lime and lime marl layers showing karstic specifications.
In the Quaternary the old and young alluvial deposits (Q) of 50 to 150 m have covered the Hamedan Plain.
The geological structure of the Hamedan Plain has endured numerous phases from Jurassic to Quaternary, and the last phase of orogenic Alpine has caused the slope and folding of the Cenozoic deposits creating the current shape. The folded

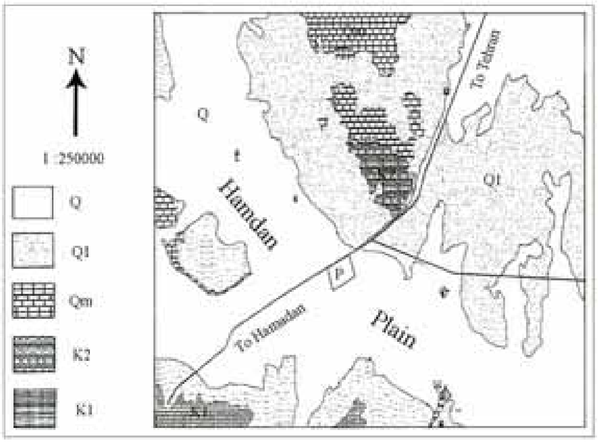

Figure2- Hamdan plain geological map

plains of Hamedan Plain are on a NW-SE direction and have been broken and moved by faults.
There is probably a buried fault in the Hamedan Plain extending to about 25 km, which has been determined by geophysical data and boreholes, in the lime bedrock. This was the path of the old Quaternary River, and currently the thickest alluvium has been measured on this fault. Some studies have shown the crush zone as effective in the formation of sinkholes (Saadati, 2003).
The geology in the area of Lar Dam includes outcrops of shale, sandstones, siltstone Jurassic conglomerates (Js), Jurassic limestone (Jl) and the Cretaceous limestone arête (Kt), which have outcrops on either side of the area. The thickness of the formations is larger to the south (Fig3).

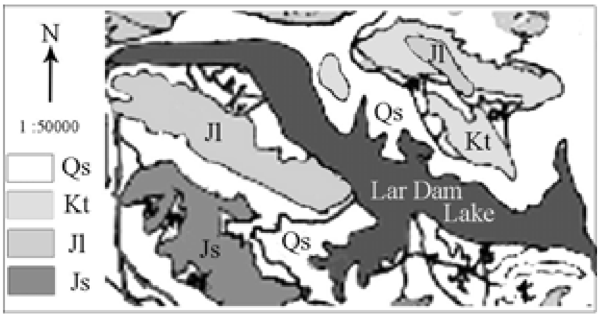

Figure3- The Lar valley geological map(After khorsandi2007)

The tuff, shale tuff and volcanic rocks (Et) are located after these with andesite rocks and pleio-quaternary (Qa) lava of the Damavand Volcano observed to the north and northeast of the area. In the Quaternary, lake deposits (Qs) of maximum 100 m in thickness were formed on the lime bed of Lar, with sinkholes shaping in them.
The geological structure of the Lar Dam region includes a syncline, to the south of which an overthrust fault has caused the drift of Jurassic geological formations on Cretaceous. To the northeast there is a number of lake faults, which continue on to the bedrock, with sinkholes formed along some faults (Fig4).

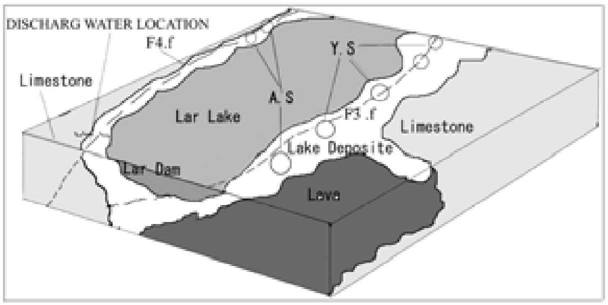

Figure 4- Schematic digram of Lar valley sinkholes and faults. A.S is old and Y.S is young sinkhol. (After khorsandi2007)

Review of hydrological conditions:

The sources of water for agricultural and industrial activities and the potable water of the residential areas of Hamedan Plain are ground waters available in the alluvium. The average thickness of the alluvium is estimated to be 100 m.

The depth of groundwater reaches down to a maximum of 20 and a minimum of 10 m, and the direction of its flow is from northwest to southeast. During a 10-year period the groundwater table has dropped by about 10 to 13 m, causing the dryness of wells in some areas and the collapse of the bed until inside the lime bedrock, resulting in intake of water from the lime bedrock.

In some of the mentioned wells, the volume of CO_2 in water is reported to be exceeding the natural limits (Amiri, 2003).

Based on available witnesses and documentations in the region of Lar Dam the groundwater is observed as pressurized and free. The groundwater is under pressure, depicting a pressurized aquifer of 100 m in thickness in the deposited materials. The groundwater in the zone next to the dam, the groundwater is observed as unconfined in the lake deposits, having no hydraulic connection with the dam's lake.

The specifications of sinkholes:

During a period of 15 years (from 1989 to 2004) around 32 sinkholes of various sizes were formed in the Hamedan Plain, which are located at different sites.

The diameters of the sinkholes vary between 2 and 100 m while their depths are between 1 and 60 m. The largest number of sinkholes is observed in the southern areas of the Plain. These are collapse sinkholes, while in other areas they are of subsidence sinkhole and Ponor type.

In the region of Lar Dam, 9 old and young sinkholes were formed in the alluvium and the lake deposits (Fig5).

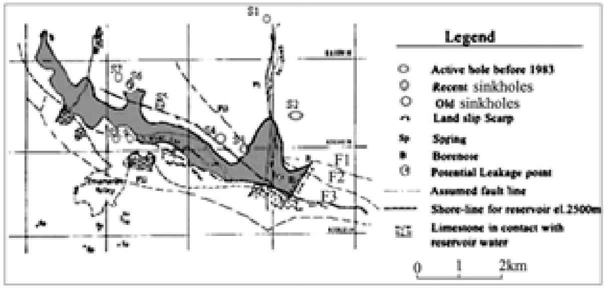

Figure 5- Location of Lar valley sinkholes. (After khorsandi2007)

Areas influenced by the Hamedan sinkholes extend to a minimum of 3 m and a maximum of 2000 m .In the region of Lar Dam,9 old and young sinkholes were formed in alluvium and the lake deposit. These sinkholes occurred from 1980 to 1989 or a period of 9 years after priming of the Dam.

Risk assessment :

The occurrence of sinkholes in the Hamedan Plain to date has caused problems in the agricultural lands and irrigation systems and has resulted in the turbidity of well water, gradual land subsidence, sudden collapses accompanied by terrifying sounds and tremor and finally the appearance of tension joints on the ground surface. Risks associated with sinkholes include the collapse of connection roads, specially the main Hamedan – Tehran road, the reduction of agricultural surface area, landslides in rural and residential areas, the collapse and landslide in the area of Hamedan power station and the risks of death and injury of residents. In the region of Lar Dam the sinkholes have occurred in the sedimentary soil of the lake accompanied by landslide and a terrifying sound. The location of the sinkholes in the sedimentary soils to the north of the lake depicts water escaping from the main factors i.e. karstic bedrock and faults. The risks in the region of the dam are associated with active faults passing beneath the Dam, which influence the occurrence and location of the sinkholes. Their movement during an earthquake will result in damages to the dam's structure.

Discussion and conclusions:

There are different parameters involved in forming the sinkholes in Hamedan Plain and the Lar Dam region. Some of these are fixed and some variable as shown in the following chart.

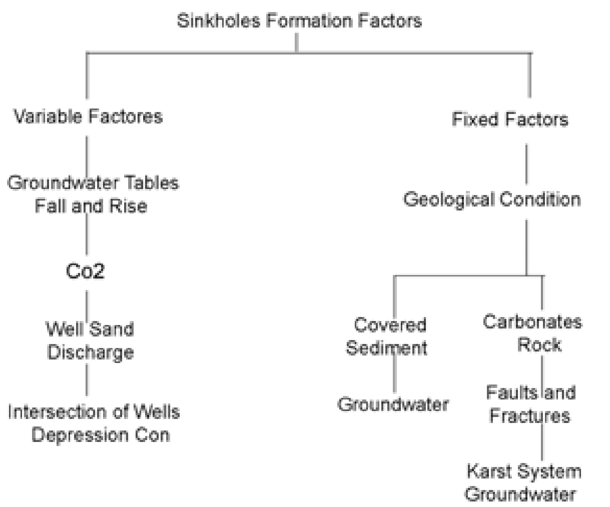

Figure 6- Flow chart of sinkholes formation parameter in Hamadan plain and Lar valley.

As observed, the fixed parameters include the geological conditions, which point to the existence of carbonated rocks and their groundwater containing covering deposits. The carbonated rocks also contain faults and fissures, karstic systems and groundwater.

The variable parameters are subsets of fixed parameters, particularly groundwater. These include the fluctuation of groundwater tables, characterized by sand discharge by wells, the intersection of the well drop cones and the infiltration of CO_2 gas.

The results of the study show:

1-A total of 32 sinkholes have been formed to the northwest of the Hamedan Plain during a period of 1989 – 2004, while in an expanse of 9 years from 1980 to 1989, a total of 9 sinkholes were formed in the region of Lar Dam in the north of Iran.

2-The sinkholes in Hamedan Plain have occurred on the alluvial deposits of 100 m in thickness located on the lime bedrock, while in the region of Lar Dam, they are located on the lake deposits of 100 m in thickness formed on the lime bedrock.

3-The reason for sinkholes in the Hamedan Plain is the drop in groundwater table, while in the Lar Dam region they have occurred after the rise of groundwater tables and the saturation of lake deposits.

4-The consequences of sinkholes in the Hamedan Plain are problems in agriculture and irrigation systems and well discharges, which have affected the residents of towns and villages, the connection roads and industries.

5-The sinkhole crisis in the Lar Dam region somehow points out to the active state of the bedrock faults and lake deposits, which pass beneath the Dam's structure and are potentially critical.

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DANGER MAPS FOR GEOLOGICAL HAZARDS IN THE BAVARIAN ALPS

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KEY WORDS: geological hazards, danger map, mass movement, rock fall, deep seated landslides, shallow landslides, numerical simulation, trajectory model.

THE PROJECT

In alpine regions natural hazards have always been present. Due to effects of climate change they possibly become more and more relevant. The most effective and sustainable method to avoid losses arising from hazardous events is to avoid the endangered areas. In areas where construction already has been established or where construction of new infrastructure or buildings is unavoidable it is essential to determine endangered areas.

In Mai 2008 the Bavarian Environment Agency launched the project “Danger Map for the Bavarian Alps”. The project is funded by the Bavarian State Ministry of Environment and Health. Project duration is until December 2011.

The aim of the project is to create a danger map for landslides and rock falls for the whole extent of the Bavarian Alps by applying the methodology established in preceding projects, i.e. “Danger maps in the western Bavarian Alps (Oberallgäu)” (Mayer et al. 2007) or the Interreg IIIb project “CatchRisk” (Mayer et al. 2005). The pilot schemes identified a numeric trajectory model as the most useful method to create danger maps for rock falls in a regional scale. In contrast the danger map for deep seated landslides is based on empirical modelling.

Project progress is structured by rural districts (Figure 1) and depends on availability of basic data.

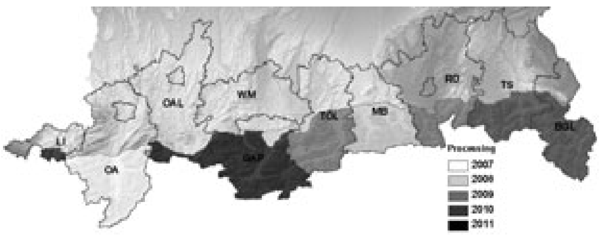

Figure 1 – Project progress by rural districts.

THE PROJECT AREA

The project area covers the alpine part of all Bavarian rural districts within the northern front of the Alps (definition of boundary according to “Landesentwicklungsplan”; the district Oberallgäu already has been completed in the pilot scheme and is not considered). It encompasses nine administrative districts totalling 3668 km². Total annual precipitation ranges from 950 mm to more than 2000 mm, mean annual temperature ranges from -5°C to more than 9°C.

Within the area four main tectonic units of the Northern Calcareous Alps can be found. The steep and cliffy peaks in the south are situated in the so called “Upper Austro Alpine”. To the north the smoother hills of the “Flysch Zone” can be found. Further north again cliffs, but much lower than those of the “Upper Austro Alpine”, represent the “Helvetic Zone”. The most northern mountains are built up by the “Folded Molasse Zone”. These four tectonic main units contain very different lithologic units with different geotechnical characteristics. For this reason any type of landslide can be found in the area.

MATERIAL AND METHODS

Essential data base for modelling the danger map is a high resolution digital elevation model (DEM) with a resolution of 1 meter for the most part, but at least 10 meters.

When available, geological maps on a scale of 1:25.000 are used. Otherwise draft maps or maps on a general scale are employed.

Information about geological hazards like landslides, rock falls and earth falls, especially in the densely populated areas in the Bavarian Alps, is available in the section “Georisk” of the Boden-informationssystem Bayern (BIS-BY, www.bis.bayern.de), a GIS-based inventory of Bavaria including numerous geological data. It is a reasonable tool to detect endangered areas (Mayer et al. 2002). However, it only contains objects where there has been evidence about geolocial hazards. Besides it only shows detected starting areas and accumulation but not the transition and potential run out zone. Comparable information has been gathered in further projects (EGAR, HANG).

To evaluate areas affected by geological hazards, simulations and modelling have to be carried out. According to Kienholz et al. 1993 the simulation models can be divided in disposition models and process models. As far as for rock falls, the disposition model describes the detachment areas. The process model describes the dynamic of the process calculating the energy, the bouncing height of the blocks, their velocity and the paths as well as their run out length.

According to this the creation of danger maps can be divided in three main steps:

- Defining the detachment zones (starting zone) => disposition model.
- Defining the transition and run out zone => process model.
- Compilation of a danger map based on results of the models mentioned above.

In our project danger maps are calculated for three important geological hazards:

- rock falls,
- deep seated landslides,
- shallow landslides.

DANGER MAPS FOR ROCK FALLS

To find the detachment zone of rock falls two empiric disposition models can be applied. The best choice is to locate the potential detachment zones by morphologic and engineering geological mappings. Information especially in the densely populated areas is available in the BIS-BY. In areas where no information is available, an even more empiric approach must be applied. It has to be assumed that every slope steeper than 45° is a potential detachment zone. Using the DEM and GIS operations it is very easy to find the slopes steeper than 45°, which are highly susceptible for rock falls.

For the process model beginning from every single potential starting point of the rock fall the path of the falling blocks can be calculated based on the DEM. Also the loss of energy, the bouncing height, the change of direction and the influence of forest is calculated. For the simulation the model of GEOTEST + ZINGGELER (Krummenacher et al. 2005) is used. It is a realistic process model which calculates the trajectories by vectors, considering form and dimension of blocks as well as damping characteristics of the slope surface. Also the damping influence of forest can be taken into account. Very important for the simulation is the selection of the suitable design event for the rock falls. That means that according to the geology, form and dimension of blocks have to be selected. The block dimension to be chosen should represent the most probable event.

After the simulation is executed, it is only a little step to create a danger map. Each area affected by trajectories is potentially endangered (Figure 2). Two scenarios are simulated: with and without considering the protective function of forest. After heavy storms or resulting from insects the forest can be destroyed and its protective effect will be lost. The two different scenarios can be a very important tool for the forest authorities to identify areas, where the protective effect of forest is essential and where priority is ascertained to protect and rebuild the forest.

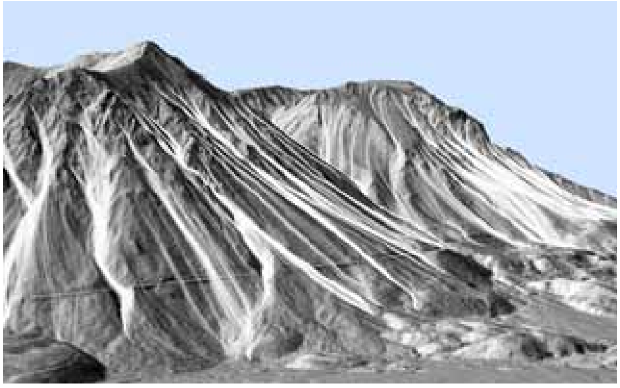

Figure 2 – Simulated trajectories for rock falls.

By buffering the trajectories the process area for rock falls in the danger map can be calculated (Figure 3).

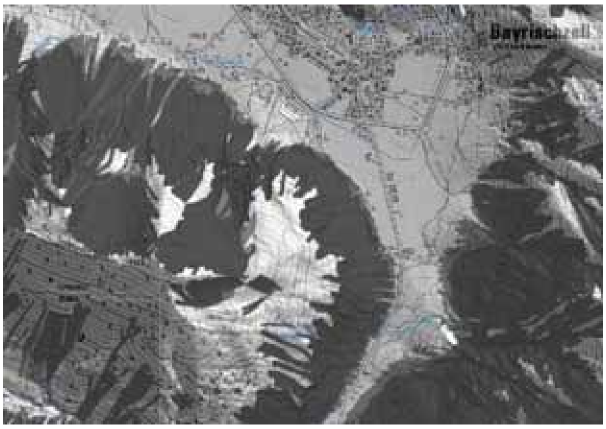

Figure 3 – Simulated danger areas for rock falls. Dark areas consider the protective effect of forest. Pale fringe areas do not implicate the protective effect of forest.

DANGER MAPS FOR DEEP SEATED LANDSLIDES

For estimation of deep seated landslides an empirical approach has been chosen. Deep seated landslides usually evolve in areas where in the past landslides already have happened. All sources of information (BIS-BY, EGAR, surveys, diploma theses, etc.) are analysed and, regarding the degree of reliability, accounted for the disposition model.

With continuing activity or reactivation of dormant landslides the areas identified in the disposition model are likely to enlarge, the detachment zone as well as the zone of accumulation. Therefore, to model the potential process area the geologic-tectonical and morphological situation has to been taken into account. On the basis of a high resolution hillshade, database information and fieldwork the potential process area is defined. If process areas reach a water flow they are always terminated because here a different process starts: the debris flow. Debris flows are hydrologically driven processes and are not subject of this project.

In addition to the detected process areas of deep seated landslides, areas with an increased susceptibility for deep seated landslides are also indicated (Figure 4).

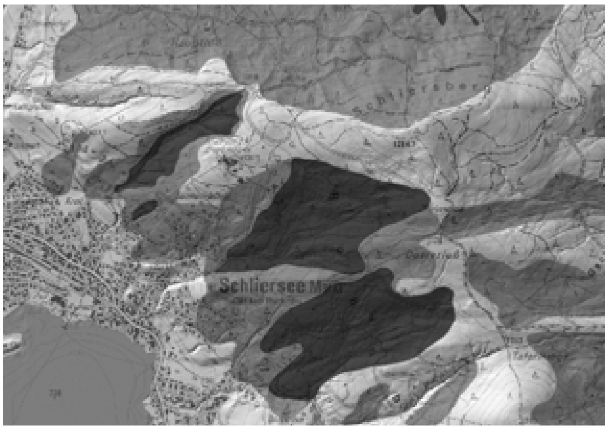

Figure 4 – Danger areas for deep seated land slides. Dark areas endangered by deep seated landslides. Pale areas with increased susceptibility for deep seated landslides.

DANGER MAPS FOR SHALLOW LANDSLIDES

The danger map for shallow landslides is calculated by numerical simulation models (Liener 2000, Geotest AG). Fundamental input parameters are morphology, slope, hydrological catchment area, thickness of debris material and tree population.

Comparable to the simulation for rock fall two scenarios are calculated: with and without considering the protective function of forest (Figure 5).

In the Bavarian Alps shallow landslides can hardly be found because over the last decades there has developed a balance between precipitation and slope morphology. If, as predicted due to climate change, heavy precipitation exceeds the normal rainfall in an area it is possible that the number of shallow landslides increases.

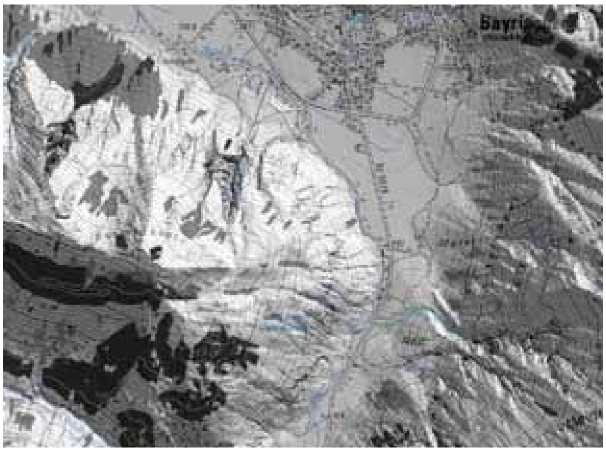

Figure 5 – Simulated danger areas for shallow landslides. Dark areas consider the protective effect of forest. Pale areas do not implicate the protective effect of forest.

RESUME

The danger map in a regional scale is a very helpful tool for planning authorities to get an overview about safe areas and areas potentially affected by geological hazards.

As important as substantiated information about endangered areas is the communication between scientists and local authorities to assure acceptance and appropriate interpretation of the danger maps as well as adequate activities.

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APPLICATION OF HIGH RESOLUTION DIGITAL ELEVATION MODELS IN LANDSLIDE AND ROCK FALL HAZARD MAPPING

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KEY WORDS: digital elevation model, terrain modelling, landslide, rock fall.

INTRODUCTION

Within the project "Danger map for the Bavarian Alps" (Mayer et al. 2007, Mayer et al. 2009), which has been launched at the Bavarian Environment Agency (Bayerisches Landesamt für Umwelt, LfU), maps on rock fall and landslides are being created. Areas affected by landslides are determined by studying historical landslides and their surroundings. In this issue fieldwork plays still an important role.

By analysing digital elevation models (DEM) with the computer, much work can now be done in the office, reducing cost and time consuming field trips.

High resolution elevation models (HR DEM) which are produced through airborne laser scanning offer better opportunities in the detection and assessment of ancient landslides and potentially endangered slopes.

The LfU is being provided with highly accurate digital terrain models by the Bavarian Office for Surveying and Geographic Information (Landesamt für Vermessung und Geoinformation, LVG). These data are utilized to process hill shaded relief maps which are used for the visual evaluation of landslides. On the other hand DEMs are used as input for dynamic rock fall simulation.

In both cases extensive data preparation steps have to be performed.

CHARACTERISTICS OF HIGH RESOLUTION DEM

At LVG, HR DEM data are collected through airborne laser scanning. In a further step raw data are filtered to eliminate vegetation and buildings, resulting in digital elevation grid datasets. The datasets are offered in different quality levels (1 m, 2 m and 5 m grid spacing) depending on height and position accuracy as well as on the available point density.

Accuracy requirements allow maximal discrepancies of 8 cm in elevation and 50 cm in position. The 1 m DEMs point density is one point per m2.

DATA PREPARATION AT LFU

Data are being provided in small tiles of 1000 m edge length by the LVG in a LVG own grid format. First step is a file format conversion, which is being carried out in a batch process for all affected datasets.

As the project area covers the Bavarian Alps entirely, thousands of tiles need to be combined for one huge dataset. This dataset (several GB large) can now be processed entirely. Due to the immense amounts of data, special requirements are met concerning the data preparation methodology. Since these data volumes can not be processed with standard GIS programs, Open Source software tools are used for better performance. These tools were embedded into shell script programs, controlling individual data processing. These programs allow conducting different serial processing steps automatically.

APPLICATION OF HIGH RESOLUTION DEM IN LANDSLIDE MAPPING

The use of DEM derived shaded relief maps in landslide mapping is a distinct improvement.

Landslides can be detected and its geometry can be captured easily and precisely. Even a pre-evaluation of affected slopes can be carried out. A good overview on the geomorphologic situation can be achieved using shaded relief maps on mobile devices in the field. As LfUs field computers are equipped with a GPS receiver, the actual location can be displayed in the model.

Figure 1 illustrates the enormous potential of high resolution digital terrain models in comparison to stereoscopic areal photographs and topographic maps as they were used in the past to support field campaigns.

Figure 1 – Areal photographs, topographic maps and HR DEMs in comparison, illustrate the high potential of HR DEMs in landslide mapping.

APPLICATION OF HIGH RESOLUTION DEM IN ROCK FALL SIMULATION

In addition to the utilisation of relief maps for visual interpretation, DEMs are also applied for complex rock fall modelling. A path simulation of falling blocks as well as bouncing heights and energy loss are calculated using DEM (Krummenacher et al. 2005).

Starting points for simulation are a large number of potentially instable locations, resulting in thousands of fall paths (trajectories). On basis of these trajectories, a rock fall danger map is being created.

In this context DEMs play a major role. DEMs are used to detect steep, potentially instable locations as well as in the simulation itself, where the terrains morphology is the most important input.

The better reality is represented in the elevation model, the more accurate simulation can be implemented.

Contrary to former DEMs, which were produced using contour lines or photogrammetry, the new airborne laser scanning based products offer considerable advantages.

Figure 2 shows details from two DEMs of the Allgäu region in Bavaria, Germany. The upper DEM has been produced especially for rock fall simulation on the basis of contour lines as a prototype. The lower one shows a high resolution DEM (1m grid spacing) as it is available since 2008.

Comparing both shows clearly, that the morphologic inventory (e.g. deep narrow channels) is represented much more precisely in the 1m DEM. Contour line based DEMs often show sinks and terrace like artefacts, which were eliminated in the presented example as far as possible.

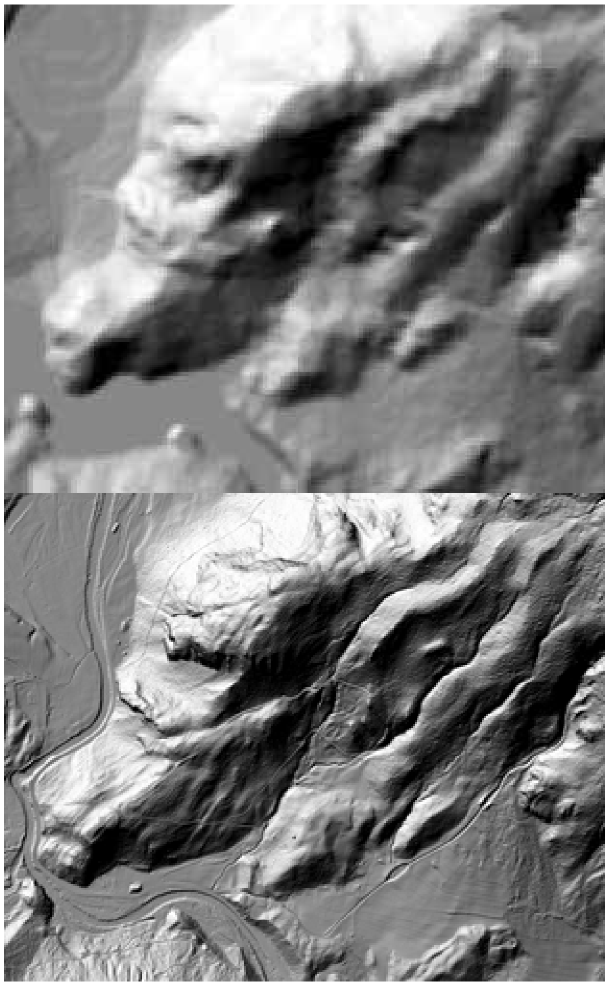

Figure 2 – DEM produced on basis of contour lines (10 m grid spacing) and HR DEM (1 m grid spacing) in comparison

RESUMEE AND OUTLOOK

Experiences in the project “Danger map for the Bavarian Alps” have shown that high resolution DEMs are well suited as an additional tool for landslide detection and assessment of potentially

endangered slopes. Also rock fall simulation can benefit from these datasets.
Through the new means of terrain visualisation, extensive preparatory work can be done in the office. Field campaigns can be planned easier and carried out more selectively.
For rock fall simulation the new datasets offer a consistent data basis. Because of high quality standards which are identical in all covered regions, highly comparable modelling results can be produced. Accordingly, danger maps which are created as well show a high level of comparability.
Up to now, HR DEMs are not available all over Bavaria. Hence DEMs with different grid spacing need to be assembled to cover the project area. As LVG works intensively on new HR DEMs, data availability will further improve.
Processing elevation data is a hardware intensive and time consuming task. Processing time often exceeds hours and days. Due to increasing computing power, processing time will be reduced in the future. Beyond this, hardware improvement will lead to the application of high resolution 3D terrain models on office computers as well as on mobile field devices for geoscientific analysis.

With the availability of different time steps of high accurate, HR DEMs interesting analysis could be made.
Alteration in morphology could be detected and mass balances on landslides could be realised (Kistler E., Attwenger M., Dorsch J., 2009).

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THE GUIDE-LINES FOR SEISMIC MICROZONATION IN EMILIA-ROMAGNA

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KEY WORDS: territorial government, seismic risk, seismic hazard, seismic microzonation.

PREMISE

The recent reclassification of the Italian territory (OPCM 3274/2003) considers the entire country seismic, attributing all municipalities to one of 4 zones characterized by a decreasing level of hazard (zone 1: high seismicity; zone 2: average seismicity; zone 3: low seismicity; zone 4: minimum seismicity) (Fig. 1).
Seismic history reveals how Emilia-Romagna has been frequently affected by earthquakes which have generated effects Is=8-9 MCS, with estimated magnitude Mw = 5.5-6 (Fig. 2).
Current seismic classification makes no provision for site effects that can derive from geological and morphological characteristics, despite the fact that these can modify seismic motion on the surface, in some cases quite drastically (amplifying seismic motion or favouring instability phenomena as sinking, landslides, failure).
Consequently, national and regional directives for seismic risk reduction (see also Eurocode 8) require that urban planning policies and building design are compatible with seismic hazard levels and geological and morphological conditions must be properly taken into account when evaluating seismic action (studies of local seismic response and seismic microzonation).
Seismic microzonation, which consists of detailed territorial subdivision based on local seismic response, is in fact one of the most valuable tools for an effective seismic risk reduction strategy; this is particularly true when it is implemented at the territorial and urban planning stage since, by identifying areas of different seismic hazard, we are able, right from the earliest planning stages, to focus urbanization on those areas of lowest seismic risk, both at a vast scale (Provincial Territorial Coordination Plans, PTCP) and at municipal and sub-municipal scale (Municipal Structural Plans, PSC).

REGIONAL GUIDELINES FOR SEISMIC MICROZONATION STUDIES (SMZ) IN EMILIA-ROMAGNA

For the reasons outlined above, in 2004 Emilia-Romagna Regional Authority set up an interdisciplinary working group, tasked with drawing up, in accordance with Regional Law n. 20/2000 "*General regulations on the protection and use of the territory*", guidelines for seismic microzonation studies (SMZ) to be adopted at the various planning stages. These *"Guidelines for seismic microzonation studies in Emilia-Romagna for territorial and urban planning"* were issued with Legislative Assembly deliberation n. 112/2007 (published in the Official Gazzette of Emilia-Romagna Regional Council n. 64 of 17/5/2007).
The working group which drew up the guidelines comprised seismologists, geophysicists, experts in engineering and geotechnics in seismic areas, geologists, town planners, jurists and representatives of local administrations.
The guidelines were compiled taking into account the following principles first and foremost:

- to harmonize SMZ with territorial and urban planning;
- to rein in costs and time expenditure, so that SMZ is carried out and implemented right from the earliest planning stages;
- to guarantee scientific reliability;
- to comply with national and international regulations and recommendations;
- to establish uniform SMZ procedures in order to obtain products that are comparable at regional level;
- to provide guidelines for professionals whilst leaving room for autonomy and responsibility;
- to provide a reference tool for officials tasked with a supervisory role;
- to share knowledge with users (Provincial and Municipal authorities, professionals).

These guidelines draw heavily on available studies, in particular those experimental SMZ studies carried out in Emilia-Romagna between 1997 and 2004.

The document consists of a text complete with 4 technical annexes:

- Annex A1, which indicates the criteria for identifying areas vulnerable to site effects;
- Annex A2, which indicates the criteria, tables and formulae for calculating coefficients of seismic amplification;
- Annex A3, which indicates a number of procedures for evaluating propensity to liquefaction, sinking and slope instability;
- Annex A4, which presents the results of a specific study set up to define regional seismic hazard and to calculate input motion for each municipal area (accelerograms and response spectra).

Under the proposed criteria, the SMZ study comprises two distinct phases of analyses and must be conducted at several different levels of detail, in accordance with the end purpose and use, and with the local hazard scenario (Fig. 3).

The first phase coincides with the mapping level 1 and entails the definition of local seismic hazard scenarios, namely the identification of those areas most vulnerable to site effects (Annex A1). This first phase is conducted at a vast scale (PTCP), covering the entire provincial territory (scale 1:25.000), and integrated, at a more detailed scale (1:5000), with municipal urban planning, restricted to urbanized and urbanizable areas.
In compiling level 1 mapping the prime requirement is the collation of all available data. In the absence of data, specific new studies must be carried out in order to define the stratigraphy, type and thicknesses of covers. For unstable and potentially unstable areas, no further studies are required during this phase, since a compulsory level 3 study applies to these areas.
Whilst preliminary and strictly qualitative, level 1 mapping, which can be completed relatively quickly and cost-effectively, does in fact constitute an important, early tool for SMZ and, therefore, territorial planning. It enables us to identify areas of lowest seismic hazard right from initial planning stages.

It is with level 2 mapping that proper SMZ is conducted. This level is required for the preparation and approval of municipal urban planning tools and applies only to built-up areas and areas indicated as subject to urbanization which are located within those areas identified at level 1 as susceptible to site effects.
A sufficient number of verticals must be surveyed to enable satisfactory spatial geotechnical characterization of the terrains in the study area.
Based on the scenarios identified in phase 1, two different levels of study are distinguished (levels 2 and 3), each characterized by different study programmes.

a) In stable areas, with slopes having an angle ≤ 15°, composed of deposits of a uniform thickness and horizontal bedding, simplified analysis is considered sufficient (level 2 study, Annex A2). Local hazard analysis can be based not only on the collation of more detailed geological and morphological data than that obtained during level 1, but also on in-situ geophysical and geotechnical standard tests. Coefficients of seismic amplification, compared to a given reference soil (subsoil class A, see. Eurocode 8), can be estimated by availing of the tables and formulae provided in Annex A2. The depth H of covering layers (or the depth of the seismic bedrock) must be measured, as well as the value of Vs of terrains above the bedrock. Amplification factors are expressed in terms of the Peak Ground Acceleration ratio (PGA/PGA_0) and the Housner Intensity ratio (SI/SI_0) for preset time intervals.

b) More in-depth analysis, meanwhile, (level 3 study, Annexes A3 and A4) is required in the following cases:

- areas susceptible to liquefaction and densification;
- unstable and potentially unstable areas;
- areas where cover thickness varies greatly;
- areas earmarked for important works of public interest.

This in-depth analysis requires a significant number of geophysical and geotechnical tests, both in-situ and in the laboratory, in order to accurately define the behaviour of terrains under seismic conditions.
The area to be tested and the scale adopted for the information products are proportional to the criticality, to the size of the area and, if applicable, to the importance of any works planned for the site.
The following data must be provided, as a minimum requirement:

- the detailed perimeter of the areas in question;
- the response spectra for these areas, for T_R = 475 y and damping = 5%, and amplification maps in terms of PGA/PGA_0 and SI/SI_0.

In unstable areas or areas with an increased risk of liquefaction and densification, studies quantifying potential landslide movement and predicted sinking must be provided.
Annex A3 outlines a number of reference procedures.
Site effects are calculated using the accelerograms established for each municipal area as input signals (Annex A4). By scaling the response spectrum at the uniform probability established for Emilia-Romagna based on PGA values for each municipal area (Annex A4), we can also obtain the response spectrum for T_R = 475 y and damping = 5% for each municipal area.

In the case of slopes, peaks and ridges with slope angle > 15° and height > 30 m, topographic effects must be evaluated (Annex A2).

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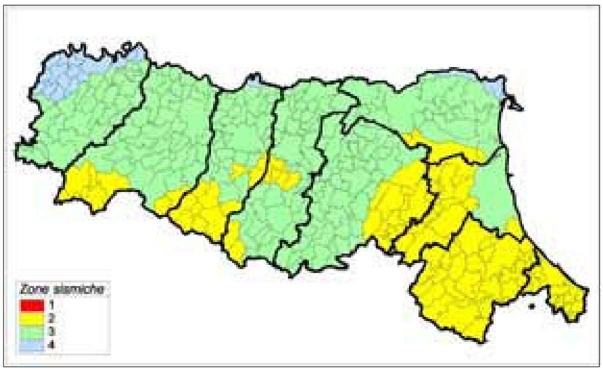

Figure 1: seismic classification of Emilia-Romagna

Figure 2: map of the most important earthquakes of the Emilia-Romagna and surrounding areas; from GRUPPO DI LAVORO CPTI (2004)

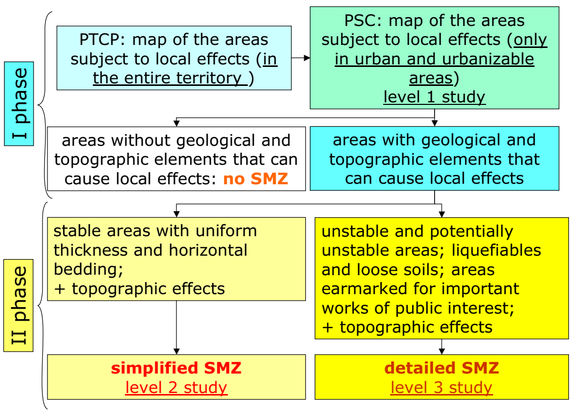

Figure 3: flowchart of the proposed method for Seismic MicroZonation (SMZ) studies in Emilia-Romagna

IMPLEMENTATION OF RELEVANT PARAMETERS TO GENERATE A DATA BASE FOR A DECISION-SUPPORT-SYSTEM FOCUSED ON MUDSLIDES

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KEY WORDS: climate change, danger map, Decision-Support-System, geotechnical calculation, knowledge base, mudslide, natural hazard, relief parameter, risk evaluation

1 INTRODUCTION

Statistics concerning the worldwide occurrence of natural hazards give a clear hint: Natural hazards still predict an assessable risk for human kind. Especially through increasing populousness in mountainous areas of high risk it gets more and more important to localize and identify hazardous territory (Hamberger et al. 2005). Besides, the number of intense rain events with successive, partly disastrous mudslides has increased noticeably in prealpine and alpine regions during the last years.

An effective risk control, to be described as the capturing of actions to define danger regions and accordingly the decrease respectively the avoidance of losses (claims) of material assets and on human population gains an increasing significance - due to the aforementioned problems. At the moment, common GI-Systems are mainly installed as early warning facilities, which display a kind of mobile capture client with the aim to evaluate local danger for users who lack fundamental geotechnical knowledge. As potential users it may be referred to property owners, risk manager, lumberjacks, or representatives of local authorities.

Despite constant efforts in designing precise simulation-technics for defining potential hazardous slopes, existing “conventional disposition models” (Damm 2000) anticipate sufficient accuracy, due to inadequate or heterogeneous input-data.

A Decision-Support-System (DSS), designed at the University of the Bundeswehr, Munich, enables - based on geological, hydrogeological and geotechnical relevant factors - a precise, reliable guideline, to generate a local scaled risk analysis as an appendix to already existing regional scaled danger maps without being based on complex field mapping. The DSS is focused on mudslides.

2 MUDSLIDES

Mudslides are characterized as shallow rapid debris flows on relatively steep slopes (30-40°) which involve thin colluvium or soil formations. According to HAEBERLI ET AL. (1991) they have to be separated consciously from deep seated gully debris flows in mountain torrent systems. Both processes correspond to flowage, according to the classification scheme of VARNES (1978) but especially mudslides emerge from shallow slides or show gradual intersection to other kinds of flow-movements or shallow slides. Mudslides are mostly triggered by severe meterological events (AGN 2004) and are very common in Bavarian prealpine and alpine environments (figure 1). Despite modest volumes involved, this type of movement is very dangerous due to its unpredictability, velocities of up to 20 m/s and pressure build-ups of up to 45 kN/m². Mudslides belong to one of the most destructive natural hazards with the ability to drag away soil and vegetation and harm infrastructure, population and fauna.

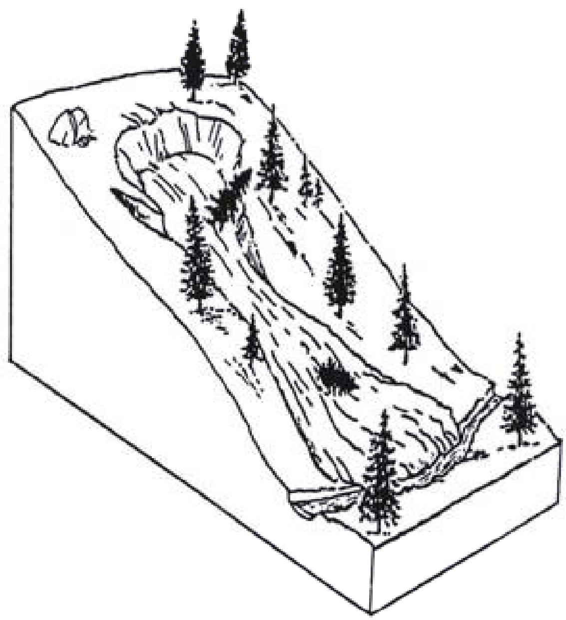

Figure 1 – Sketch of a mudslide (Simpson 2002)

3 AIMS

Based on weak points of current regional scaled danger maps, like impreciseness and overall statements by data-, processing and measurement-errors the designed Decision-Support-System represents an economical, time efficient and transparent alternative to existing stability and risk analysis by GI-Systems. To achieve these aims the data base has to be generated based on relevant factors of interdisciplinary expertises to optimize the knowledgebase of the system and to specify the analysis results of existing simulation systems. The DSS will however - comparable to already existing danger maps - not give any description of intensity, probability and point in time.

By applying the DSS, the complexity of a simulation-process is avoided. Instead the DS-system enables, mainly users without any substantiated background in mapping and laboratory work, to access a reliable working base for a refined risk quantification of their project area. In the foreground the system pursues to generate a decision-support by giving a summary and quantification of all decisive parameters relevant for a reliable risk analysis. This procedure also exhibits a comprehensive compendium for data acquisition and draws a bow for higher accuracy of simulation systems.

4 APPROACH

4.1 Workflow

To focus precisely on the risk potential of a particular slope and therefore to gain a preferably high accuracy in defining mudslide areas, the rating of the slope stability is based on a three-step-workflow. In step I a first risk evaluation is accomplished by relief parameters, such as inclination, altitude, exposition and morphology.

In step II stability analysis calculations are carried out according to DIN 4084 (1991) for an infinite slope. Based on grain-size distributions values of shear strength and bulk density are gained by USCS (Unified Soil Classification System), originally developed by CASAGRANDE (VSS 1996). The amount of grain-size distribution samples required for an optimal accuracy is prescribed by a given screen in the DSS.

The application of preferably simply structured mathematical equations asks for the implementation of a further step - step III - to evaluate further decisive, influencing factors such as vegetation, water distribution networks, and other anthropogenic influences. In addition several phenomena get implemented, which have not gained enough consideration in existing, large scaled DSS yet, but show accordant to newest research results an important influence on slope stability in general. In this connection influences like drainage along timber tracks, but also shrinking cracks have to be taken into account, which together forward the intrusion of surface water into soil in a negative way.

For a final risk evaluation the results of step III get reimplemented into step II to finalize in a YES/NO Decision. The deliberate maceration of a fixed order within the workflow, added with dynamic retraces to preceding request steps offers a dynamic system. In step I and III the workflow provides an independent evaluation of requests (figure 2). Flow-charts, e.g. by the Swiss Workgroup of Geology and Natural Hazards (AGN 2004), serve as a basis of the decision making process.

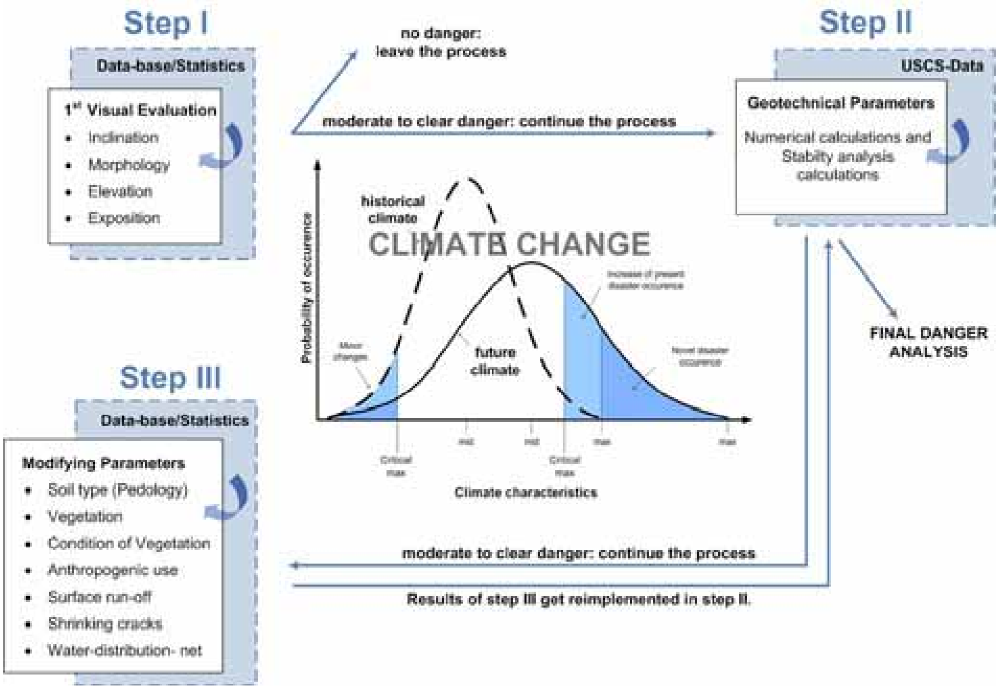

Figure 2 – Sketch of the Decision-Support-System under the influence of climate change

4.2 Statistical evaluation of influencing factors

For quantifications of relief parameters of step I and further influencing factors of step III historical field-data out of research projects get implicated and evaluated statistically. The results are managed in a knowledge base which contributes to a better and more exact understanding of mudslide processes. The knowledge base of this work is based on numerous alpine field data, i.a. on results of data-collection-sheets developed by the Workgroup of Prof. Moser at the Friedrich-Alexander-University of Erlangen-Nürnberg (Büch 2003, Hamberger 2000, Werner 2001, et al.).

In a first attempt all data was implemented uncoupled of geological units and morphological peculiarities of different mapping areas. Surprisingly, the statistical evaluations give up to now definite tendencies of agreement between different geological settings, which enables a transferability of existing data and thereby a first danger quantification for any slope of interest.

Exemplary for the evaluation of other parameters out of step I of the DSS, figure 3 shows a scatter plot of the relationship between the parameters of inclination and altitude, based on 336 single values of mudslides out of different alpine mapping areas. The values spread over a large range: from an altitude of 650 msl to 1950 msl and an inclination of 15° to 55°. The data underlines especially a high dissemination over a large range of altitude but a concentration of mudslide events concerning the parameter of inclination with different degrees in density. To carry out an exact categorization of hazard potentials it has to be referred to figure 4, which shows separate plots of inclination and altitude data, presented with increasing value. The different gradient-sections of each plot predetermine different hazard potentials, which can then be transferred into figure 3. By this procedure the highest risk potential for common slopes can be assumed between 1175 msl and 1400 msl with inclination values between 33° and 41°. This categorization roughly agrees with data of IIDA (1999), quoting that the actual hazard area starts at an inclination of about 35°.

Figure 3 underlines further results: with increasing altitude, between 1400 msl and 1700 msl, source areas of mudslides affect preferably slopes with high inclinations of above 34°. Source areas of mudslides situated in lower altitudes spread clearly over a bigger range of inclination. Furthermore it demonstrates that the parameter of altitude itself does not allow a restriction of a mudslide area with such a high ambiguity than the factor of inclination. In step I the parameter of inclination is therefore rated with a higher influence on the whole system than the factor of altitude (figure 2).

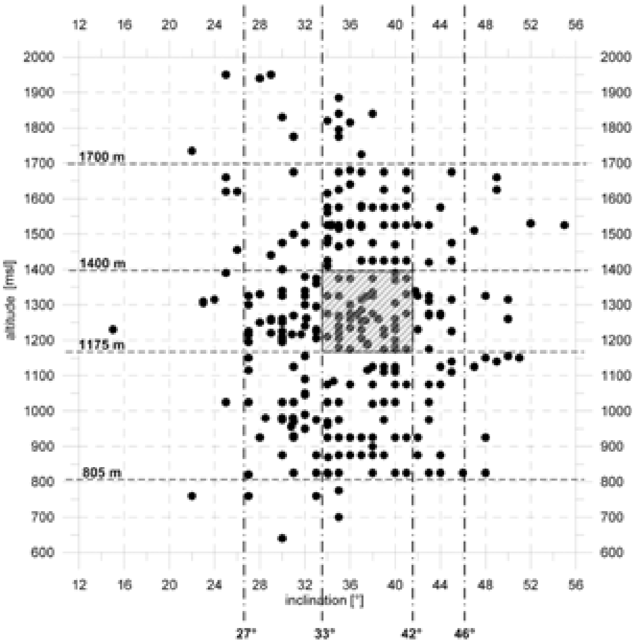

Figure 3 - Scatter plot of 336 inclination and altitude values out of alpine investigation areas

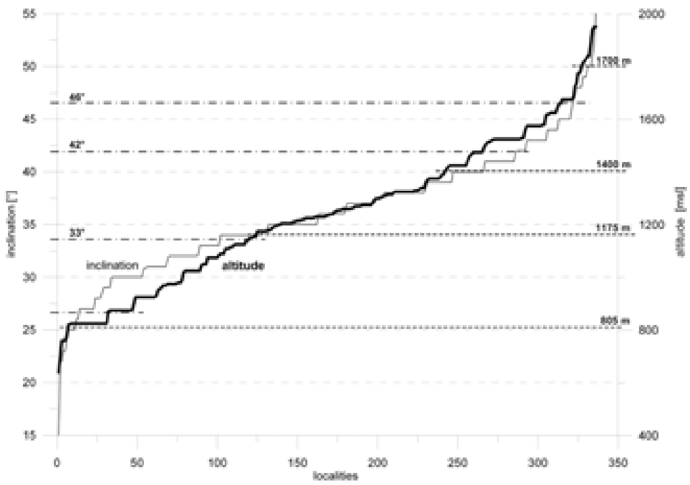

Figure 4 – Separate plots of inclination and altitude, divided into sections of different gradients

4.3 Impact of climate change

Actual influences of climate prognoses are highly accommodated in an increasing "loading case climate change" (KLIWA 2005), which will be implemented into the risk analysis. Climate change and especially its consequences has an enormous impact on numerous factors out of step I and III of the DS-System and asks for a rating geared to the aforementioned problem (figure 2). Especially increases in precipitation, which go directly along with climate changes, will affect surface water intrusions and infiltration rates and therefore have strong impacts on the formation of shrinking cracks in soil.

Regional climatic prognosis for the Northern alpine hemisphere predict an average increase in air temperature of about 2° C and in precipitation of about 40 mm until the year of 2050 (KLIWA 2005). According to the assumptions of KLIWA (2005) the precipitation rates will not change significantly, but a change in seasonal precipitation behaviour is expected: summer months will turn hot and dry, heavier precipitation is expected to occur during the winter.

Precipitation as an internal cause has a huge impact on the triggering of mudslides. It belongs to the worst-case scenario of mudslides. Yet, for the present questioning it is not of any importance at which precipitation rate a mudslide starts activating but rather that the main disposition factors of any slope show tendencies of failure under the influence of heavy precipitation. Therefore precipitation itself keeps unconsidered in the design of the DSS, but not its influences on the slope.

4.4 Processing

The procedure of gathering field information in the aforementioned steps I and III is based on a data-form (data-collection-sheet) which is geared to surveyors with varying degrees of field and laboratory experience. The processing has always to be seen under economical and social aspects but has to grant the given requirements of objectiveness. Therefore the system offers a minimal concept for questions and investigations, but still covers all geogenic and anthropogenic influences with high accuracy.

5 CONCLUSION

The designed Decision-Support-System offers a precise objectiveness on a local scale, which allows additional risk probabilities according to existing regional scaled landslide danger maps, by being cost efficient and quick in presenting results – even for users without any substantiated background. A main goal of the process is to establish an efficient and reliable medium for distributing information to any responsible hazard manager. Thereby the present work generates a discussion basis for the formation of mudslides by using current compendiums and quantifications of all deciding parameters, to constitute a guideline for data acquisition and additionally to draw a bow for higher accuracy of existing simulation systems. By combining statistical evaluations and mechanical statements a reliable tool for planning of stabilization works on slopes and mudslide areas is available now.

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ADVANCED DANGER MAPS AND RISK INDICATION MAPS FOR ROCK FALL IN THE BAVARIAN ALPS

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KEY WORDS: danger map, advanced danger map, rock fall, ArcGIS, overlay method, index method, intensity, spatial probability, risk.

INTRODUCTION

In alpine regions the significance of georisks is getting more and more relevant. Reasons are an increase in events, especially in the context of extreme rainfall as well as an increase in the risk potential due to the growing populousness which goes along with the settlement in endangered areas and an increasing amount of loss. To avoid further losses, by avoiding endangered areas or installing safeguards, the identification of these critical areas is required. These areas can be shown in danger maps, hazard maps and risk maps. In May 2008 the Bavarian Environment Agency launched the project "Danger Map for the Bavarian Alps" which identifies amongst others areas affected by rock fall (MAYER ET AL. 2009). These regional scaled maps are based on a numerical trajectory model by ZINGELLER + Geotest (KRUMMENACHER ET AL. 2005). According to the definitions of the Swiss Environmental Agency (BUWAL 2005) a danger map should give a general view about the situation without specifications about the degree of hazard and the intensity or probability of an event. Primarily they should be a basis for land use planning. Within the bavarian project all of these requirements can be fulfilled for rock fall.

Since external users like local authorities are mostly not used to interpret these maps it could be very helpful to offer more information shown directly in the danger map. Indicating the degree of hazard or involving vulnerable objects, it would be easier to carry out quickly which areas should be observed first. However, indicating the degree means also to create a hazard map, which is, according to the BUWAL (2005), based on detailed studies for a local scale and contains information about the intensity and probability of an event. As the project area is too large to carry out these studies without enormous financial and personal resources and as there are no complete time series of rock fall events to give solid statements about the probability of rockfall occurrence, another way to achieve this goal has to be established. Requirements are to keep the regional scale, to work on the basis of results of the trajectory model and to accomplish everything with standard tools of ArcGIS (ESRI).

As a first step there must be a definition for a new map which allows to provide further information about the hazard but also indicates that the study is still based on a regional scale and is not established for a detailed view on special objects. Therefore the goal should be the creation of an **"Advanced Danger Map"** for rock falls and based on that the creation of a **"Risk Indication Map"**. The sample area is located in the municipality Kreuth which belongs to the bavarian district Miesbach and encompasses about 7,5 km² (Figure 1).

Figure 1 – Sample Area showing rock fall trajectories.

ADVANCED DANGER MAP FOR ROCK FALL

Based on the concept for hazard maps the advanced danger map has to consist of intensity and probability of a rock fall event. One of the results of the rock fall simulation is a layer showing the energy of each stone from its starting point till its deposition area. This layer can be used as the intensity input without any modification. Since there are no time series of rock fall events to obtain the probability of rock fall occurance at a specified point the spatial occurance of the trajectories is supposed to be used as the probability. Beneath that the rock fall simulation is based on block dimensions carried out on field work for each geological unit. This design event is already included in the simulation as the most probable event.

Both layers, intensity and probabilty, shall be arranged into six classes and combined into the Advanced Danger Map.

INTENSITY

The energy layer as a result of the rock fall simulation is already classified into six energy classes. The class breaks are based on typical values used for the dimensioning of rockfall fences. For the following process the layer is converted into a 10x10 m raster file and reclassed again using indices from 1 - 6 while 1 means the lowest energy and 6 high energies (Figure 2).

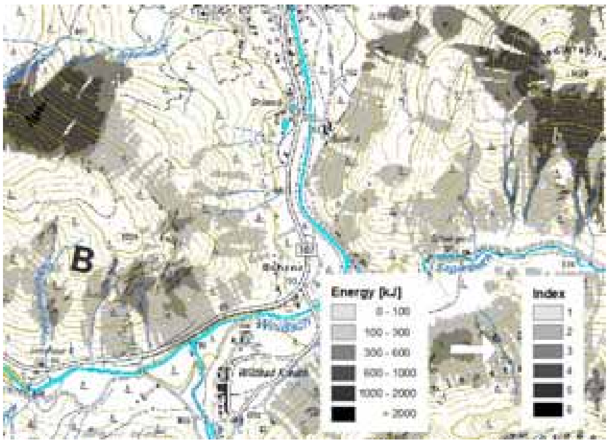


Figure 2 – Intensity Map based on energy classes.

SPATIAL PROBABILITY

To compute the spatial probability the number of trajectories in a specified area will be used. Since the rock fall simulation is based on a digital elevation model (DEM) with a resolution of 10 m, the trajectories have to be counted for area sections of 10x10 m as well. As a first step a new layer has to be created consisting of polygon sections with edge lengths of 10 m. One possibility is to use the "create fishnet"-command located in the Data Management Toolbox of ArcGIS, which creates a net of lines. Afterwards this net has to be converted into a polygon using the "feature to polygon"-command also located in the Data Management Toolbox. Because an ArcInfo licence is required for the last command another possibility is to use external tools written for ArcGIS like "Hawth`s Tools" or "ET GeoWizard" which can be integrated in the ArcGIS environment easily. With these tools a polygon vector grid can be created in one step. To guarantee that the vector grid fits with the intensity layer, both of the methods namend above allow to set an extent of an existing layer like the energy layer.

To obtain the number of trajectories passing each of the 10x10 m polygons the trajectories have to be joined to the polygon vector grid. With choosing the option "Join data from another layer based on spatial location" and "Sum" as the summarize option each polygon will be given a summary of the lines that intersect it in a 'Count' field of the attribute table. Figure 3 shows a small extent of the vector grid with the number of trajectories as labels.

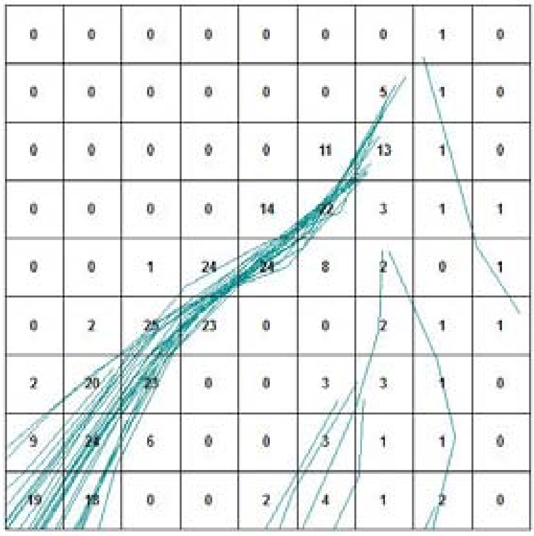


Figure 3 – Result of the spatial join between the polygon vector grid and the trajectories. The vector grid now has the number of intersecting lines as an attribute.

This new layer has to be converted into a 10x10 m raster file choosing the count field as value. Like the energy layer the count layer must be reclassified into six classes by giving indices from 1 - 6 while 1 means a small number of trajectories and 6 a high number. Since the evaluation of the acceptable number of trajectories passing a specified point is quite subjective, the default classification methods in ArcGIS cannot be used. For the sample area the count ranges from 1 - 687 trajectories and the class breaks have been set to 2, 5, 10, 15, 100 and the maximum count (Figure 4).

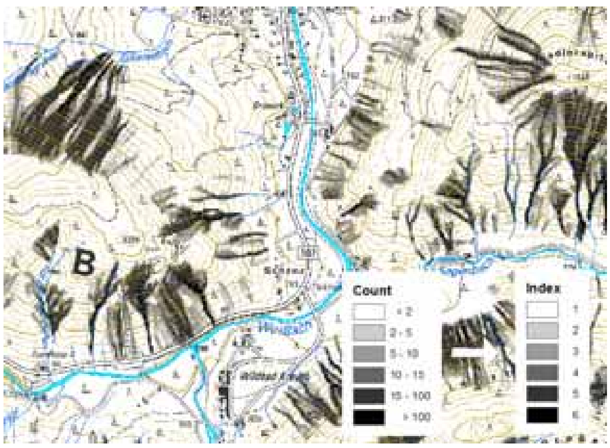


Figure 4 – Probability Map based on the number of trajectories passing a raster cell.

Like mentioned before the classification is subjective, thus the break points could be changed in other areas. To achieve comparable results the classification of the sample area will be applied for the whole Bavarian Alps.

ADVANCED DANGER MAP

The Advanced Danger Map is a result of the combination of intensity and spatial probability:

Advanced Danger Map =
Intensity Map + Spatial Probability Map

The combination will be carried out with the Raster Calculator of ArcGIS. The result for the sample area is a grid with values ranging from 2 - 10. As well as the layers before the map will be reclassified into six classes. Since the values could basically range from 2 - 12 the break points will be set to 2, 4, 6, 8, 10 and 12. Figure 5 shows the Advanced Danger Map which gives an idea of the degree of hazard in a regional scale.

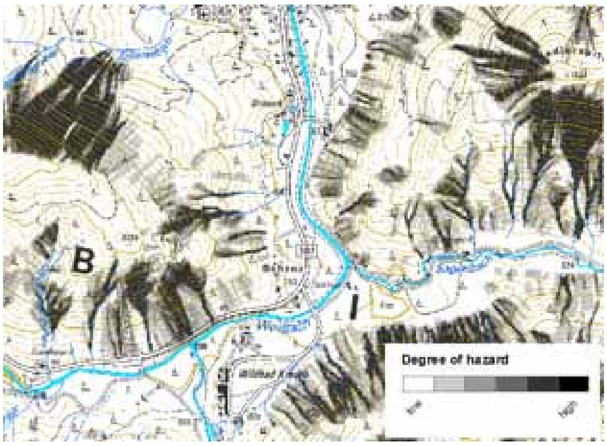


Figure 5 – Advanced Danger Map

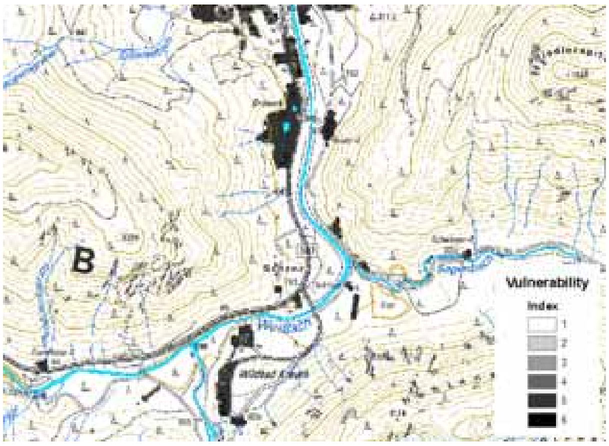
RISK INDICATION MAP FOR ROCK FALL

To get information about potential damage or loss caused by rock fall, objects like buildings or streets have to be known as well as their spatial location and vulnerability. Information about the occurance of objects in a specified area can be obtained from digital landuse models (DLM) which are offered by cadastral offices. For the sample area datasets from the ATKIS 25 (Amtliches Topographisches Informationsystem) are used. At first the vulnerable objects occuring in the sample area have to be figured out. After that these objects have to be evaluated on the basis of the degree of their vulnerability. The evaluation is realized with indices from 1 - 6 (Table 1) while 1 means a low vulnerability and 6 a high one.

Object category	ATKIS-ID	Object name	Index
Settlement	1001	Building inhabited	6
	1002	Building uninhabited	5
	2111	Settled area	4
	2112	Commercial/ industrial area	5
	2201	Sports facility	4
	2202	Leisure facility	4
Transport sector	3101	Street	4
	3102	Path	2
	3103	Public place	1

Table 1 – ATKIS objects indexed on basis of their vulnerability.

The result can also be shown in a vulnerability map (Figure 6).



Figur 6 – Vulnerability Map

Risk is a composition of hazard and vulnerability. A risk map shows the potential damage or loss depending on a certain hazard and the vulnerability of the affected object. Therefore the Risk Indication Map is a result of the combination of advanced hazard and vulnerability:

Risk Indication Map =
Advanced Danger Map * Vulnerability Map

The combination will be carried out with the Raster Calculator of ArcGIS. The result for the sample area is a grid with values ranging from 1 to 24. As well as the layers before the map will be reclassified into six classes. Since the values could basically range from 1 - 36 the break points will be set to 6, 12, 18, 24, 30 and 36. Figure 7 shows the Risk Indication Map which gives an idea of the degree of risk in a regional scale.

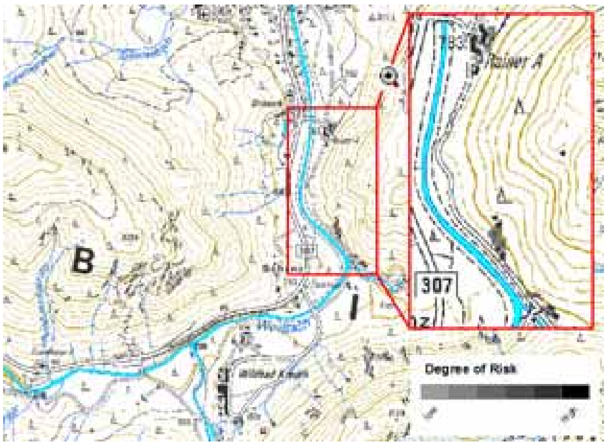


Figure 7 – Risk Indication Map

RESUME

Since it is mostly difficult to analyze and process large areas within a given time period and with limited financial and personal resources the mentioned method is showing an easy way to put more information into a regional scaled danger map. The procedural method of the Risk analysis on the other hand should be reviewed. With combining the Advanced Danger Map and the vulnerability the information about the degree of hazard and vulnerability gets lost. Observing a given area section with a medium risk index, we do not know any more if the degree of risk is the result of high danger and low vulnerability, low danger and high vulnerability or medium danger and medium vulnerability.

As different users are usually interested in different object categories another approach could be to create separate risk maps for every object of interest without evaluating the vulnerability. Road departments for example would get a map showing the combination of advanced danger and streets only.

To define further procedures there should basically be a close collaboration and communication with the potential users.

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ADVANCED CREATION OF FLOOD HAZARD MAPS WITH HYDRAULIC 2D-MODELLING

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KEY WORDS: flood, hazard map, hydraulic modelling, DEM, DTM, floods directive, risk management

INITIAL SITUATION

Since 1996, flood plains have been determined in Bavaria using an extensively standardised procedure. Both with the compilation of basic data and also with the application of hydraulic models, strict accuracy requirements have been demanded in order to achieve a precise differentiation of the flood plains for a 100 year flood event on a cadastral scale.

As basis for the data, runoffs, river channel and flood plain topography as well as surface roughness must be surveyed in detail. This information forms the basis for the creation of hydraulic models with which the flood event can be simulated in the computer. Due to the high technical and personnel expense, and thus also the financial expense, much energy has been expended by the Bavarian Environment Agency (LfU) in the past years in organising the determination of flood plains efficiently without forfeiting any accuracy in the process.

The preliminary work was carried out in several pilot studies before the methods were further developed and optimised and employed on a large scale within the framework of the EU-funded Project FloodScan. Project FloodScan started in the middle of 2006 and is expected to be completed in 2010. The most important tasks in the project (Fig.1) are:

- Up to 2010, creation of a countrywide Digital Terrain Model (DTM) on the basis of laser scan data.
- Optimisation of the post-processing of the laser scan data including the creation of software for an intelligent thinning out of the data.
- Broad application of the newly developed methods and creation of flood hazard maps on the basis of the optimised basic data and using 2-dimensional models. Tools for the individual steps are to be developed.
- Evaluation of information and communication concepts.
- Redesign of an internet-based map service.

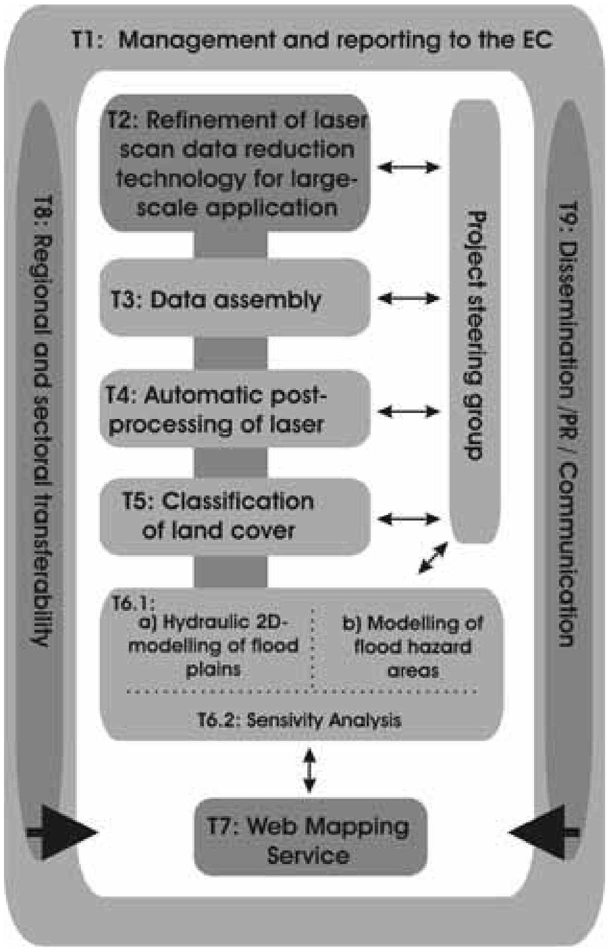

Figure 1 – Tasks in the Project FloodScan.

Thus, in the project, important basic principles for the implementation of the EU Floods Directive, which came into force in November 2007, are elaborated. In the directive, inter alia, the comprehensive creation of flood hazard maps is required from the member states. Along with the determination of flood scenarios of various intensity (low, medium and high probability) the representation of the depth of water is also demanded. In addition, if necessary, the flow velocity is to be given. 2-dimensional computer models have the advantage that the aforementioned parameters can be displayed immediately as result of the runoff simulation. In order to provide the persons concerned with optimum basic principles for the estimation of the flood hazard, in Bavaria the creation of flood hazard maps is also to be based on the greatest possible accuracy.

IMPROVEMENT OF THE BASIC DATA

The Bavarian Water Management Administration has for some time relied on aerial photographic survey with subsequent stereophotogrammetric creation of digital terrain models (DTM) and land cover maps (Oberhauser 2001). Significant improvements in sensor and computer technology have also, in recent years, made laser scan data into a real alternative as foundation for highly accurate calculations of flood plains. Following several pilot studies concerning the quality of the new generation of digital terrain models from laser scanning, for reasons of cost one has worked towards a methodical change (Oberhauser & Rieger 2005). At the forefront of this was the development of a thinning out routine, which enables an efficient handling of the data in combination with the employment of 2d-runoff simulations.

Meanwhile a stable software packet (LASER_AS-2d) has become available, with which a data reduction of more than 95% is possible without hydraulically-relevant loss of accuracy and extensively without manual reworking (Fig. 3). All structures important for the simulation (dykes, ditches, roads etc.) continue to be preserved, provided they are resolved in the DTM (Michel 2006). Small structures such as walls or fences can be integrated as additional breaklines.

On instruction by the LfU the software could be so refined that the computation rate with the application of multi-core processors is significantly reduced. As a result flood plain meshes are displayed which can be used as input for the modelling software employed (HYDRO_AS-2d). The Bavarian Water Management Administration in the meantime possesses a federal state licence for both software packets and has been able to test functionality in numerous model projects. Through its own-trained personnel the extensive concentration on *one* software solution has proved itself to be very reliable in practice. On the free market the products are also enjoying increasing popularity, which is assessed as confirmation of own efforts with the promotion of the further development. Here a significant reduction of the costs for the procurement and further processing of the data is involved.

On the part of the Bavarian Agency for Surveying and Geographic Information (LVG) an attempt is also made to improve the original product further, which also has a further positive effect on the result of the thinning out. Thus the filtering and the quality control of the original laser points are further optimised. This is, above all, of great significance in the area of dykes or other hydraulically-relevant longitudinal structures (Fig. 2).

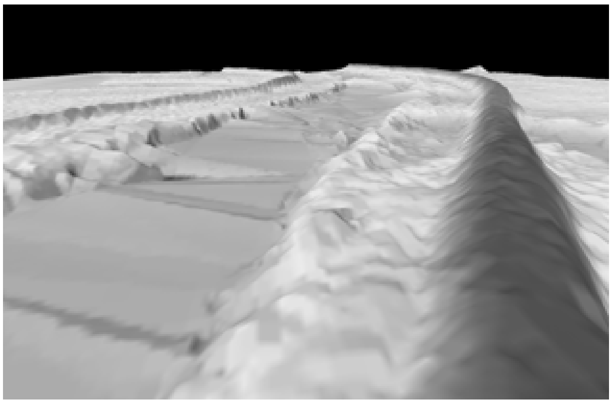

Figure 2 – Example for a dyke as it is represented in the laser scanner DTM.

HYDRAULIC MODELING

Within the framework of FloodScan “Best-Practice Approaches“ are being developed for a broad spectrum of natural types of surface waters, in order to guarantee a countrywide employment of the methods. To this end, broadly applied model investigations on a great number of study areas are necessary. At the forefront of this are variations with the basic data applied and/or with the creation of the model. Currently the employment of the various data sources is being tested in a series of projects within the scope of the 2d-modelling:

- What influence do the digital terrain models with different graticule widths and height accuracy have on the quality of the modelling?
- How efficiently and with what cost saving can information be derived about land cover and how well does the further processing in the model function (assignment of roughness)?
- Which work steps can possibly be simplified and where must a higher degree of accuracy be applied? These should be ascertained within the scope of sensitivity analyses.

Tools, which highlight one or more effective solution paths, have been or are being produced for each of the individual work steps. End product of FloodScan will be a manual on the creation of flood hazard maps on the basis of the newly developed operational procedures. With this, the comprehensive employment of 2d-models is fundamentally at the forefront. From the technical aspect this procedure is favoured for the implementation of the statutory constraints. The water management offices in Bavaria have available well-trained specialists, who themselves take on part of the tasks or could at least guarantee a high level quality assurance. Prerequisite is the creation of models according to defined quality standards. This would very much simplify an effective updating as is laid down every six years by the directive.

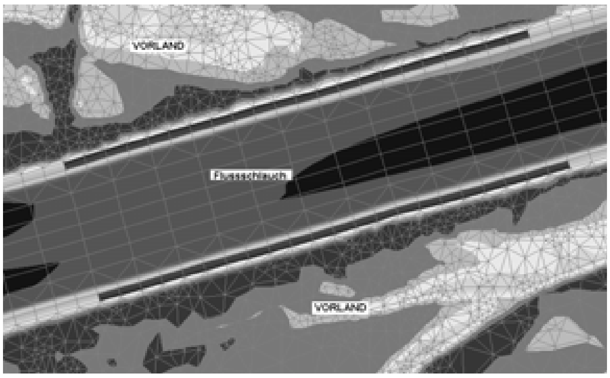

Figure 3 – Optimised mesh on the basis of thinned out laser scan data.

RISK COMMUNICATION

An important module of FloodScan is the subject of risk communication. This is handled under the leadership of the Chair for Forest and Environmental Policy of the Munich University (TUM). Here, in the first instance, one is concerned with the evaluation of various communication strategies such as, for example, internet map services or flood steles. Communication instruments, with which a best possible raising of public awareness of the subject “Hazards due to floods“ can be achieved, are developed on the basis of the results from surveys and investigations. Thus, for example, over the next few months, a redesigned telephone call box will come into service via which those of the public who are concerned or are interested can be informed using audio spots, maps and pictorial material about the entirely specific flood situation locally.

WEB MAPPING SERVICE

A special form of risk communication is the representation of flood maps in the internet. Already in 2004 the LfU established an “Information service on endangered flood plains” in the form of a map service (www.iug.bayern.de). In this the known flood plains can be made available for everybody at up to and including cadastral scale. In collaboration with the LVG this service has been radically redesigned and has been expanded for the significantly more complicated contents, as is required by the floods directive. As is already evident in the prototype (Fig. 4), for example events of various intensity (plausibility) are contained, just as are the representations of water depth. The implementation of the map service takes place via Web Map Service (WMS) technology.

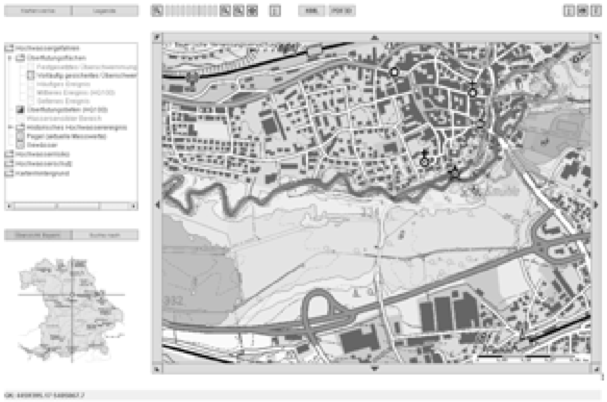

Figure 4 – Prototype of the new map service © LVG Bayern

OUTLOOK

Within the scope of the implementation process of the floods directive as a first step the preliminary flood risk assessment is necessary. Using this work step, which currently is being carried out at the LfU, flood hazard maps and flood risk maps should be produced for areas that could be potentially damaged. The intensive efforts in the cost-benefit optimisation with the determination of flood plains allow also the determination of flood hazard maps using 2d-models. In particular with the production of DTM and land cover as well as with the post-processing within the scope of hydraulic modelling an enormous saving potential can be achieved compared with earlier processes.

Currently, within the framework of several sensitivity analyses, the influence of the variability of the various input parameters on the accuracy of the overall results are being investigated in more detail. In focus are the possibilities of simplification of the creation of the models in small creeks and with extreme flood events. Here further simplification should be possible and sensible.

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RISK OF SUBSIDENCE IN AN URBAN AREA: FROM HAZARD ASSESSMENT TO EMERGENCY MANAGEMENT. SALLENT CASE-STUDY

Sallent Working Group (*) and Antoni Roca [(1)] as reporter

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(*)Multidisciplinary technical team constituted by members of the Institut Geologic de Catalunya (IGC), GEOCAT, Institut Català del Sòl, Universitat Politècnica de Catalunya and Direcció General de Protecció Civil.

KEY WORDS: subsidence, salt mine, urban area, risk management.

ANTECEDENTS

The Conca Potàssica Catalana (Potassic Salt Catalan Basin) is located in the so called Central Catalan Depression, within the Ebre river Depression. This basin is made of a great saline unit, composed by an alternation of potash salts (sylvinita and carnalita mainly) layers.The potash salts have been traditionally exploited since ancient times, being still the most important mining activity in Catalonia. Balsareny, Cardona, Sallent and Súria are the main towns in the Bages region with mining activities (Figure 1).

The town of Sallent, according to the 2004 population census has 6,417 inhabitants. Two areas of the town, L'Estació and La Rampinya neighbourhoods, are on top the exploitation zone of an old underground potash mine, called Enrique Mine (Figure 2).

Enrique mine was opened in 1932 and it is known that some important ground water flooding took place during exploitation. In 1934, during draining works a great vertical cavity of about 40 meters of diameter and 110 meters of height was found.

This cavity was partially filled with materials detached from roof and walls. In the seventies, when the mine was closed, all mine cavities were flooded, including the natural largest one, with water saturated with salt (ClNa) with the purpose of stopping dissolution processes and the ground subsidence present during mining activity. However, twenty years later, in the 1990's the measures taken to avoid ground subsidence were demonstrated to be insufficient for the new present day conditions with the expansion of the urban zone above the old mine exploitation area.

In the early 1990's several buildings damages were reported in L'Estació neighborhood and so the Catalan ministry for Territorial Planning and Public Works (DPTiOP, by its initials in Catalan) started a series of studies through the Geology Unit of the Cartographic Institute (ICC), at present the Geological Institute of Catalonia (IGC), to investigate the causes for the damages in the area of study and to propose possible solutions.

OBJECTIVES AND METHODOLOGY

The objective of the investigation program was to identify, quantify and model the subsidence phenomena in this area (ICC, 2003) in order to propose solutions to this problem. For this reason many studies and monitoring actions have been implemented since 1997 in order to:

- Determine the causes of the ground subsidence at the Estació and Rampinya neighbourhoods.
- Detailed measuring and monitoring of deformation to evaluate the areal extension and its evolution in time.
- Determine the adequate preventive and corrective measures to reduce the risk due to ground deformation.
- Implement and improve security plans and soil use regulations in the area of study.

From the beginning of the study in the 1990's to the present day, the implemented monitoring techniques and surveys have consisted of:

a) Implementation of a high precision surveying network

b) Ground deformation measuring through remote sensing techniques: Radar Satellite Differential Interferometry, DInSAR, since 1992 to present day; and Ground Based Radar, GBSAR, during 2006.

c) Monitoring deformation with a network of extensometers and inclinometers at different depths

d) Geophysical prospecting campaigns for suboil recognition

e) Core drilling to identify geological stratigraphy

f) Geological, geotechnical and hidrogeological studies

g) Geomechanical numerical modelling for evaluations of ground stability.

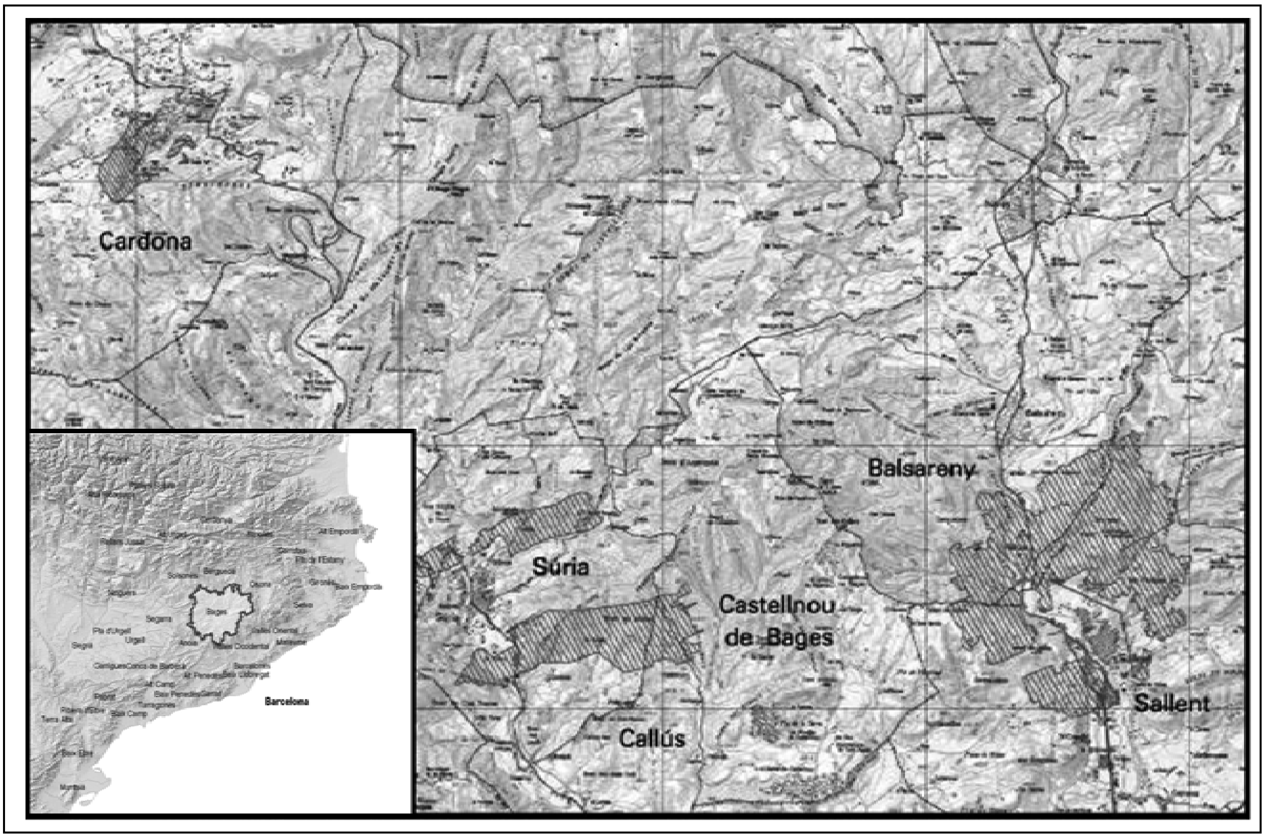

Figure 1 – Figure 1 – This map shows the situation of the main towns with mining activities (grid areas) of the Bages region.

RESULTS FROM THE MEASURING CAMPAIGNS, SURVEYS AND STUDIES

The main results from all the performed studies were integrated analyzed and evaluated (ICC 2003, IGC 2009), allowing the following facts to be stated:

•The structural problems of buildings at the neighborhoods of L'Estació and La Rampinya are the results from large ground subsidence phenomena that extend within the former exploitation limits of the Mina Enrique.

•Data from extensometers and results from geological and geophysical studies showed that ground subsidence is related mainly to the mining cavities. In particular, at L'Estació area the largest vertical ground deformations, up to 5 cm/year, occur over the above mentioned large cavity. Subsidence decreases at increasing distances from this cavity. It should be mentioned that although the values of vertical ground motion are much lower far from the cavity, near the limits of the old mining exploitation the gradient is higher, thus producing differential displacements, deflection and the consequent damages on buildings.

•Decrease of the deformation is not expected in the nearest future and damages in buildings within the neighborhoods are expected to continue.

SUSCEPTIBILITY ZONATION AND CIVIL PROTECTION

It is well known that buildings are especially vulnerable to angular distortion. This parameter can be used to establish levels of building structural damage and thus to assess risk criteria, though the relationship between ground subsidence and building structural damage depends on various factors (e.g. ground subsidence velocity and duration time; size, type and orientation of structural elements). At L'Estació neighborhood, as said before, a belt above the limit of the old mine exploitation, although do not present the largest values of absolute subsidence is the zone with the largest building damage. In this zone, angular distortion induces the largest differential settlements and horizontal deformation induces tensional-compressional loads between buildings.

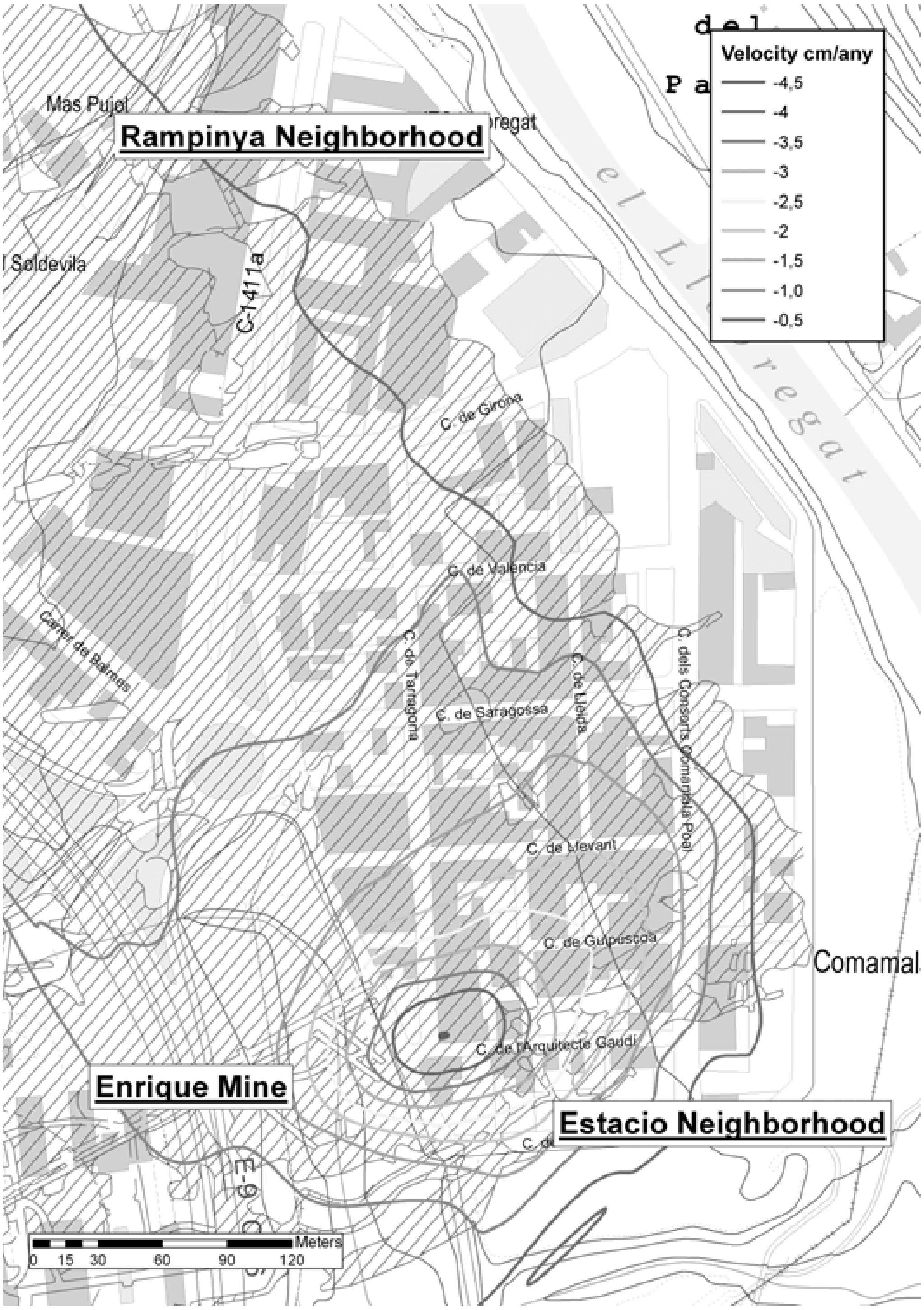

Figure 2 – Estació neighbourhood showing the limits of the Enrique mine and the subsidence velocity contours.

Once the extension and magnitude of ground subsidence and the building susceptibility were assessed, technical solutions were discussed. None of the solutions was technically and economically feasible. The only option was to establish a program for medium term evacuation of inhabitants of the neighborhood and relocation in new urban areas. Since this solution requires some time for the construction of new houses, evacuation is not being performed immediately and temporal preventive measures have been adopted for securing people:

- Demolition of the most damaged buildings (in 2004).

- Implementation of an alert system and an emergency plan for an organized an efficient response of the civil protection authorities. The institutions participating in the plan development involved different government levels and different scientific institutions (Municipality of Sallent; the Catalan Ministries responsible of territorial planning and public works, civil protection and of environment and housing; the Cartographic and Geologic Institutes; the Institut Català del Sòl; the Polytechnical University of Catalonia, neighbour local associations).

The plan has been elaborated and implemented. Triggering levels for the plan are defined on the basis of deformation rates automatically detected by a surveying network of monitoring points. The monitoring consists of:

1.-) Monthly high precision topographic surveying

2.-) Periodic surveying of buildings behaviour

3.-) Automatic underground monitoring network composed by 16 extensometers, at depths between 50 and 140 m to measure deformation velocities and accelerations.

4.-) Ground automatic surveying (taquymetric) network at the area with the largest subsidence rates (the southwestern section of the Estació neighborhood). Twenty seven monitoring points are located at different buildings. They are monitored with automatic readings in 2 hours time intervals. If the measurements give values above the predetermined rate limits, then an instant message is sent.

Data from the automatic underground (3) and building (4) measuring systems are continuously recorded locally and sent to the reception center at the Geological Institute (IGC) who is in charge of informing immediately the civil defense centre for executing the actions established in the emergency plan, which includes protocols for increasing the frequency of performing topographic (1) and building (2) surveys from monthly to fortnightly or weekly

ALERT ACTIVATION

In December 2008 the control networks showed a significant increase in the speed of subsidence, mainly at the SW area of L'Estació neighbourhood, the zone of maximum subsidence.

This increase in the rate of subsidence led to some points measured beyond the alert thresholds set in the Emergency Plan. This situation led to the activation level of alert in the emergency plan and the meeting of different groups in order to assess the activation of the plan. Finally, the preventive evacuation of about 120 residents from 43 homes in the neighborhood has been planned.

CONCLUSIONS

The analysis of the data obtained by different techniques, satellite radar interferometry, ground based radar interferometry and high precision topographic surveying, has been crucial for determining magnitude and extension of ground subsidence. Geological, geotechnical and geophysical prospection have aided for identification of the existing materials and the conditions that produce ground movements. The information acquired allow to conclude that ground subsidence will not stop in the nearest future and will continue affecting buildings. The performed studies are the scientific-technical basis for the development of the present protection measures that have been implemented. The automatic monitoring network which is operative in the area is the basic element to activate the emergency plan in the case that acceleration in the subsidence process is detected, and so to provide security to the inhabitants.

ACKNOWLEDGEMENT

This communication is a synthesis of the work carried out during more than 10 years by multidisciplinary teams of geologist, geophysics, geological and civil engineers, architect, urban planners and civil defence professionals. All the mentioned studies, surveys and works have been funded by the government of Catalonia.

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GLOBE OF NATURAL HAZARDS – A NEW RISK MANAGEMENT TOOL

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KEY WORDS: Natural hazard, risk management, Globe of Natural Hazards

INSURED LOSSES 2008

A large number of tropical cyclones and the earthquake in Sichuan made 2008 one of the most devastating years on record. Throughout the world, more than 220,000 people died as a result of natural catastrophes that year. Overall losses totaled some US$ 200bn (2007: US$ 82bn). Insured losses in 2008 rose to US$ 45bn, about 50% higher than in the previous year. Mainly driven by high losses from weather-related natural catastrophes, 2008 was – on the basis of figures adjusted for inflation – even the third most expensive year on record for the insurance industry, exceeded only by the hurricane year of 2005 and by 1995, the year of the Kobe earthquake.
Munich Re, a worldwide operating reinsurance company, is a world leader in terms of investigating risks from natural hazards of all kinds. 2008 has again shown the insurance industry how important it is to analyse risks like natural hazards and climate change in all their facets and to manage the insurance business accordingly.

GLOBE OF NATURAL HAZARDS

An excellent example of the wealth of knowledge Munich Re has developed in natural hazard assessment is the DVD “Globe of Natural Hazards”. It combines the geo-scientific data and findings Munich Re has accumulated over a period of almost 35 years. First devised as a wall-map in 1978, the product has established itself as a standard work for the identification, exposure assessment and risk management of natural hazards. Over 80,000 copies of the CD-ROM version of 2000 have been provided to clients – a mark achieved by no other service product in Munich Re’s history. Since the beginning of 2009, the the fully updated fourth-generation version has been available. The bilingual DVD (German and English) shows natural hazards and climate effects at a glance: the global maps are presented on a 3D globe, with satellite images in the background.

RIVISED HAZARD INFORMATION

Figure 1 – Hailstorm hazard

The hazard complexes of hail, tornado and winter storms have been completely revised and flood incorporated as a new hazard. Users can intuitively home in on and enlarge any location on earth, and an extensive location database makes searching easy. The knowledge modules for historical catastrophes, megacities and change processes can be linked with each other and displayed on the maps. Completely new is the integration of the topic of climate change: various depictions of climate effects and projections show in which regions of the world risk situations have to be reckoned with in future. Thanks to its comprehensive information, the globe is an important tool for identifying risk locations worldwide and evaluating them from a geo-scientific perspective. Thus, the transparency of insurance portfolios can be increased and legal requirements can be met.
Munich Re’s multi-discipline Geo Risks team combines a wealth of global experience and contacts. Clients benefit from a first-class natural hazard consultancy service and valuable support for introducing and implementing geographical information technology systems. The team can

also provide the knowledge and technology to help clients plan and set up in-house solutions tailored to different classes of business in this innovative field of underwriting.

With the new DVD “Globe of Natural Hazards” the insurance industry, scientists, schools and the public have access to Munich Re’s natural hazard maps. The Globe of Natural Hazards is natural hazard risk management tool that is easy to use and understand. Earth’s exposure to extreme natural hazards will continue to increase. To overcome these challenges the insurance industry will need accurate and competent information.

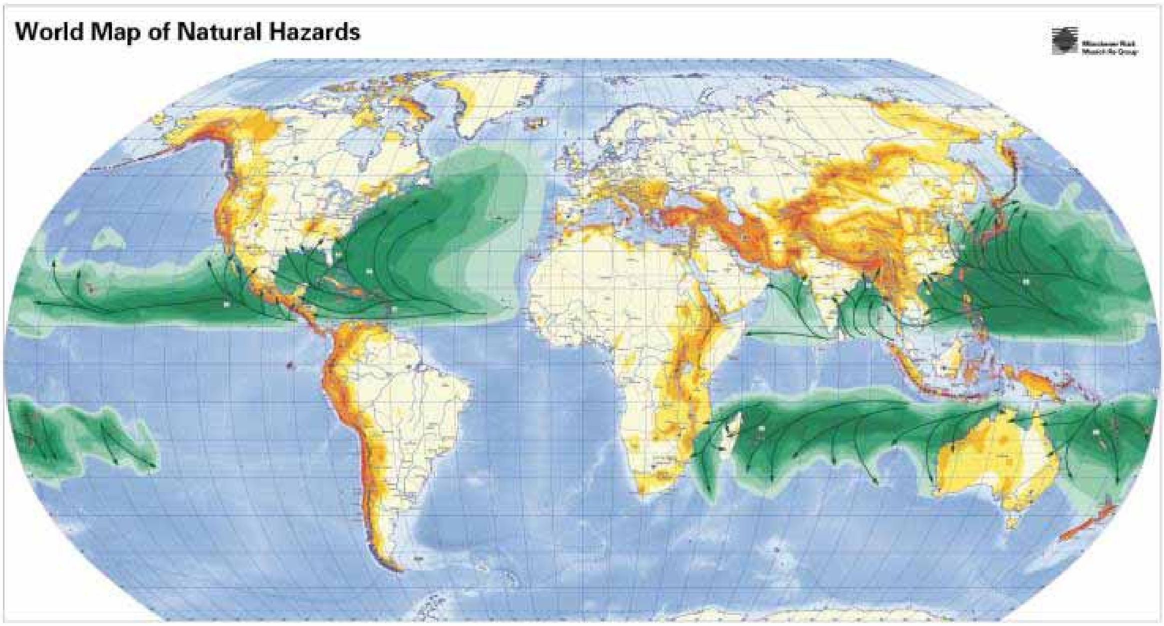

Figure 2 –World Map of Natural Hazards

SOURCES:

Munich Reinsurance, 2009: Geo risk expertise pooled on a new Globe of Natural Hazards. Press Release Feb. 16th 2009.

MONITORING OF SUBSURFACE DEFORMATIONS USING TIME DOMAIN REFLECTOMETRY

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KEY WORDS: landslide, subsurface deformation, monitoring, time domain reflectometry, inclinometer, Aggenalm.

INTRODUCTION

In context of the global climate change an increase of extreme precipitation events is expected for Europe and the Alps (Alcamo et al. 2007). As heavy rainfall is an important trigger for landslides, the frequency of hazardous landslide events is also expected to rise. Luckily in most alpine regions the awareness of landslide hazards has risen in the last years, driven by national and regional hazard mapping programs (e.g. in Bavaria (LfU 2009), Switzerland (Lateltin et al. 2005) and South Tyrol (Willerich et al. 2008).

Although many potentially hazardous landslides have been identified, due to economic reasons only few are continuously monitored. In many cases only sporadic geodetic surveys are performed, which is not sufficient when infrastructure or even human life is at risk. In order to overcome this, efficient and economic measurement systems for landslide monitioring are needed.

In order to evaluate a deep seated landslide, observations from the surface are not sufficient. Detailed Information about the depth of the slope movements and their changes through time are needed.

MONITORING OF SUBSURFACE DEFORMATIONS

The direct measurement of subsurface deformations is only possible in boreholes. To date, if countinous monitoring is required, usually inclinometer chains are used for this task. While these allow to determine subfurface deformations with high precision, the associated costs are quite high. So often continuous monitoring is rejected in favor of cheaper sporadic measurements.

With a Time Domain Reflectometry (TDR) measuring system continuous monitoring of subsurface deformation can be performed at 25 % and less of the costs compared to inclinometer chains. However the landslide mechanism has to meet some premises in order to be able to use this measuring system, as it is limited to the detection of localized shear zones.

TIME DOMAIN REFLECTOMETRY (TDR)

A TDR measuring system consists of three major elements (figure 1): 1. the measuring device (TDR cable tester including data logger and multiplexer), 2. the measuring cable (usually semi rigid coaxial cable for easy installation) and 3. the lead cable (low loss coaxial cable) which connects the measuring cable to the measuring device.

For landslide monitoring the measuring cable is installed into a borehole and connected to the rock mass with grout. When the rock mass starts to move in a shear zone, the coaxial cable is deformed, altering the distance between inner and outer conductor of the cable. This change in the cables geometry can be identified, localized and analyzed using a TDR cable tester (Singer et al. 2006).

TDR can simplified be described as "cable-based radar" (O'Conner & Dowding 1999): The TDR cable tester emits electric pulses which are sent through a coaxial cable. When these pulses approach a deformed portion of the coaxial cable a signal is reflected to the cable tester. As with radar, due to the known propagation velocity of the electromagnetic wave within the coaxial cable, by measuring the time span between emission and reception of the electric pulse, the distance to the deformation can be determined with high accuracy. Furthermore the analysis of the reflected signal (amplitude, width, etc.) can reveal information about the type and amount of deformation.

If the measuring cable is bent with a large radius (for landslides: gradual deformation over several decimeters or meters of soil) the distance between the inner and outer conductor of the coaxial cable is not changed sufficiently to produce a TDR signal. Therefore TDR measurements generally are limited to discrete deformation zones with a width of centimeters to decimeters. In this context the mechanical properties of the grout used to connect the measuring cable to the surrounding rock mass is of utmost importance.

But not only the grout composition (strength, mode of deformation) influences TDR measurements, also the measuring cable type (conductor material, diameter) and lead cable type and length (signal attenuation) have to be considered. Prior to installation all these parameters have to be chosen according to the expected deformation mechanism and velocity of the landslide.

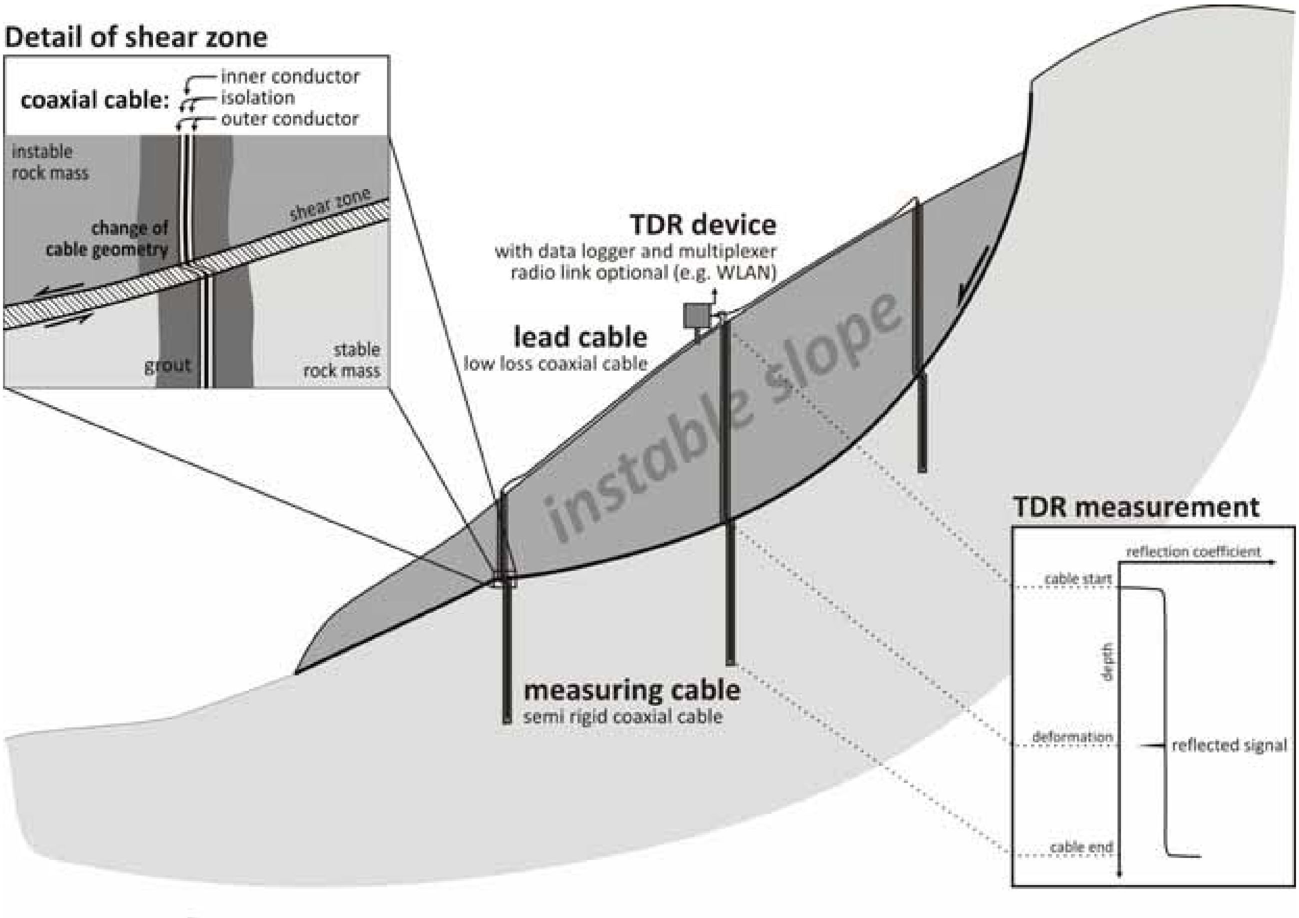

Figure 1 – Installation scheme of a TDR landslide monitoring system (according to Singer et al. 2006, edited).

LABORATORY SHEAR TESTS

In order to characterize and then optimize the installation parameters of the TDR measuring system, a large number of laboratory shear tests were conducted in an especially developed test stand (Singer et al. 2006), which allows to shear grout colums with varying diameters at different shear rates and with varying shear zone thicknesses.

GROUT

Main focus was thereby put on the grout: different cement-bentonite-water mixtures were analyzed (Festl 2008), starting from mixtures which usually are used when installing inclinometers. Considering also the viscosity and stability (shrinkage) of the grout, only a relatively small variety of mixtures seem suitable for TDR installation (figure 2).

Depending on the type and speed of the observed landslide different grout mixtures should be used. E.g. for a slow rock slide (> 1,6 m / year according to Cruden & Varnes 1996), mixtures with high water and bentonite content should be used, resultig in a higher measurement lifespan before cable failure. In an extremely slow earth slide (< 1,6 cm / year) a mixture with less water and medium bentonite content should be used, which leads to a high sensitivity but not too high strength of the grout. This ensures that the moving rock mass is able to fracture the grout and will not plastically flow around the grout column.

BOREHOLE DIAMETER

When selecting the grout mixture also the borehole diameter has to be considered as another factor controling the total strength of the grout column. For good measuring results (especially in soft rocks) the coaxial cable should be covered by at least 1 cm of grout. For a typical 12 mm semi rigid coaxial cable (see below) the minimum drilling diameter thus would be 32 mm. The centered installation of the coaxial cable can be assured using spacers, as they are used for armored concrete.

Besides an exclusive borehole installation, TDR cables can often also be installed into sheared inclinometer casings, thereby considerably extending the usability of an existing borehole.

MEASURING CABLE

Generally any coaxial cable can be used as measuring cable. O'Connor & Dowding (1999) suggest using semi rigid coaxial cables, as these on the one hand make an easy installation possible, and on the other hand seem to enable to achieve a relatively high reproducibility (and thus accuracy) in the TDR measurements. A well tried rigid coaxial cable for deformation measurements is the Commscope P3-500 JCA with 12 mm diameter, aluminium outer conductor, copper claded steel inner conductor and a PVC jacket, which is availiable at a comparable low price of about 3 €/m. The jacket protects the aluminium cable from corrosion, which is an issue especially when installed into ground water.

LEAD CABLE

One great advantage of the TDR measuring system is that multiple measuring cables can be read out with one measuring device, thereby drastically reducing the costs per measuring site. In order to achieve this, the different measuring sites have to be connected to the TDR measuring device using high quality low loss coaxial cables. However, with increasing length an exponential attenuation of the signal was observed, limiting the lead cable length depending on the type of cable used to under 150 m (Woytowitz 2008).

CALIBRATION

All the above installation parameters have to be considered, when analysing TDR signals. Based on the ongoing laboratory shear tests installation parameter combinations are currently being defined for typical landslide settings. For these combinations extensive calibration shear tests are performed in order to quantify the reproducibility and accuracy of the TDR measurements and to determine calibration curves as basis for an automated signal analysis, which will allow to not only determine the position of the deformation zone with high accuracy, but also the amount of deformation. In the laboratory environment accuracies below 5 mm have been achieved for the quantification of the deformation amount.

ANALYSIS SOFTWARE

With help of the newly developed TDR signal analysis software “tumTDR” the raw data received from the measuring device can be visualized in various different ways, allowing an experienced user to perform a first evaluation and interpretation of the collected data. After that an automated deformation analysis of the data is possible, whereby deformation zones are automatically identified and the deformation is quantified using the calibration curves determined in the laboratory shear tests (Singer et al. 2009). The software currently is in a beta status with all major functions operable.

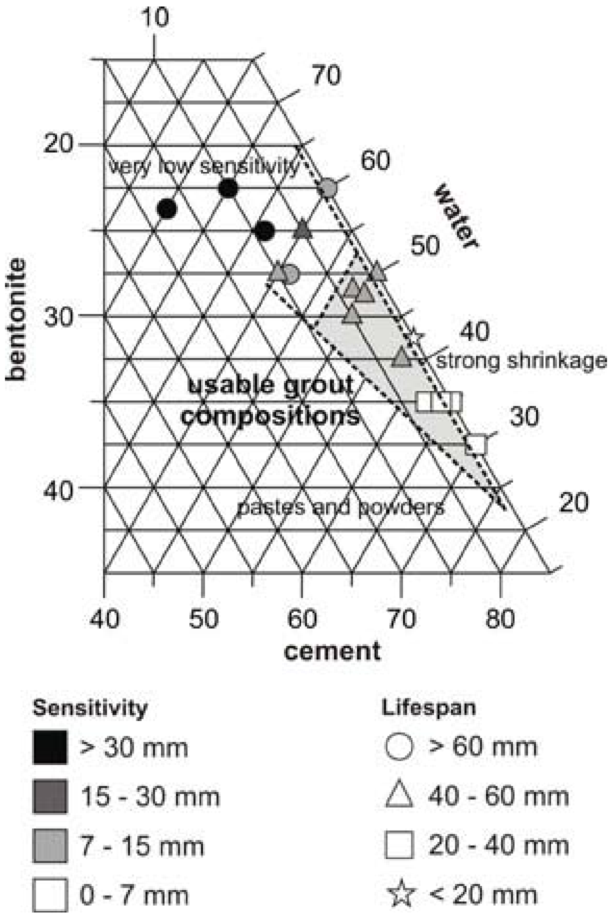

Figure 2 – Results of several TDR shear tests with different cement-bentonite-water mixtures (mass-%) (according to Festl 2008, edited). The shear tests were conducted with a shear width of 15 mm and a shear rate of 2 mm / min. In each test the sensitivity and the cable lifespan was determined. Additionally the shrinkage of the grout during hardening was measured. As the grout has to be pumpable during installation, also the viscosity limits the useable grout mixtures for TDR deformation measurements (grey area).

FIELD TEST

A calibrated TDR measuring system has been installed at the Aggenalm Landslide near Bayrischzell (Bavarian Alps) as part of a geo sensor network containing several other measuring devices for surface deformations and trigger factors (e.g. precipitation, ground water levels) (Thuro et al. 2009).
This installation is the first test for the signal analysis based on a calibrated installation setup. The parallel installation of TDR and inclinometers will make an evaluation of the measurement accuracy in field possible. In other actual landslide installations the TDR measuring system was proven functional (figure 3), but in lack of a calibrated setup the amount of deformation could not be determined accurately.

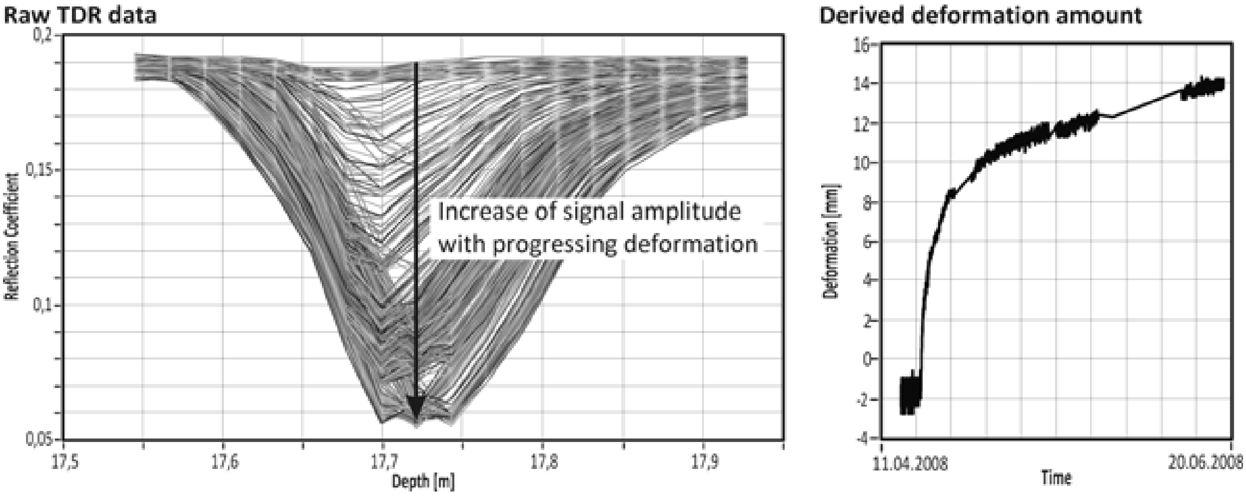

Figure 3 – Results of a TDR field test in a slow earth slide. The depth of the shear zone can be determined with high accuracy. In lack of a calibrated installation the accuracy of the deformation amount can not be stated, although the results were in compliance with inclinometer measurements conducted parallel to the TDR measurements.

CONCLUSION

If the Aggenalm Landslide field test is successful (especially regarding the measurement accuracy), the TDR measurement system will have proven to be a powerful technique for subsurface deformation monitoring if the landslide mechanism fulfills some premises (discrete shear zone) and calibrated installation setups are used. Compared to inclinometer the installation costs can be cut down by up to 75 % due to the low minimum borehole diameter, low material costs and the fast and easy installation. Also the expenses for a measurement device (including data logger) are reasonably lower than those for an inclinometer chain, which allows continuous monitoring – a task easily achieved with TDR. Continuous monitoring is generally strongly recommended when using TDR, since this leads to reduced personnel costs and at the same time provides the best data basis for an automated deformation analysis using the tumTDR software.

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ASSESSMENT OF SOIL SLOPE DEFORMATIONS USING PHOTOGRAMMETRIC METHODS: LABORATORY TESTING APPLIED ON PHYSICAL MODELS

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KEY WORDS: Slope stability and deformations, laboratory testing, digital photogrammetric method.

ABSTRACT

This article assesses the stability of man-made slopes. The presented method, which is based on the combination of laboratory work and its digital processing interpretation, allows evaluation of the directions and extent of movement. Based on this vector analysis, possible slope failure can be assessed. The lower described method is applied on man-made slopes, but also allows investigation and evaluation of the stability of natural slopes.

INTRODUCTION

One of the most common applications of soil mechanics is computation of soil slope stability (VANICEK, 1983). The stability of slopes is affected by the huge variety of factors that may result in the different types of slope movements. Among the most common factors that initiate sliding are increased rainfall (especially in the case of land clearing and consequent higher exposure of slopes to precipitation), earthquakes, and specific man-made constructions on the slopes - engineering constructions, such as cutting roads into the slopes or overloading of the crest, top or the slopes themselves can initiate sliding in the previously stable areas. Naturally, slope stability is affected by slope gradient, character of bedrock and regolith, and further overlaying types of soils and their physical properties. All of the above-mentioned facts aggravate conditions of further laboratory research, landslide modeling and its interpretation.

LABORATORY TESTING APPLIED ON PHYSICAL MODELS

Experimental physical scale modeling allows laboratory observation of processes taking place in the rock material due to the changes of natural environment external conditions. It allows investigation of geotechnical phenomena's mechanisms, predicting stress changes and their demonstration caused by overloading, etc.

To simulate the natural conditions, rock environment is usually substituted by equivalent materials. In the scale of the model, these materials agree with rock properties and respect the character of failures simulating those in rock material. The laboratory experimental models are usually constructed from a mixture of various, mostly easily available materials, e.g. sand, bentonite, gypsum, mica – vermiculite, composite mortar, cellular concrete, and water. The experimental scale models, which stem from basic rules of the physical modeling and fulfill both principles of geometrical and physical similarity, are used.

According to the kind of the solved problem, experimental scale models can be constructed as 3-D or 2-D models (TRCKOVA, 1998; VACEK, SEDLACKOVA, 2005). 2-D models, which represent a materialized cut of focused area, are used for the solution of such problems, where the main movement is executed in a one-way direction, usually vertically. These models can be for example used for solution of:

- Deformation under the foundations of different types of engineering constructions.
- Subsidence effects due to the undermining.
- Other problems linked with construction and operation of underground structures.
- Solution of naturally and human-caused landslides.

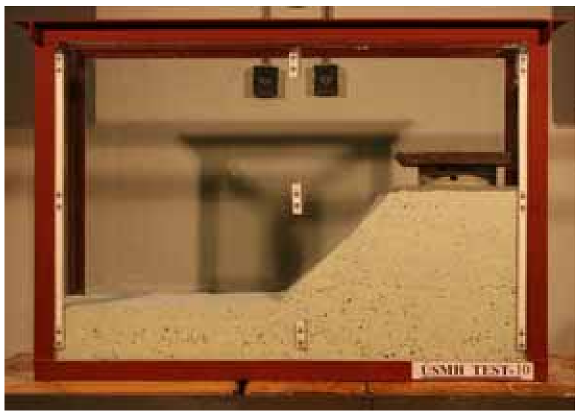

Figure 1 – Experimental physical scale model.

These 2-D models are constructed in a special kind of stand, where the inner wall of the glass board defines the deformation plane of the model.

One of the methods used for assessment of soil slope deformations is the modified digital photogrammetric method. As stated above, this method is applicable especially in the case where the main deformation effect is assumed in a one-way direction.

DIGITAL PHOTOGRAMMETRIC METHOD

The huge expansion of digital photographic cameras with high differential capacity allows its utilization for evaluation of deformation processes on the experimental scale models. Before that, photo-theodolites and obtained photographs on glass plates were processed by “wet way” and consequently scaled with the help of standard photogrammetric devices (stereo comparators), and calculated coordinates of individual point movements on the model surface were drawn in with the help of automatic coordinatographs as a situational plan (VENCOVSKY, M., 1973).

New technology, which arises from the above described “traditional” data processing, derives benefit from the utilization of high resolution digital photographic cameras and accessible and less expensive software products. There are other photogrammetric software products as well, but usually very expensive, and for our purposes useful only after complicated changes.

The presented photogrammetric method enables us to determine from two photographs of model surface, which are obtained in two different deformation periods of experiment, appropriate deformation of the model surface. Generally, one of the photographs, the so-called initial photograph, is exposed in the state before the deformation process itself starts. All the detected vectors of movement of selected points on the model surface are related to this photograph. If the photographs are exposed from one place, by the same photographic camera and with the same oriented axes of the view, then these photographs make a so-called stereo pair created on the time base. It enables us to analyze the deformation process in the deformation plane of the model surface, on the basis of morphological model, which come into being by stereoscopic observation of a stereo pair of photographs. Stereoscopic observation of a photograph pair, which are consequently oriented into rectangular directions, leads to creation of stereoscopic models of two moving surfaces $P_x(X,Y,dX)$ and $P_y(X,Y,dY)$, which illustrates field of vector components in rectangular directions.

These both planes are defined, similarly as topographic planes, by analytical location of point collection, which are appropriately chosen with regards to the morphology of the model’s surface. Coordinates of the certain point X, Y, dX, dY in the model plane are obtained by colinear transformations.

The fixed net of planimetric control points, which is designated in the plane of the model, serves as a basic net for analytical processing of photographs. The accuracy of the whole method is strongly affected by the accuracy determination of rectangular coordinates of the planimetric control points. Due to the fact that the deformation changes, which come into being during the experiment on the model surface, are on order of tenths of millimeters up to millimeters, it is necessary to determine the fixed net of planimetric control points with maximum possible accuracy (VENCOVSKY, M., 1989).

For the analyses of deformations on the experimental physical scale models, the following programs are used:

- Z-Anaglyph V 1.5.3.. Before the interpretation process begins, stereo photography of the examined model is created. It is done by freely downloadable software (Z – Anaglyph V 1.5.3) from the World Wide Web.
- Surfer 8. This program is used for consequent interpretation of stereo photography – signification of planimetric control points on the model’s surface; signification and marking of so-called moving points (it allows consequent assignation of spatial displacements of identical survey points between two arbitrary deformation phases).
- Programs that were developed at the Institute of Rock Structure and Mechanics, Czech Academy of Science, v.v.i., in Prague, which allow computation of identical survey point displacements.

CONCLUSION

The method presented above comes from accessible and less expensive software products. It was primarily developed for the evaluation of rock environment changes, which takes place in connection with construction and operation of engineering constructions. In particular, this method is focused on monitoring of changes, which stem from enhanced loading of engineering constructions’ seat rock. On the other hand, this method can be also used for assessment of natural slope stability as well.

The whole method is based on the digital processing of the spatial displacements of identical survey points between two arbitrary deformation phases. The final product of the evaluation process is a figure (see Figure 2), which illustrates direction and extent of identical survey points displacement. It represents an effective tool for the solution of different types of natural hazard and engineering problems, especially in the case where these laboratory experiments are in conjunction with their numerical solutions.

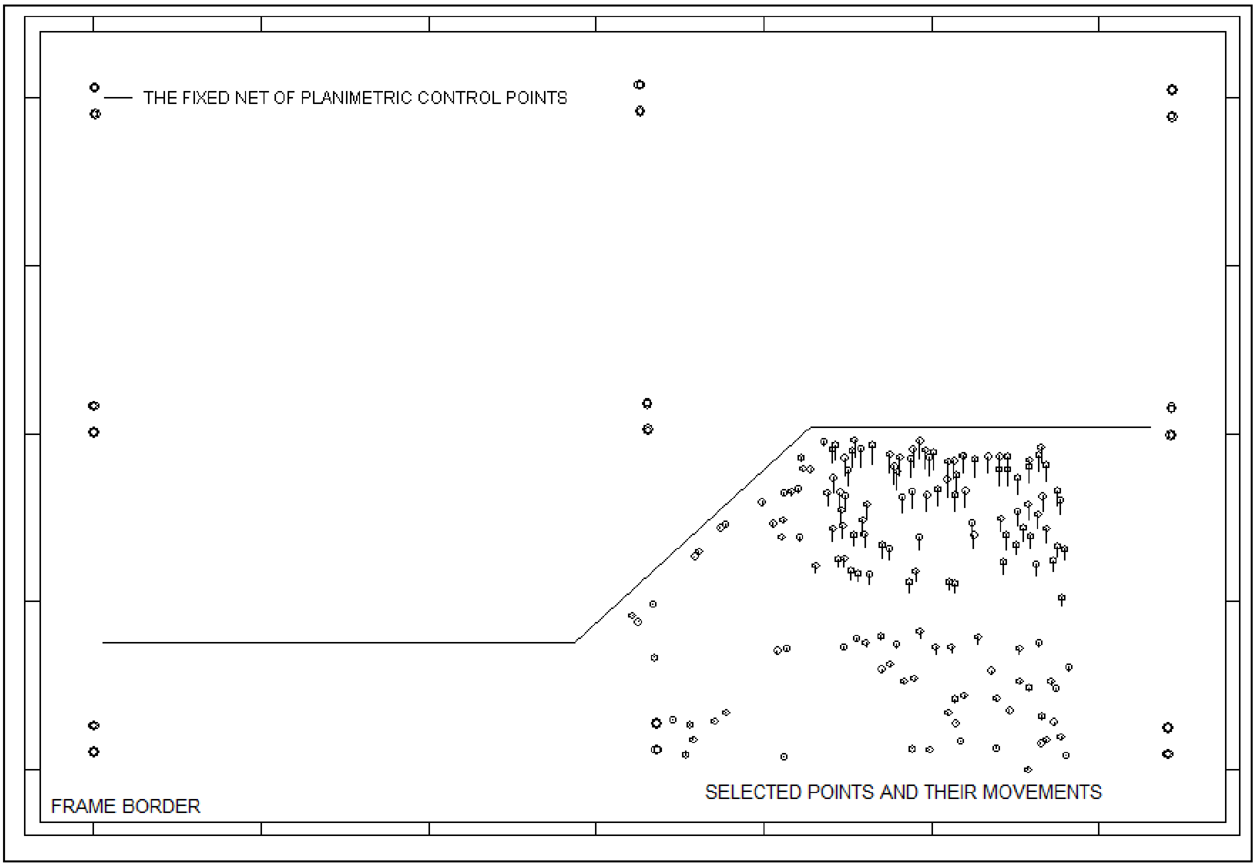

Figure 2 – Slope deformations: Spatial displacements of identical survey points between two arbitrary deformation phases.

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A COUPLED GEOINFORMATION AND SIMULATION SYSTEM FOR LANDSLIDE EARLY WARNING SYSTEMS

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KEY WORDS: Landslides, Geotechnical Models, Early Warning, Decision Support, GIS, Finite-Element-Analysis

INTRODUCTION

Recurring disastrous landslides cause great damage worldwide. According to GEOTECHNOLOGIEN (2008) the losses amount up to 100 billion US-dollars per year and more than 4 million casualties have been recorded due to these hazards in the last century.

Obviously there is a strong demand for reliable warning systems to save lives and properties. Although strong efforts have been made to develop early warning systems for natural hazards like earthquakes and tsunamis, the warning and the forecasting of disastrous events, especially for landslides in soils, are particularly difficult tasks.

As a consequence to the increasing demand for warning systems, the GEOTECHNOLOGIEN-initiative has been launched by the German Ministry of Education and Research. Our research project “Development of an interconnected information and simulation system” is part of that initiative and focuses on the development of a linked GIS-FEA-module (Geographical Information System – Finite-Element-Analysis – module) for a user-friendly and assisted investigation of the behaviour of slopes due to various scenarios.

This approach enlarges existing sensor-data based warning systems, since an insight to the physical processes, which cause slope failures and may result in landslides, are provided on basis of analyses on mechanically well-founded geotechnical models (TRAUNER et al. 2008b).

The research work is carried out jointly by the Institute for Soil Mechanics and Geotechnical Engineering and the Geoinformatics Research Group at the University of the Bundeswehr Munich.

Moreover, the project is integrated in the multi-disciplinary project “Development of suitable information systems for early warning systems”, which combines approaches from the fields of geology, geotechnics and geoinformatics for the identification and investigation of landslide susceptible areas and the early warning of disastrous events. Therein, techniques like FE-Analysis (BOLEY 2007, TRAUNER et al. 2008a), statistical and linguistically analyses (GALLUS & KAZAKOS 2008, GALLUS et al. 2008) are combined with GIS (ORTLIEB et al. 2008a) and a 3D/4D geo-database for the storage and management of spatial and time-related data (BREUNIG et al. 2008).

For the detailed architecture of the joint project BREUNIG et al. (2007) refers.

COUPLED GEOINFORMATION AND SIMULATION SYSTEM

The combination of a geographical information system and a FE-Analysis-component allows for an investigation of the behaviour of slopes due to various action effects (i.e. loads, accelerations, geometrical changes, etc.) in a numerical simulation. Thereby the GIS component provides user-assistant functions for the set-up of geotechnical models and the processing as well as the assessment of computation results.

The connection between the FEA-module (simulation system) and GIS is schematically shown in Figure 1. When a geotechnical model shall be generated for a specific slope, the area of interest is selected within the GIS. The geometrical data is supplemented with information about the subsoil structure, boundary conditions and action effects.

Following the data transfer from the GIS to the FEA-module, the geotechnical model can be set up automatically to a large extent. Subsequently the simulation is executed as defined by the user in the GI system.

After the simulation the results are written to an output file and transferred back to the GIS for processing and visualization of the data in regard to the assessment of the endangering by possible slope failures. Thereby the data preparation is carried out in such a manner that the results are understandable for decision makers.

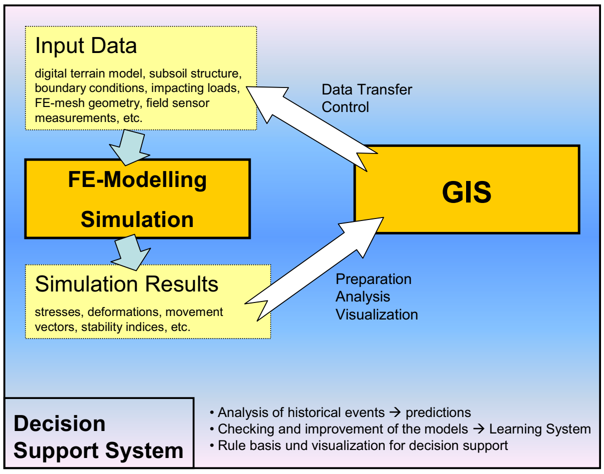

Figure 1 – Connection between FEA-module and GIS

APPLICATION MODES OF THE COUPLED SYSTEM

The coupled system of GIS and FEA is intended to be used for two different purposes (ORTLIEB et al. 2009).

If a slope shall be examined for its behaviour due to various scenarios or due to events of different magnitudes (e.g. earthquakes of different intensity) the coupled system can be applied as learning system (Figure 2). That means, that no acute danger may exist, but knowledge about critical magnitudes of events and the possible consequences of these scenarios may be essential for the assessment of the susceptibility of an area to landslides and e.g. for the definition of restricted zones. In general, the mechanical characteristics of the slope under investigation can be examined to be available in future, if a concrete event has to be evaluated.

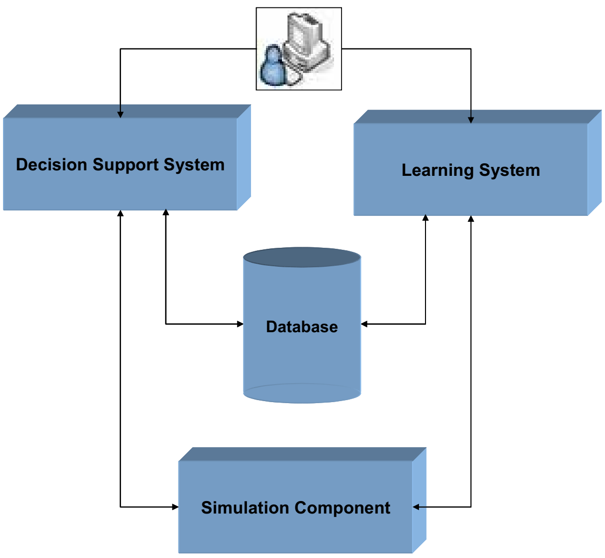

Figure 2 – Connection between FEA-module and GIS

In addition to the learning system, the coupled system can serve as a decision support system, if a specific event is awaited and has to be assessed regarding its consequences to the stability and deformation of the slope. In this mode, the focus is on a fast decision whether to issue a warning or not.

In both application modes the coupled system GIS-FEA is connected to the geo-database, where the data required for the numerical simulation is stored. Moreover outcomes of the computations are archived in the database to be available for future queries.

STUDY AREA

The illustrated concepts are implemented in a prototype to evaluate their advantages regarding the assessment of landslide susceptible slopes.

The area under investigation for the prototype is located in the Isar valley south of Munich, Germany, where the river eroded a deep valley into layers of quaternary gravels and tertiary sediments of partially high plasticity. Consequently, steep and instable slopes were formed, where landslides occurred from time to time (BAUMANN 1988).

Although the erosion of the river has been stopped for decades now, parts of the slopes are still in motion, since a state of static equilibrium has not been reached yet.

The last slope failures were observed in the early 1970s and gave reason for the installation of sensors (extensometer, inclinometer, ground water level tubes, etc.) and the start of a deformation measurement campaign for the slopes. These devices are still in the field and the measurements have been continued until this day. Thankworthy, the Bavarian Environmental Agency has made the measurement data available for use in the research project.

GEOTECHNICAL MODEL

The stability and deformation of slopes due to action effects are investigated within the simulation component by application of the Finite-Element-Method. Therefore geotechnical models, which represent the slope in a realistic manner to a large extent, have to be generated.

The area of interest, which shall be modelled, is selected within the GIS on basis of maps like topographical maps or orthophotos. In addition maps prepared by project partners can be considered, which suggest areas of increased landslide susceptibility on basis of statistical analyses (GALLUS et al. 2008, GALLUS & KAZAKOS 2008). Once the area of interest has been selected, data for the description of the geometry of the slope (topography and subsurface structure) is queried from the geo-database. In the database ground models or data obtained from site investigations (geological profiles, material properties) are stored (BREUNIG et al. 2009).

Finally, the geometrical description is supplemented by boundary conditions, action effects and other details and a geotechnical model of the slope is compiled. A simple three-dimensional model for a segment of the slopes in the Isar valley with its FE-mesh is shown in Figure 3.

Figure 3 – FE-model for a segment of the slopes in the Isar valley

To represent the slope's behaviour in large parts almost realistically, the applicable description of the material's characteristics is essential. Thus, appropriate constitutive equations with corresponding material parameters have to be applied and reasonable values for the parameters defined.

The calibration of the model is done on events observed in the past. Recorded slope deformations by sensors are compared with computation results in the GIS environment and the model adjusted (e.g. variation of material parameters, change of constitutive equations or geometry of the model) to bring the simulation in line with the slopes' real behaviour.

Once the geotechnical model has been calibrated successfully and shows similar behaviour compared to the real slope, it can be applied for prognosis purposes. The consequences (deformations, change in material strength utilization, etc.) of different scenarios for the slope under investigation and adjacent areas can be determined.

Subsequently to the simulations, relevant computation results are compiled in an output file and transferred to the linked GIS for further processing and visualization of the data.

DATA PREPARATION FOR DECISION SUPPORT

The outputs of the simulation are several parameters (e.g. stresses, strains or deformations, degree of material utilization). In Figure 4 the deformation vectors of a 3D simulation are shown.

Figure 4 – Visualized 3D simulation results

To identify the important parameters, namely the deformation direction and deformation length of the deformation vectors, the depiction has to be strongly enlarged. But therewith the overview of the whole slope will get lost. That means, the simulation results are too complex and too extensive to be presented like that for decision support. Therefore they have to be linked with decision rules to allow for a user-friendly preparation with appropriate methodologies.

In a first step the deformation vectors can be divided according to their length and their deformation direction into classes. Afterwards clusters can be detected, which include deformation vectors, which belong to the same deformation class, to the same direction class and are spatially adjacent. After the aggregation of the deformation vectors in the clusters the area of validity is determined. The result of this method can be visualised and presented the responsible decision-maker for decision support (ORTLIEB et al. 2009).

Moreover, the prepared computation results can be enriched by additional data from any other resources in the GI system (e.g. land development plans, infrastructure facilities plans or susceptibility maps obtained by statistical or linguistic analyses) to support the decision-making process.

CONCLUSIONS

With the focus on innovative methodical investigations and the implementation of new easy-to-use information technologies into the operational workflow of hazard management, the research project contributes to the reduction of threats posed by landslides.

The generation of geotechnical models in a coupled GIS-FEA-module allows for the improvement of early warning systems, since calibrated models can be applied to determine critical values of action effects (thresholds) that may trigger landslides, on a physical basis.

The conception of the module with its possibility for connection to other modules based on different approaches (statistics, analytical computation methods, etc.) via GIS and the integrated assistance functions in the module for decision-makers, provide a user-friendly and reliable medium for warning purposes.

ACKNOWLEDGEMENTS

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INTEGRATING LANDSLIDE INFORMATION IN THE FLEMISH SUBSOIL DATABASE (DOV)

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KEY WORDS: DOV, database, soil, subsoil, Flanders, landslides, mapped landslides, landslide susceptibility.

INTRODUCTION

The database for the subsoil of Flanders "Databank Ondergrond Vlaanderen", DOV has been established in 1996 within the Ministry of the Flemish Community. Today it is a cooperation between three entities of the Flemish government: the Land and Soil Protection, Subsoil and Natural Resources Division, the Geotechnics Division and the Operational Water Management Department. Subsoil and soil data are offered free of charges through a geodata infrastructure on the website http://dov.vlaanderen.be.

The database is built around 3 main themes: geology, geotechnics and groundwater. Recently a fourth theme was added to DOV: pedology. This part covers soil aspects such as landslides, soil erosion and mitigation measures, pedological heritage, …

In Flanders (Belgium), the occurrence of landslides is mainly concentrated in the area of 'The Flemish Ardennes'. The geological and topographical conditions in this region are particularly favourable for the initiation of landslides, i.e. an alternation of clayey sand layers and clay layers (Tertiary sediments), in combination with steep slopes. The majority of landslides are old and well integrated in the present landscape. Because of a lack of historical data, they are assumed to be over 100 years old, probably of late Pleistocene or early Holocene origin (Van Den Eeckhaut et al., 2007a). Hence they have been initiated under different climatic and land-use conditions. However, recent activity or reactivations within the perimeter of old landslides have been observed, as well as recently initiated landslides on intact (not previously failed) hillslopes. These may be the result of human or natural causes, or a combination of both. In many cases, human activities are responsible for a permanent decrease of slope stability, thus acting as 'controlling factors', whereas high cumulative amounts of precipitation act as a 'triggering factor' (Van Den Eeckhaut et al., 2007b). Human activities decreasing slope stability are (e.g.) the local excavation or accumulation of hillslope material for the construction of houses and other infrastructures (roads etc.), and poor water management such as improper drainage or the sealing of natural springs (Van Den Eeckhaut et al., 2006).

Figure 1 –Example of a landslide causing significant damage to a private property

AVAILABLE MAPS

The architecture of DOV is web-based: a jsp-viewer communicates through ArcIMS with the ArcSDE which is based on a Informix database. In order to keep up with European legislation (INSPIRE) and customer needs, the architecture is currently being migrated towards the newest ArcGIS-packages (a combination of ArcIMS and ArcGIS server 9.3), which will enable DOV to offer different kinds of open standard services.

In the DOV database, the geological, geotechnical, groundwater and pedological data are represented by different kinds of objects: points, lines, polygons and rasterdata. Data of various type, origin, ownership and age, are all included and managed in the same database.

The geological part includes drillings, lab tests, different kinds of descriptions and interpretations, isohypses and isopaches of the most important geological units and other maps such as the Tertiary and the Quaternary map, …

The most important data of the geotechnical part are point data such as cone penetration tests. In the near future, geotechnical maps will be integrated as well.

The groundwater part consists both of point data and maps: all active groundwater licences are free for consultation, as well as groundwater quality measurements, level measurements, observation wells, groundwater capture zones and protection areas, groundwater vulnerability maps, … Maps of groundwater bodies and systems will be available in the future.

As for the pedological part, the first steps were taken in 2003. Currently, different maps are available, such as landslides, soil erosion and mitigation measures and pedological heritage. This part will surely continue to expand in the future with for example soil maps, wind erosion maps, …

In 2003, the Flemish government (Land and Soil Protection, Subsoil and Natural Resources Division) launched a two-phased project for the creation of an inventory of existing landslides and a landslide susceptibility map for a 710 km² study area in the Flemish Ardennes. The results were presented and made available on the internet by the end of 2007.

The inventory of landslides was obtained by detailed field surveys and by the analysis of LIDAR (Light Detection and Ranging)-derived hillshade maps (Van Den Eeckhaut et al., 2007c). A statistical multivariate method, i.e. rare events logistic regression, was used to create the landslide susceptibility map. This methodology is based on the hypothesis that future landslides will have the same causal factors as the landslides initiated in the past. Information on natural controlling factors such as slope gradient, aspect, lithology, and soil drainage, was extracted from digital elevation models derived from LIDAR and from topographical, lithological and soil maps. According to the statistical model obtained, the presence of landslides in the study area is clearly linked with landslide hillslope gradient, four clayey lithologies and orientation (SE to NW) being the most important predicting variables. The model only incorporates natural factors affecting the inherent susceptibility for the occurrence of landslides and the resulting map shows the spatial distribution of actual and potential slope failures. Controlling factors caused by human activities decreasing slope stability are not predictable and hence are not considered in the model. Rainfall as a triggering factor could not be taken into account, since the time of initiation of the landslides and the prevailing climatic conditions are not known. Hence, it was not possible to create a hazard map providing information on the timing and the magnitude of the predicted landslide event. However, the information provided by the available map is considered to be sufficient to allow better land-use decisions in the study area (see further).

Two maps have been incorporated in the Databank Ondergrond Vlaanderen (DOV) and can be consulted by any user. The “Mapped landslides” show the locations of existing (inventoried) landslides in the study area. The attribute table of this map contains a link to a document containing detailed information collected during field work for each of the mapped landslides. The “Landslide susceptibility map” shows the inherent susceptibility for landsliding, based on the predicted chance of occurrence of a landslide, classified into four classes, i.e. very high, high, moderate and low susceptibility. This map was based on a grid cell size of 10m by 10m.

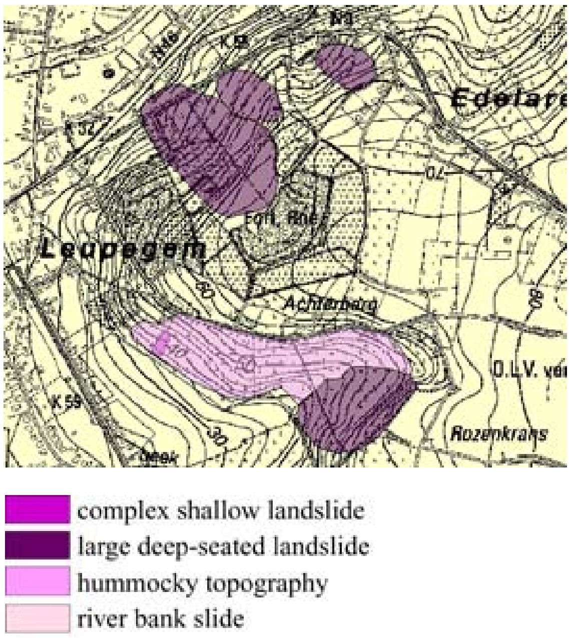

Figure 2 –Mapped landslides in DOV

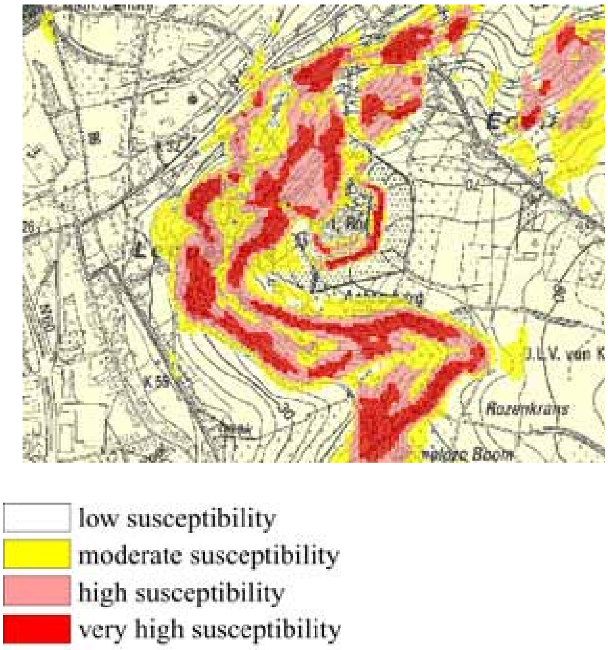

Figure 3 –Landslide susceptibility in DOV

USE CONSTRAINTS

Through the Databank Ondergrond Vlaanderen, both maps can be consulted by any citizen with an internet connection. The maps may provide useful information for local or regional authorities, planners, architects, engineers, notaries, insurance companies, or anybody involved in the construction or trading of buildings or other infrastructure. For instance, a citizen interested in the purchase of an existing house can verify the susceptibility for landslides and hence the chance of encountering (hidden) damage. Architects and engineers can get a first idea on the stability of a building site and the need of further geotechnical investigations. Local (or other competent) authorities can use the maps in the decision process of delivering building licences within the study area. Recently, the consultation of the available maps has become an obligatory element within the effect group 'soil' when drafting environmental impact assessments for projects located in the study area.

However, the maps must always be interpreted with care and with sufficient knowledge on the process of landsliding, and using additional data sources related to topography, geology, soils and hydrology.

These may be provided by maps but also from reports and previous drillings or standard penetrations tests, hydrological investigations etc. Such information can also be found in the Databank Ondergrond Vlaanderen. Of course, any information 'on paper' must be combined with an elementary visual investigation of the terrain and if there are indications that landsliding is likely to occur, a further geotechnical investigation is advisable. A clarifying document on the interpretation of the available maps is provided on the DOV website, more specifically on the general pages related to the landslide maps. This must help the user to interpret the different vulnerability categories in combination with additional information and an elementary field investigation. It needs also be stressed that the susceptibility map is the result of a computer model, implying that not all the local variability or specific site information can be accounted for. For more information on the scientific background, a link to the website of the Flemish government (Land and Soil Protection, Subsoil and Natural Resources Division) is also provided. On this webpage (http://www.lne.be/themas/bodem/grondverschuiving/grondverschuiving), the project is further explained and all documents can be downloaded free of charges.

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ANALYIS OF A LARGE DEEP-SEATED CREEPING MASS MOVEMENT – THE STUPFARRI LANDSLIDE, KAUNERTAL, AUSTRIA

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KEY WORDS: Tyrol, deep seated, creeping mass movement, sagging, rock flow, rock slide, geomorphological observations, geographical information system

PREFACE

In 1939 AMPFERER described slow but very spacious mass movements, which he found all over the Eastern Alps. STINI extended this topic 1941 under the name "Talzuschub" (valley close-up) and turned it into an engineering challenge by drawing the attention to the constructive consequences despite the hardly measurable incidences. Since terminology varies to a large extend in international scientific literature, the terms "compound sagging" (acc. HUTCHINSON 1988) or "rock flow" (acc. VARNES 1978) should be applied for complex large deep-seated, creeping mass movements like the one presented below.

Several such saggings/rock flows are known in the European Alps; nevertheless most of them are largely unexplored. In the following a "Talzuschub", a deep seated mass movement, is described and possibilities are shown to make first presumption with conventional methods to set up a basis for further research. For easier reading the Stupfarri is referred simply as a rockslide.

STUDY SITE

Figure 1 – Map of Austria(grey). Arrow shows the location of the study site.

The area is situated in the entrance of the Kauner Valley, Tyrol/Austria (fig. 1). The Stupfarri mass movement covers an area of 7,2 km^2 and the height of the slope reaches about 1760 m (from 1040 to 2800 m a.s.l). Geometrically the mass movement has a width of 1950 m and a length of 3700 m, respectively and a preliminary estimation of the volume, based on a equation by BEYER (1987), yields about 0,8 km³.

The area is characterised by a typical alpine climate Zone with long period of freezing in winter and spring and changeable summers. Per annum approximately 820 mm/m² of rain falls, whereas the maximum heights of snow reaches about 2-4 m. The area is drained by several small creeks which can dry up in season with sparse rainfall. All creeks drain into the main river of the Kaunertal Valley named "Fagge".

GEOLOGICAL AND STRUCTURAL SETTING

The study site the area is situated within the poly-metamorphic Ötztal-Stubai crystalline complex of the Austroalpine units. In the study area the crystalline complex is composed mainly of layers of paragneisses, micaschists, orthogneisses and amphibolites. After deglaciation several slope instabilities occurred in this region as a result of stress redistribution by valley steepening and deepening within the low strength paragneisses and schists. The Stupfarri rockslide system is located within an extensive paragneiss complex which is framed by amphibolitic rock masses. Generally, the paragneissic series are characterised by a variable content of plagioclase, biotit and quarz. A detailed map of the region can be found in WEISSFLOG (2008).

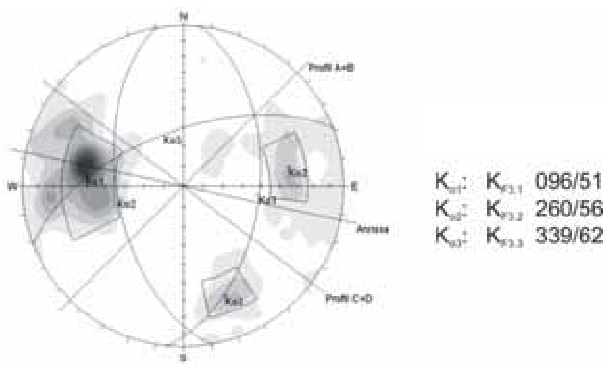

Figure 2 – Stereoplot of measured joint sets K 1-3 (lower hemisphere).

The foliation is folded and the dip direction ranged from NW to N with a dip around 30°. Based on individual outcrops and systematic scanline measurements three major joint sets were distinguished (fig. 2) of which one joint set (K1 096/51) is dominant. Some of these prominent joint sets were also found by ZANGERL and PRAGER (2008) on the Kreuzkopf rockslide system located in the Inner Kaunertal valley. Several brittle fault zones were measured near the "Kaunergrat" ridge. One more distinctive fault zone strikes NE-SW and dips with a mean angle of 50° towards SE.

GEOMORPHOLOGICAL OBSERVATIONS

Generally, this study focused on the mapping of geomorphological and lithological features of the rockslide system. Lithologically the major part of the area was already mapped by ZANGERL (1997). Therefore a primary aim of field work was related to the study of geomorphological key-features i.e. boundary of the rockslide mass, different sliding masses, uphill facing scarps, extensional cracks (fig. 3).

Figure 3 – Extensional cracks and scarps facing uphill.

The digital elevation model (hillshade) in fig. 5 shows impressively the main but also secondary scarps which point to several individual sliding masses. Obviously the upper part of the rockslide boundary is defined by a major brittle fault zone already referred above. At the main scarp area double ridge formation can be observed (fig. 4). Considering all facts the rockslide has slid more than 200 m downhill in the main scarp region. At the toe of the slope a large bulge formed and it seems that the valley was closed in the past. This hypothesis is confirmed by the accumulation of back-water sediments upstream of the valley restriction and a meander-like behaviour of the river "Fagge". Moreover fig. 5 displays several linear structures in the upper part of the slope transverse to the slope line. These extensional cracks have uphill facing scarps with aperture widths up to 10 m and depths up to 8 m (fig. 3).

Within the mass movement the gneisses are highly fractured and disaggregated, there are only a few small areas with relatively intact rock mass. Most of the surface is covered with talus and glacial till deposits. Typically there is a lack of surface water within the moving area. In the village of Kaltenbrunn streets and buildings are damaged.

Figure 4 – Double ridges at the Stupfarri crest.

GEOLOGICAL AND KINEMATICAL MODEL

Considerations related to the underground geometry are based on surface investigations. Neither boreholes nor geophysical investigation are performed within or close to this area and furthermore no deformation measurements are available. Therefore the geometrical-kinematical model presented herein is only a first assessment and possess a high degree of uncertainty.

Given the lack of deformation measurements the activity is unknown. Because of damages of roads and some buildings in the lower part of the rockslide it is suspected that movements are still proceeding at least in this area. The degree of internal deformation may result from dissimilar movement rates by the individual sliding masses as described above. Based on observations at the scarps, the large slope displacement and geometrical reasons the depth of the mass movement may reach 200 – 300 m. Another consideration is the possibility that the movements fade away in depth and on account of that no discrete sliding zones exists. Due to the adduced arguments above, this mass movement can be characterised as rock slide or rock flow (nomenclature by UNESCO 1978) depending on the constitution of the surface of rupture.

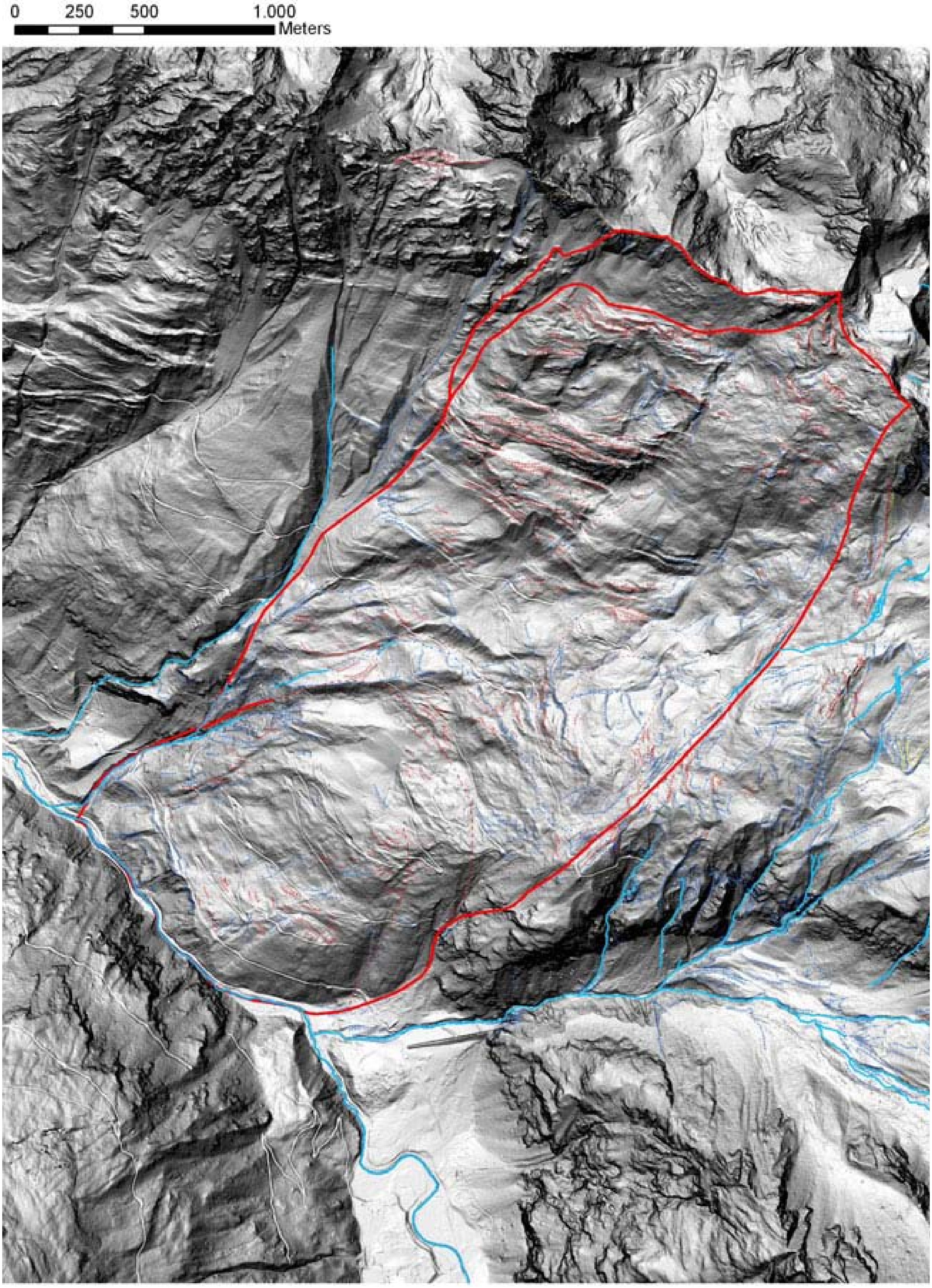

Figure 5 – Airborne laser scanning based digital elevation model (hillshade) showing geomorphological features of the Stupfarri rockslide (e.g. sliding masses, boundaries, uphill facing scarps, extensionl cracks)(LIDAR Höhenmodell – Amt der Tiroler Landesregierung, Geoinformation).

Of course this is a first estimation and has to be verified by subsurface investigations. The results of the structural analysis showed three distinct joint sets. The schistosity of the paragneisses is predominately dipping moderately to NW or N. Thus the joint sets and the foliation are orientated transversal to the slope and therefore unfavourably in order to promote slope failure due to in-plane shear.

CONCLUSION

In this field study it was possible to obtain a first impression of the character of the Stupfarri mass movement. Field investigations and data analysis could confirm the hypothesis of a large-scaled sagging/rock flow. Intensive field mapping helped to outline the mass movement on surface and to make presumptions about subsurface structures and geometries. GIS-based analysis of the field data provides a first geological–kinematical model of the rockslide system.

It is not clear to what extent the rock mass structures determine or influence the mass movement. A unique relationship between the structural inventory and the failure mechanisms of the rockslide was not found (fig. 6).

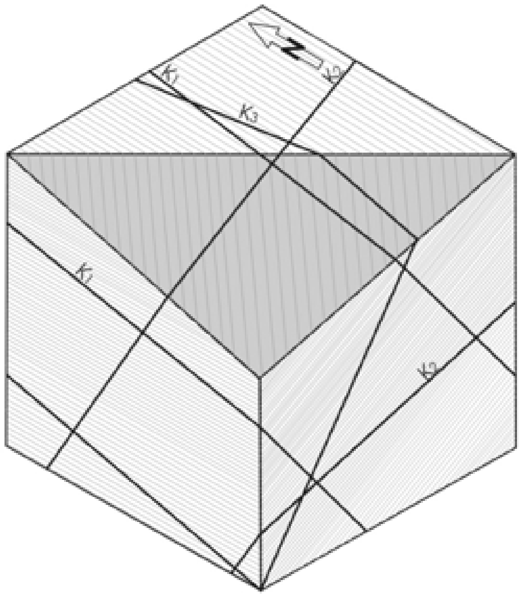

Figure 6 – Block model of joints sets with generalized surface.

By processing the data within a geographic information system a profound basis for further investigations was created. The next step may focus on a survey of the underground (by drilling) to reassess the suggested assumptions linked to the sliding process and to quantify them if possible. Also a long-term geodetic monitoring of the slope's surface could shed light on its activity. Such data could be interesting for the design of constructions sensible to deformation on the one hand and for scientists to gain important information on this common type of mass movement in alpine regions on the other hand.

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INTEGRATION OF LARGE DEEP-SEATED, CREEPING MASS MOVEMENTS IN A REGIONAL HAZARD MAP

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KEY WORDS: South Tyrol, hazard map, mass movement, monitoring, accelerating creep, material law, failure relation, forecast, probability of occurrence

INTRODUCTION

In the last two decades hazard maps (HM) have been established as one of the major tools for risk assessment and urban planning in alpine regions. During this time, various efforts and methodical adjustments could be recognized that significantly supported reliability and applicability of hazard maps. All those adjustments are based upon the fundamental Swiss system of geological hazard assessment and mitigation, the so called BUWAL, which is by now broadly accepted and considered to be the main fundament for the elaboration of hazard maps in alpine areas. One of the last problems that can be regarded as almost unsolved in terms of local hazard zoning and elaboration of a regional hazard maps is the integration of large deep-seated and creeping mass movements (i. e. "Talzuschub", "Sackung") Since terminology varies to a large extend in international scientific literature, this paper applies the terms "compound sagging" (acc. HUTCHINSON 1988) or "rock flow" (acc. VARNES 1978) for complex large deep-seated, creeping mass movements like the one presented below.

PROJECT "TALZUSCHUB ALGUND"

In 2007 the Autonomous Province of Bolzano started the graduated elaboration of hazard maps for all municipalities belonging to the territory of South Tyrol. These hazard maps have to be compiled in accordance to the official guidelines (A.P.Bz 2007) that refer to the approved principles and publications of BUWAL.

Almost each municipality north of a geographical line from the Swiss border near Glurns via Meran and Sterzing to the northeast corner of South Tyrol (Ahrntal) is affected by the geological phenomenon of compound sagging / complex rock flow. The classification of hazard zones that are to be depicted by the hazard map requires the assessment of "intensity" and "probability of occurrence" as basic information (Figure 1). Therefore the Office for Geology and Building Material Testing (Office in charge for all geological aspects of HM in South Tyrol) is now forced to provide a reliable and applicable method for the integration of complex large deep-seated, creeping mass movements in the municipal hazard maps. Dealing with an integration of this geological phenomenon, one is faced with two major problems in contrast to other phenomena like rock falls, slides, debris flows, etc. These problems are:

- large variations in activity over extremly long periods of time, clear acceleration only towards failure (see section 5),
- therefore distinct time-dependence of intensity,
- intensity is only determined by velocity (rate) as moving rock mass (volumina) and depth of surface of rupture always correspond to a "high"-grade intensity and thus appear to be irrelevant for classification,
- therefore probability of occurence is the main parameter for classification respective the BUWAL matrix,
- impossibility of mitigation (reducing hazard) – necessity to reduce vulnerability and exposition (risk assessment and risk mitigation).

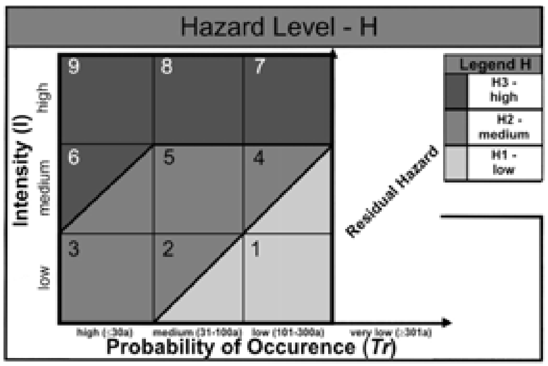

Figure 1 – BUWAL-Matrix for classification of hazard levels that are to be depicted in a HM (from A.P.Bz 2007, modified).

Considering these general conditions, it becomes obvious that integration of compound saggings / complex rock flows forces persons in charge for the affected hazard map to investigate the relevant area in a manner that

- reveals internal structures of the creeping rock mass and allows separation of homogeneous (and more or less independent) units,
- shows possible interactions between these single units of the mass movement,

- permits definition of movement thresholds for defined scenarios like damage/loss of houses, infrastructures, danger to traffic, etc.,
- enables a prediction for probability of occurence and failure forecast, respectively,
- detects all processes and phenomena directly linked to the large moving rock mass, i. e. (proceeding) disintegration of the rock mass, rock fall, toppling, debris flow .

To meet all those special needs corresponding to the area wide elaboration of hazard maps in South Tyrol, the Office for Geology and Building Material Testing of the Autonomous Province of Bolzano established several research projects dealing with compound saggings / complex rock flows. One of those is the research project "Talzuschub Algund", established in 2007 in close cooperation with the Chair for Engineering Geology of the Technische Universität München.

"TALZUSCHUB ALGUND" – FRAMEWORK

The sagging / rock flow of Algund is situated in South Tyrol, about 10 km west of Meran (figure 2). The large deep-seated mass movement ranges from the crest/ridge at "Rötelspitz" (2545 m a. s. l.) down to the Etsch valley and the villages of Vellau, Plars and Algund at about 400 m a. s. l. It is laterally confined by the brooks of "Töllgraben" (west) and "Grabbach" (east, figure 3).

Figure 2 – Location of project area "Talzuschub Algund".

The slope is built up predominantly by gneisses (ortho- and paragneiss) and to a much less extend by mica schists and amphibolites. The metamorphic rocks belong to the Texel Unit and are thus part of the Austroalpine Unit. The Texel Unit was formerly considered to be part of the "Ötztalmasse". During the Oligocene (alpine orogenesis) dykes with andesitic intrusions were formed as a consequence of the intense tectonic activity. Today, large areas of the slope are covered by quaternary deposits. These are glacial till, detritus from rock fall and debris flows and alluvial sediments from the local brooks and the Etsch river. Since till deposits could be found in large scarps of the mass movement the field works for the project could prove that the sagging / rock flow of Algund and Vellau started already before the last ice age (i. e. pre-Würmian). The rock mass is disintegrated and jointed to an enormous extend. Intensive morphologic structures that can be related to the movements have developed. Those are scarps, trenches (at some places similar to a "graben"), transverse ridges and cracks. The crown/main scarp and the toe of the movement can be identified easily in the field (figure 3). Several surfaces of rupture have to be assumed and investigated (figure 4) and local focuses of creeping movements can be distinguished from parts with generally minor activity or displacements. The largest features related to the creeping rock mass are scarps, trenches and holes / depressions of up to ca. 1500 m extend parallel to the slope and ca. 150 to 200 m perpendicular to the slope (spreading displacements, sagging). These large gaping structures reach depths up to ca. 40 m. The following concept for the assessment of the Algund mass movement in terms of a reliable hazard maps is bases on

- detailed field work (geologic and geomorphologic mapping),
- petrografic analysis,
- rock mechanics laboratory tests,
- application of suitable rock mass classification (GSI acc. HOEK 1997, MARINOS 2000),
- development and realization of a detailed monitoring concept.

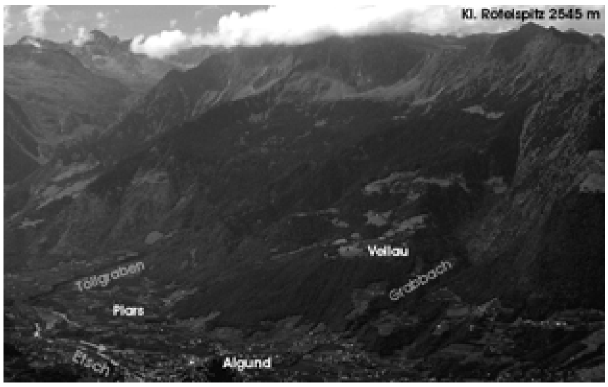

Figure 3 – View of mass movement "Talzuschub Algund".

FROM MONITORING TO HAZARD MAPS (HM)

Based on the intense geologic field works and the further research described above, a detailed monitoring system has to be projected and installed at the slope affected by the sagging / complex rock slide of Algund. This research fundament enables to determine focuses, i. e. places that show a significantly increased number of prominent features and structures related to the creeping mass movement or places with a high exposition/vulnerability with respect to the sagging/rock slide and its linked processes and phenomena (as listed in section 2).

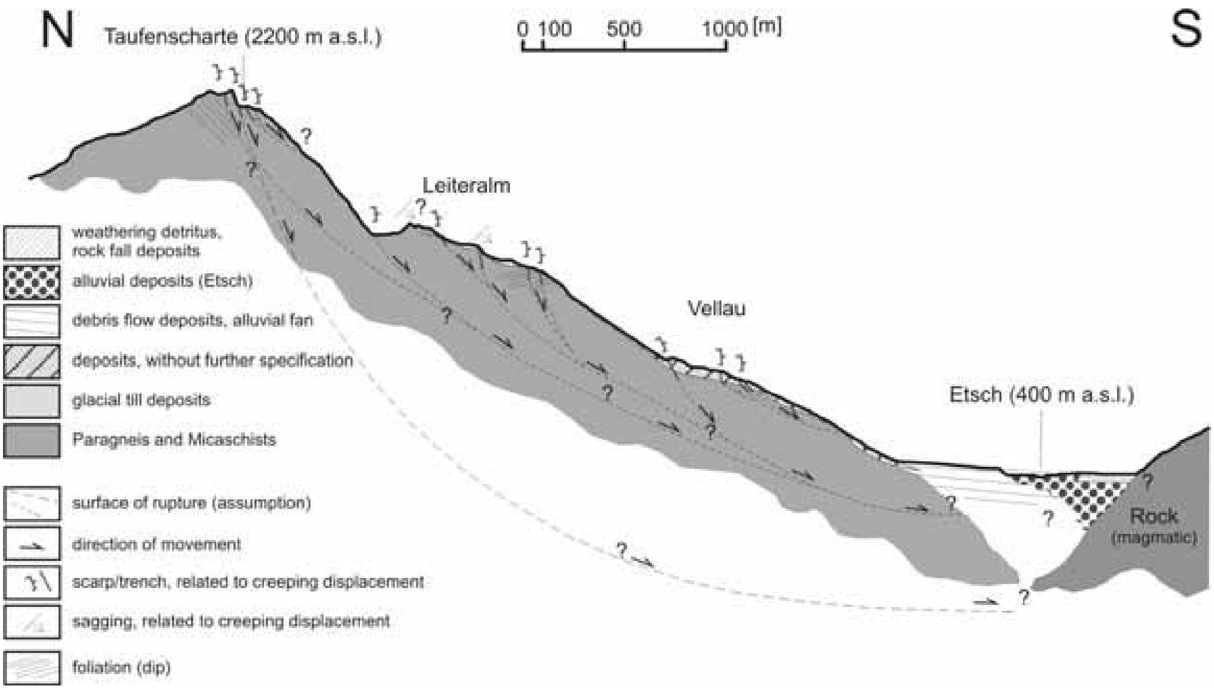

Figure 4 – Characteristic cross section of "Talzuschub Algund", ranging North to South from the ridge area via Vellau to Etsch valley near Algund.

The data gained by monitoring systems have to allow or support

- determination of all relevant surfaces of rupture (depth and extension),
- determination of separated, possibly interacting units within the sagging/complex rock flow,
- numerical modelling of the mass movement by use of suitable codes like UDEC or FLAC,
- elaboration of sections of particular creep curves that are suitable for application of appropriate creep theory and failure relations for time related forecasts/ predictions in the sense of the BUWAL-matrix (see following section).

It has to be emphasized, that the problem of classifying a large deep-seated creeping mass movement in view of its probability of occurrence (as required for a hazard map) can only be solved by applying well established and mathematically based theories and methods for failure prediction of creeping rocks (and soils respectively). For this type of mass movement both numerical modelling and failure prediction based on mathematical analysis of creep curves can only be carried out on an adequate level if monitoring lasts for at least three to four years (CROSTA 2003).

APPLICABLE CONCEPTS OF CREEP THEORY

Sound research, published in various papers during the last decades, showed that almost every slope movement takes place in correspondence to the theories of "accelerating creep", no matter if one regards falls, topples, slides or a spreads in bedrock or soils. This statement corresponds also to the broad experience the Office for Geology and Building Material Testing gained by monitoring slope movements and slope failures all over South Tyrol. The observed creep curves may vary in dimensions of velocity, time and acceleration or due to seasonal or meteorological influences but the basic pattern always remains (CROSTA 2003). Complete creep curves can be divided in three stages (EMERY 1978, figure 5). Those are "primary" creep after instantaneous elastic response (I), "secondary" or "steady state" creep (II, can last for enormous periods of time) and "tertiary" or "accelerating" creep (III) that leads to material failure and slope failure, respectively, in terms of mass movements.

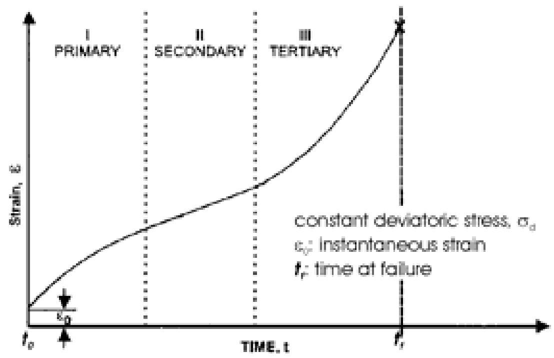

Figure 5 – Ideal creep curve showing creep behaviour in different stages (EMERY 1978, modified).

In other words: the art of integrating compound saggings / complex rockslides like "Algund" in a regional hazard map is the art of determining their actual position(s) on their particular creep curve(s) and to predict the curve's shape towards failure. Based on the broadly established relations / laws of SAITO (1966, 1980) and FUKUZONO (1985) a material failure relation, introduced by VOIGHT (1988), provides a powerful tool for very well approximated failure time calculations of mass movements. Its general application and its constraints were demonstrated in several publications (e. g. TILLING 1988, VOIGHT 1989, CORNELIUS 1993, CROSTA 2003). In the following a very short introduction in Voight's concept is given, as it appears to be fundamental for dealing with saggings/complex rock flows in view of a regional hazard maps. With this concept rate changes are related to rates during accelerating creep by the materials failure relation as

$$\ddot{\Omega} = A\dot{\Omega}^{\alpha} \quad (1)$$

Ω is a measurable quantity like displacement / strain. The dots refer to differentiation with respect to time – i. e. one dot stands for velocity/rate, two dots for acceleration/rate change. A and α are dimensionless constants and can be derived from a given dataset (monitoring data, rate vs. time) as

$$\dot{\Omega} = \left[A(1-\alpha)(t-t_0) + \dot{\Omega}_0^{(1-\alpha)}\right]^{1/(1-\alpha)} \quad (2)$$

Eq. (2) is the solution with respect to rates for general cases α ≠ 1, with initial (start monitoring) time and rate t_0 and Ω_0. It allows to calculate failure time t_f with single-differentiated Ω_f (rate at t_f) as

$$t_f = \frac{\dot{\Omega}_f^{(1-\alpha)} - \dot{\Omega}_0^{(1-\alpha)}}{A + (1-\alpha)} + t_0 \quad (3)$$

VOIGHT (1988) states that time to failure can ascertained graphically by drawing reciprocal rate curves ($t - \dot{\Omega}^{-1}$-graph). The intersection of the resulting graph with time axis can be taken as t_f (figure 6).

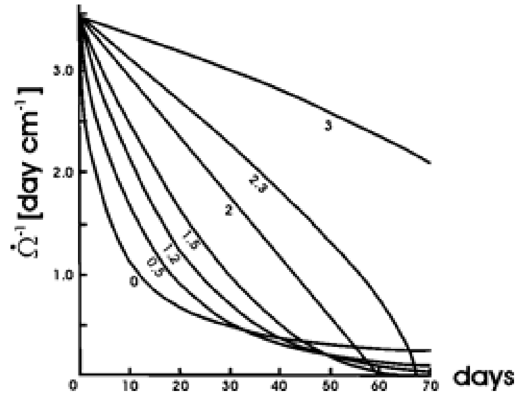

Figure 6 – Typical reciprocal rate curves, illustrating sensitivity and difficulties resulting from calculated α (VOIGHT 1988, modified).

As figure 6 shows, the curvature of the reciprocal rate curves is controlled by α. Results are linear for α = 2, concave for α < 2 and convex for α > 2. This is one of the most dangerous effects for applying this concept in view of creeping mass movements since research of the authors named above proved that α typically ranges between 1.6 and 2.2 for rocks (CORNELIUS 1993, CROSTA 2003) and single values may fall outside this limits. So t_f easily might be undervalued for α < 2 and overvalued for α > 2 which is both a serious threat to a reasonable forecast in view of a reliable HM. The method depends to a large extend on sophisticated calculations and statistical fits of α.

CRUDEN (1987) stated the reliability of SAITO-based forecast-methods for slope failure and threshold definitions (q.v. CROSTA 2003) in periods of 6 months and thus their fitting to the temporal specifications of HM matching the BUWAL-matrix.

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DISTRIBUTING REAL-TIME EARTHQUAKE INFORMATION IN ITALY THROUGH DYNAMIC WEB PAGES AT INGV

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KEY WORDS: seismic hazard, earthquake monitoring, Gis application, web pages

THE INGV-CNT MISSION

The National Earthquake Centre (Centro Nazionale Terremoti, CNT) is the branch of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) that is responsible for the real-time earthquake monitoring in Italy. It manages a large and high-quality network of more than 250 seismic stations distributed in Italy and in the Mediterranean (Amato et al., 2006).

Data from broad band seismometers, accelerometers and continuous GPS receivers are sent to the seismic monitoring facility in the CNT headquarters, in Rome, and backed up in Grottaminarda. Trained personnel is on 7H24 duty to check and revise locations and magnitudes determined by automatic procedures, and to inform quickly the national Civil Protection Department (DPC).

First automatic locations are available within 20-30 seconds after each earthquake occurring in Italy, and revised information are sent after a few minutes.

Figure 1 – INGV Seismic Monitoring headquarter

Soon after the official data is delivered to DPC, all the relevant information about a seismic event is published on the INGV web site (*www.ingv.it)*, in order to inform authorities and people living around the area struck by the earthquake. As shown in the example below, maps showing previous ancient and recent seismicity, the seismic hazard and classification of the region are provided, together with (for stronger events) rapidly determined shake maps (Michelini et al., 2008), and earthquake moment tensors.

Also, maps with felt effects retrieved via web are compiled and shown soon after the earthquake (De Rubeis et al.,). These latter maps are published in subsequent steps, as soon as new data and results become available.

GIS APPLICATION: SisMap and SisWeb

Sismap is the work space used by the INGV personnel on duty for real-time seismic monitoring. With Sismap the seismologists can visualize in a georeferenced environment all the earthquakes recorded, the seismic stations, several seismological and geographical information levels. One can also make queries on seismic catalogues, visualize earthquakes recorded worldwide by other international agencies (USGS, GFZ, EMSC, etc.), run applications to visualize seismic waveforms, determine hypocentral parameters, update earthquake database, send information to DPC, update web pages.

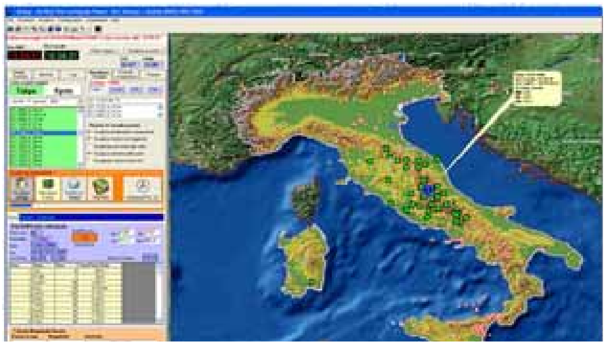

Figure 2 – Sismap Interface

Sisweb is the application which generates the contents of the pages published on the INGV web site. Both Sisweb and Sismap are developed in ESRI ArcGIS Engine on a Miscrosoft Visual Basic platform. Sisweb automatically produces the maps for each specific earthquake, including historical and recent seismic activity, the seismic hazard and seismic zonation of the region. Each map is

generated switching on and off the different information levels and performing temporal queries. In addition, a text box summarizing the main data on each seismic event is filled in and published (event ID number, date, location, depth, magnitude, etc.), and a legend is added to each map. Miniaturized images are also created for fast visualization of the web pages.
All the images are posted on a private ftp account, where other maps are also sent by different applications A template file called “event.php” is
also generated. This file is entirely developed in PHP and HTML to guarantee highly dynamic web pages.
Besides the “standard” automatically generated text, for significant earthquakes (typically M>4) it is also possible to insert and publish outright a text with more information written by the expert seismologist on shift. This text summarizes the available information and reports an evaluation on the ongoing seismic activity, which is updated as new data are recorded and analyzed.
An automatic procedure looks after the possible existence of other new or updated information for each specific event, such as Moment Tensors*,* Shake Maps*, “Did you feel it?”* questionnaire results, and, if present, it pr publish them after the standard maps.

THE DEC. 23, 2008 M5.1 EARTHQUAKE IN EMILIA-ROMAGNA (NORTHERN ITALY)

At 16:24 of December 23, 2008, a M5.1 earthquake struck the Emilia-Romagna region, near the town of Parma and Reggio Emilia. We show here the information produced by our procedure and published on the INGV web site

Figure 3 – Map showing the epicenter and summary of the hypocentral parametres

procedure and published on the INGV web site a few minutes after the event. The earthquake, although luckily just below the damage threshold, has been felt by millions of people in northern and central Italy. The first information is a summary of the hypocentral parameters, with a map showing the epicenter (star and 20-km circle surrounding the epicentral region) and the main towns involved. Below, the text describing the earthquake occurrence, the seismic activity evolution and some information on previous geologic and seismologic knowledge, is reported, followed by the list of towns within 10 and 20 km from the epicenter. The first thematic map is the one showing the seismic stations (squares) used by the INGV seismologists to locate the earthquake. The number and the geographical distribution of the network give an idea of the location accuracy.

Figure 4 – Map showing the seismic stations to locate the earthquake

Figure 5 – Recent and past seismic activity

All the subsequent thematic maps are centered around the epicenter and provide information on the previous seismicity (three maps) and on the seismic hazard and the seismic zonation of the region (two maps).

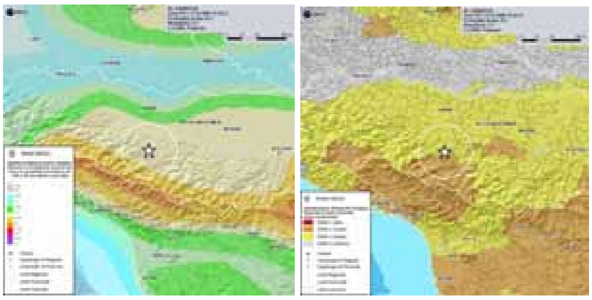

Figure 6 – Seismic hazard maps

In addition, for the strongest earthquakes, other results are obtained from the seismic data and published on the web. First of all, automatically derived Shake Maps (Michelini et al., 2008) are shown, in terms of predicted felt effects (macroseismic intensity, see figure below) and of PGA (Peak Ground Acceleration) and PGV (Peak Ground Velocity). These maps are extremely useful to give a first, fast evaluation of the extent of the region struck by an earthquake, and by the level of expected shaking and damage.

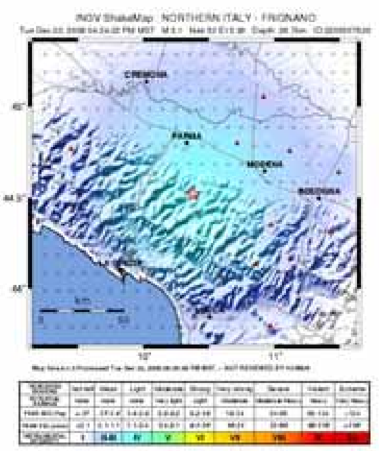

Figure 7 – Shake map (macroseismic intensity)

Another interesting information reported is the one derived from the “Did you feel it?” felt effects questionnaire, which is available on-line for every earthquake in Italy (De Rubeis et al., 2009). For the M5.1 event in Emilia-Romagna, the map shown below was obtained by more than 1500 questionnaires posted on the INGV web site in a few hours after the earthquake. Comparing this map with the Shake Maps described above, it is possible to have a good idea of the pattern of effects produced by the earthquake.

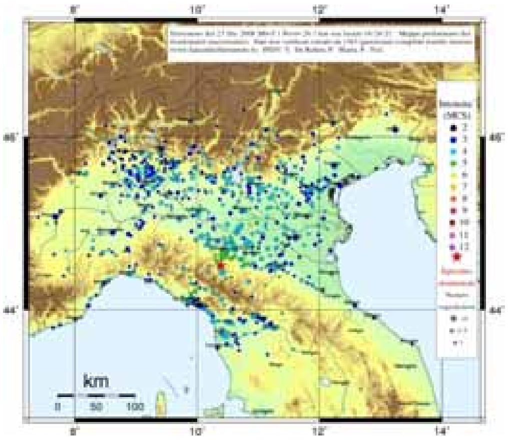

Figure 8 – Map derived from felt effects questionnaire

Other, more technical data are reported with automatically generated maps, including the focal mechanism of the earthquake obtained with different techniques from seismological data (Pondrelli et al., 2007; Michelini et al., 2008), maps with previous focal mechanisms, and the possibility of downloading seismic waveforms in SAC format.

All the published web pages for all the located earthquakes are available on the web site of the Centro Nazionale Terremoti (http://cnt.rm.ingv.it). In case of a large earthquake, the INGV web pages described above are accessed by several thousand people in a few hours. For the M5.1 event described above we registered an increase by a factor of 20 on a daily basis. The number of visits to the site were less than 1,000 in the previous days and increased to about 15,000 on Dec. 23, from 16:24 to midnight (see figure below).

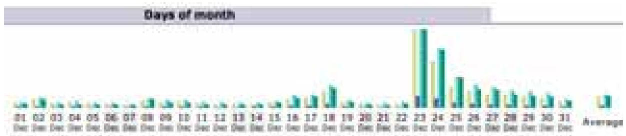

Figure 9 *– Visits to the site on December 2008*

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GIS-BASED FLOOD RISK ASSESSMENT IN UNGAUGED BASINS USING DEMS

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Abstract

Flood risk assessment in ungauged basins, where the lack of detailed hydrologic information avoids the use of standard inundation models, is here achieved by implementing and applying an automated GIS procedure able to optimize the use of available DEMs and rainfall information.
The proposed method is able:

1) to characterize the diffusive behavior of the surface flow on the hillslopes as compared to the concentrated channelized drainage pattern within the valleys, with the aim of accurately modeling the spatio-temporal distribution of the runoff field. This leads to a more detailed interpretation of some hydrologic and geomorphic properties that are often used in rainfall-runoff modeling in ungaged basins (e.g. time of concentration, the Horton ratios) (Nardi et al, HSJ 2008);
2) to simulate the hydrologic forcing by using the Width Function Instantaneous Unit Hydrograph (WFIUH) concept - based on the estimation of the residency time distribution of the rainfall drops falling within the basin – that converts the accurate interpretation of the flow directions and velocities into a robust estimation of the hydrograph and its main properties (peak, volume and duration);
3) to provide a preliminary delineation of flooding risk - by interpreting the available digital topographic information (DEM) In conjunction with the simulated hydrologic information – using a hydrogeomorphic delineation methods that identifies low laying flood prone areas in the river basin (Nardi et al., WRR 2006). The method is carefully tested by applying the GIS tool to several river basins, located in Central Italy, using different data sources (DEMs) and working at different spatial scales (e.g. basin size and DEM resolution/precision).

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METHANE SEEPAGES IN TRANSYLVANIA (RUMANIA) AND THEIR IMPACT ON THE ENVIRONMENT – A CASE STUDY

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KEY WORDS: Miocene, gas pool, seepages, environment, Transylvanian Basin, Rumania.

INTRODUCTION

There have been noticed in Rumania since long time ago, spontaneous gas seeps occurred in several areas in the Transylvanian Basin (e.g. Cucuteni, Dumbrăvioara, Glodeni, Grebeniş, Tăuni, Deleni, Bazna), similar with the ones noticed elswhere in our country. The first comments upon such appearances are Georgius Vette's, issued in 1676 (Pop, 1942)

Some of these processes have developed since centuries, but others ones have been induced as collateral effects of the beginning of some gas pools exploitation. The gas seeps were studied systematically just with the beginning of the previous century (Bányai, 1932; Peahă, 1965; Paucă, 1969; Filipescu & Humă, 1979; Paraschiv, 1979), in order to remove them, because the methane greenhouse effect.

In this presentation, we display a case study referring to the Tăuni gas pool.

LOCATION

The Transylvanian Basin evolution refers to several generations of overlapped and incongruent sedimentary basins, the last one beginning to function in the middle Miocene (Ciulavu et al., 2000, 2002). Its Miocene sediments concerns: Badenian (rhyolitic tuff, salt, marl), Sarmatian (various clastic and terrigenous rocks, volcanic tuff interbeddings) and Pannonian (mainly marl and clay, with rare sand interbeddings; Ciupagea et al., 1970). An essential control factor in the evolution of the basin was the Badenian salt tectonics (Krézsek & Bally, 2006), which outlined gas traps.

A typical gas pool in Transylvania is Tăuni, located on the southwest side of the Transylvanian Basin in Alba district, 19 km westward from Mediaş town (Fig. 1).

The surface survey, the seismic prospection and the drillings carried out for gas marked free methane-bearing deposits. The drillings crossed Badenian, Sarmatian and Pannonian molass deposits.

The middle Badenian salt level was intercepted by 7 gas wells (3, 13, 15, 18, 19, 20, 22) among which just the gas well 3 – which is the deepest – succeeded in crossing the salt (which is 214 m in thickness), then intercepting the underlying Dej Formation (early Badenian).

The stratigraphic sequence of interest for gas accumulations refers to Badenian and Sarmatian. The highest weight of methane volumes accumulated in traps belongs to the Sarmatian granular reservoirs (99.5%).

The stratigraphy rely mainly on microfauna studies. The correlations between boreholes were facilitated by the distinctive presence of the Ghiriş and Hădăreni tuffs as lithological markers.

The gas-producing sedimentary sequences, about 1400 m in thickness (between 100 and 1500 m) was divided into 14 gas complexes, overhand labelled as: I, (I-II), II, III, IV, V, VI, VII, VIIIa, VIIIb, IX, X, XIa, XIb. The I–IX complexes are Sarmatian, while the Xa, XIa and XIb complexes are Badenian.

THE TECTONIC PATTERN

Tăuni pool is an asymmetric anticline trended northwest – southeast, about 10 km length and 5 km width. Its southern flank exceed in dipping the northern one (7-8 degrees in Sarmatian and 10 in Badenian in southern flank *vs.* 5-6 degrees in the northern one).

Thus, it emphasized a change of the pattern depth function, caused by the structural disharmony. Therefore, the anticline apex calculated on the Sarmatian marker levels (complexes I–III) is centred in 120 Tăuni well area, while in the deeper VIII-XI complexes, the apex moves inside the 122-125 wells field, about 1000m southward. This apex migration proves the movement of the depocenters, result of Badenian salt tectonics. The differential compaction of the sediments played an important role too. The Tăuni pool is devoid of faults.

THE FLUIDS INITIAL DISTRIBUTION

The production trials into the gas wells emphasized gas accumulations in Sarmatian and Badenian.

Therefore, the gas complexes are: Sa - I + (I+II), II, III, IV, V, VI, VII, VIII a, VIII b, IX ; Bd - Xa, XIa, XIb.

GAS TRAPS

The following type of traps could be outlined:

- structural traps, developed as asymmetric brachy-anticlines (in I–VIIIb complexes),
- mixed, structural + lithological traps (in IX, Xa, XIa, XIb complexes).

The seal concerns marl and tuff levels. However, an exception occurs in the complexes I + (I-II). Due to erosion on valleys and removal of the Pannonian seal, the gas-bearing deposits reach shallow depth - about 20 m to the surface -, releasing the free migration of gas into the atmosphere, sometimes generating craters.

TĂUNI GAS SEEPAGES

Gas seepages had been observed long time before the beginning of the gas extraction, as related by natives.

The first well was dug in 1949 (well # 1), now abandoned. Then, other 204 wells had been dug.

Since the first wells dug in Tăuni gas pool there were reported gas seepages, especially in the depression areas, as on Lungă, Mărului and Tăului valleys. Larger gas seepages began in the spring of 1988, related to damages occurred in casing columns of 4 gas wells, all belonging to the 20 group (121, 141, 161, 187). In this manner, the gas escaped behind these casing columns, where the adherence of cement was compromised.

These phenomena led to some high amount gas seepages and crater growing in the areas of 20 and 100 well groups. The feeding source of the gas seepages is estimated to be in the Sarmatian I and II productive horizons, located at about 95 m depth in the 187 gas well.

Actually, the active craters are located on the right side of the communal road linking the villages Valea Lungă and Tăuni (Figs. 2, 3). There are seven craters, four in activity and three dormant. The largest one exposes three active holes, spread on 700-800 m^3.

As a result of the snow fall and the heavy rain occurred in spring of the year 1997, several new gas seepages, as well as two new craters occurred. The wells 18, 147 and 205 were damaged. The previous known gas seepage areas extended too. The main cause of these damages is related to the landslides which broke and deformed the casing columns. The methane natural gas which escapes is uplifting behind the casing columns until 50-60 m in depth from surface, than spreading into the sand interbeddings. Only a small amount of gas escapes through the well cellars.

Over the years one tried to decrease the effects of this process at Tăuni, trough technological means. From time to time, one pumped viscous drill mud into the reservoir in order to lock the gas-bearing layers and to decrease the activity into the craters. In spite of these technical solutions, the gas seepages and crater activities could not be completely stoped, but the amplitude of the process, decreased.

CONCLUSIONS

The Tăuni gas pool exposes both natural and man induced methane seepages. The natural ones are related to the shallow depths of some reservoirs. The second ones, rise from technical problems occurred in boreholes, as the low quality of case column cementing or damages induced by landslides.

The gas wells interventions –by pumping viscous and dense drill mud into the reservoirs bearing gas– did not succeed to stop the seepages, but the gas emissions amount decreased. As a matter of fact, this gas pool has to be continuously observed, in order to keep under control the emission budget of the methane.

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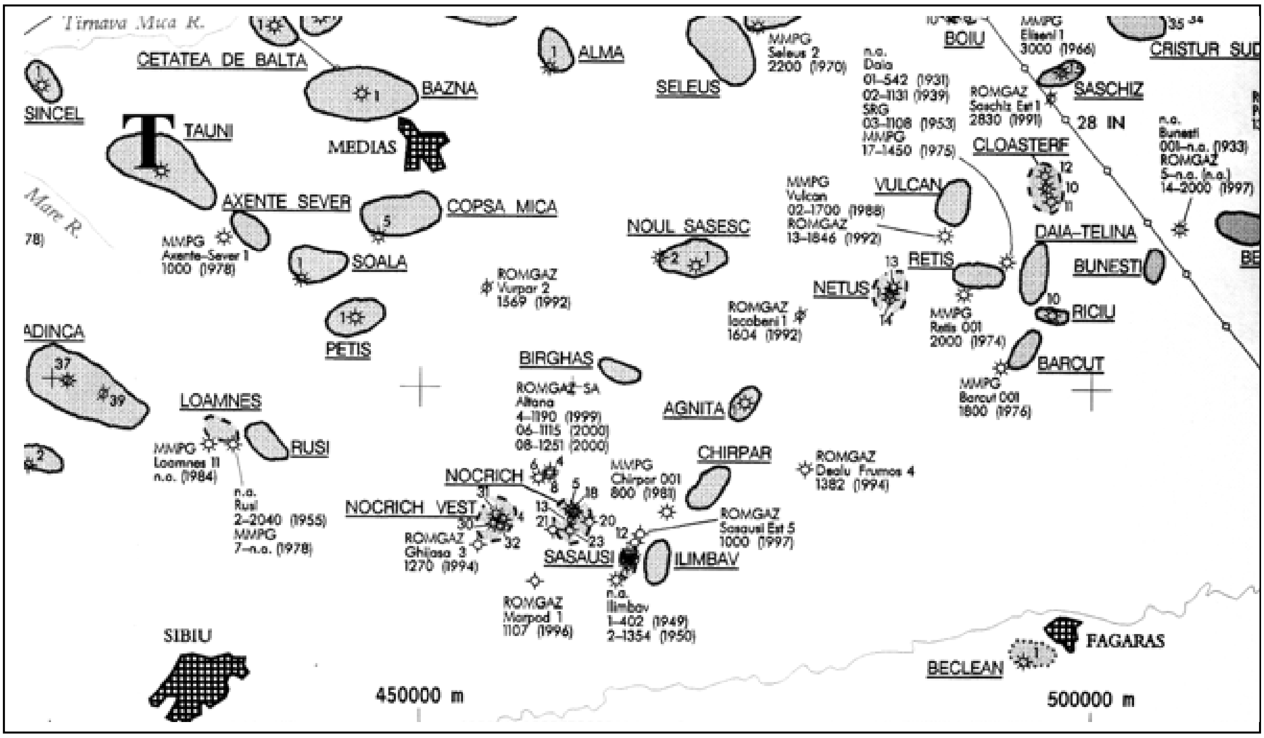

Figure 1 – Location of Tăuni gas pool (labelled T) in Transylvania (modified, after www.ihsenergy.com)

Figure 2 – Crater occurred by gas seepage, as waterhole.

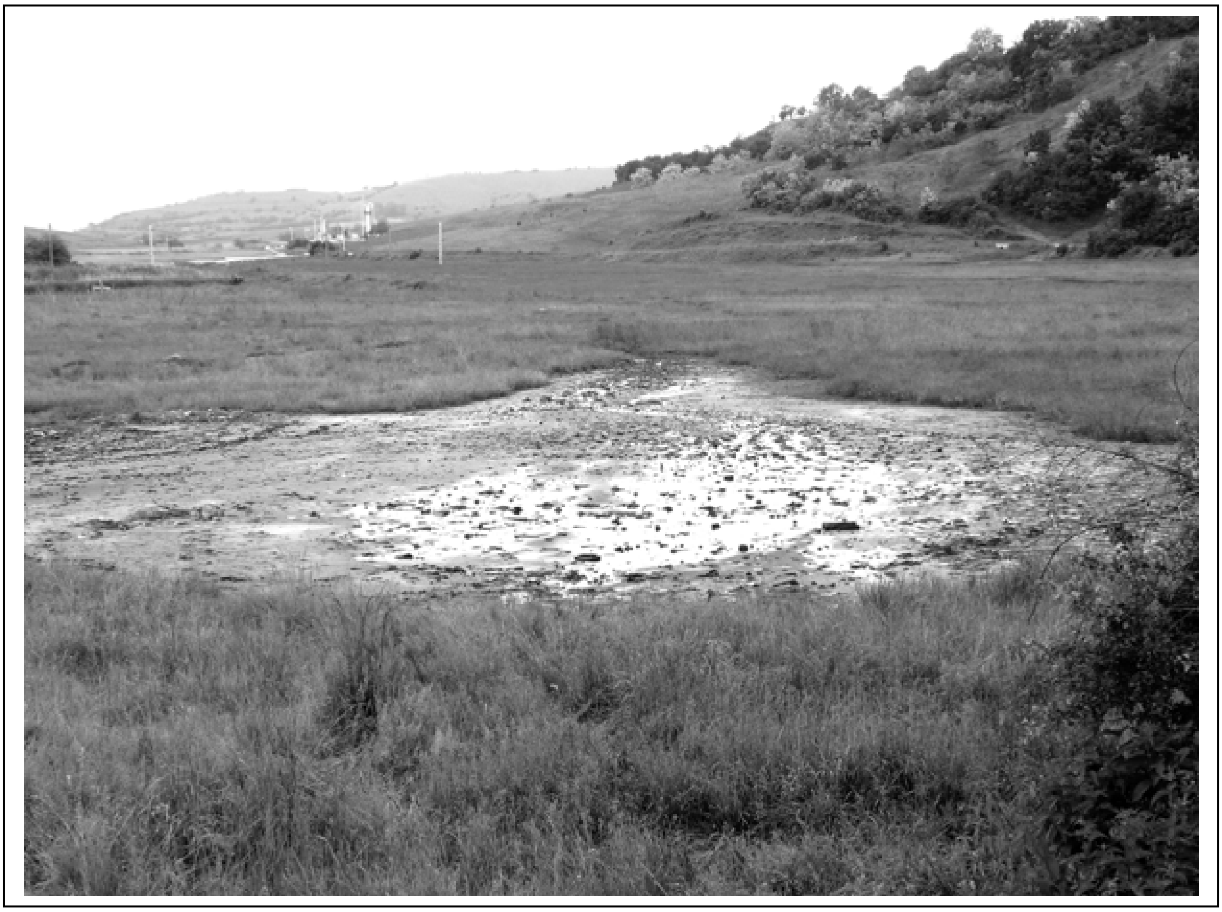

Figure 3 – Crater occurred by gas seepage, nearby Tăuni.

GEOLOGICAL ASPECTS OF LAND SUBSIDENCES DETECTED BY DIFSAR AT SANT FELIU DEL LLOBREGAT, CATALONIA, SPAIN

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KEY WORDS: differential interferometry, subsidence, consolidation, water extraction.

INTRODUCTION

The Differential Interferometry of Satellite Radar (DInSAR) analysis on the entire Catalonian territory from 1993 to 2006, allowed identifies major zones affected by subsidence (ICC, 2007) One of these zones is located along the Llobregat river basin, at Sant Feliu de Llobregat town, 20 km NW from Barcelona City. At the "El Pla" industrial zone (Figure 1), DInSAR maximum deformation rates are up to 0.70 cm/year.

In order to investigate and evaluate the possible triggering factors that control and generates the subsidence, hidrogeological, geological and geotechnical information, as well as the influence of human activity has been compiled.

The objective of this paper is to present the geological conditions and processes to quantify deformation and correlate them with the deformation measured by remote sensing techniques (IGC, 2008). The results serve as guidelines for future and more detailed research.

GEOLOGICAL CONTEXT

The study zone is located on materials of the lower Llobregat river plain to the northwest of the Sant Feliu del Llobregat urban zone (around twenty kilometres NW from Barcelona). Geologically, the materials that form this river plain are quaternary fluvio-deltaic materials that overlaid the basement, composed by paleozoic rocks (mainly composed by siluric shales) and Neogene materials(NP), Figure 1.

The Quaternary sediments are related to five sedimentary cycles delimited by stratigraphic disconformities. Each cycle is characterized in the lower portion by fluvial terrace deposits that laterally can change to alluvial and colluvial deposits. The distribution and thickness of these deposits have depended on the substratum paleorelief and the migration of the river current through time. At the study zone, layers formed by gravels and a upper layer silty-clay that belong to the youngest Llobregat river terrace (Qt1, Figure 1), contain the main aquifer of the LLobregat River. This is a non-confined aquifer within interbedding of gravels, silts and clays, Figure 2.

HYDROGEOLOGICAL CONDITIONS

A high density of water wells and industrial land use was recognized at the zone. This fact lead to the comparison of phreatic levels measurements from the monitoring network of the Catalonian Water Agency (ACA) existing at the zone with DInSAR deformation measurements, Figure 3. Complete information for the same period (from 1993-2006) for the largest deformation zone was possible only for two piezometers, Piez. Estrella 6 and Piez. 9, Figure 1. These comparisons show good correlation between phreatic lower levels and terrain subsidence and recovering periods with lower rates of deformation, Figures 3 and 4.

GEOTECHNICAL EVALUATIONS

The geological and geotechnical investigations allowed to identify and characterized the geological layer that potentially could cause the ground deformation measured by DInSAR. At the area of study the first 15-20 m below de surface consist in a deformable layer of silts and clays deposits. Below this layer there is a sequence of gravels and sands down to 30-40 m that contains the shallow Llobregat aquifer (ICC, 2004). Both silt-clay and gravelly layers belong to what is defined as geological unit Qt1 and Qt2 (Figure 2 and 3). Silts and clays are sediments very susceptible to consolidate by modifications of their natural conditions. Therefore, the principal hypothesis in this study is that the shallower deformable layer is capable to generate the observed deformation by consolidation processes due to changes of water table. In Table 1, appears the laboratory measured deformability parameters used in the analytical evaluations of deformation.

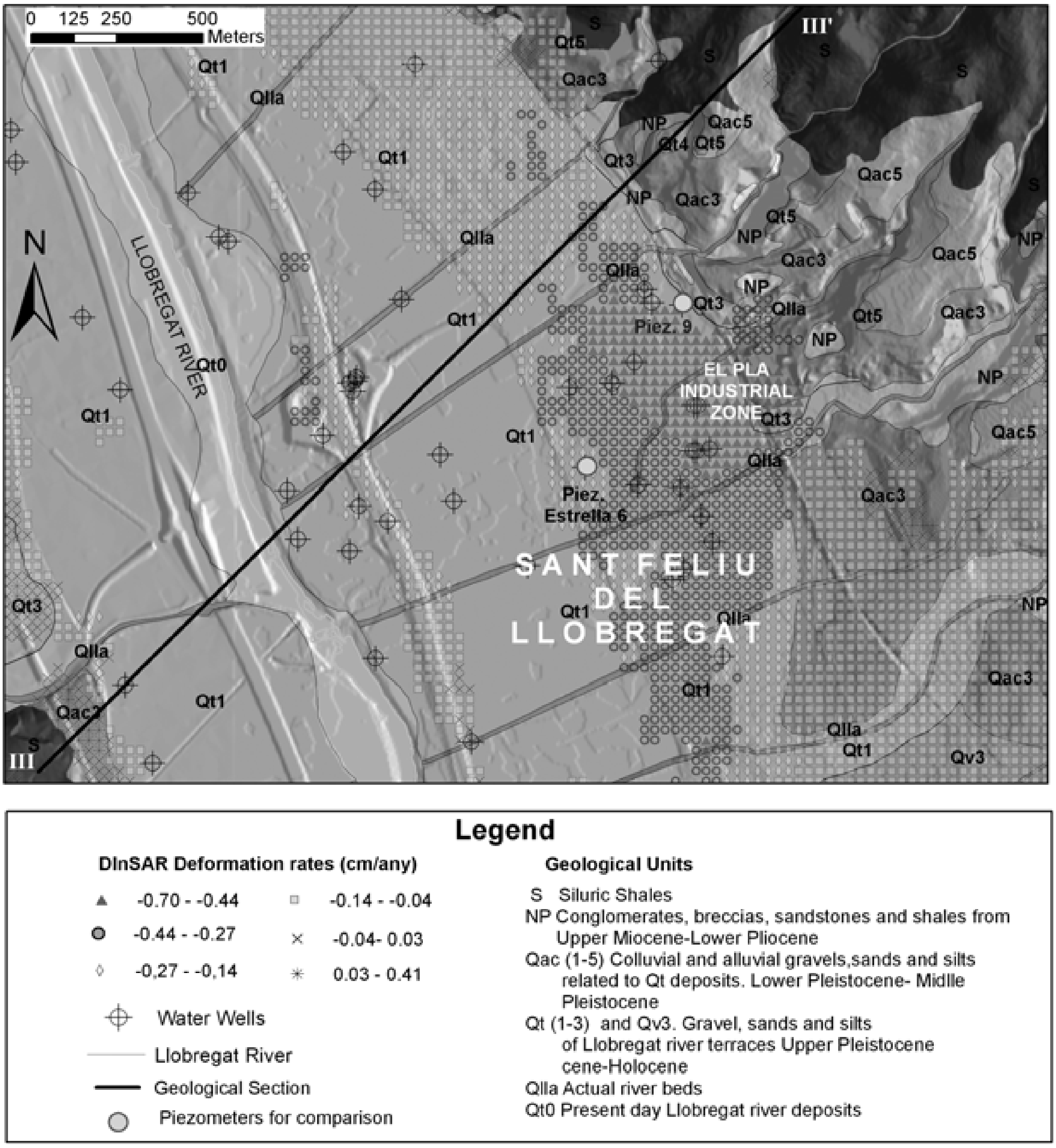


Figure 1 – Detailed geologic map of the zone of study (after ICC, 2006).

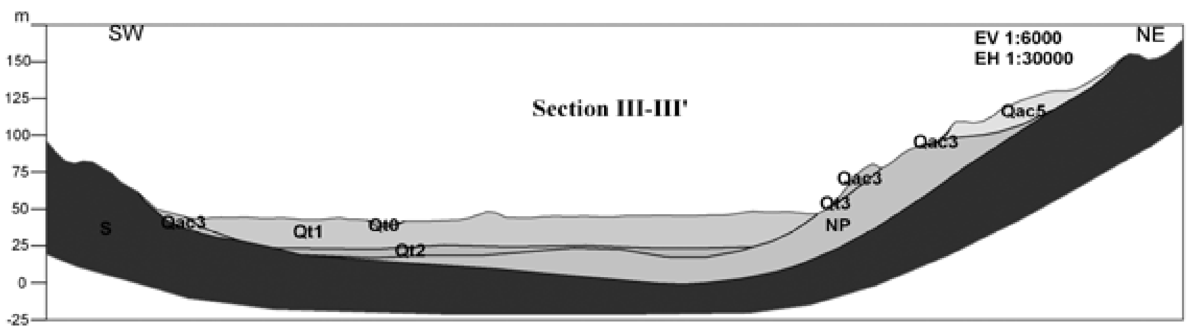
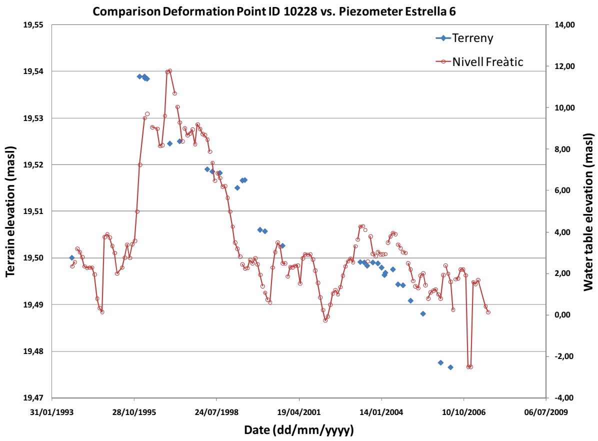
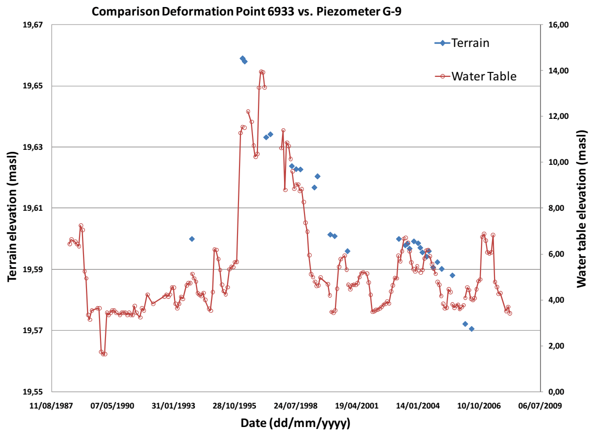


Figure 2 – Section III-III' with the main geological units (after ICC, 2006).



a)



b)

Figure 3 – Piezometric levels and terrain surface deformation correlations within the DInSAR analysis period (1993-2006) for a) Piezometer 6 and b) Piezometer 9 located at Figure 2.

Table 1 – Geotechnical parameters of the silty-clayey layer used in the analytical quantification of deformation.

Parameter	Value	Units
Dry density, g_d	17.50	KN/m^3
Porosity, n	0.55	--
Initial void ratio, e_o	0.562	--
Compression Index, C_c	0.130	--
Swelling Index, C_s	0.012	--

The analytical evaluation consisted in using the one-dimension consolidation theory from the classic Terzaghi's formulation (Jimenez-Salas and de Justo-Alpañes, 1975) where the vertical deformation (*s*) is calculated from the following equation:

$$s = \frac{H}{1+e_0} \cdot C_c \cdot \log\left(\frac{\sigma'_0 + \Delta\sigma'}{\sigma'_0}\right)$$

Where:
H: the thickness of the layer of interest
e_0: initial void ratio
C_c: compressibility index from consolidation tests
Ds': effective stress change related to changes of phreatic levels
s'_0: initial effective stress

The analytical approach considered 10 stages of decrements of water table position to calculate differential changes of thickness. This calculated deformation was compared with the observed DinSAR terrain measurements at the piezometer Estrella 6, Figure 4. The resulting theoretical curve has the same tendency as the measured DinSAR deformation and phreatic levels variations. Though the analytical values are not similar, the order of magnitude is the same and shows that consolidation process is a large component of the total deformation observed within the area of interest during the period of study.

,

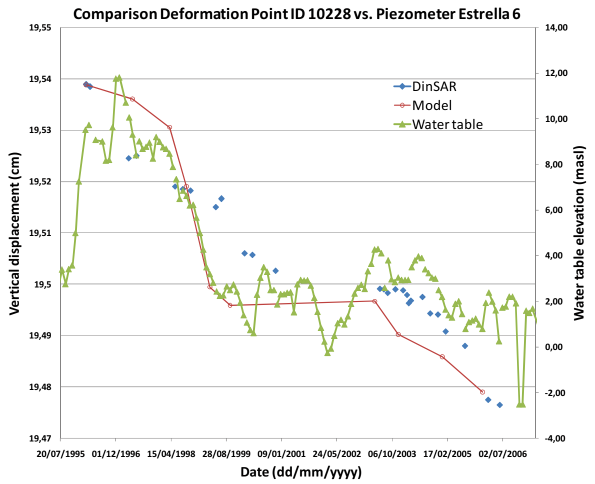


Figure 4 – Comparison of phreatic levels, DInSAR deformation and calculated deformation through time at Estrella 6 piezometer

Comparing only phreatic levels increments versus increments of deformation, the DinSAR measured increments of deformation are scattered and form a highly dispersed cluster (Figure 5) while the 10 calculated values follow the expected incremental lineal relationship. (Figure 6). Scattering of the measured data might be due to the intrinsic DinSAR technique precision or other geological or anthropic aspect that have not yet identified such as: not registered points of water extraction, basement morphology, lithological heterogeneities, inelastic recovering of the materials etc., that result in a complex deformation field curve.

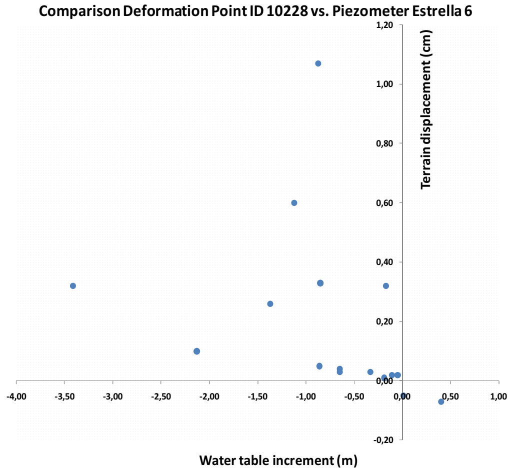


Figure 5 – Comparison between changes of phreatic levels and corresponding DInSAR deformation changes

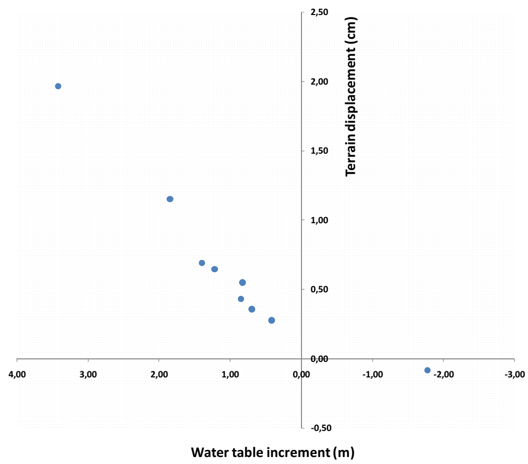


Figure 6 – Comparison between changes of phreatic levels and corresponding calculated deformation changes

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DSS AND GIS TOOL FOR CIVIL PROTECTION PLANNING IN CASE OF FLOODING HAZARD

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KEY WORDS: Civil Protection, Emergency Management, Hazard and Risk Potential Scenario, GIS, Work Flow Management.

INTRODUCTION

The Civil Protection purpose is to better protect people, their environment, property and cultural heritage in case of major natural events or man-made disasters (Foster, 1980, Alexander, 1998, Alexander, 2000). The management of a critical event has precise goals: people safeguard, taking care of the injured, coordination of first aid activities, recovery of primary public services, management of personnel, organization of resources and communication with public and private institutions, government agencies, authorities and citizens (Cate, 1994).

In a broader view, the role of Civil Protection is carried out through three key modes of action: prevention, preparedness and response. These actions encompass:

a) the prevention of risks and damage to people, properties, infrastructure and in so doing environment, in the event of disasters, detecting and studying causes of disasters, improving means and methods of forecasting, analysing the characteristics of the damaging event together with the vulnerability of the territory, respectively;
b) the increase of the degree of preparedness of people involved in Civil Protection, in order to raise their ability to quickly and effectively respond to an emergency; the cooperation requires a rapid mobilisation of intervention teams, experts and other resources in the event of major emergencies in order to alleviate the effects of a disaster during the first days. The Civil Protection is entrusted to facilitate these actions as well to offer technical or technological support, if required;
c) the improvement of the techniques and methods of response and taking care emergencies;
d) the enhance of the public information, education and awareness, helping citizens to protect themselves more effectively. Information is the key to successful co-operation in Civil Protection matters. The dissemination of information can be carried out in advance or during the emergency;
e) the granting of financial assistance to the affected areas via the Solidarity Fund.

STUDY AREA

The methodology proposed herein was settled and tested in a local Mountain Consortium of Municipalities in Valtellina di Tirano, an area of about 450 km2 located on the Italian Central Alps (Lombardy Region, Northern Italy). The territory is subdivided among 12 municipalities and it has about 29,000 inhabitants (prevalently sited on the valley floor).

Valtellina has an unenviable history of intense and diffused landsliding: it represents one of the primary causes of life injury and property damage, resulting in enormous casualties and huge economic losses. Field surveys allow to map mainly rainfall-induced, small size and thickness slides soil slips and/or soil slip-debris flows and slumps affecting Quaternary covers; their volumes range from few up to some hundreds cubic metres These phenomena remove portions of cultivated areas, often causing the interruption of transportation corridors and disruptions in inhabited areas, sometimes determining the temporary evacuation of people.

METHODOLOGY

According to the Italian legislative framework (National Law 225/92, D.Lgs. 112/1998; D.Lgs. 267/2000; D.P.R. 194/2001; D.P.C.M. 12/12/01; D.P.C.M. 24/07/02) contingency plans have been carried out to identify and prepare in advance people in charge to take actions, and define the activities to perform in case a damaging event occurs, on the base of available resources. A workflow based on decisional processes and rules was set up and uploaded in a Decision Support System (implemented in a Geographical Information System) for a real-time management of prospective emergency situations.

The requirement to protect people and to correctly manage resources during a crisis phase is strictly linked to the capability to profile the potential damaging events in advance. For that reason, we suppose that the crisis phase can be related to a prospective flooding event, whose physical characteristics are supposed to be well-known in advance, being derived from the application of a 1D-2D hydrological model (hazard scenario, Figure 1). On the base of the geographical distribution and type of vulnerable elements and the physical and economic consequences due to the occurrence of the damaging event, a risk scenario has been defined, describing the possible effects on the social, economic and infrastructural affected system.

This paper is primarily intended to describe the last step of our methodology targeted to manage a crisis phase, due to the occurrence of a flooding event (as described in the hazard and risk scenario), in a real-time by GIS and DSS.

In detail, contingency plans were prepared and managed by PETer® (Protection and Emergency TERritorial plans), a software developed by the cooperation between an Italian ESRI® Business Partner (Globo® inc.) and researchers applied in the Institute for the Dynamic of Environmental Processes (National Research Council, Milan, Italy) and in the Department of Environmental and Territorial Sciences (University of Milano-Bicocca, Milan, Italy). The software was developed by using Microsoft® Visual Basic® 6.0; the geographical features are managed by ESRI® MapObjects® and the database is available in a standard release (with Microsoft® Access database and ESRI® Shapefile™ for features) or in an enterprise release (with Oracle® or SQLServer™ database and ESRI® Shapefile™ for features by ESRI® ArcSDE™). The application couples data processing capabilities by GIS tools with workflow management modules by Decision Support System; it automatically performs organizational and operational activities within a Civil Protection Plan, in line with the regulations in force.

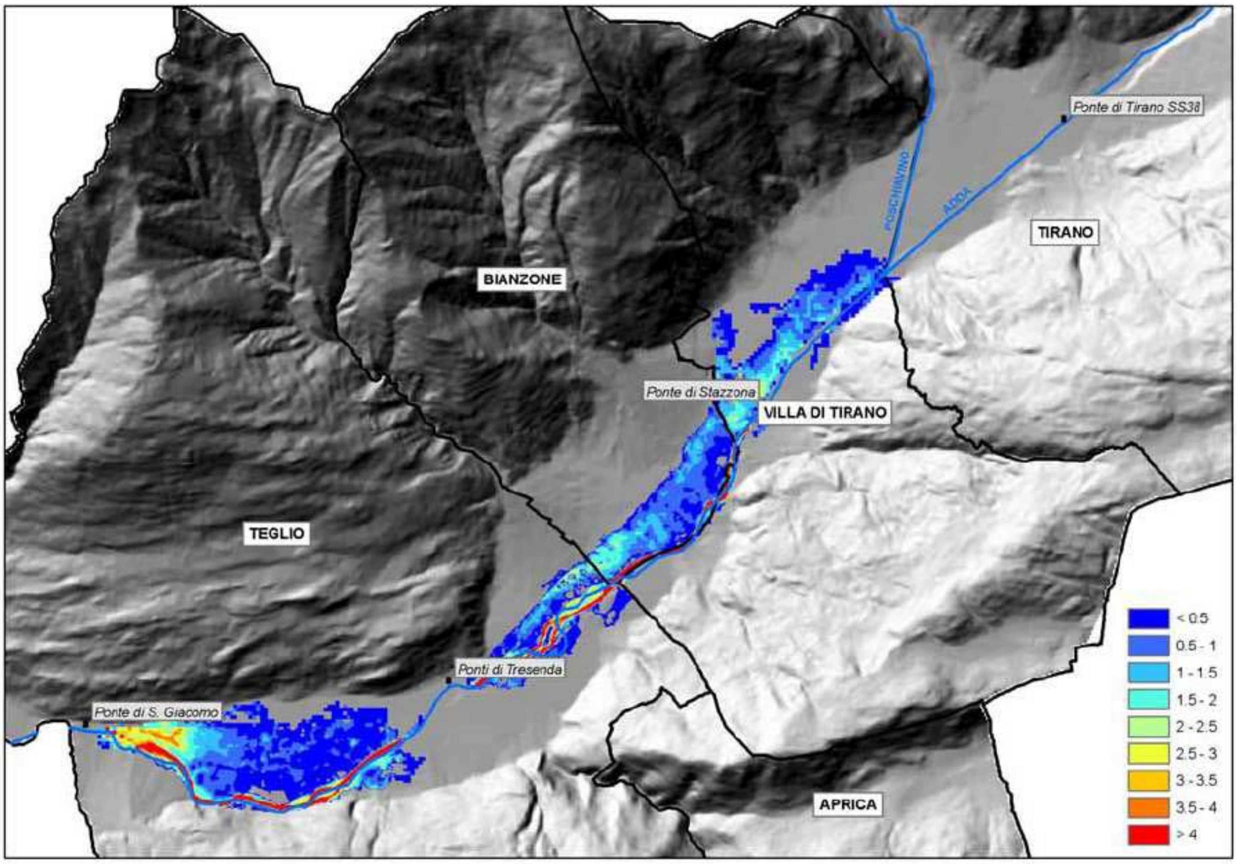

Figure 1 – Hydrological model, hazard scenario

PETer accomplished an integration between GIS tools (for storing, managing, analysing and representing geographical data), Decision Support Systems, and Information and Communication Technology (ICT) for defining and controlling decisional processes in terms of:

- definition of the procedures and actions (workflows) to be sequentially executed for the management of emergency situations (according to the laws in force);
- identification of the people (individually or aggregated in agencies, companies, squads, etc.) responsible for each procedure;
- description of the instructions to be followed to perform each action;
- list of the documents to be drawn up during or immediately after each action;
- transfer of the procedures to people in charge of taking actions;
- management of the resources really available for coping with each phase of the emergency.

PETER APPLICATION STRUCTURE

PETer allows a well-informed management of data and resources during a crisis phase, ensuring the connectivity and interoperability of the expected Civil Protection tasks. In our specific case, it was used to prepare, apply, and coordinate Civil Protection Plans by accessing data stored at a municipal and/or centralised level.

Each municipality can access the system of the neighbouring municipalities but only for consultation purposes (changes are not allowed). On the contrary, the Central Office of the Consortium of Mountain Municipalities of Valtellina di Tirano has read/write rights on data stored in each municipality. By this cooperative structure, the individual plans can operate in a combined and integrated way. The possibility to access municipal or centralized data from remote terminals in multi-user mode plays an important key-role in the management of emergency situations. By this way, data transfer among administrative entities and people involved in the management of the emergency situation, is based on new tools which makes use of more efficient and well organised technological methods (web and mobile tools).

The architecture of the software provides two different applications, designed to meet the needs of different users:

- PETer Site: allows the complete management of a Civil Protection plan. Data and workflow can be stored, managed, and analysed.
- PETer Net: allows the consultation via Web of each individual plan.

Different functionalities were offered to manage information at different level of emergency:

- Uploading and management of data (at a municipal and inter-municipal level) to be used in emergency situations
- Management in real-time of resource, people and institutions potentially involved in the emergency
- Designing procedural workflows and running simulations of emergency events
- Printing and plotting reports; automatic filling and posting of documents; management of communications
- Assessing data security and integrity (by means of different passwords for different types of users)
- Allowing the publication of the Civil Protection Plans by Web

The application was thought for a complete chain of information, linking all the people in charge of taking actions: crews in the field, the mobile command post and control rooms. It is targeted to manage the aftermath of critical hydrogeological events and it is based on a cooperative organizational structure (Figure 2), by which information may be provided and managed at different administrative levels.

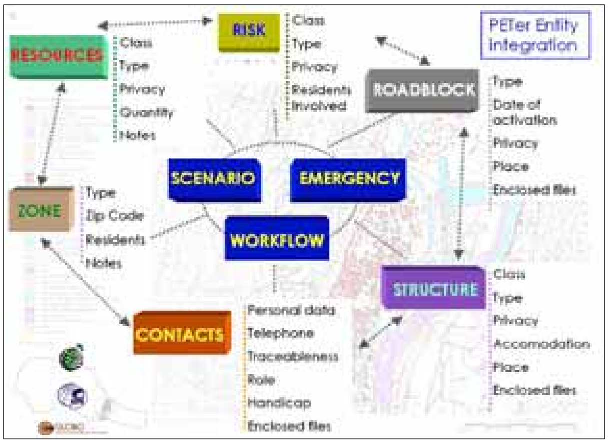

Figure 2 – Organizational structure of Peter

DATABASE STRUCTURE

A multi-scale database (whose content is published on the website www.cmtirano.so.it) was prepared to collect, integrate, manage and analyse new and existing data, derived from different sources characterized by different degree of accuracy, from a basin scale (1:50,000; 1:25,000) to a local scale (1:10,000; 1:1,000).

Database content can be accessed by PETER for supporting civil protection activities.

Data organized in database for the 12:

- 44 risk scenarios
- 290 contacts (personnel, groups, volunteers, first aid support, fire brigades, police, etc.)
- direct links to Registry Office database of the Consortium (age, gender, telephone number, disabled people, etc.)
- 554 structures (warehouses, hospitals, barracks, etc.)
- 239 resources (materials, vehicles, instruments, etc.)
- 148 roadblocks
- 11 Workflow models for guiding Civil Protection activities and entity management (during PRE-ALARM, ALARM, EMERGENCY, and POST-EMERGENCY phases)
- Documents to be used in each phase above mentioned available in digital format for a prompt use (rtf, doc)

All georeferenced information stored in the database as maps (both in vector and raster format) and related tables were completely available on demand (creation, maintenance and updating).

CONCLUSION

The increasing frequency of natural hazards, combined with a higher urbanisation and growth in economic activities, has significantly raised the vulnerability of our society. As a consequence, losses are growing rapidly. Programmes targeted to the prevention, preparedness and response to natural disasters are continuously developed and updated by government agencies, public and private institutions and authorities at a national, regional, and local level.

In this study a methodology for a real-time management of emergency situations was suggested. It may assist local and regional planners, regulators and land surveyors, in optimising the management of a crisis phase, mitigating their consequences, and accelerating the recovery phase. The methodology suggests an appropriate course of actions, combining generic and time varying site-specific information (via electronic links from field and from data sources stored in specific databases). The integration of GIS tools with workflow management modules and information and communication technology may be considered as an effective support for the definition of emergency planning and management strategies, permitting a real time monitoring of activities, procedures and information communication and sharing.

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METHODOLOGICAL APPROACH FOR THE CHARACTERIZATION OF CATALAN FLOODING AREAS ACCORDING TO GEOMORPHOLOGIC CRITERIA

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KEY WORDS: flooding mapping, geomorphology criteria, alluvial fan, Catalonia.

INTRODUCTION

After the development of the Flood Protection Civil Plan of Catalonia INUNCAT, during years 2006 and 2008, the Catalan Water Agency (ACA) and the Geological Institute of Catalonia (IGC) are collaborating on the definition of fluvial environment (Fleta et al, 2008). As a product of this work, an improving project related to Catalonia flooding areas was carried out. The goal was to create a uniform and continuous database throughout the territory in a geographic information systems format and to establish a methodological basis for the delimitation of flood areas and alluvial fans according to geomorphologic criteria.

Generated information:
• Criteria for geomorphologic mapping of flood areas and of hidrogeomorphologic units.
• Delineation of the flood areas.
• Alluvial fans.
• Associated databases.

CRITERIA FOR THE GEOMORPHOLOGIC MAPPING OF FLOODING AREAS

Some protocols have been defined with its methodological bases for improvement of the flood areas (Figure 1), the river system, the alluvial plains, the alluvial fans and the mountain streams (Fleta et al, 2008b).

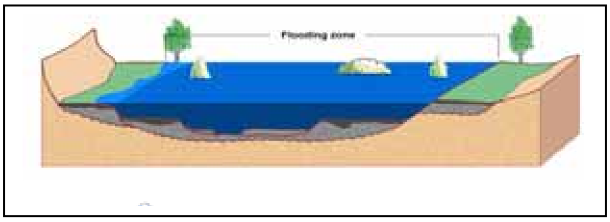

Figure 1 – Delineation of the flood zone.

In addition, the criteria used for zoning the river area according to hidrogeomorphological criteria are described (ACA, 2003). These criteria are effective to consider and interpret the morphology of river systems, as has been demonstrated successfully in the French region Provence - Alpes - Côte d'Azur (PACA diren, 2007). Therefore, this method of hidrogeomorphological approximation has been adapted to the fluvial spaces of Catalonia.

DELINEATION OF THE FLOOD ZONES

An exhaustive inventory of the mapping of potential flood zones has been performed (Figure 2). The available documents come from variable scales (from 1:1.000 to 1:5.000). In the digitizing process codes and database structures are unified.

The homogenization and synthesis of the flood areas cartography is done (Figure 3). With the delimitation of flood areas, each represented element has an identifier based on a thematic dictionary.

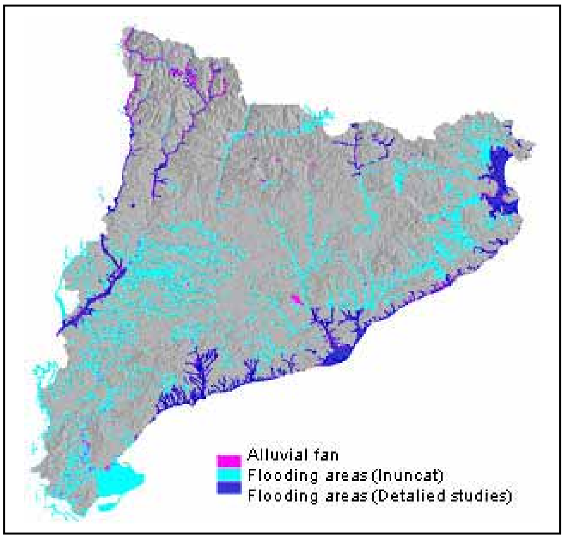

Figure 2 – Distribution of the flooding zone.

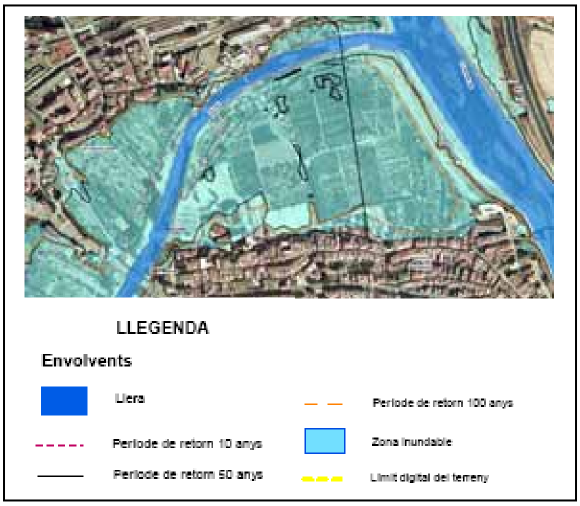

Figure 3 – Example of zoning for the river area on orthophotomap (ACA website).

ALLUVIAL FANS

An inventory of alluvial fans identified and a preliminary assessment of the hazard have been produced. We have also considered the hazardousness of the alluvial fans associated basins according to objective criteria (Figure 4). The criteria considered for the basins corresponds to extension, average slope, climate, extent of surface deposits, morphology and land use. These criteria are adapted to Catalonia from the FEMA methodological bases (FEMA, 2003). The results of preliminary assessment of the alluvial fans hazardousness allows to identify the more dangerous fans (Figure 5).

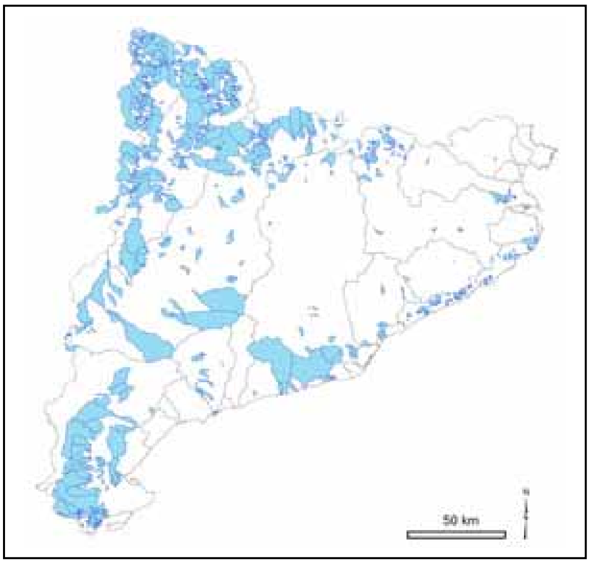

Figure 4 – Major watershed basins associated with the studied alluvial fans.

Figure 5 – Detail of an alluvial fan close in the proximity of a village.

DATABASES

A database set related to the flood areas and alluvial fans have been generated. The structure of cartographic information and data model of the flood areas have been defined. The associated thesaurus are divided according to the following topics: flood, geomorphology, flow, supply, actions, land use, protected areas and others.

CONCLUSIONS

This study is a breakthrough in the understanding of the flood areas of Catalonia which will allow better management of the territory. A continuous and homogeneous mapping of flood areas in Catalonia and a first assessment of the alluvial fans hazard have been produced.

In addition, the methodological bases have been developed for the preparation of the flood areas cartographies following geomorphologic and hidrogeomorfologic criteria.

The territorial area of the study corresponds to all the Catalan hydrographic net. The floodable zones, delimited according to geomorphologic criteria, arrive to the 6% of the extension of Catalonia and the number of alluvial fans inventoried approaches near the 1200 cases located mostly in the western Pyrenees. Of these, 1% are alluvial fans evaluated as extreme dangerousness.

Finally, all this information is published at the ACA's website (www.gencat.cat/aca) expressed in the form of maps, data sheets, and other technical documents. Thus, datum and documents generated within the project are accessible.

ACKNOWLEDGMENTS

We thank all people, organizations and institutions that have participated in the ACA-IGC first agreement. We are especially grateful to Geoconsultores, HQA, Typsa, INCLAM, KV Consultores and Marenostrum that have participated in this project.

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LANDSLIDE SUSCEPTIBILITY AND GIS

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KEY WORDS: Landslides, GIS, susceptigility, hazard, DEM, landuse, thematic maps, catography, statistic, runoff.

ABSTRACT

Aim of this work is to determine the landslide susceptibility of a territory using the data banks and the information normally available to civil services. The landslide hazard is defined as the probability that an event happens in a certain period. The landslide susceptibility points out the tendency to the instability of the slopes calculated on the basis of qualitative judgment, without a temporal reference. The use of GIS and of statistic treatment of the data, has allowed to develop suitable methodologies to determine the landslide susceptibility of a territory.

INTRODUCTION

Varnes et al. (1984) has defined the natural hazard as "the probability of occurrence of a potentially damaging natural phenomenon". The landslide susceptibility estimates the propensity to the instability of slopes, calculated on qualitative judgments; it misses in this case the temporal reference (Carrara et al. 1998). Normally susceptibility is represented in cartographic form with different colors depending on their possibility to be interested by movements of mass. This study is based on the individuation of the factors that influence the dynamics and the generation of the landslides. The use of GIS and of statistic processing of data, allows to develop useful methodologies for the individuation of the propensity to environmental diseases (Van Western 1994; Carrara et al. 1995).

METHODOLOGY

The factors that influence the stability of slopes are: the lithological properties of rocks, the vegetation, the morphology and the soil wetness. In statistical studies, that make use of geographic information systems, it is necessary to use the available information, that unfortunately don't correspond always to what it is in demand for a right determination of the instability of the slopes.

Rocks properties are of difficult mapping, particularly the fracturing and cementing levels of the rocks, or the layer's positions are hard to show, therefore they are rarely usable in a GIS.

Several factors influence the stability of slopes, some are surveyed directly on the field or from aerial photo, others are obtained by digital elevation models.

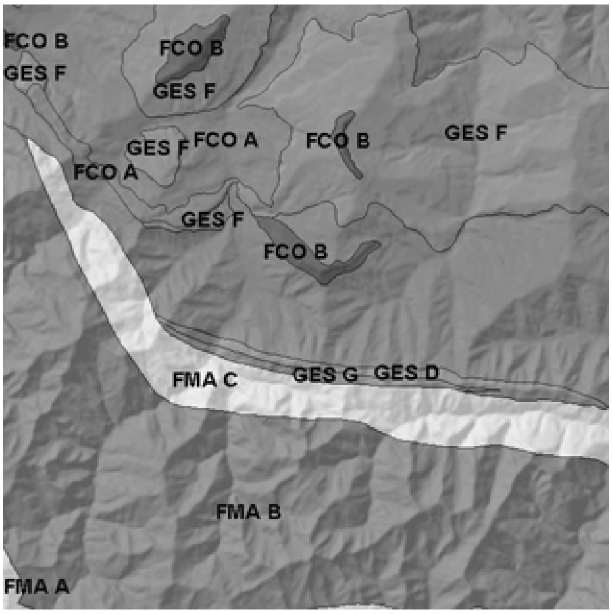

Fig.1 – Lithology

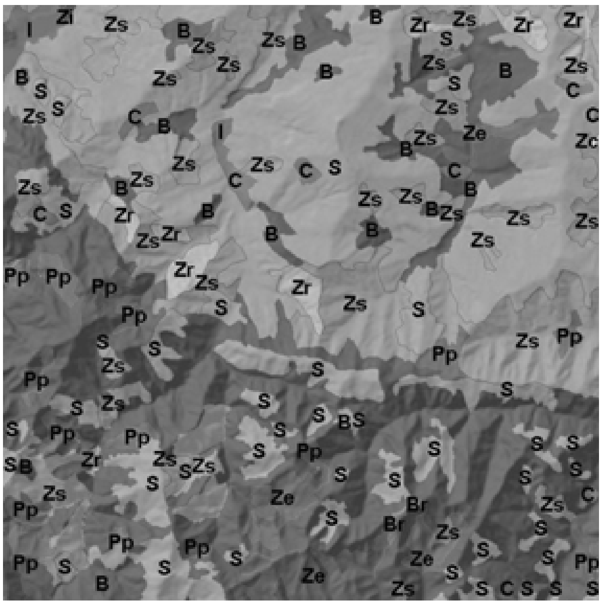

Fig.2 – Land use

The lithological (Fig.1) and land use maps (Fig.2) belong to the first case, the remainders, derived from DEM, are:

- aspect map (microclimate and soil wetness)
- slope map (morphology)
- convexity and concavity map (morphology)
- wetness index map (soil wetness)

The digital elevation model of the studied area has been realized using 5 meters contour line interval and elevation points collected from 1:5000 scale cartography. A TIN (triangular irregular network) is achieved in this way and has been afterwards converted in a GRID whose cells have extent of 10 meters. To eliminate part of the inaccuracies that are connatural to the calculation procedure, depressions (sinks) have been removed from the model and subsequently an algorithm of smoothing has been applied.

From DEM derived the aspect (Fig.3) and slope (Fig.4) maps.

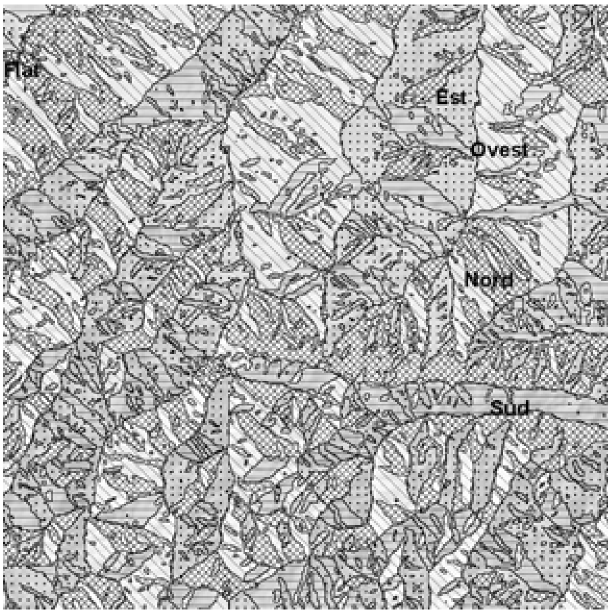

Fig.3 – Aspect map

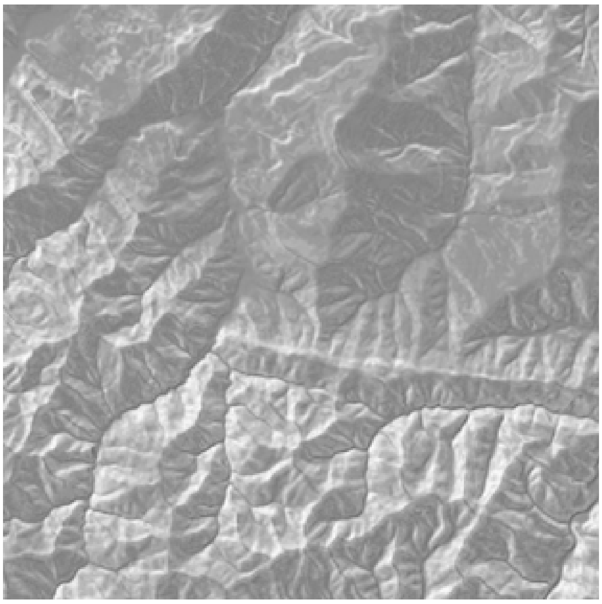

Fig.4 – Slope map

More complex it is the realization of the grid that represents the convexities and the concavities (Fig.5). This map has the purpose to distinguish the areas in which the runoff converges from those in which it diverges (Beven 1997), and the areas in which runoff accelerates from those in which it decelerates (Moore et to the., 1991).

Fig.5 – Convexities and concavities

Fig.6 - Wetness index

LANDSLIDE DISTRIBUTION

To locate the areas in which new landslides can verify in the future, it is necessary to use a map in which actual and past landslides are represented (Jennings & Siddle, 1998).

WEIGHTS ATTRIBUTION

The used method consists in the calculation of landslide distribution inside every cartographic unity and in its relationship with the average density of landslides in the whole area. Such relationship determines the weight of the single unity:

$$Wu = \frac{\sum Lu.}{\sum L} \times \frac{A}{Au}$$

where:
Wu = weight of unit
Lu = landslide inside unit
L = total landslide
A = totale area
Au = area of unit

CALCULUS OF SUSCEPTIBILITY

The weight of susceptibility (Fig.7) is equal to the product of the single partial susceptibilities.

$$S(tot) = L \times U \times A \times S \times C \times W$$

where:
S(tot) = Landslide susceptibility
L = Lithological weight
U = Land use weight
A = Aspect weight
S = Slope weight
C = Concavity and convexity weight
W = Wetness index weight

CONCLUSION

From the elaborated data it emerges how lithology will influence the definition of the landlside susceptibility to a large extent, followed by landuse; the slope aspect have a marginal influence on the contrary.

The inherent inaccuracies in this method are of various origin and nature, from cartographic errors, to the approximations in the correct elaboration of the digital elevation model. Despite this about 80% of landslides are inside areas with susceptibility greater than the average of the territory.

The datum confirms the effectiveness of the adopted method, despite the presence of some inherent limits in the starting data.

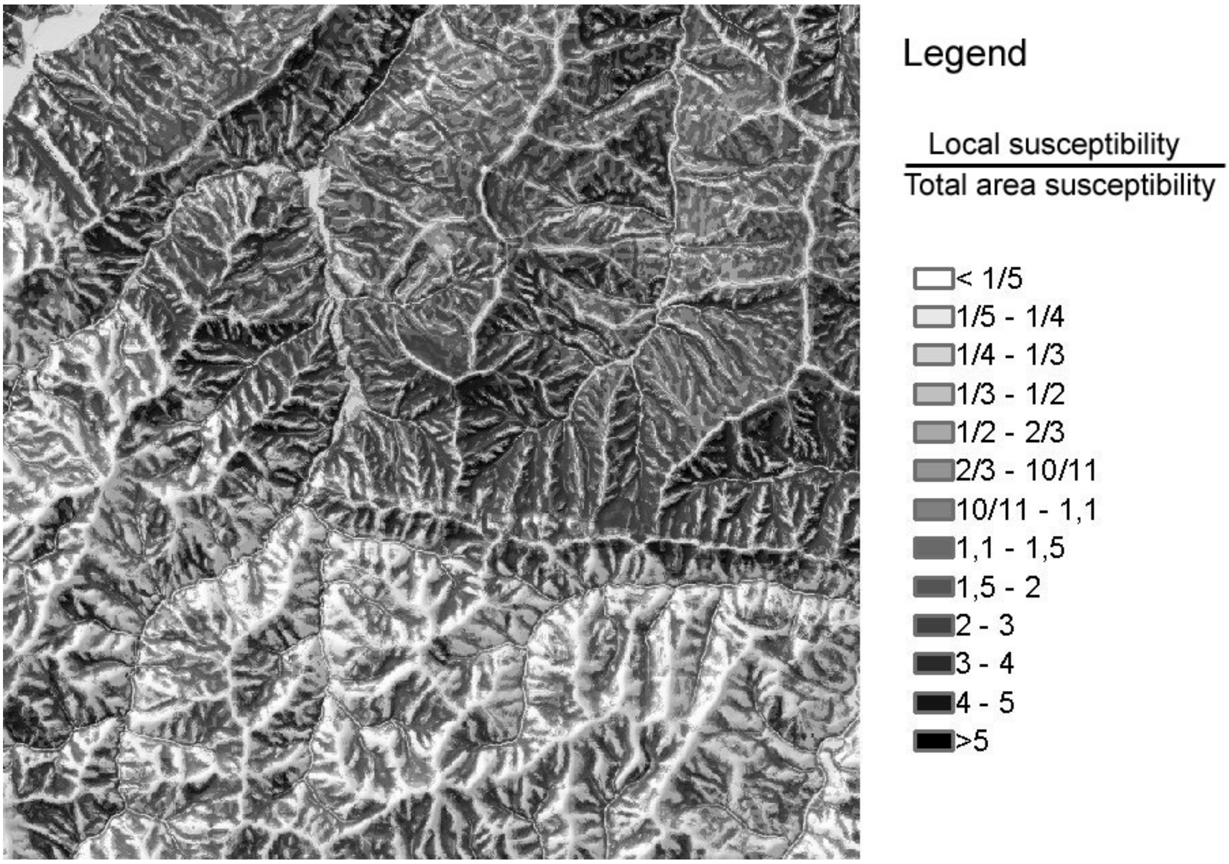

Fig.7

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RAPID, AUTOMATIC EARTHQUAKE DETERMINATION AND EARLY DAMAGE SCENARIOS IN THE IGC SEISMIC NETWORK

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KEY WORDS: seismic network, automatic damage scenarios.

VSAT SEISMIC NETWORK

In 1999, a new concept of seismic network was designed and planned by the *Institut Geològic de Catalunya* (IGC) in order to provide rapid information for Civil Defence services and society in general and to obtain systematically high quality data for the scientific community (Goula et al, 2001). The project of the network has been developed in several steps. It was planned to create robust, high performance field infrastructures and install up to 21 stations equipped with three component broadband sensors and a high dynamic range. In 2009, 18 stations are operative, 14 BB and 3 accelerometer in land, and 1 BB on the sea bottom. A real time system based on a VSAT seismic network has been developed and is now operational for earthquake monitoring in Catalonia (Spain).

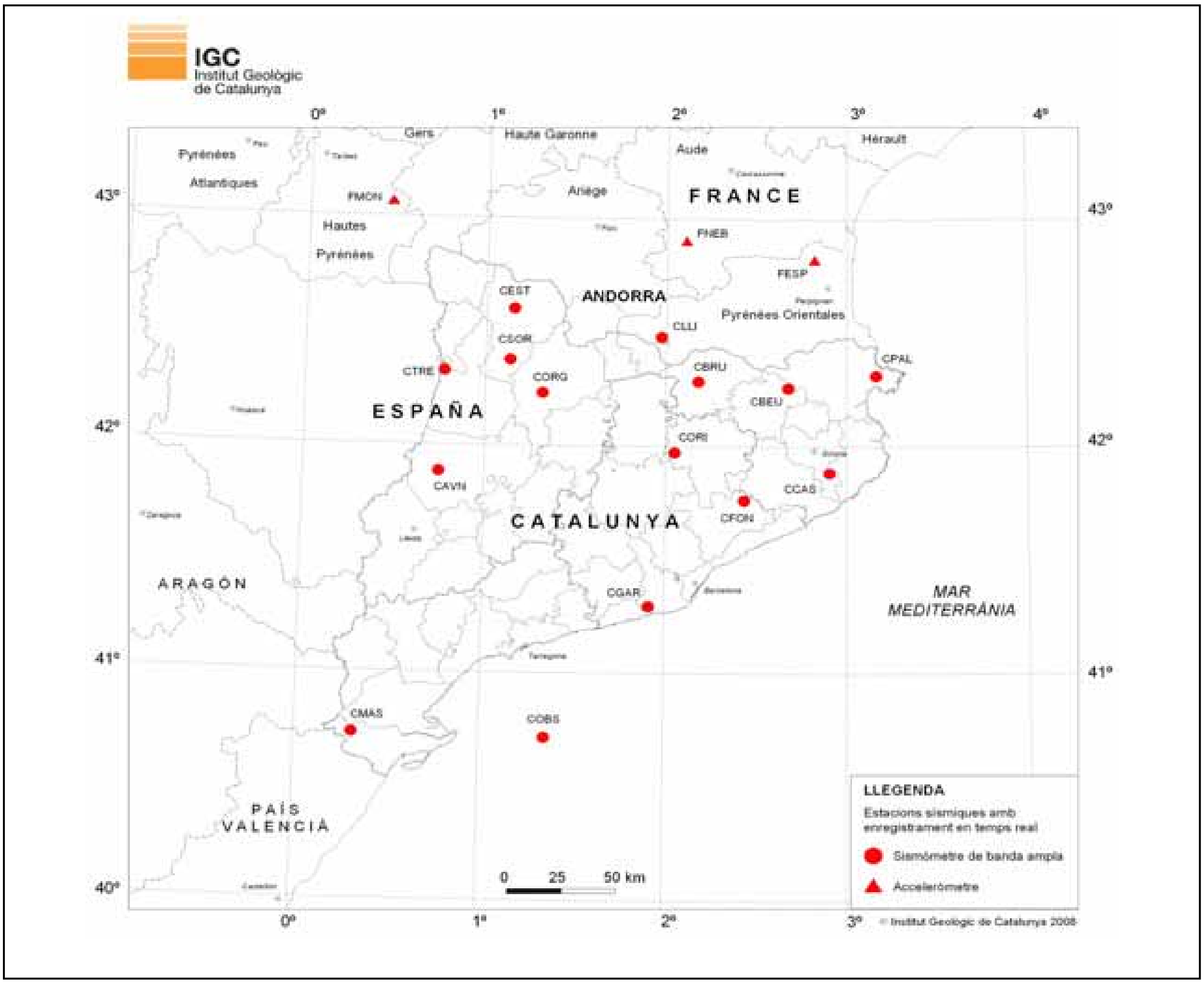

Figure 1: Map of situation of seismic stations of the Pyrenean VSAT Network .

Real time automatic processing system (DAS)

Real time continuous data are received at IGC satellite Hub (Barcelona). Data reception system modularity accepts different kinds of data formats and protocols, and allows data exchange with many institutions (Orfeus, IGN, etc...). A near real time automatic processing system has been implemented using.

Earthworm (USGS, 2005) and specific developed tools (Romeu et al., 2006). System flexibility guarantees its interoperatibility with others systems.

A simplified diagram of its architecture is shown in Figure 2.

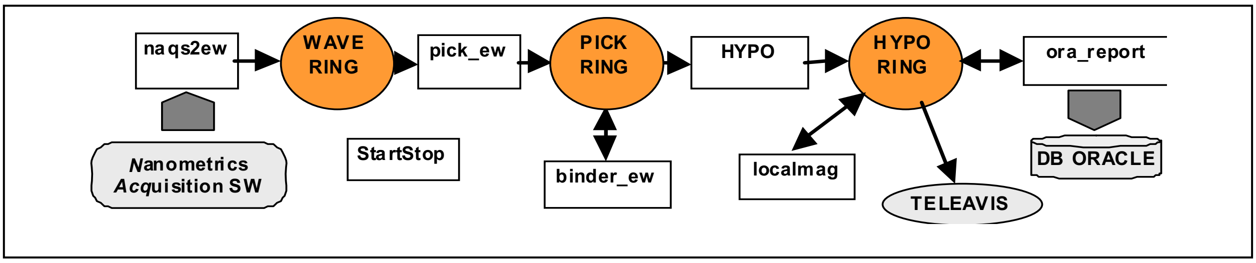

Figure 2. Simplified diagram of the Automatic Earthworm modules installed at Barcelona data centre

Generation of automatic damage scenarios (TELEAVÍS) SECTION

When an event is detected and located, the alert system sends an alert message according different criteria. The automatic generation of a seismic risk scenario based on vulnerability assessment methodologies, using GIS techniques has been developed and is implemented.

TELEAVÍS is an application designed for the automatic generation of reports from the hypocentre data of the earthquakes detected by DAS and for its transmission by fax, SMS, ftp and electronic mail. From the data received from DAS, TELEAVÍS develops an epicentral location map with planimetry of 1:250000 and other maps with the results of the damage scenario automatic computation and with the PGA and PGV computed from records of seismic stations. Damage scenarios have been computed (ESCENARIS soft) using methodologies proposed by Susagna et al. (2006), Roca et al. (2006) and those defined in the ISARD project (Irizarry et al., 2007).

Two different methods are used to compute automatic damage scenario, in function of data availability:

- Level 0 method is based on the following hypothesis:

a) the unit of work is the total area of the municipality

b) soil conditions are not considered

c) EMS'98 scale is used to define vulnerability classes, and Damage Probability Matrices.

- Level 1 method:

a) the units of work are differentiated polygons in each municipality,

b) soil effects are considered,

c) typologies are defined by structural and constructive criteria and vulnerability indexes and functions are used for each typology following RISK-UE methodology (Mouroux and Lebrun, 2006).

The application of these methods relays in the development of statistical distributions for both the vulnerability classes and the representative structural typologies of the studied regions. The distributions developed within the project are characteristic of the pilot zones considered. In order to apply these methodologies to other sites new statistical distributions should be developed. These methodologies had been included in an exercise to assess the applicability of different software packages to earthquake loss estimation in the context of rapid post-earthquake response in European urban centres (NERIES project) (Strasser, et al. 2008).

Acknowledgements

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LANDSLIDE TYPES AND GRAVITY SLOPE PROCESSES IN THE REBRNICE AREA (VIPAVA VALLEY, SW SLOVENIA)

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KEY WORDS: Rebrnice, landslide, limestone scree, flysch, Hrušica nappe, Vipava fault, active tectonics, geohazard, Slovenia

INTRODUCTION

The Rebrnice area extends over the part of the southwest slope of the Mt. Nanos between Podnanos and Razdrto. To the west, it extends into the Vipava valley, to the southeast, into the Pivka basin (Fg. 1). The area is crossed by a regional road. At the moment, the motorway section Razdrto-Podnanos is being built there, so geological structure and local geohazard of this area is a rather important topic. The Hrušica nappe (Placer, 1981) consists of a thick sequence of Jurassic and Cretaceous carbonate rocks that are thrust onto the Eocene flysch rocks of the Vipava valley (Pleničar, 1970; Buser, 1973). They are developed in a typical flysch that mainly consists of alternating sequences of sandstone and marlstone and subordinately of claystone or calcarenite. Carbonate rocks as well as flysch layers gently dip into the slope i.e. towards the northeast. Physical weathering of the Upper Cretaceous limestone and erosion processes have produced large amounts of limestone scree deposited on the underlying flysch rocks.

The steep NW-SE striking Vipava fault has been recognized in the southwestern (lower) slope of the Rebrnice area (Placer, 2008). New, as of yet unpublished data suggests its probable present activity.

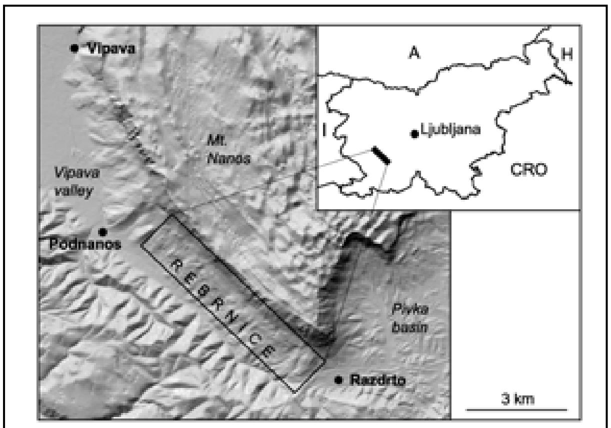

Figure 1 – Location of the investigated area.

The aim of this paper is to describe different types of landslides in this area and at the same time to find a connection between landslide movements and tectonic activity of the nearest structural elements such as the Hrušica nappe and the Vipava fault. The investigations included detailed geological mapping of the wider area, description of deposits from geomechanical boreholes and geologic surveying of construction operations of the motorway.

GRAVITY SLIDING PROCESSES

Two distinct types of landslides have been found in the Rebrnice area (Fg. 2). The first type are the most likely inactive deep-seated landslides in the flysch (Placer, 2007). The second type are recent movements of large masses of limestone scree and breccia. Both types of landslides are directly connected to the geological structure and active tectonics of this region.

Deep-seated fossil landslides are indicated by back depressions a few meters deep in the upper part of the slope, near the thrust plane of the Hrušica nappe. Circular shear planes that caused block-type rotational movements were seen inside partly weathered flysch rocks in the profile of a larger dig. Rotated blocks inside the flysch, up to 500 m in diameter, which also include limestone scree, created flat areas along the Rebrnice. In the upper part of the slope, flysch rocks are locally folded and heavily deformed due to the proximity of the thrust plane. In the lower (southwestern) part of the slope, flysch layers are also affected by the fault zone of the Vipava fault, however, lower slope inclination inhibits formation of gravity slides.

Moderate sliding of limestone scree and breccia has been measured by borehole inclinometers. Movements ranging from a few millimeters to a maximum of 15 millimeters per month were detected (Jež, 2007). Sliding has already caused deformation of the regional road and damage on objects in the village of Lozice. Groundwater flow near the border of flysch rocks and limestone scree creates clayey zones that significantly assist formation of shear planes. Groundwater usually springs under permeable limestone scree at the thrust border between limestone and flysch rocks or from calcarenite layers inside the flysch. Spring water percolates through permeable scree toward the edges of limestone scree deposits. Clayey

zones have very poor geomechanical characteristics that cause destabilization of the limestone scree above. Limestone scree and breccia form a ridge structure in the Rebrnice area. The thickness of sediments varies from a few metres to 30 meters, in some boreholes it exceeds 45 meters. Limestone scree is not homogenous over the whole thickness, in the upper part it usually has a sandy to siltysandy matrix. It is sometimes transformed into breccia. The bottom part of the scree layer, several meters in thickness, is composed of mixed clasts of limestone and flysch rocks, mostly sandstones. This part is usually more clayey.
The quantity of limestone scree is much dependant on the orientation of carbonate rock beds with regard to the local surface. Above the Rebrnice area the Upper Cretaceous beds dip perpendicularly to the surface, so physical weathering is most rapid at the frontal parts of beds and large quantities of scree are produced there. In contrast, on Mt. Nanos slope above Vipava (Fg. 1) the limestone beds are in vertical position and because of slower physical weathering there is only a relatively small amount of limestone scree.

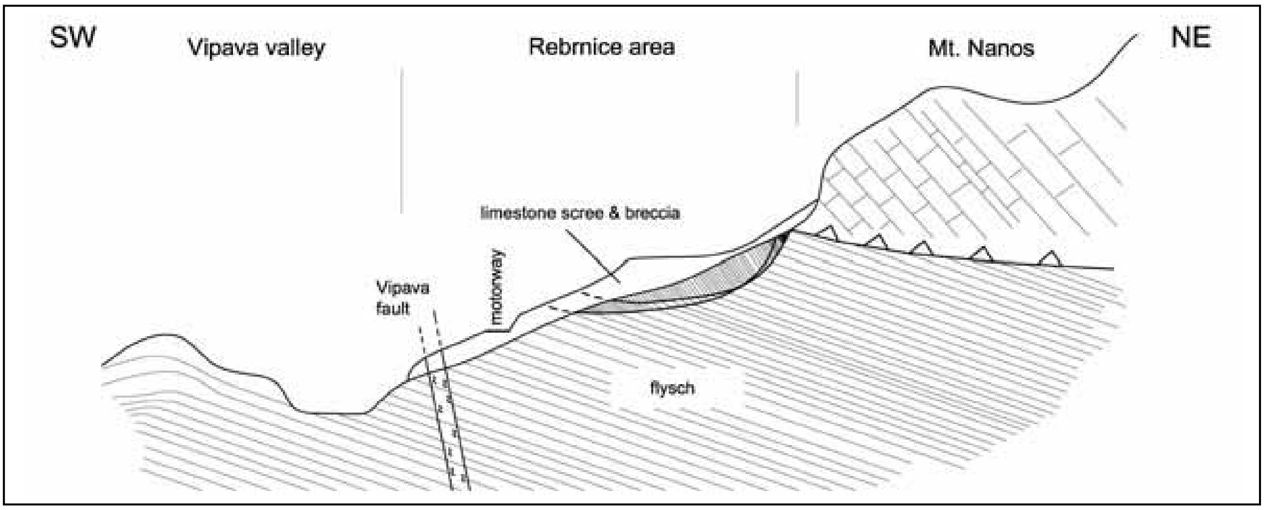

Figure 2 – Schematic cross section perpendicular to Rebrnice area.

CONCLUSION

New data (Rižnar et al., 2007) shows recent activity of some larger structural elements in western Slovenia. This allows the possibility that some other accompanying regional tectonic elements are also active but measurements of movements on these structures have not yet been made. The thrust fault of Hrušica nappe and Vipava fault can be also placed into this group.
Movements along these structures in the form of slips along the Vipava fault (Placer, 2008) and thrusting or underthrusting along thrust fault of Hrušica nappe additionally reduce the stability of sediments and sedimentary rocks in the Rebrnice area. Underthrusting of flysch rocks of the Vipava valley under limestones of Hrušica nappe may cause deformations in flysch rocks and increase slope inclination. Among these two factors we expect higher activity along the wider Vipava fault zone.

Active gravity slope processes in the Rebrnice area affect the regional road (Razdrto-Vipava) and some objects (such as digs and viaducts) on the future motorway. We have distinguished at least three regions where the movements have taken place during construction of the motorway and at least four regions which are deemed to be potentially critical for sliding. Because of many stability problems the construction of the motorway has been rather difficult.
Despite relatively slow sliding movements of limestone scree, we can estimate that long lasting rainfalls and/or seismic activity may cause sudden quick slides of larger quantities of scree or even reactivation of deep-seated fossil landslides.

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ADAPTALP WP6 – COLLECTIVE COPING WITH CLIMATE CHANGE IN THE ALPINE AREA THROUGH INTEGRATED RISK MANAGEMENT

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KEY WORDS: natural hazards, integrated risk management, climate change, Alps, AdaptAlp

INTRODUCTION

Climate change is to a large extent constituted by increasing temperatures and changed precipitation patterns. Any change of these critical factors has implications on the frequency and the extent of natural hazards. The uncertainties and the increase of natural hazards due to the impacts of Climate Change require concerted management, especially in the Alpine Space.

Figure 1 – AdaptAlp is part of the Alpine Space Program.

AdaptAlp will improve the information on impacts of Climate Change especially on regional level (e.g. high resolution modelling, design events) and evaluate different methods of risk assessment, hazard mapping and risk management in the Alpine Space. The activities concentrate on identification of best methods and transferring of best practice experiences into adaptation measures in model regions. Risk reduction by raising the awareness of local stakeholders is a further issue in AdaptAlp.
The know-how generated in AdaptAlp will be synthesized and integrated into practice of technical authorities. Recommendations will be given to policy makers and local stakeholders.

Reasons for transnational Approach

Due to Climate Change the entire Alpine Space is significantly and increasingly affected by natural hazards. Due to the special topography of the Alps impacts of Climate Change affect several countries at the same time and manifest themselves more strongly than elsewhere. Enormous efforts in the field of risk prevention respectively natural hazards will be part of the future life of the alpine population. Thus a transnationally harmonized, effective risk management and raising the populations awareness are essential. With regard to the considerable variety of Climate-Change-impacts, no single (national) adaptation strategy is sufficient or adequate. Joint transnational actions increase the potential for success. Transnational cooperation is indispensible for identifying effective and practicable prevention, adaptation and reaction strategies. There is a clear need for transnational cooperation, as it enables fast and efficient exchange of knowledge and experience transfer to save time, financial means, settlements and life and keep the Alpine Space attractive.

Work Package 6: Integrated Risk Management

Work Package 6 (WP6) centers on a pragmatic transnational approach for the improvement of risk prevention and management.
Based on:

- good examples,
- case studies,
- expert hearings and
- workshops

the transnational network will open an integrated risk dialogue to identify the most effective methods.

Figure 2: Road in Bavaria during 1999 flood

Figure 3: The Risk Management Cycle – Core of the integrated Strategy

Risk Management education modules for practicioners will then be developed and tested to increase the quality of decision making on integrated prevention and management of natural hazard risks on a regional and local level.

Project Partners in WP6

- Bavarian State Ministry of the Environment and public health
- Swiss Confederation – Federal Office for the Environment FOEN
- Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria)
- Geological Survey of Slovenia
- Regional Government of Carinthia – Department for Water Management
- Aosta Valley Autonomous Region – Department for the Territory, Environment and Water Resources
- Piemonte Regional Agency for Environment Protection – Regional Center for Territorial and Geological Health
- Grenoble Institute if Research and Study for Prevention of Natural Hazards
- EURAC Research, Bolzano
- Bavarian Environment Agency

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GEOMETRY AND KINEMATICS OF THE ROCCAMURATA LANDSLIDE (NORTHERN APENNINES, ITALY)

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KEY WORDS: geomorphological evolution, landslides, building damage, Northern Apennines, Italy.

INTRODUCTION

The Emilia-Romagna side of the Northern Apennines is characterized by the widespread occurrence of landslides of different type, size and state of activity. In many areas, landslides are so widespread as to constitute the most mapped unit of the "Geological Map of the Emilia-Romagna Apennines 1:10.000" of Emilia-Romagna Region. Since the early 90s the Emilia-Romagna Region (Servizio Geologico, Sismico e dei Suoli) has created the digital Database of the Regional Geological Map, which is continously updated; in particular, the Database contains the Inventory Map of Landslide on 1:10.000 scale, which is an essential tool in territorial planning. This map also identifies the villages that insist on areas of active or dormant landslide and, consequently, to progressively update the list of inhabited centers to be consolidated or transferred, as required by specific legislation of the Emilia-Romagna Region (Regional Law 7/2004).

The increase of damage affecting the buildings of Roccamurata village (Taro valley, Parma Apennine) after the year 2000 led the Emilia-Romagna Region (Servizio Tecnico Bacini degli Affluenti del Po, STB, Parma) to investigate the causes of these damages within an agreement with the CNR - Institute of Geosciences and Earth Resources, Operative Unit of Pisa, for the geological and geomorphological study of the Roccamurata area (Municipality of Borgo Val di Taro).

This contribution presents the main results of this study which, integrated with borehole stratigraphy and inclinometer data, led to the individuation of an active rotational landslide as cause of the damage affecting the buildings and the main road of the Roccamurata village.

GEOLOGICAL SETTING

The Roccamurata area is located in the Parma sector of the Northern Apennines of Italy, a fold and thrust belt that resulted from the Cenozoic post-collisional processes between Europe and Adria plates. The Northern Apennines is a tectonically active region where the uplift started in the uppermost Late Miocene with not homogeneous rates (e.g. Cerrina Feroni et al., 1997; Balestrieri et al., 2003). According to the Italian Seismic Hazard Map (Gruppo di lavoro MPS, 2004) the study area is included in the zone 2 (medium to high hazard). The seismicity of the region is mainly influenced by the NE-SW directed Molinatico thrust fault, a structure associated to the Taro Fault System (Boccaletti et al., 1985; Vescovi, 1991).

The Roccamurata area is characterized by the occurrence of the Ligurian Units which represent the upper nappe in the Northern Apennines structural stacking. The Ligurian Units were derived from the Ligurian-Piedmont oceanic basin and its transition to the Adria plate margin and are formed by slices of Jurassic ophiolites and detached Upper Cretaceous-Middle Eocene shales, and calcareous and arenitic turbidites (for a review see Catanzariti et al., 2002).

In particular two main lithostratigraphical units crop out: the Casanova Complex (Lower Campanian) and the Scabiazza Sandstone (Coniacian-Santonian).

The Casanova Complex consists of several lithofacies without a definite stratigraphical superposition order, characterized by monomict and polymict shaly-matrix or arenitic-matrix breccias with olistolites mainly of massive and brecciated serpentinites, basalts and Palombini Shale.

The Scabiazza Sandstone is made up of arenaceous-pelitic turbidites consisting of an alternance of lithic arenites and marly pelites organized in thin to thick beds.

The contacts between the different lithofacies of the Casanova Complex generally show a subhorizontal attitude. This attitude sets up a structural setting which is not particularly favorable for the development of gravity-induced movements. On the contrary are the bad geomechanical properties of these rocks, generated as debris flow deposits, to be an intrinsic factor of high landslide propensity.

Figure 1 – The Roccamurata slope along the right side of the Taro Valley (satellite image from http://earth.google.it).

GEOMORPHOLOGICAL EVOLUTION

Along the right side of the Taro Valley, the Roccamurata village is located in the lower part of a slope which evidences an height difference of about 700 m from the watershed to the valley (Fig. 1). The slope displays a great spreading of landslides and other gravitational slope movements which insert in a complex morpho-evolutive framework.

In particular the slope can be subdivided into three parts. The central part is characterized by relict landslides showing subhorizontal upper surfaces delimited by steep slopes. These landslides were formed during an early morphogenetic cycle with different climatic conditions and then deeply eroded during the following uplift phases which determined new landslides both uphill and downhill which now characterize the upper and the lower parts of the study slope.

The upper part evidences rock block slides and lateral spreadings connected with the lithology of the Casanova Complex consisting of huge basaltic olistolites above shale-dominated deposits. A large earth-flow with floating basaltic blocks developed for a lenght of more than 900 m and overlapped the relict landslides of the central part of the Roccamurata slope.

The lower part of the slope is mainly characterized by dormant earth-flows developed in the Casanova Complex breccias. The easternmost part of the Roccamurata village is above a dormant earth-flow showing a tongue-shaped geometry for a lenght from head to toe of more than 600 m (surface area 800 ha). The landslide belonging to the lower part of the slope directly affecting the Roccamurata village will be described in the next chapter.

According to the available radiocarbon data the geomorphological evolution is post-glacial in age with subsequent evolutive steps corresponding to the most rainy periods of the Holocene (Bertolini et al., 2005 and references).

THE ROCCAMURATA LANDSLIDE

In order to investigate ground conditions of the area where the Roccamurata buildings suffered remarkable damage two boreholes (ROCC1 and ROCC2) were drilled. The stratigraphical logs showed that the bedrock of the landslide deposits is represented by alluvial deposits overlapping an alternance of sandstones and silty marls referable to the Scabiazza Sandstone formation (Fig. 2). In order to determine the position of the slip surface and the rate of sliding the boreholes were equipped with inclinometers (Fig. 3).

These data have revealed that the damage of the Roccamurata buildings can be referred to an active landslide. This landslide is a rotational slide (rock slump) with a concave sliding surface at a depth of up to 36 m; it developed in the serpentinitic breccias of the Casanova Complex and has a surface area of about 250 ha being 180 m long for a maximum width of 160 m (Figs. 4 and 5).

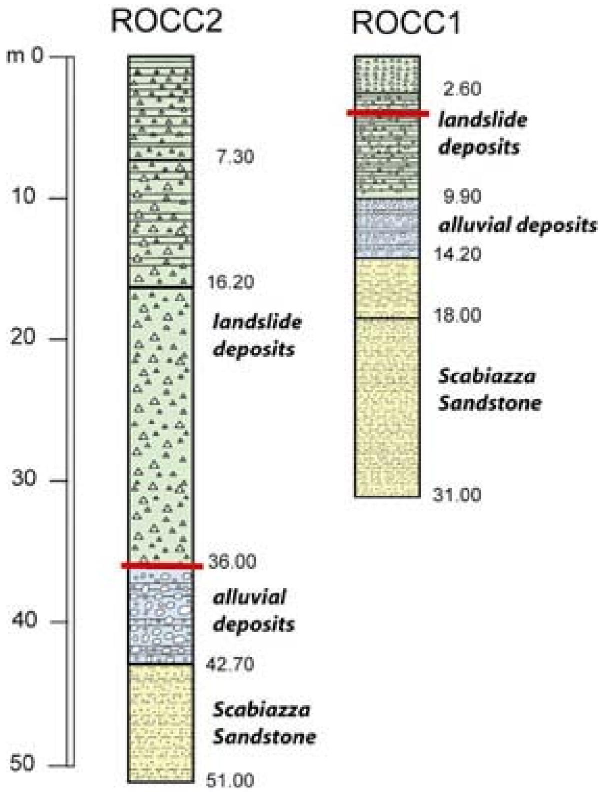

Figure 2 – Interpreted borehole stratigraphical logs (the red lines represent the sliding surface). Location of boreholes in Figs. 4 and 5.

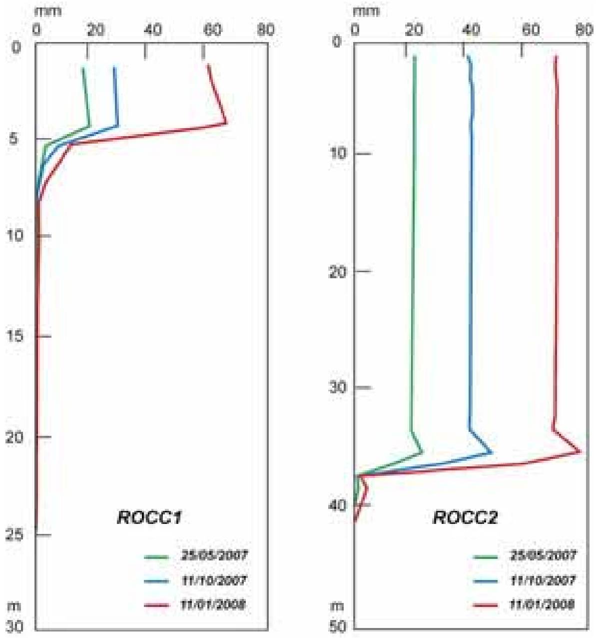

Figure 3 – Displacement graphs from inclinometer measurements in boreholes ROCC1 and ROCC2 (initial 15/02/2007).

The head of the rotational slide has scarce morphological evidences while downslope the sliding surface seems to cross the main road running along the Roccamurata village which appears deeply deformed. The sliding surface corresponds with the boundary between the landslide body and the alluvial deposits (borehole ROCC2) while downslope the sliding now occurs within the landslide body (borehole ROCC1).

The inclinometer measurements, collected during a period of 11 months, indicate that the Roccamurata slide is active moving northwestward with a valuable mean displacement of 8 cm/year.

According to the classification by IUGS/WGL (1995) it is therefore a very slow landslide.

The Roccamurata rock slump was generated as secondary sliding in the frontal part of a wider rock block slide involving a few lithofacies of the Casanova Complex characterized by breccias (Figs. 4 and 5).

Taking into consideration both the rock block slide and the Roccamurata landslide, the complessive area subjected to slope gravitational deformation has a surface area of about 600 ha.

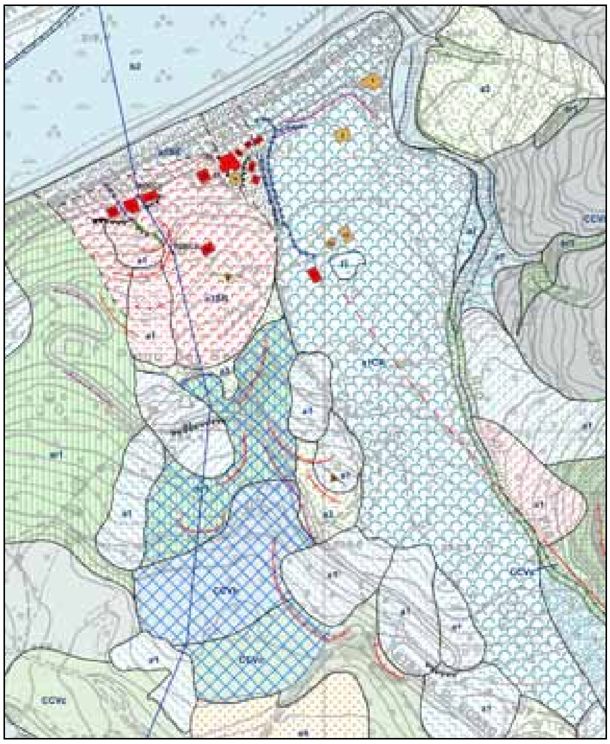

Figure 4 –Geological-geomorphological map of the Roccamurata area (acronyms as in Fig. 5) . Buildings with cracks (red squares) and trace of the geological cross-section (blue line) are indicated.

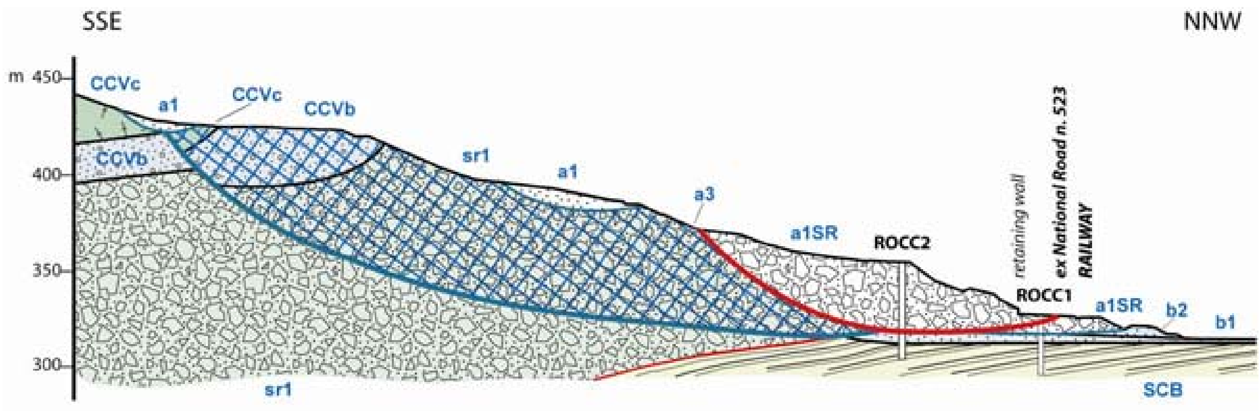

Figure 5 – Geological-geomorphological cross-section of the Roccamurata landslide (horizontal scale as vertical scale; location in Fig. 4). a1SR: Roccamurata rotational slide; a1: dormant earth-flows; a3: undifferentiated slope deposits; b1, b2: alluvial deposits; SCB: Scabiazza Sandstone; Casanova Complex: shaly-matrix polygenic breccias (CCVb); arenitic-matrix polygenic breccias (CCVc); serpentine breccias (sr1). The crossed area represents the wider rock block slide from which the Roccamurata slide generated. ROCC1 and ROCC2: boreholes equipped with inclinometers.

BUILDING AND INFRASTRUCTURE DAMAGE

The area of active landslide includes several residential buildings that were built along the main road of Roccamurata starting from the 50s. Eight of these houses are affected by serious damages and one of these has been completely abandoned in 2006/2007. The cracks appeared during the 70s and 80s with a worsening after the year 2000. Complessively the damage could be classified from light to moderate following the scheme of Chiocchio et al. (1997).

Also the main road of Roccamurata (ex National Road n. 523) is deformed by the active landslide. On the contrary, the railway line Parma-Borgo Val di Taro running just downslope yhe road does not seem affected by the slope movements.

Figure 6 – Cracks in a house of Roccamurata.

CONCLUSIONS

Even though the monitoring period is relatively short, the analysis of geological, geomorphological and borehole data leads to the conclusion that the damage affecting the Roccamurata buildings can be connected with an active rotational landslide whose geometry and kinematics have been defined.

This study allowed also the updating of the Inventory Map of Landslide of the Emilia-Romagna Region and it will allow to valuate if the Roccamurata village had to be included in the list of inhabited centers to be consolidated.

ACKNOWLEDGMENTS

This paper is dedicated to the memory of our friend and colleague Francesco (Chechi) Baldacci.

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THE VLORA – ELBASAN – DIBER FRACTURE, ALBANIA

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KEY WORDS: deep cross fracture, evaporite diapir, earthquakes.

INTRODUCTION

The Vlora – Elbasan-Diber segment with direction SW-NE in Albania, represents an earlier transversal deep fracture, which has played an important role in development and structuring of Albanides in two sites of this segment. On the northern site, is developed the Near Adriatic Lowland, while on the northern site are formed carbonate massifs with a hard mountain relief of the Ionian zone.
To this thrust are related many geological phenomena (Figure 1): Evaporite diapires of Dumrea and Peshkopi, tectonic windows of Okshtuni; the tectonic displacement of the Shpati ultra basic massifs and Quaternary; the presence of the many buried anticlines under molasses formations; the new tectonic movements evidenced from the fresh normal tectonics and the forming of the erosion valleys; the presence of many hydrocarbons deposits and the oil earmarks on surface; the source of the sulfur hot waters; the presence of the some hydrothermal mineralization and the last, the frequently and strong earthquakes, being active and now .

EVAPORITE DIAPIR OF DUMREA

Evaporite diaper of Dumrea, represents one of the most interesting geological nodes of the Albanide tectonic structure, mainly according to the geodynamic site of their forming, also for the role that played in the structuring and tectonizing of the Vlore -Elbasan – Diber segment. It represents a large massif as like as “iceberg”, with big surface and thickness, respectively 170 km^2 and up to 5000 ml. The most part of this massif is plunged in deep. On surface, it is rounded from a flysch hilly ring. From the drill dates “Dumrea 7”, we have got the interesting facts, which evidenced that evaporites of this diapir represent an inclusion inside of the Lower Oligocene flysch formation. From the drill “Paper 1” (deepest one), is confirmed that the roots of this diapir are oriented to East and North – East to Elbasani city. The big thickness, up to 5000 ml of this evaporite formation, taken from the drill “Dumra – 7”, is not the real stratigraphic thickness, but dapiric ones, formed from the flow, as a result of the evaporite features. The normal stratigraphic thickness of the Permo - Triassic evaporates in Albania is about 100 ml. So, Dumrea evaporites have had a distribution five times more than this exposed today in surface (NAÇO et al. 2007).

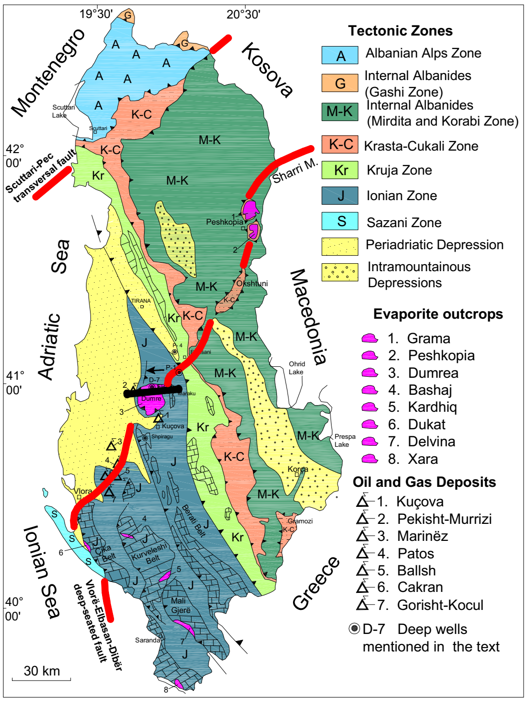
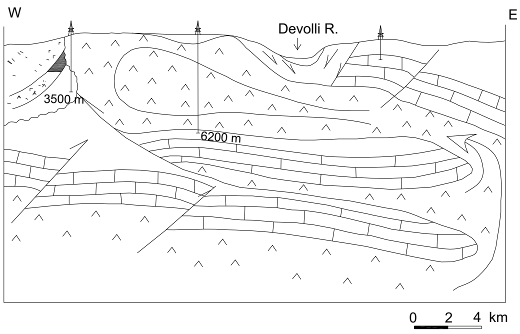


Figure 1: Interpretation of the seismic profiles performed on the Okshtuni tectonic window

This fact allows to understand the mechanism of the evaporate massifs forming, to explain exact geological construction of the region, also to approve that the earlier deep fracture, have served as possible road for the flows of the evaporites from the big deeps. In the same time this makes possible to explain the importance of the transversal fractures, their interference with longitudinal tectonics and as result, the mechanism of their forming in the tectonic weaken nodes. Also here are explained many others phenomena.
Evaporites have cut the sedimentary carbonate – flyschy cover. On the Eastern, Northern, and

North- Eastern sites, the evaporite massif is covered from the Oligocene flysch, with gentle incline in concordance to massif contours, whiles on the Southern site and Southern – Western site, the flysch formation is placed on front of the evaporate, on extension, in concordance, but with strong dip , overturned. So, the evaporite eruption has happened along the lower Oligocene. The Permian - Triassic ductile floor has begun to flow through the weaken node, which coincides to the interruption of the cross fracture of Elbasan – Diber, with the longitudinal fractures which limit on west Maraku anticline and Kruja tectonic zone (Figure 2).



Legend

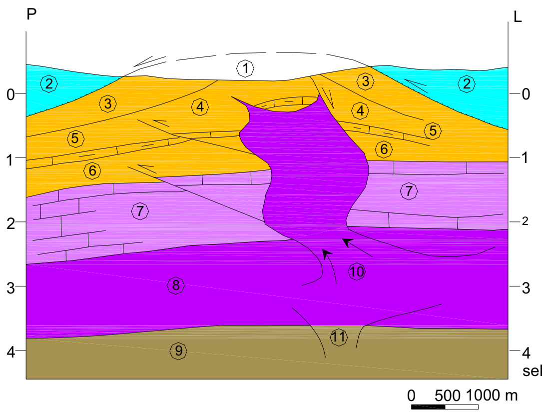
- The transgresive placement of Torthonian molasse formation
- Triasic - Eocene carbonate formation
- Permian - Triasic evaporite formation
- The Oligocene flyschy formation
- Uplifting formed on the conditions of Devolli depressive valley (Mollas)
- The intrusion mechanism of the evaporites
- The development module of Dumrea evaporite massif

Fig. 2 The geotectonic construction nearby the Elbasani city (after seismic information and drillings). The profile cut cross the Vlora – Elbasan –Diber deep fracture.

On this weaken node, the evaporites are uplifted, overturning from floors as up floors. As a result of this complex and tectonic process, are destroyed and reformed some hydrocarbon deposits as like these of Kozanit, Pekishit – Murrize, Kuçovë, Patos, Marinez, Selenicë etj.
The evaporite eruption is associated with the strong changes of the geological construction of the territory, so we can call it as tectonic evaporite phase.
The evaporite eruption, have cut the territory in two sectors with very different tectonically regimes. The sectors on east and southeast of the fracture, continues to have a compressed regime, the orogeneses structuring, which continues and today. The western and northern – southern sector is included in this inverse movement as result of the extender regime, created from the flow of the evaporites, associated with the continuous down of the tectonic units, which continues and today.

EARTHQUAKES

Along the segment Vlore – Elbasan – Diber, are registered the strong earthquake epicenters, placed up to a narrow belt, with northeastern extension, which is known as Vlora – Elbasan – Diber seismic line.
On the extension of this line there are the strong epicenters of the earthquakes, with magnitude from 5.6 to 6.6 and epicenter from 3 km to upper mantle (SULSTAROVA et al.1980) The earthquakes along this fracture have been frequently ones and associated from many seismic shakes with footprints on surface, as normal accidents. The earthquake happened on November 30, 1977, on Golloborda zone, associated with a outcrop of a tectonic disjunction with length about 10 km, with northeastern extension, about 40 km, sitting down the block on its south east about 0.5 m.
These dates, as well solve of the mechanism of this earthquake centre, speak for a down along a plane with the big angle of the dip, 62^0, which is in concordance to general plane of the large transverse of Vlore – Elbasan – Diber. The interpretation of the seismic profile done in the geological node of the Okshtun, support this conclusion (Figure 3).



Legend

1. Okshtuni tectonic window 2. Internal Albanides 3. Paleocene - Eocene Flysch 4. Maastrichtian flysch 5. Limestone level with globotruncana 6. The flysch formation under the limestone with globotruncana 7. Sequence with powerful reflector, Triassic-Jurassic carbonate formation 8. Sequence with karstic reflector, Permian - Triassic evaporitie formation 9. Sequence with powerful reflector, the terrigene formation under the evaporites 10. Evaporite intrusion via the weaken tectonic node 11. Fragment where the reflector breaks, deep tectonic thrust.

Figure 3: Interpretation of the seismic profiles performed on the Okshtuni tectonic window

In the Elbasani zone, earthquakes have been characterized from low magnitude and from many shakes for a long interval of the time. As it looks, it is related to the evaporite diapir intrusion of Dumre, which behind the fracture front, create an extensional tectonic regime. On these tectonic conditions is formed Elbasan – Cerrik – Devoll graben, expressed clearly with the large river valleys, with quaternary depositions, up to 200 m in thickness, also with erosion stairs of Sulova crest (Figure 4). To calculate the seismic risk on Albania, on general, which is characterized from a high level of the seismicity average dimensions, the dates are taken for the period 1964 – 1995, which are as fellow : 15 earthquakes with magnitude up to 5 Mercal grade, 350 with 4.5 – 4.9 Mercal grade, 3160 with 3.0 – 3.9 Mercal grade and 12475 with under 2.9 Mercal grade. As we above mentioned, the deep transverse Vlore – Elbasan – Diber is a continuously source of the earthquakes, especially on the intersecting points of it to the longitudinal deep fractures, as result, permanently it is a serious threat for the community and invests.

OKSHTUNI TECTONIC WINDOW

It represents one of the elements which, is formed as result of the above tectonic transverse. On the truth it represents a large anticline structure with dimensions 26 x 6 km and on the same time it is a tectonic window with age before the geological formations of Maastrichtian – Eocene, rounded as ring from the Jurassic – Cretaceous flysch . The fact is the northern orientation of the structure, concordant to the Vlora – Elbasan – Diber transverse extension, which is encounter with Albanide (northern – western) extension of the tectonic unit. As result, Okshtuni tectonic window, at the same time the anticline unit with the same noun, is formed from of the transverse activity above mentioned and belongs the tectonic structuring phase.
The activity of the earlier transverse of Vlora – Elbasan – Diber, the evaporites introducing through it, have made possible the forming of this dominant element, in geological structure of Albanides.
From the interpretation of the seismic profile (Fig. 4), made nearly above Okshtun village, we have got information which speaks for the existence of the transverse to 8 – 10 km. The transverse comes from the deep bigger than the evaporite thickness. These last have used this fracture to began the uninterrupted process of the intrusion, mixing so the segment in the continuous movements and shakes.

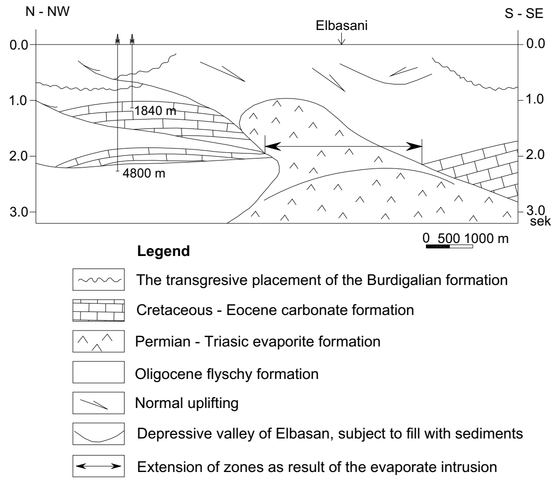


Figure 4: The geotectonic construction nearby the Elbasani city (after seismic information and drillings). The profile cut cross the Vlora – Elbasan –Diber deep fracture.

THE PESHKOPIA TECTONIC WINDOW

The Peshkopia tectonic window there is on the most northern – northeastern continuation of the Okshtuni tectonic window. These are confirmed as like because the evaporites have cut the Eocene flysch cover and are developed as superficial diapir massifs.
What the diapirs couldn't to do on Okshtun, have done on evaporite massifs of Peshkopia, penetrating all the Eocene flysch cover of the Diber unit (Krasta tectonic subzone), being lift of in the same time with it and the old formations, framed in Korabi tectonic zone, but are placed tectonically up Eocenic flysch. On the northeastern continuation, evaporite diapir leaves the place the cordilleras massif of the Shari Mountains, which form a geological structure with considerable extension and are raised in relief evidently, as a Cordelier. But what is more important, the extension of the geological structure of the Shari Mountains is commensurable to the extension of the general structure of the tectonic window line of the Okshtuni – Peshkopi. From this, we understand that the same geodynamic process, which had structured Okshtuni and Peshkopia tectonic window, has structured and the Cordilleras massif of Shari. So in the phenomena centre is Vlora – Elbasan – Diber – Biçec transversal, as weaken tectonic line, via of which, evaporites have cut and introduced, the sedimentary formations of Triassic – Eocene- Oligocene. From this we conclude, that evaporites when enter in the process of the introducing, have the sensitive influence in tectonic – structure evolution, not

only regions near of them, but and on the other geological territory. With this we have in mind the Elbasan – Okshtun – Peshkopi – Malet e Sharit structuring line and the essential change of the structuring scale on north and south of the Dumrea evaporite massif. The intrusion of the evaporites through weaken tectonic lines, means, the tectonic, deep and old fractures, compose the premise that these segments to overlive the continuously motions, as a result of the fluidity of evaporites, being so constantly, object of the earthquake shakes.

CONCLUSIONS

- Vlora – Elbsan – Diber – Biçec deep fracture represents one of the most important tectonic that cut cross the Albanide geological structure and more largely.
- This transversal has evidently influence, as in tectonic – structure evolution of the geological units on both site of it, also and on geomorphologic evolution.
- On two sites of this transversal, the geological construction has evident differences. Mention here, Ionian tectonic zone, which on its north, faces with Adriatic Lowland, Shpati ophiolitic massif, which on north it confronts with Krasta subzone, Okshtuni anticline structure, which cut cross the ophiolitic belt of Shebenik – Bulqize, Peshkopia evaporite window, which on northeastern direction, structurally leave the place the large cordilleras of Shari mountains, cutting cross the geological structure of Balkanides.
- Also on geomorphologic point of view, it is expressed on evident element, what are active ones and today. Mention here, the deep and large alluvial valleys of Shkumbini and Devoll rivers on Elbasan - Cerrik –Kuçove, erosion stairs of Krraba and Mollas saddles, formed on the conditions of extensive tectonic regime, the deep erosion valleys of Okshtun, the whose axis is commensurable with axis of the anticline with the same noun, formed in the conditions of the elevator tectonic regime, the cordilleras arc of Mali Bardhe - Malet e Sharit, formed in the conditions of compressive tectonic regime, the large alluvial fields near coastal, which everywhere elongate on northeast of Vlora – Elbasan transversal, formed on conditions of extensive tectonic regime, giving possibilities the rivers to play a primary role for their forming.
- As active evidence of the existence of Vlora – Elbasan – Diber transversal, appreciate the frequent earthquakes which happen along this segment, associated time to time with catastrophic consequences, the fresh tectonics that read on surface, on Letan and Marak (NAÇO et al. 2005), the frequent sliding as result of the extensive regime that associate it etc.
- Meantime as evidence of the big deep of its activity, we mention, the source of the Elbasani and Peshkopi telethermal water, with temperature 60 – 70^0, the oil deposits, discovered on its extension, telethermal mineralization of Kerçisht, Biçaj etc, the dates these that speak for the thermal flux from the big deep of the underground.
- Finally we formulate that the Vlora – Elbasan – Diber – Biçec, represents an active sector with high seismicity and continuously motions, as like it must to be calculated from the investments and community.

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LIVING WITH GEOHAZARDS. A STRATEGIC CONTRIBUTION TO ITS MITIGATION: THE GEOLOGICAL HAZARD MAP OF CATALONIA 1:25 000

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KEY WORDS: Hazard, susceptibility, risk, multihazard, cartography, prevention, urban planning.

INTRODUCTION

The high density of urban development and infrastructures in Catalonia requires geo-thematic information for planning. Geo-hazard mapping is a fundamental part of this information. Despite some tests having been carried out with wide land recovery (Mountain Regions Hazard Map 1:50000 [DGPAT, 1985], Risk Prevention Map of Catalonia 1:50000 [ICC, 2003]), in 2006 the Catalan government made a strong commitment to produce the Geological Hazard Prevention Map of Catalonia (MPRGC).

The MPRGC is a 1:25000 scale map where terrain is zoned according to geological hazard. The purpose of this tool is to support urban, road and infrastructure planning. The map is intended to enable government and individuals to have an overview of the territory, with respect to geological hazards, identifying areas where it is advisable to do detailed studies in case of action planning. At the same time a database is being implemented. It will incorporate all the information coming from these maps. In the future it will become the Geological Hazard Information System of Catalonia (SIRGC).

GEOLOGICAL HAZARD PREVENTION MAP OF CATALONIA

In the MPRGC, evidence, phenomena, susceptibility and natural hazard of geological processes are represented. These processes are generated by the external geodynamics (such as slope, torrent, snow, coastal and flood dynamics) and the internal Geodynamics (earthquake). Those areas likely to generate hazard due to human causes are not considered.

The phenomena considered in the map are:

- slope movements (rock-falls, landslides, complex movements, flows ...)
- Sinking (subsidences and collapses).
- Avalanches
- Floods
- Earthquakes

The information is distributed on different maps at different scales on the published sheet (Figure 1). The main map is at scale of 1:25000. Landslide, avalanche and flood hazard (according to geomorphologycal approach) is represented. Several complementary maps at 1:100000 scale show the different phenomena hazard, separately in order to facilitate their understanding. Two additional maps, flooding and seismic hazard, represented at 1:50000 and 1:100000 respectively, are added on the sheet.

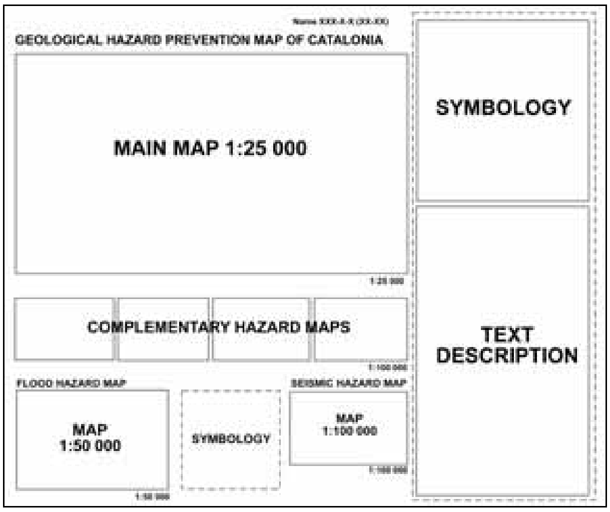

Figure 1 – Outline sheet. It shows the distribution of the different maps.

MAIN MAP

The methodology used to work is synthesized in the following phases:

1. Mapping Inventory

1.1. Bibliographic and cartographic search: the information available into archives and databases is collected.

1.2. Photointerpretation: carried out on vertical aerial photos of flights from different years (1957, 1977, 1985, 2003, etc.). The observation of the topography and the vegetation allows the identification of areas with instability signs coming from the identification and characterization of events that occurred recently or in the past, and from activity indicators.

1.3. Field survey consists of checking and contrasting on the field, the elements identified in the previous phases. Field analysis allows a better approach and understanding, and therefore identifying signs and phenomena not observable through the photointerpretation.

1.4. Population inquiries: the goal of this stage is to complement the information obtained in the earlier stages, especially in aspects such as the intensity and frequency. It is done through a survey to witness who lives and/or works in the study areas.

2. Determination of the susceptibility

Areas susceptible to be affected by the phenomena are identified from the starting zone to the maximum extent determinable at the scale of work. Their limits are drawn taking into account the inventory of phenomena, signs of activity geomorphological indicators, and from the identification of favourable lithologies and morphologies of the terrain. This phase includes the completion of numerical models to support the determination of the starting and run-out zone.

3. Determining hazard

Based on the analysis of the magnitude and frequency of the observed or potential phenomena, susceptibility areas are classified according to hazard matrix represented in Figure 2.

Hazard zones are represented as follows: in white, areas where no hazard was detected, in yellow, zones with low hazard, in orange, the medium hazard zones, and in red, areas with high hazard.

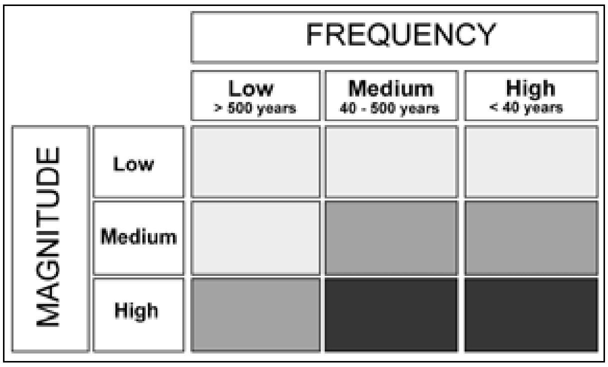

Figure 2 – Hazard matrix (based on Altimir et al, 2001).

Each one of the hazard levels indicates some considerations for prevention. These considerations inform about the need for further detailed studies and they advise about the use of corrective measures.

	PREVENTION	
HAZARD	DETAILED STUDIES	HAZARD MANAGEMENT
Not observed	------	------
Low	Recomendable	Necessary in certain cases
Medium	Indispensable	Necessary in many cases
High	Indispensable	Necessary in most of the cases

Figure 3 – Prevention recommendations.

Hazard of each phenomena is analyzed individually. The main challenge of the map is to render the overlapping hazard of different phenomena easily. With this objective a methodology that identifies that this overlap exists has been established. It indicates what the maximum hazard overlapped is (Figure 4), but in any case, not obtaining new hazard values.

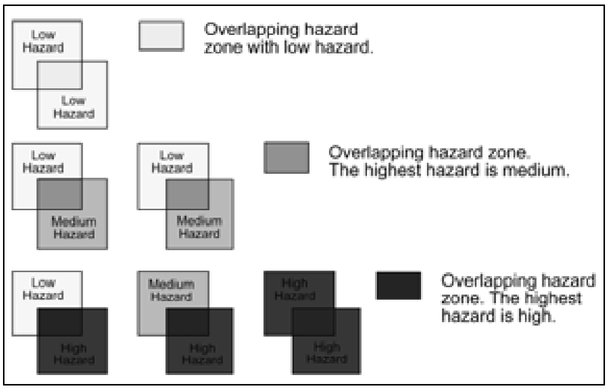

Figure 4 – Multi-hazard representation.

To identify which phenomena corresponds with each one of the susceptibility areas, different outline patterns are represented, as shown in Figure 5.

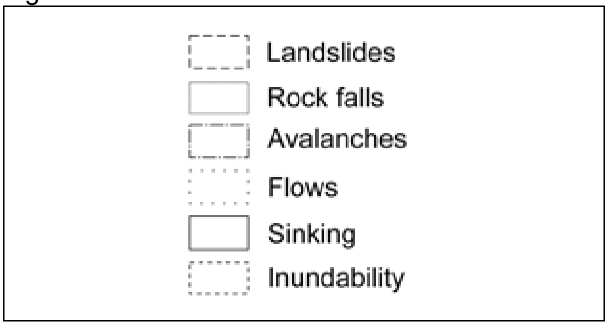

Figure 5 – Outline patterns identifying at what phenomena the hazard belongs.

Figures 6 and 7 show the final outcome of the procedure.

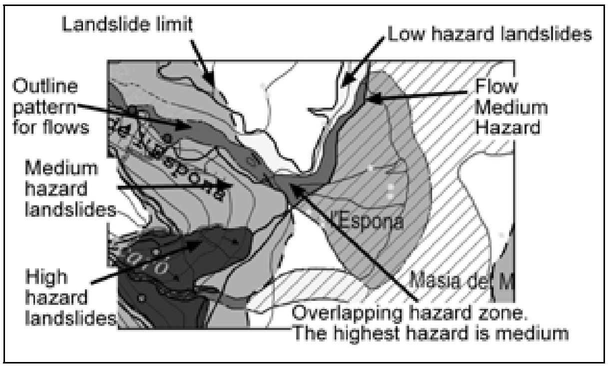

Figure 6 - Example of multi-hazard representation.

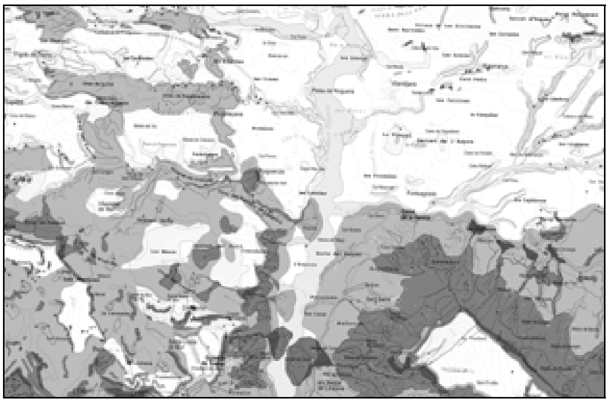

Figure 7 – Main map 1:25000, which includes landslides, avalanches, sinking and flooding according to geomorphologic criterion.

COMPLEMENTARY MAPS

Complementary maps represent the hazard determined for each individual phenomena at 1:100000 scale. The purpose of these maps is to facilitate the interpretation of the main map. Depending on the type of phenomena identified in the main map, the number of complementary maps can vary from 1 to 6.

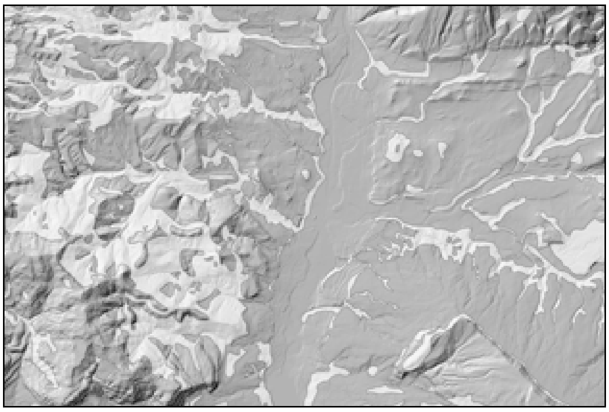

Figure 12 – Surface landslide hazard complementary map.

SEISMIC HAZARD MAP

This map was obtained from the map of seismic areas (for a return period of 500 years) for a middle ground, and considering the effects of soil amplification.

To take into account the amplification of the seismic motion due to soft ground, a geotechnical classification of lithologies from the Geological Map of Catalonia 1:25000 into 4 types were carried out: R, A, B and C, based on the speed of the S-wave through them (Fleta et al., 1998):

Type R: corresponds to hard rock (example: Paleozoic and Mesozoic).

Type A: corresponds to compact rocks (example: Paleogene or Neogen).

Type B: corresponds to semi-compacted material (example: evaporitic rocks or old Quaternary deposits).

Type C: corresponds to non cohesive material (example: non consolidated deposits with organic content).

To each group of lithologies the proposed amplifications were assigned as follows:

Type R and A: No addition of any degree of intensity.

Type B and C: Addition of 0.5 degrees of intensity.

On the final map (figure 8) the values of the basic seismic acceleration of the compulsory "*Norma de Construcción Sismoresistente Española*" (NCSE-02) for a placement in rock, and the intensity of the seismic emergency plan (NCSE-02, 2002) are represented.

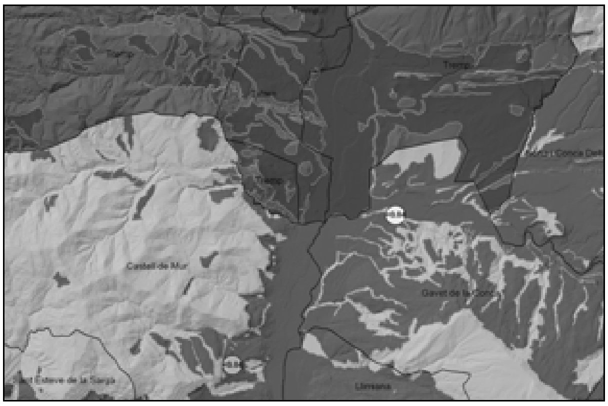

Figure 8 – Seismic hazard map 1:100000.

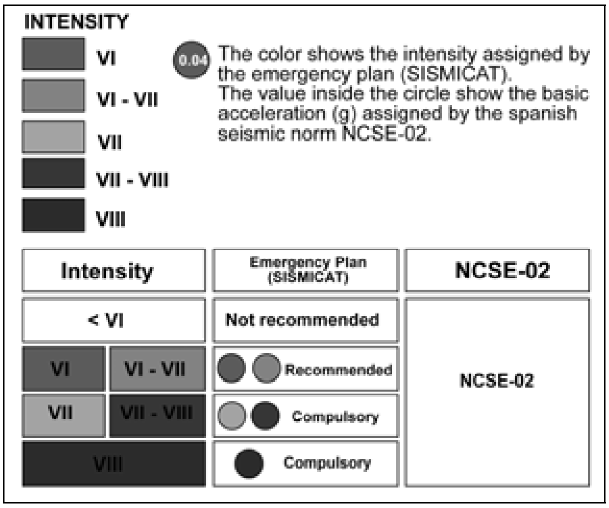

Figure 9 – Seismic hazard map simbology.

FLOODING HAZARD MAP

On the flooding hazard map at scale of 1:50000, the limits of the hydraulic modeling for periods of 50, 100 and 500 years provided by the Catalan Water Agency (ACA) are represented.

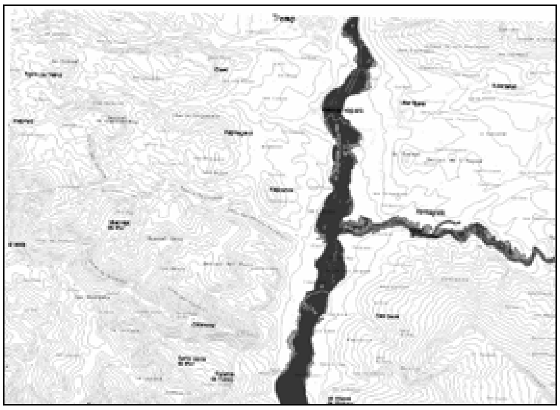

Figure 10 – Flooding hazard map based on hydraulic modeling.

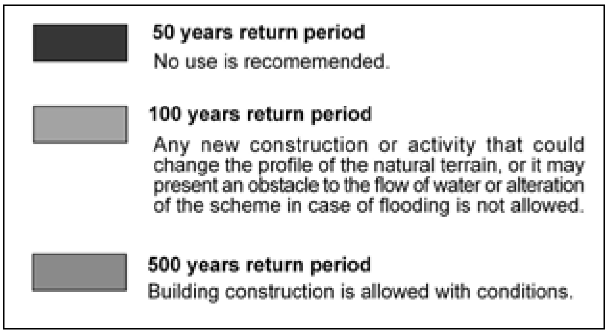

Figure 11 – Flooding hazard map simbology.

CONCLUSIONS

The MPRGC will replace the shortage of hazard mapping in Catalonia.

It permits the consultation of the integrated geological hazard information at medium scale in a single document, to facilitate its understanding.

This work is the beginning of the geological hazard database, currently under construction. It will become the principal reference of geological hazards in Catalonia.

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SEISMIC HAZARD – THE NEW APPROACHES TO THE DETAILED QUANTITATIVE ASSESSMENT

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KEY WORDS: seismicity, hazard, assessment, method, magnitude, prediction.

APPLYING METHODS

The extraregional seismotectonic method is used for determining the maximal magnitude of the expected earthquakes. Founding on the detailed deep typification of the Earth crust, it is based on the set of parameters reflecting its modern state and structure. The zonation of vast areas according to the crust types represents the original seismotectonic base. The combining a such seismotectonic zoning with seismological data results in the detailed spatial distribution of the predicted Mmax (1:100000). The repeating seismotectonic setting in space is favorable for prognostic assessment of the seismic potential on the detailed level for different regions, including ones with poor seismological data (fig.1). Comparison of the obtained values of Mmax with faulting pattern allows the outlining the potential source zones of the strong earthquakes. The paleogeoseimological method, including “trenching”, deals with the traces of the ancient earthquakes in the trenches and relief, manifesting as seismogenic ruptures, buried soils, ancient landslides and so on. The scale of the found seismic ruptures and their displacing pattern are the tool for determining the energy and source mechanism of the generating earthquakes. The age of the paleosoils gives the hint on the occurrence period of the strong earthquakes/volcanic eruptions for the special area (fig.2).

METHOD COMBINING

Applying the extraregional seismotectonic method, the prognostic values of Mmax are received for the most part of the Northern Eurasia, for some areas these are the first assessments of the seismic hazard. In some cases the predicted Mmax are confirmed by real strong earthquakes, occurred after our calculations. Among them it should be mentioned the Kaliningrad earthquake of 21st September, 2004 with M=5.0 (Mb, Ms) - 4.7 (Mw) as well as strong Altai earthquake of 27th September, 2003 with M=7.3. Both extraregional seismotectonic and paleogeoseismological methods are fruitfully combined for investigation of the seismic potential of the different regions. Thus, high predicted Mmax in some area, especially where no strong seismic event occurred, resulted from the extraregional seismotectonic method applying, is the leading criteria for conducting the paleogeoseismological investigation. The brightest example is the Altai region, where the first values of Mmax=>7 were obtained using the extraregional seismotectonic method. The conducting paleogeoseismological study in these potential source zones discovered the signs of the repeated ancient strong earthquakes. The seismic shock on 27th September, 2003 with M=7.3 was the natural confirmation of the scientific prediction.

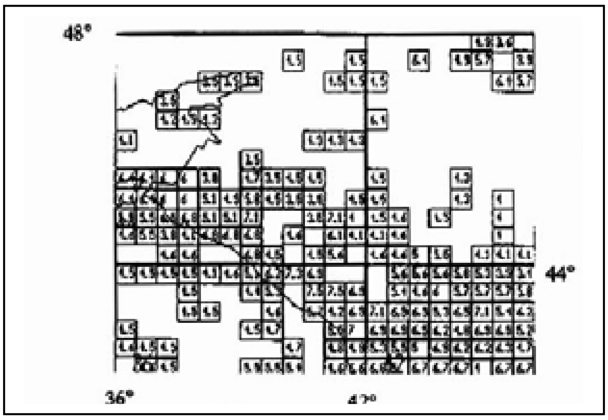

Figure 1 – Predicted Mmax within North-Western Caucasus, obtained using the extraregional seismotectonic method

Results of paleoseismological investigation

The evidence of the unknown ancient earthquakes within the Central Caucasus is discovered applying the paleogeoseismological approach. The dating the paleoseismic ruptures show that during the last 7 thousand years four strong earthquakes with M=6.5 - 7.0 had occurred in the vicinity of the volcano Elbrus. The seismic activity took place 5500-5700, 3900, 2300 and 300-400 yeas ago. Applying the paleogeoseismological approach were also received the evidence of the ancient eruptions of the volcano Elbrus: during the last 7 thousand years four eruptions of the volcano

Elbrus took place. The occurrence period of strong earthquake is 1500-1900 years while the occurrence period of volcano eruptions is 1000-2000 years. Manifestation of these natural disasters is characterized by some asynchrony though the volcanic process may be accompanied by seismic activity. Thus, paleogeoseismological investigation proved the Elbrus volcano to be the potential seismic active area.

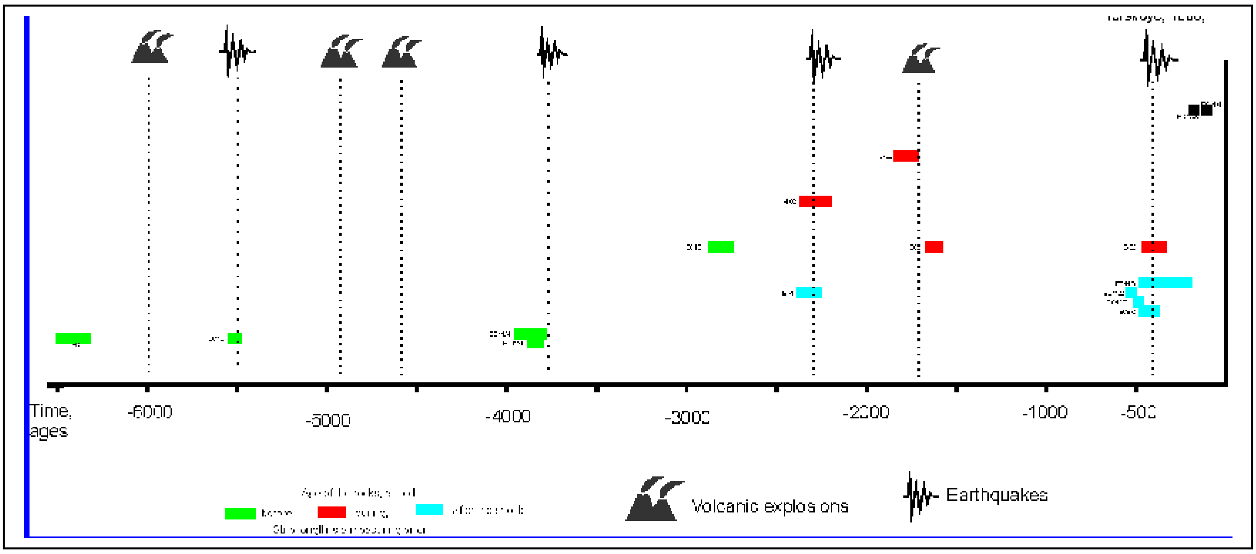

Figure 2 – Relationship between seismic and volcanic events within Caucasus

CONCLUSION

Thus, the new approaches for seismic hazard assessment are developed at the Institute of Physics of the Earth RAS: the extraregional seismotectonic method and the paleogeoseismological method. These methods being combined allow determining the spatial distribution of the predicted maximal magnitudes and potential seismic source zones as well as ancient strong seismic and even volcanic events with their occurrence period. Their applying allows the assessment of the prognostic values of maximal magnitudes of earthquakes for the most part of the Northern Eurasia, for some areas these are the first assessments of the seismic hazard. It is of great importance that high predicted magnitudes are obtained in some areas, where no strong seismic event yet occurred. Both extraregional seismotectonic and paleogeoseismological methods are fruitfully combined for investigation of the seismic potential of the different regions, especially for intraplate areas.

SECTION

We are grateful to the Organizers of 6th EUREGEO for their excellent informational service helping in the process of contribution preparing.

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REGIONAL SEISMIC HAZARD IN THE MIDDLE AND LOWER RHINE REGION – COMPILATION OF THE GERMAN STANDARD DIN 4149:2005-04 TO DETAILED HAZARD MAPS OF THREE GERMAN STATES FOR BUILDING CONSTRUCTION.

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KEY WORDS: Seismic activity, Seismic hazard, Geological ground classes, hazard maps

SEISMIC ACTIVITY

The level of seismicity in the Rhine area is well documented in many historical reports and remnants as well as in the recent instrumental earthquake registrations. The strongest event which is known for the German part of the Lower Rhine Embayment is the 1756 Düren event which is even revealed in the memorial plaque in front of a chapel near the city of Aachen: “In the year 1756 / Praised be Jesus Christ / One demands to intercede for the donor of the chapel / Which is built up in the glory of God / The earth quaking” (Fig. 1).

Figure 1 – Memorial plaque at the St. Vincent chapel in Aachen-Niederforstbach

From macroseismic studies (e.g. [1]), the magnitude of this earthquake could be quantified with an order of ML = 6,3. According to the local tradition, an additional plaque was added at the chapel wall after the recent ML = 5,9 Roermond event of 13 April 1992 (e.g. [2]), which caused 60 people injured and a high amount of material damage. Beyond the existing catalogue of historical and instrumentally recorded events covering a period of some 1.200 years (e.g. [3]), clues for possible strong earthquakes were studied with the techniques of paleoseismology. With a number of field investigations at active faults in the Lower Rhine graben, evidence for earlier strong events since the Late Pleistocene could be derived for the Bree fault system in Belgium (e.g. [4]).

The tectonic activity of the Lower Rhine Embayment is linked with those in the Middle Rhine and the Upper Rhine Graben by the major tectonic regime (e.g. [5]). This entire zone along the trend of the river Rhine represents the region which is distinguished by the highest seismicity in Germany. In order to take precautions against serious harm to the inhabitants especially in those regions, measures against construction failure caused by possible strong earthquakes has to be taken as a major task of the community.

SEISMIC HAZARD

General considerations

Services of public interest lie in the responsibility of the community as the European Communities state in a special paper ([6]). Accordingly, activities in the field of seismological observation, earthquake hazard assessment and protecting regulations should be supported by the authorities. One important measure in the context of seismic hazard is the development of adequate technical rules for building construction. The establishment of the Eurocode 8 ([7]) is an important attempt to harmonise the existing national standards in order to aspire to a universal solution according to the actual state of science and engineering.

Seismic hazard estimations developed from deterministic techniques estimation to probabilistic methods which are recently used in the field of geotechnical engineering (e.g. [8]). This philosophy was considered in the new version of the seismic code DIN 4149 in April 2005 ([9], [10]), superseding the formerly valid code of 1981. The hazard level is now defined by a certain recurrence period of usually 475 years, i.e. the probability of 10 % in a time span of 50 years for an earthquake which reaches or exceeds a defined intensity or ground acceleration, respectively, at the site to be studied.

The code DIN 4149 focuses the regulation of precautions for usual buildings in Germany. This restriction is made in order to treat buildings, from which secondary hazard may arise in case of failure, in an adjusted way. For those facilities, like reservoirs, nuclear power plants or chemical units, special regulations exist in form of technical rules or guides. The higher amount of hazard is realised with the application of different concepts, e.g. adapted deterministic methods, probabilistic estimations considering recurrence periods of 2.500 years, or the use of the design accelerations given by the DIN 4149 combined with defined importance factors.

Requirements of hazard zoning

Earthquake Hazard zones

The definition of earthquake hazard zones in DIN 4149 is directly connected with design accelerations and intensity intervals assuming a hazard level which is related to an event recurrence period of 475 years (Table 1). With these conditions, the map of earthquake hazard zones may be understood as an applied part of the Global Seismic Hazard Map ([12]). The isolines of design accelerations are represented in [9] as (virtual) border lines of hazard zones. In the original documents, these borders are given as smoothed lines on the basis of small-scale maps due to the model concept and related uncertainties.

Earthquake hazard zone (EZON)	Intensity interval I (EMS 98, [11])	Design acceleration a_g (cm/s^2)
0	$6.0 \leq I < 6.5$	–
1	$6.5 \leq I < 7.0$	0.4
2	$7.0 \leq I < 7.5$	0.6
3	$7.5 \leq I$	0.8

Table 1 – Earthquake hazard zones, Intensity intervals, and design accelerations according to DIN 4149 ([9])

Geological ground classes

The introduction of geological ground classes aims at the establishment of a category which allows the qualitative consideration of the effect of seismic shaking dependent on the ground conditions. There are three rough categories defined: *R* – hard rock, *S* – deep-reaching sediment basin, *T* – transition zone between *R* and *S*. [9] gives a more detailed description.

The combination of earthquake hazard zone and geological ground class is used as basis for an adequate engineering model of building constructions. The detailed package of measures are listed in [9].

REALISATION OF HAZARD MAPS

The transition from scientific model results to a detailed technical rule raises the question of how to draw the isolines differing distinct classes on the real surface. In practise of the application discussed above, this means that an object with a defined position has to be assigned to a defined earthquake hazard zone and geological ground class. The former version of the DIN 4149 realised most of the assignment of the hazard zones to entire municipal districts. From some spot checks with the actual code, it was obvious that this distinction would be too rough in the distribution of zones.

A first attempt was for an assignment of administration districts to the categories defined in DIN 4149 was made by [13] in frame of a project of German Institute of Constructional Engineering (DIB), Berlin. With these results, a map of earthquake hazard zones and geological ground classes for the area of the federal state Baden-Württemberg ([14]) was finished in 2005. The design of this map was used throughout as an example for the graphical layout by the other federal states.

After this step, it was an important issue to give consistent planning criteria for the federal states which cover the earthquake hazard area along the river Rhine (Figure 2). On the basis of the preparatory work [13], the federal states of North Rhine-Westphalia, Hesse, and Rhineland – Palatinate arranged for a detailed solution under consideration of the actual administration data and detailed knowledge of the local ground conditions to be developed:

[15] – *North Rhine – Westphalia:* Ministry of Building and Transport, Düsseldorf; Geologischer Dienst Nordrhein-Westfalen, Krefeld.

[16] – *Hesse:* Ministry of Economics, Transport, Regional and Urban Development, Wiesbaden; Hessisches Landesamt für Umwelt und Geologie, Wiesbaden.

[17] – *Rhineland – Palatinate:* Ministerium für Umwelt, Forsten und Verbraucherschutz, Mainz; Landesamt für Geologie und Bergbau Rheinland-Pfalz, Mainz.

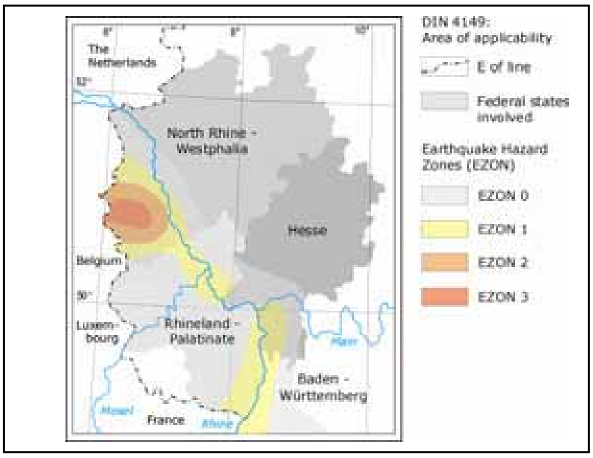

Figure 2 – Area of applicability of the new maps of the federal states North Rhine – Westphalia, Rhineland – Palatinate, and Hesse, Germany, and the extension of the earthquake hazard zones according to [9]

Now, the assignment of earthquake hazard zones and geological ground classes were presented with maps on the resolution level of local subdistricts (“Gemarkungen”) and on scales ranging from 1 : 200.000 (Hesse) to 1 : 350.000 (North Rhine – Westphalia). An example of the map layout in given in Figure 3, representing a typical situation in an urban region.

Recently incorporated in the binding technical rules, the maps have been proven to be a useful tool for the practise of construction engineers, architects and builder-owners.

CONCLUSIONS

With the new version of the seismic code DIN 4149 of 2005, a probabilistic concept was introduced for a hazard estimation in Germany. Design accelerations or intensity intervals are considered assuming events with recurrence periods of 475 years. Additionally, the principle ground conditions were introduced as influence factors for sites at the surface. The geological surveys of the federal states North Rhine – Westphalia, Hesse, and Rhineland – Palatinate have recently developed a series of detailed maps as an instrument of seismic hazard assessment. With this tool, the user is enabled to assign the ruling categories for hazard estimation unambiguously to any subject in the respective areas. The realisation of these maps is an important step toward detailed planning concepts for building construction and is part of the measures to be taken by the authorities to ensure the services of public interest.

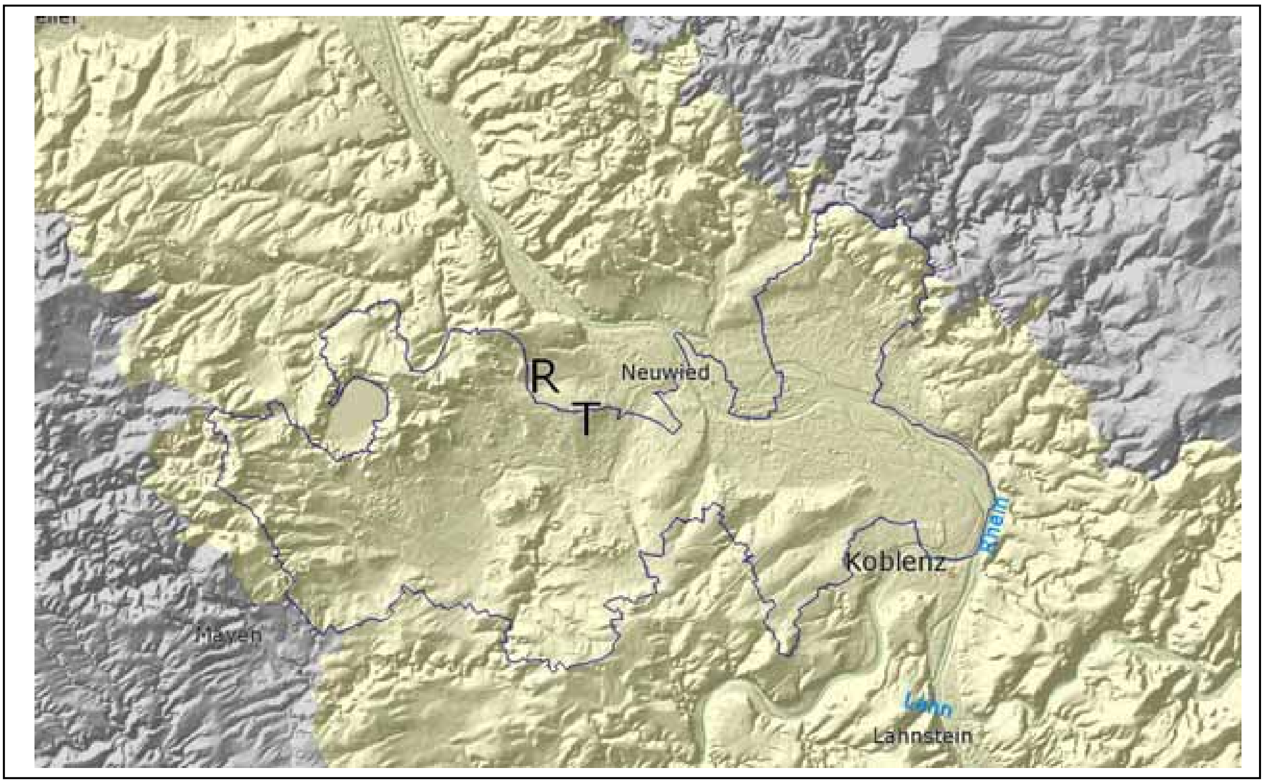

Figure 3 – Detail from the Map of Earthquake Hazard Zones and Geological Ground Classes of Hesse ([16]) for the Rhine / Mosel area, Germany: Colours assign the administration units to hazard levels, red lines represent the borders of the geological ground classes

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LANDSLIDE SUSCEPTIBILITY MAPPING BY MEANS OF ARTIFICIAL NEURAL NETWORKS PERFORMED FOR THE REGION GASEN-HASLAU (EASTERN STYRIA, AUSTRIA)

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KEY WORDS: landslide susceptibility map, neural networks, modelling, regionalisation, data reduction, precipitation

INTRODUCTION

In August 2005 a prolonged rainfall event (about 200 mm in 48 h) with relatively low intensity (about 15 mm per hour) triggered more than 600 landslides in the region of Gasen-Haslau, Eastern Styria, Austria. By means of Artificial Neural Networks a landslide susceptibility map was generated using 368 landslide points. Main focus of this study is to analyse the capability of this method in assessing landslide prone areas and in particular when using general available data. Furthermore it should be analysed, how much a reduction of landslide data as model input is affecting the performance of the Neural Network results, since in many cases the number of mapped landslides being available for a model is quite low.

STUDY AREA AND DATABASE

The study area is located in the eastern foothills of Fischbacher Alps in Styria and covers an area of 60 km². The geology is mainly composed by phyllitic mica schist and phyllites, but also blackschists, carbonates and orthogneiss occur. The elevation ranges from 600 to 1.500 m.

The landslide database used for the Neural Network contained 368 spontaneous landslides (soil slips and earth flows), which occurred during the event of August 2005. Landslides caused by channel erosion were excluded. The parameters *streets, forest, slope, aspect, plane curvature, profile curvature, curvature classification, flow accumulation, lithology, bedding direction* and *digital elevation model* with a resolution of 50 m served as input data for the modelling. According to the standard of Neural Networks computing, the data was split into a training dataset, a validation dataset and an independent test dataset (see next chapter). It turned out that the land use variables (*forest* and *streets*) of the used digital cadastral map in many cases did not correspond to the field mapping results. To test the effect of this general available data on the model results, a fourth dataset, named regionalisation data, was created. This regionalisation dataset contained the land use of the general available digital cadastral map and was used to create the final 50 m raster susceptibility map. The other three datasets (training-, validation-, and test data) contained at the location of landslide points the more accurate mapped land use information, while in areas of no landslides they contained the information of the less accurate digital cadastral map.

MODELLING WITH ARTIFICIAL NEURAL NETWORKS

In the last years several applications of Artificial Neural Networks have been published in the field of susceptibility maps (in Austria: FERNANDEZ-STEEGER & CZURDA (2002)), since they are very suitable for non linear and complex connections. A network consists of nodes (which contain activation functions) and connections between them (which contain weights). In a multi layer perceptron (used here) the nodes are arranged in layers, where the input layer obtains the variables and the output layer provides the result (here the susceptibility). In between several hidden layers can be placed. The network is trained by feeding the network with training- and validation data, where the measured output is given. The network minimizes step-by-step the error between measured and calculated output by optimizing the weights. In this training process the input variables and many network parameters are varied in order to find the best result. To test the quality of the network, it is fed afterwards with independent test data, which were not used for the modelling itself.

In order to choose significant variables for the model, a statistical analysis of the variables was performed, detecting the correlation between the variables and the occurrence of landslides as well as the correlations of the variables among each other. Afterwards a great variety of networks with different combinations of variables and Network parameters were computed. The best network (=best result) was chosen by comparing the validation results among each other (see next chapter). Hereby it was of importance that just proper variables explaining slope instability were used (see SCHWARZ & TILCH (2008)). The selected "best" result was the susceptibility map of network 10 (see fig. 1), including the variables *streets, forest, slope, aspect, profile curvature, curvature classification* and *flow accumulation.* In the susceptibility map of the "best" result high landslides susceptibility values tend to appear outside the forest, on middle and steep slopes, on southern to south-eastern hillsides, at concave profile curvatures and on hillsides with great flow accumulation.

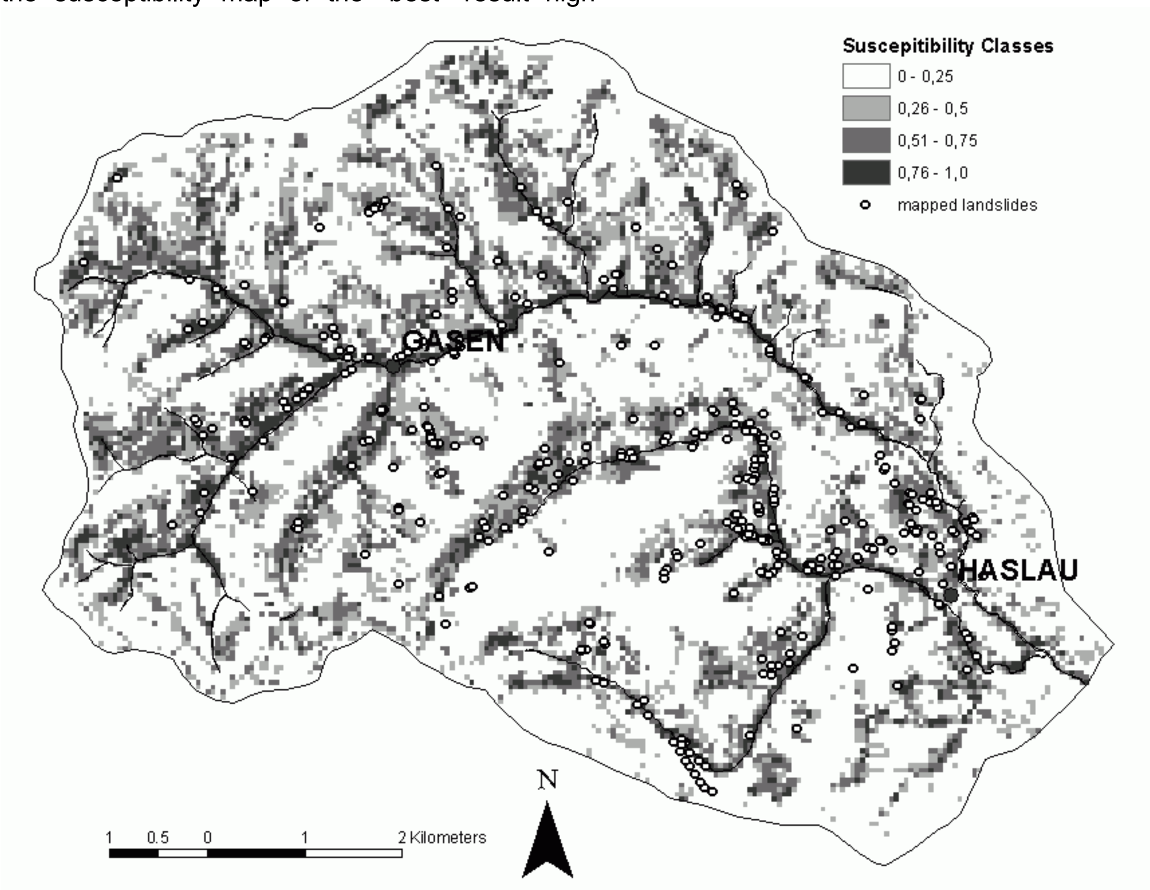

Figure 1 – Susceptibility map of the "best" result (regionalisationdata of network 10)

VALIDATION OF MODEL RESULTS

With regard to the test dataset the result of network 10 showed a recognition rate of 82,9 %. The recognition rate is the percentage of the landslide points lying inside the calculated landslide prone areas (= susceptibility > threshold of 0,5). Further also the Spatial Prediction Model Validation after CHUNG & FABBRI (2003) (see fig. 2) was performed, which is a more meaningful validation than the recognition rate alone, because it describes also landslide density. The x-axis of figure 2 shows the percentage of the susceptibility classes referring to the whole study area, where the susceptibility is sorted from the highest to the lowest values. The y-axis indicates the corresponding percentages of the mapped landslides. High susceptibility classes are expected to have a high density of landslides, which is shown in a steep graph (gradient > 3 is aimed after CHUNG & FABBRI (2003)), while low susceptibility classes should have a flat plot (gradient < 0,2 is aimed after CHUNG & FABBRI (2003)). Hence, the more upper left the curve is located the better the result.

The curve of the independent test dataset (= prediction rate curve) in figure 2 indicates a good result of network 10, because the above mentioned criteria are mostly fulfilled. Furthermore the curves of training- and test-dataset are situated close together, so we can assume that the network also has a good capability of generalisation. The plot of the regionalisation dataset is located below the two other curves, indicating that the general available land use map is less suitable for the regionalisation, although the result is still satisfying.

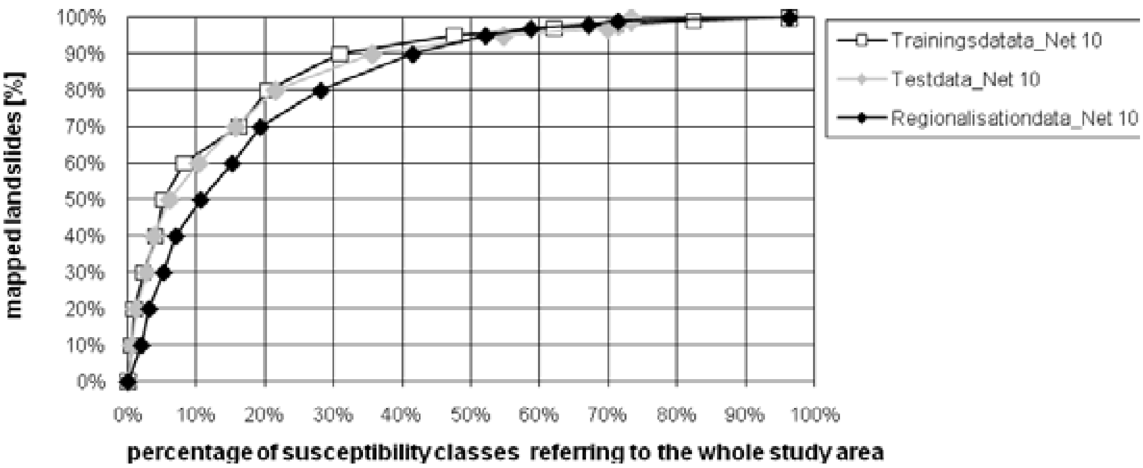

Figure 2 – Valdiation after CHUNG & FABBRI (2003) for the "best" result (network 10)

ADDING PRECIPITATION DATA

Since only landslide data of the August 2005 event was used for the model, the question has to be discussed, if this susceptibility map was just valid for this single event. Hence, in order to create a susceptibility map with more general validity (valid also for other, similar precipitation events), it was tried to add also the Integrated INCA (Nowcasting through Comprehensive Analysis) precipitation data of the August 2005 event into the modelling. INCA precipitation data (HAIDEN ET AL. (2007)) is available for nearly whole Austria with a temporal resolution of 15 min and a spatial resolution of 1 km². It is derived from radar data calibrated on station data.

In a first step a susceptibility map for the August 2005 precipitation event was calculated in network 26, which included all parameters of network 10 and additionally the parameter *precipitation*. Second a "worst case" map (network 26a) with more general validity was created by spreading the highest occurring precipitation of the event uniformly over the whole study area.

The result of network 26 showed that the Neural Network is responding to the parameter *precipitation*, because areas of higher precipitation show increasing susceptibility values, while areas of lower precipitation show decreasing susceptibility. The result of network 26a showed for a large extent of the study area high landslide susceptibility, but these high susceptibility values showed equal occurrence over all precipitation classes. Looking at the recognition rate network 26 performed good (85,6 %) and network 26a performed better (94,2 %) than network 10. The high recognition rate of network 26a is not surprising, since it displays a high percentage of the study area with high susceptibility values. Looking at the Spatial Prediction Model Validation of CHUNG & FABBRI (2003), network 26 performed better, while network 26a performed equal to network 10. So it turned out that by adding the variable *precipitation*, the quality of the network result could be improved or at least it remained at the same level. Despite that fact, it has to be pointed out that the precipitation data itself still showed strong uncertainties.

Due to the large area of high susceptibility values in network 26a, it was tried to adjust the threshold of the recognition rate in this network from 0,5 up to 0,72. This produced a susceptibility map looking quite similar to the map of network 10 (94 % of the pixel matched). Hence, a landslide susceptibility map with more general validity can also be produced with the landslide data of just *one* event and without precipitation data. But this is only valid, if there is no other variable, which divides the study area in a large scale, and if there are enough landslide points available. Despite that fact, if the landslide data originates from just *one* precipitation event and there is a precipitation map of this event available, the important trigger factor precipitation should be included in the model at any rate.

REDUCTION OF LANDSLIDE DATA AND REPRODUCIBILITY OF RESULTS

The quality and density of landslide data within this study was very high. This is quite an exception, because often the number of mapped landslides being available for a model set up is much lower with uncertainties in spatial location. For this reason it should be investigated, how much a reduction of the number of landslides as model input is affecting the result of the susceptibility map. This was performed by gradually reducing the number of landslide points from 100% over 80, 60, 40, 20, 10 to 5 % of the original dataset and studying the change of the recognition rate and the validation of CHUNG & FABBRI (2003). Since the landslide points were chosen randomly, this procedure was repeated several times in order to capture a more representative range of the recognition rate. For capturing the full possible range, at 10 and 5 % a “worst case” scenario was created by choosing landslide points that are situated in locations which are expected to have a low susceptibility towards slope instability (inside forests, on flat slopes, etc.). Moreover the reproducibility of Neural Networks was tested by calculating one network several times with equal settings (number of hidden layers, number of nodes, number of network parameters) but different initial weights and comparing the range of the recognition rate and the validation of CHUNG & FABBRI (2003) of the results. This was done for 100 % of the landslide data.

This reduction analysis and the reproducibility analysis was validated on the entire test data points and the results of both analyses were drawn in the same graph in figure 3. It displays the curves of the recognition rate. The plots indicate that the range of the reproducibility (at 100 %) and of the data reduction generated randomly is nearly the same. The range is spreading slowly from the high percentages to the very low percentages, reaching the highest range of the recognition rate at 5 % of the landslide points. But the theoretically possible range is indicated when looking at the very low values of the “worst case” scenarios at 10 and 5 %. Analysing the absolute values, the plots remain at the same level till about 40 % and start to decrease at about 20 %. The validation method of CHUNG & FABBRI (2003) also indicated increasing range with decreasing percentages and decreasing values not before 20 %. This was astonishing and denoted that by using only 40 or even 20% of the original landslide point sample, results of nearly the same quality could be generated by an Artificial Neural Network. Consequently a density of about 2 landslide points per km² could be sufficient for calculating a susceptibility map with Neural Networks in another similar study area of similar size, if the points can be considered as being representative and accurately located.

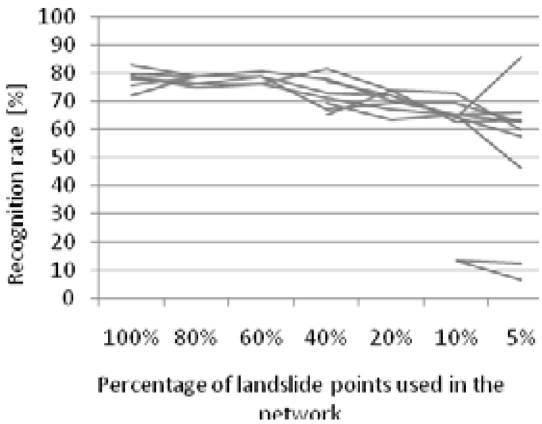

Figure 3: Reduction of landslide data (100 to 5 %) and reproducibility at 100 %: Recognition rate for entire test data

CONCLUSIONS

The use of Artificial Neural Networks enables good results in susceptibility analysis and shows a good capability of generalisation. Limitations occur for the regionalisation of these results over a 50 m raster by using a general available land use map. Precipitation as input data can slightly increase the result and contributes in creating a susceptibility map of more general validity. The analysis of data reduction indicates that by using only about 30 % of the original landslide data, a susceptibility map of nearly the same quality could be generated, like by using the total point sample.

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S.I.S.M.A. PROJECT: SYSTEM INTEGRATED FOR SECURITY MANAGEMENT ACTIVITIES TO SAFEGUARD AND PROTECT HISTORIC CENTRES FROM RISKS.

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KEY WORDS: seismic hazard, vulnerability, multi language Glossary, historic center.

INTRODUCTION

The main objective of SISMA project was the safeguard of the human life and the protection of the historic centres from the calamitous events such as earthquakes. Many times Umbria has found itself dealing with the destructive effects of an earthquake, in terms of both human lives and the enormous damages to the historic-cultural heritage of the historic centers; in Umbria alone it was necessary to face the problem of the rehabilitation of 184 seriously damaged historic centers and villages with the involvement of around 30.000 people, requiring huge financial, legislative, organizational and social efforts.

The proposal of the SISMA project was immediately accepted by Italian regions as Marche, Emilia Romagna and Abruzzo and by the Italian Civil Protection Department, also by the partners from Greece, Slovakia and Slovenia. Proving how deeply the problem of earthquake risks is felt and, consequently, how necessary it is to share and develop the sharing and comparison of experiences, research and studies to define policies and actions that are increasingly effective for prevention and are able to counter the destructive force of earthquakes.

Figure 1 – CADSES Co-operation Area

PROJECT'S OBJECTIVES

Along the project's life the partners have worked to achieve the project goals:

• to identify methodologies, based on the experiences and practices of all the partners, to be made available on a transnational level as a useful starting point for defining prevention policies and actions on the basis of the needs and characteristics of the areas in question;

• to work so as to increase, through information and training, the awareness of the "citizen as first rescuer";

• to promote dialogue and the comparison, exchanging, and divulgation of the experiences developed and of the work in progress, being fully aware that we can counter the unexpected and destructive force of an earthquake that may strike in any part of Europe with the strength of a shared response as Regions and as organizations, operators and individuals working in the various areas of research in this field.

WORK SYSTEM STRUCTURES

In keeping with the criteria provided for by the cooperation program and for the organizing of the project activities, five lines of activities (Work Packages) were planned, each of which coordinated by one of the partners. The Steering Committee approved all the scientific development and research lines of each Work Package and approved the activity results at the periodic meetings. A special Expert Group from the scientific community such as Franco Barberi, Anna Arvanitaki, Paolo Avarello, George Drakatos, Luciano Marchetti, Costantino Marmo, Vincenzo Petrini and Eikaterini Valadaki provided the directions for research and the comparison of know-how, and also supported the Steering Committee in providing directions for activities and checking the consistency with the results achieved in relation to the goals that were set.

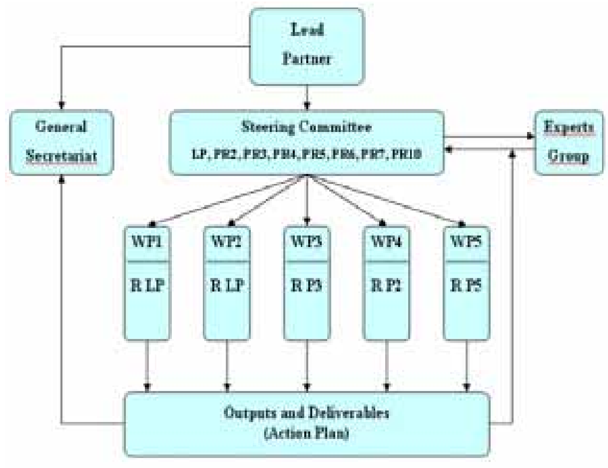

Figure 2 – The project layout

RESULTS

A first goal of the SISMA project was to make the enormous background of existing knowledge available in an organized manner, with particular attention given to the studies conducted by the partners and their experiences within the earthquake prevention. The know-how collected, with contributions from all the partners, was organized through the collecting of forms ordered according to subject and transferred to a section of the SISMA web portal (www.sismaproject.eu). Making this detailed database on the state of the knowledge and know-how available to the scholars and experts of the project partners represented an important project achievement. Indeed, a common platform of knowledge was created that served as a springboard for arriving, by working together, at the achieving of other objectives. This collection of knowledge and know-how made it possible to examine which directions the research and experimenting should take in order to elevate the quality of the prevention actions, and also to establish the minimum level of knowledge that needed to be acquired regarding a given historic center and the territory of reference for preparing an appropriate prevention action. Lastly, it became the lever for confirming the necessity of an integrated approach to earthquake prevention. Thus for the first time there was not only teamwork between different European partners working on seismic risk prevention, but also teamwork between different professions: geologists, architects, engineers, territorial planning experts, communications experts, and civil protection experts. Different organizations and people who worked together and together dealt with the topic of earthquakes as a complex phenomenon of many interweaving problems which requires a detailed, comprehensive response that is the fruit of a collective process.

As a consequence the following work was developed as foreseen by the SISMA workpackages:
• identification, analysis and comparison of expeditious models for the assessment of the vulnerability of the “historic center system”;
• verification of the use of urban planning instruments for the planning of prevention actions aimed at reducing the degree of risk for the historic center;
• integration and use of urban planning instruments at the same time with the organization of civil protection;
• development of models for informing and involving the people who are residents of the historic center, making them aware of how important the action and behavior of the “citizen as first rescuer” can be during an earthquake emergency;
• preparation of a multi-language Glossary for the Project Observatory established among the partners;
• checking, through experimentation in sample areas, of the know-how acquired;
• constant exchanging and comparing of information between the partners and with the operators involved in the respective countries, through workshops, meetings, transnational conferences, and the SISMA web portal.

Figure 3 – The “Historic center system”

CONCLUSIONS

The complexity of the subjects dealt with gives an idea of the work of intense interaction and close comparisons that was generated during the three-year period. It can be said that each of the workpackage research topics could have been the subject of its own specific project. The work that was done, which is far from being complete and exhaustive, can be considered an initial starting point at the transnational level as a useful reference for those people – operators in the sector, researchers, public officials – who work on the topic of seismic prevention in historic centers.

With the SISMA project, in keeping with the spirit of the INTERREG cooperation programme, we have begun a process of sharing and exchanging with other European countries on the topic of earthquake risk prevention that is decisive for the protection of the population and for the safeguarding of the heritage represented by our historic centers.

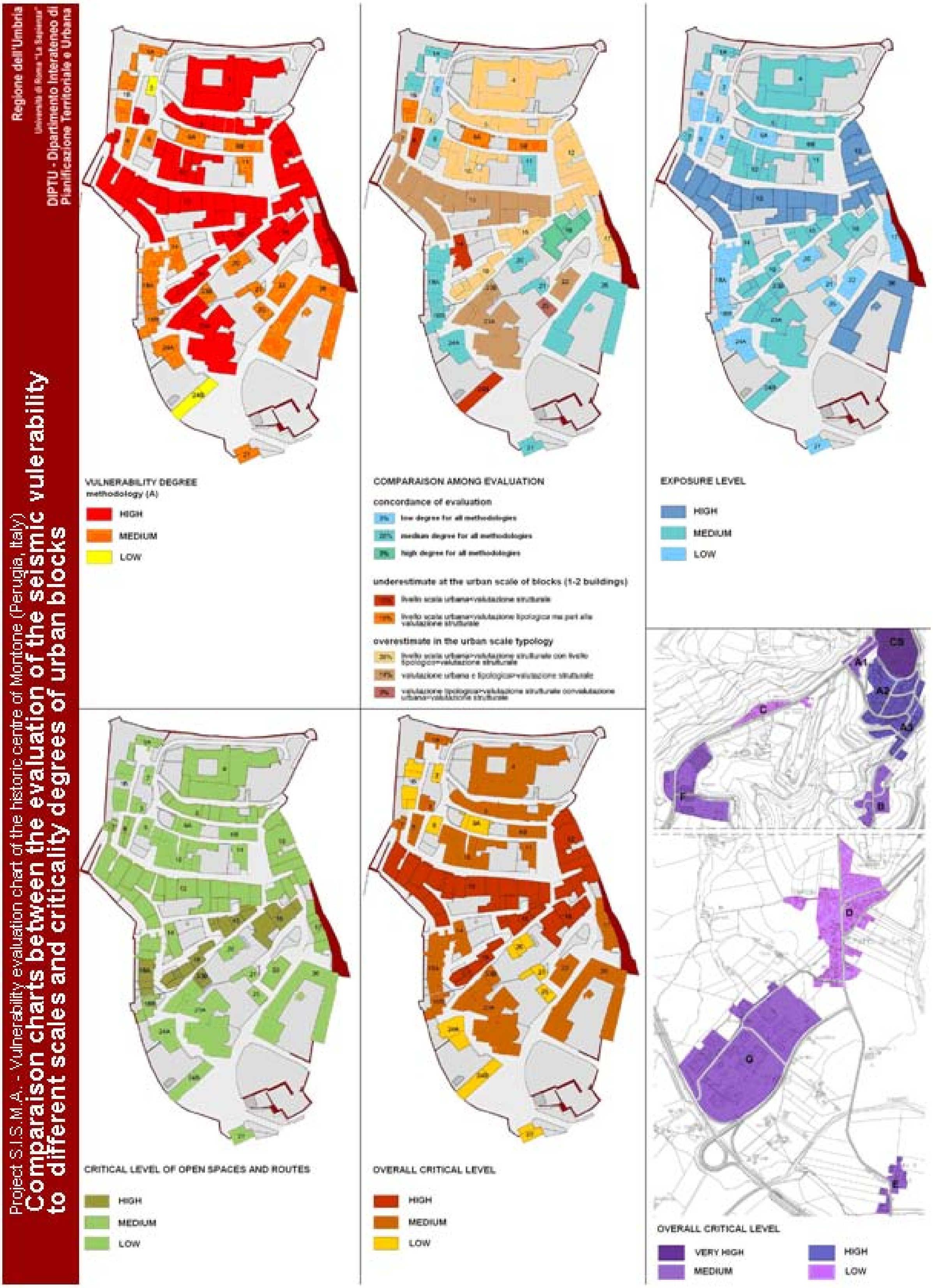

Figure 4 – Vulnerability evaluation chart of the historic centre of Montone (Perugia, Italy): comparison charts between the evaluation of the seismic vulnerability to different scales and criticality degrees of urban blocks.

THE BAVARIAN SEISMOLOGICAL SURVEY: RESULTS OF SEVEN YEARS OF CONTINUOUS MONITORING

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KEY WORDS: seismicity, earthquake, natural hazard, Bavaria, Germany.

INTRODUCTION

The first instrumental registration of earthquakes in Bavaria dates back to 1905, when a 1,2 ton Wiechert seismograph was installed at the royal observatory near Munich. Until the year 2000 the seismological network of Bavaria consisted of 4 broad-band and 4 short period seismometers mainly operated in trigger-mode without online access to the data. It was oriented towards the routinely analysis of teleseismic events. As a research network of the Munich university it was basically not aimed at real-time analysis of local/regional events, nor for immediate information of the public and authorities. A detailed description of the history of seismological observation in Bavaria can be found in Förtsch 1966.

THE MODERN SEISMOLOGICAL NETWORK

With the implementation of a modern seismological network in 2000 - 2004 a new era of earthquake monitoring in Bavaria began. Today the recording and scientific assessment of earthquakes is principally undertaken by the Department for Geo- and Environmental Sciences at the Ludwigs-Maximilians-University of Munich and the Bavarian Environment Agency (forming together the Bavarian Seismological Service).

The network consists now of 24 stations (20 short period seismometers and 4 broad-band stations). They are distributed throughout the country and are continuously and automatically delivering data to the data centre at the geophysical observatory at Fürstenfeldbruck, close to Munich. The distribution of the stations reflects the historical seismicity pattern of Bavaria. Besides a state-wide network of 9 stations there are two sub-nets in areas of known activities of swarm earthquakes: Bad Reichenhall and Marktredwitz (Fig. 1).

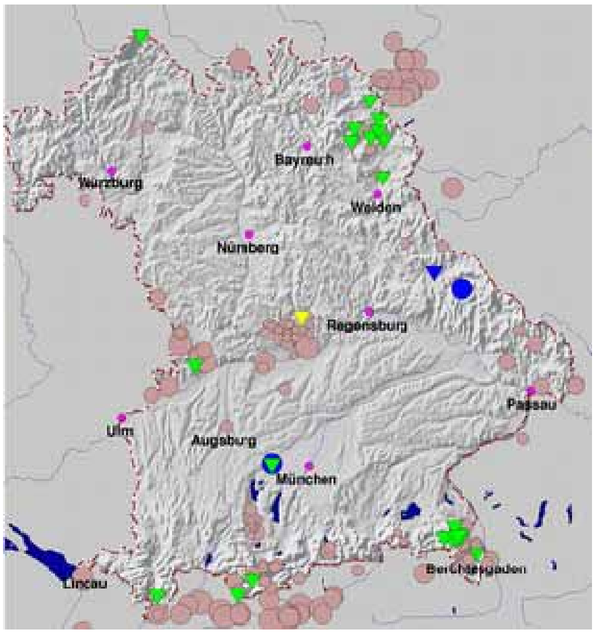

Figure 1 – Station distribution of the seismological network in Bavaria including the sub-networks in Bad Reichenhall und Marktredwitz. Red circles: historically felt earthquakes. Green and yellow triangles: stations of the Bavarian Seismological Survey. Blue circles: stations of the German Regional Seismological Networc (GRSN). Blue triangle: privatly owned station (data available on request).

This configuration proofed to fulfil the design criteria of monitoring all events down to a magnitude of $M_l \geq 2$ throughout Bavaria. In addition the two sub-nets allow the investigation of swarm earthquakes with very high resolution down to $M_l = 0{,}5$ (and even below). The number of registered and located events increased by a factor of 10 to now 70 – 90 events/year (excluding “swarm events”). The actual performance can be seen in Fig. 2.

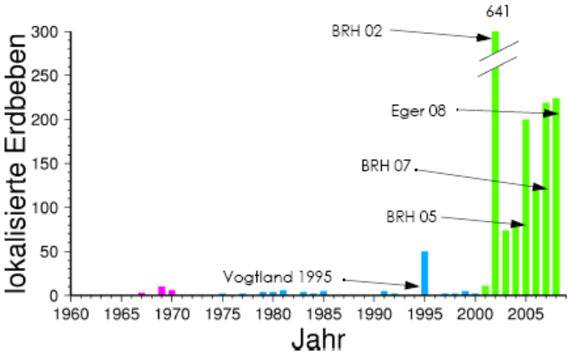

Figure 2 – Statistics of located events since 1960. Note the dramatic increase of located earthquakes since the implementation of the modern digital network. Arrows indicate swarm events (BRH: Bad Reichenhall/Alps). Of the 2008 Swarm event in the Eger-Graben only events with $M_l \geq 2$ are included.

SCIENTIFIC PROJECTS AND RESULTS

The results obtained so far confirmed zones of known active seismicity, but also revealed areas of earthquake activity hitherto unknown.

Data collected by the sub-net Bad Reichenhall during the swarm-event 2002 were used in a thorough scientific analysis leading to the understanding that there is a strong correlation of meteorological effects and seismic activity in this region (Kraft et al., 2006; Hainzl et al., 2006).

The seismic station at the Environmental Research Station "Schneeferner Haus" (2650 m a.s.l.) on the Zugspitze (Germany's highest mountain) is an excellent example for the combination of seismic survey and research. It serves – together with a nearby station in the valley (760 m a.s.l.)- as an important station for monitoring the earthquakes in this area of the northern alps. On the other hand it is also used for the scientific investigation of topographic effects on seismic wave fields. Registrations from these two stations can be compared to numerical simulations to discriminate the topographic effect. The results may provide new insights on the seismology of active volcanoes or for earthquake-resistant building.

Of high importance is the investigation of several recent small scale events in the Bavarian molasse basin, SE of Munich. It seems as if this area has been previously aseismic. The new activity has to be carefully examined (Kraft et al., 2009).

Data acquired by the Bavarian Seismological Network have been used and are presently being used in a number of thesis and diploma works, which demonstrates the close connection to research and teaching.

The results of these works are beneficial for the development of new methods for real-time monitoring and automatic detection of earthquakes, which in turn improves the quality of the Seismological Service.

INTERNATIONAL COLLABORATION

The seismological survey of Bavaria takes part in many national and international activities for seismological data exchange and infrastructure. The stations Fürstenfeldbruck (FUR) and Wettzell (WET) are part of the German Regional Seismic Network (GRSN) for the observation of the worldwide seismic activity. It contributes to the annual bulletin "Earthquakes in Germany" and to the "Data catalogue of earthquakes in Germany and adjacent regions" (published by the Federal Institute for Geosciences and Natural Resources (BGR)). Data of events (event times, amplitudes, phases, magnitudes, intensities) are transmitted to various international services:

- NEIS, World Data Center A, Denver, USA
- EMSC: European-Mediterranean Seismological Centre, Bruyeres le Chatel, F
- ISC: International Seismological Centre, Newbury, GB
- Institut f. Geodäsie und Geophysik, TU-Wien, A
- Landeserdbebendienst Baden-Württemberg
- Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, D: SZGRF and SDAC
- Zentralanstalt für Meteorologie und Geophysik, Wien, A
- IPE-Brno, Czech Republic
- Geophysical Institute, Prag, Academy of Sciences of the Czech Republic, CZ
- Institut für Geophysik & Geologie, Universität Leipzig, D
- Schweizerischer Erdbebendienst, ETH Zürich, CH

To some of the neighbouring institutions we grant direct access to the data of selected stations, such improving the surveying of regions close to the respective borders. This proved to be very successful for the swarm earthquakes starting October 2008 in the so-called Eger-Graben with up to now more than 10.000 events. The close cooperation and data exchange of the four participating institutions allowed for a fast and precise information of the public

INFORMATION OF THE PUBLIC

One of the major goals of the establishment of the Bavarian Seismological Survey was better and faster information of the public and authorities.

To achieve this goal a number of steps have been undertaken:

- Providing the necessary data by installing a modern homogenous digital seismic network
- Ensuring real-time data delivery to the data centre at Fürstenfeldbruck
- Development of real-time methods for continuous data analysis
- Providing up-to-date information to the public via internet and – in case of stronger events – special announcements to authorities and the media

In 2008 the web appearance was completely re-designed and is now adapted to the "corporate design" of the Bavarian Environment Agency. It can be reached from the web-sites of the cooperating institutions, but also under its own domain name: www.erdbendienst.de and www.erdbeben–in-bayern.de.

Here the public can find real-time seismograms of all active stations, an up-to-date map of all verified earthquake locations of the last 365 days, a glossary and additional information on local and global seismicity.

During the seven years of its existence the Bavarian seismological Survey has greatly contributed to the geoscientific knowledge of Bavaria. The cooperation between state authority and university guarantees an efficient use of capacities, a continuous improvement of data quality and interpretation and the preservation of a high technical level of the network. It's a good example for very successful cooperation between public administration and university.

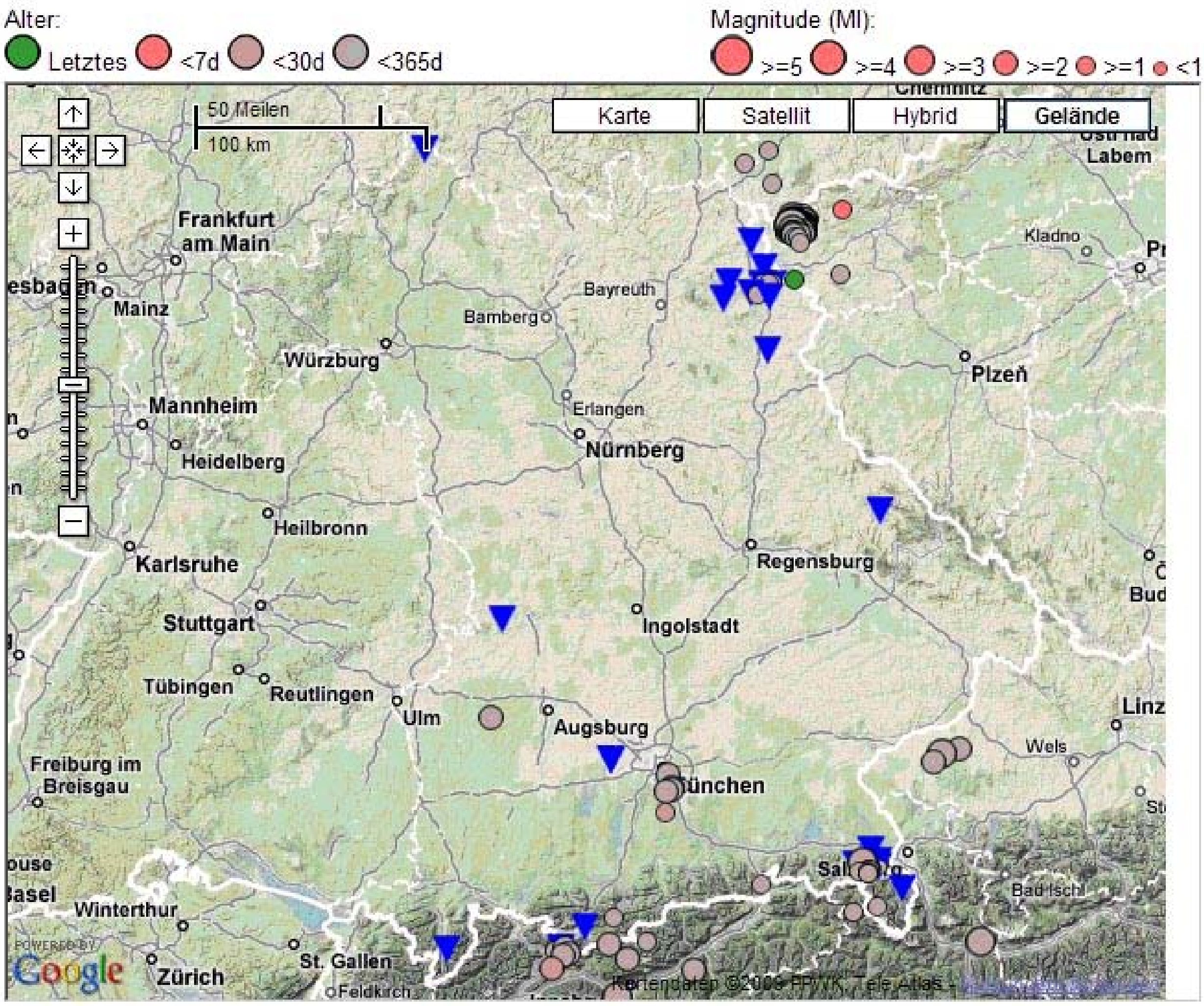

Figure 3 – Seismicity in Bavaria for the period 02/2008 – 02/2009. Triangles: Stations of the Bavarian Seismological Survey.

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