# Abstract Volume
# 9th Swiss Geoscience Meeting

Zurich, 11th – 13th November 2011

## 15. Geoscience and Geoinformation - From data acquisition to modelling and visualisation

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Geosciences
Platform of the Swiss Academy of Sciences

ETH
Eidgenössische Technische Hochschule Zürich
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# 15. Geoscience and Geoinformation - From data acquisition to modelling and visualisation

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*Swiss Geological Survey,*
*Swiss Geodetic Commission,*
*Swiss Geotechnical Commission,*
*Swiss Geophysical Commission,*
*Swiss Hydrogeological Society*

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# 15.1

# Managing authentication and permissions to OGC services with GeoShield: presenting the new GeoServer Resource Access Manager plug-in and the Sensor Observation Service protection

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Enterprises are increasingly feeling the need of more sophisticated data access control to OGC services. Nowadays there aren't many solution to manage data access control. Using actual techniques, administrators can mostly define read or write permission to specific services.

GeoShield meets this need by offering a centralized way to define security access-control to OGC services through a nice user friendly web interface. Basically it acts like a proxy, intercepting all the communications between clients and OGC compliant services (WMS, WFS, SOS). GeoShield is able to manage users and groups, it handles authentication and privileges settings among groups and registered services. It is capable to analyze requests applying the configured permission filters and/or manipulating the response accordingly.

This year GeoShield extends his capabilities introducing two major improvements: the Sensor Observation Services protection and the GeoServer Resource Access Manager plug-in.

The SOS protection introduces the definition of permissions for core and transactional profiles. Data managers can now set read permissions for each Observation Offering, and authorize writing permissions to transactional profile requests only to authorized users.

Thanks to the latest GeoServer release (2.1), GeoShield can be directly integrated with the new Resource Access Manager plug-in. This extension give some benefits in term of speed and reliability, GeoShield's proxy capabilities is bypassed, minimizing response time.

The presentation will introduce the attendees with GeoShield and the newly developed features throughout a practical demo.

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OGC Standards - http://www.opengeospatial.org
GeoServer – http://www.geoserver.org

# 15.2

# Protect-Me: web service for protection work catalogue

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The executed study aims to realize a complete system for the catalogue, management and visualization of information related to the natural hazard protection works. Having a comprehensive understanding of where, how, when and in which status the executed mitigation works are is crucial for an effective natural hazard risk management.

The Institute of Earth sciences (IST) to fulfill the need expressed by the Swiss Confederation, at a national level, and by the Canton Ticino, at a local level, has design and realized a system (PMES, ProtectME Service) composed by: (i) a data model defined using XSD schema, (ii) a Web service, similar to those defined by the Open Geospatial Consortium (OGC) and (iii) a Web based user interface for the access to the developed service.

The system has been implemented by using the Python and JavaScript programming languages, throughout the usage of specific libraries, and taking advantages of the PostgreSQL database with the PostGIS spatial extension. This paper present the cognitive investigation on the state of the art in Ticino, the three components of the system and finally some conclusions and consideration.

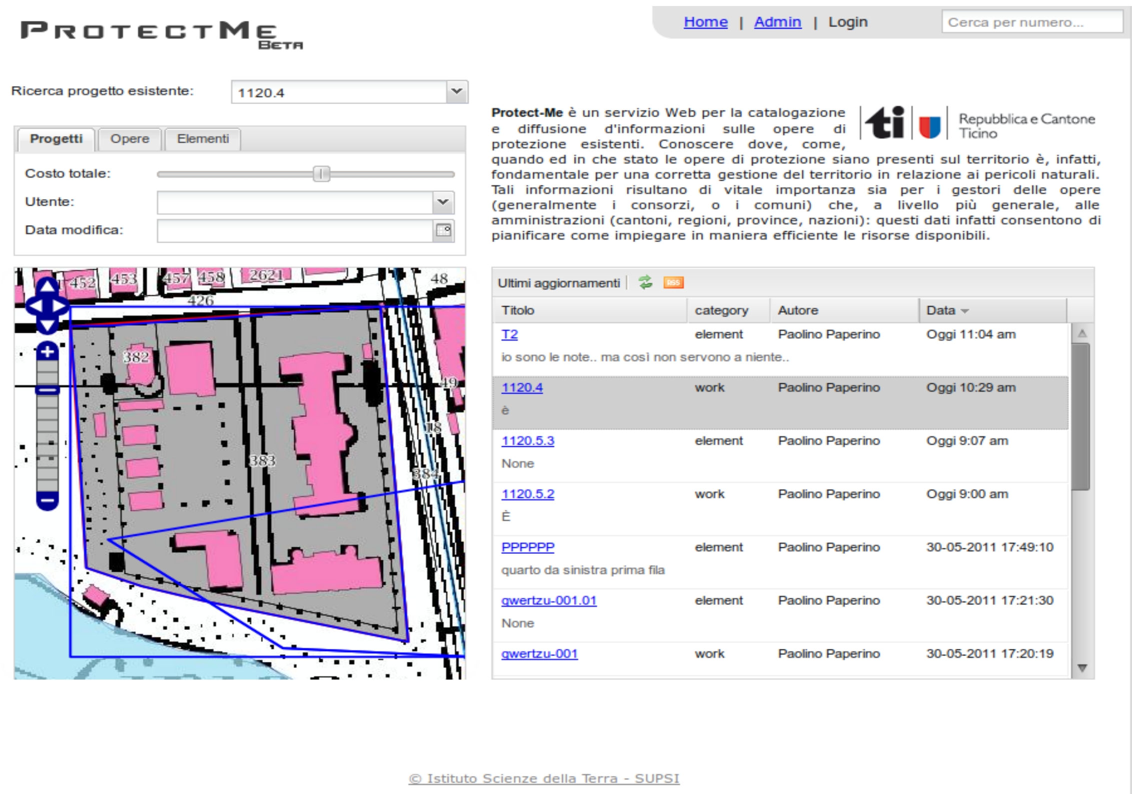


Figure 1. Home page of the developed Protect-Me application web interface.

# 15.3
# GIS-based modeling for landslide-generated tsunamis

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The recent tragic events occurred in Japan have shown once again the high vulnerability of communities towards the risk of tsunamis and the need for continuous improvements both in terms of alarm systems and adoption of appropriate protection measures. From this point of view, numerical modelling is a very important resource because it allows to create flood maps which can provide useful information about the areas most likely at hazard and the probable intensity of an event.

At the Swiss Geoscience Meeting 2008 a procedure for the risk assessment of earthquake-induced tsunamis was presented; here the authors intend to present a model for the simulation of tsunami generated by subaerial landslides in lakes and artificial basins. The model, based on the equations proposed by Heller et al. (2009), has been spatially implemented within the GIS GRASS and allows to simulate the wave generation due to the landslide impact, its propagation toward the basin, the generation of run-up wave and the consequent inundation along the coast. A specific module named *r.impact.tsunami* has been specifically implemented.

Moreover the authors have compared the propagation and run up estimated using the empirical equations of Heller et al. (2009) with that obtained using an approach based on non linear shallow water equations (Cannata & Marzocchi, 2011). The case study, located on Como lake (Italy) concerns the falling of a rock column of 50'000 $m^3$ into the lake and the successive generation of a tsunami wave.

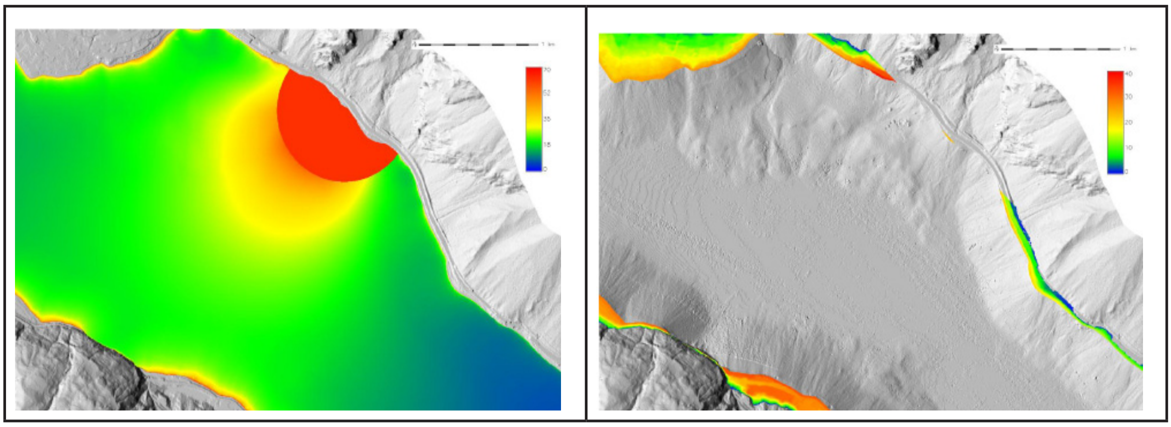

Figure 1. Wave height propagation and inundation maps estimated by the *r.impact.tsunami* model.

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# 15.4

# The geological 3D-model of the Basel region – new insights

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In the last years, the use of subsurface geothermal resources (e.g. deep and shallow thermal energy) strongly increased. In addition, the research for the storage of nuclear waste and sequestration of carbon dioxide is intensified. As open space in urban areas is limited and infrastructure grows into the depth, and comparable to the space at the surface, the space in the subsurface is limited, too. Existing installations, e.g. for groundwater use, react very sensitive to changes of the subsurface environment. Therefore, use conflicts with new installations will be inevitably. Rules and management strategies for the subsurface use are needed to find solutions in potential or already existent conflicts.

Aware of these problems, in 2008 the geological surveys of France (BRGM), Baden-Württemberg (RPF-LGRB), Rheinland-Pfalz (LGB) and the Applied and Environmental Geology Group of the University of Basel initiated the EU project "GeORG" (www.geopotenziale.org) with the idea to establish a tool for 3D planning of the subsurface across political boundaries along the tri-national Upper Rhine Valley. The essential element of the project is the development of a geological 3D model between Basel (CH) and Mannheim (D), which can be used as a flexible tool for the evaluation of the possibilities and risks of the deeper underground. The main focus is the use of deep geothermal energy and issues as earthquake hazards and the sequestration of carbon dioxide.
In this context, the geological 3D-model of the Basel region (Fig. 1) was established as the Swiss contribution to the "GeORG"-project. Although, the development of the model is still in progress, it was already used to answer questions for urgent issues in the Basel region like risk evaluation in the context of deep geothermal energy, development of rules for the use of shallow geothermal energy, use of groundwater resources and construction of highway tunnels.
The example of the 3D model from the Basel area demonstrates the large potential of subsurface 3D models. It allows to set constraints and boundary conditions in different use conflicts and gives a rationale base for a sustainable management of the subsurface for the future.

The geological 3D-model of the Basel region comprises 600 km$^2$ and reaches to depth of about 6 km. 15 reflection seismic lines, geological maps and about 9000 boreholes represent the most important data for the geometric modelling process. The model comprises 20 different geological horizons between the Quaternary unconsolidated rocks and the Palaeozoic crystalline basement. About 150 faults are still integrated. Their distribution in space is strongly related to the basic data sets. Especially, the eastern part of the model, representing the Tabular Jura, shows a very distinct fault pattern in different scales.
The data density decreases with growing depth. In the canton of Basel-Stadt, there are about 3600 boreholes available, but only 14 reach depths of 250 m and more. Such heterogeneity in data distribution is influencing the quality of the different model areas. To communicate the geographical distribution of the model quality, it was tried to quantify and to visualize the resulting model uncertainties.

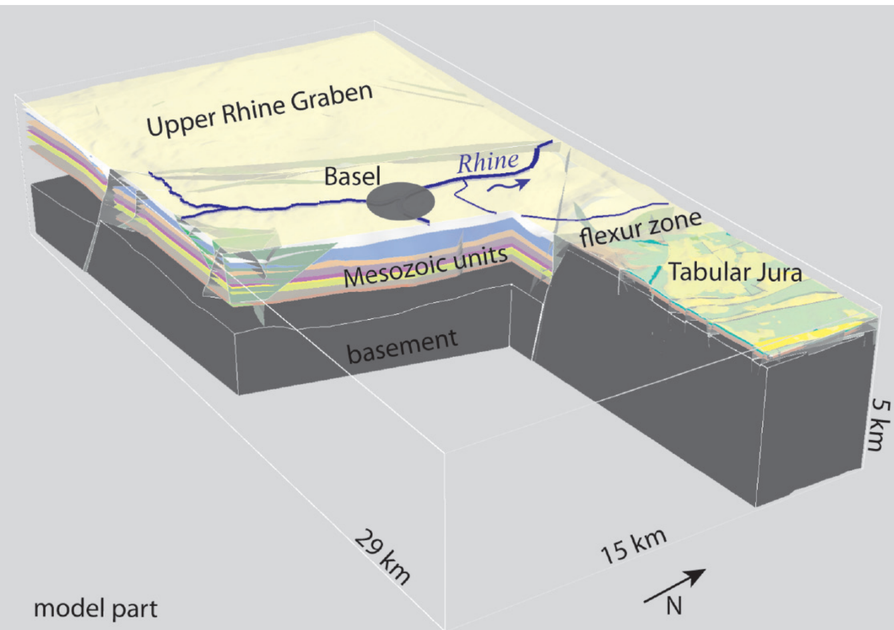


Figure 1. Part of the geological 3D-model of the Basel region (not all horizons shown)

# 15.5 Earth Modeling Seen from a Multiphysics Perspective

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From the perspective of mathematical physics planet Earth can be seen as a huge spatial domain in which a multitude of physical, chemical and biological processes evolve in time, e.g. mechanical deformations, fluid flows, chemical reactions, electromagnetic fields, heat transfer but also the spread of diseases or even the evolution of organisms. Today, the perception of various Earth Science disciplines (geology, geophysics, geomechanics, geochemistry, hydrology, and related disciplines such as environmental, reservoir and civil engineering) moves towards a holistic view. We become aware of the various couplings of the above processes. Some of the most exciting science topics and most vital problems of the Earth are related to highly coupled, non-linear interactions of fields. This perception is reflected also in the need to model Earth's complexity in a more sophisticated way. Recent advances of computing hardware pave the way for the feasibility of such models not only on clusters but desktop computers. In our talk we focus on our project to provide the Earth Science community with a software tool, capable of modeling nearly arbitrary processes in the Earth on arbitrary scales of time and length. We report some of the latest achievements of users and invite further contributions to this platform.

**Fundamentals and Key Requirements**

Most processes on the Earth can be generally described in terms of transport of mass, momentum, charge, and energy but also general entities such biological species. Based on fundamental conservation laws and empirical material relations they can be described by systems of partial differential equations (PDEs). On a mathematical level, a vast class of problems can be described by the following general form PDE:

$$e\frac{\partial^2 u}{\partial t^2} + d\frac{\partial u}{\partial t} + \nabla \cdot \Gamma = f$$

where 'u' is a vector of unknown field variables, Γ is a generalized flux vector depending on spatial and time derivatives of 'u' and '*f*' is a generalized source. Coupling and nonlinearities can arise from both material properties and loads depending on arbitrary field variables. By numerical discretization, such systems can be transformed into large sparse matrix systems. For an efficient and unified modeling tool in Earth Sciences we have identified the following key requirements regarding discretization, problem definition, solvers and interfaces:

- Geometry handling from digital elevation models to submicroscopic pores as well as built in 2D and 3D drawing
- Large repository of predefined equations and abstraction levels inviting multi-scale modeling
- Ability for user-defined equations and model interfaces
- Parallelized numerical algorithms (meshers and solvers) able to run on multiple OS and platforms from standalone PCs to clusters,
- Parameterization of material properties, loads and geometries
- Sensitivity analysis, optimization and parameter estimation
- Powerful Visualization without the need of external tools
- Interfaces to programming languages (C, Fortran, Matlab, Java)
- Interfaces to databases (e.g. geochemistry)
- Sustainable organization of the code: GUI, help system, support, community platform

**Recent Applications**

Recent contributions from Swiss geoscientists include applications from electromagnetic hydrogeophysics: (Maurer, Friedel & Jäggi, 2009, Bauer-Gottwein et al, 2010), geothermal modeling in permafrost areas, (Noetzli, Gruber & Friedel, 2007). Other applications include geomechanical stress analyses with Cam-Clay material model, mineral dissolution and crystal growth in anhydritic claystones, diffusion studies for nuclear waste deposits, and radar investigation of tunnel integrity. The openness of the code to couplings to other simulators in illustrated by Wissmeier and Barry (2010) who present a simulation tool for variably saturated flow with comprehensive geochemical reactions coupling COMSOL to PHREEQC.

The unified simulation platform COMSOL Multiphysics inspires to model real world processes with complex couplings between physical, chemical and even biological quantities. A large amount of predefined equations keeps the focus of the user on the model's experiment and theory rather than on numerical details. Openness to user-defined equations as well as couplings to other simulators invites further contributions to this novel multi-disciplinary approach to Earth modeling.

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## 15.6

## Building the national geological model of Great Britain

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There is a growing realisation in the environmental and social sciences that to address the grand challenges that face the world a whole system approach is required. These challenges including climate change, natural resource and energy security and environment vulnerability raise multi- and inter-disciplinary issues that require integrated understanding and analysis.

Many scientific disciplines have been modelling during the past 5 to 10 years in order to best understand and analyse the processes and conditions within their areas of interest. This has led to a multitude of discipline specific models, modelling system software and workflows with greater or lesser success depending upon the quantity and sources of data and complexity within the scientific discipline concerned. The challenge is to better link these models and enable users at all levels to make decisions based upon fully integrated environmental models. The fundamental role of a Geological Survey Organisation to support integrated environmental modelling is to develop a single, dynamically constructed multi-scaled 3D geological model of the UK and figure 1 shows progress being made towards this goal at the British Geological Survey (BGS). The difference to the core product of the past, the 2D map is that the model will be constructed at varying scales and will be maintained dynamically as geological understanding changes or new data becomes available.

The image below shows the initial fence diagram which was constructed using the GSI3D methodology and on which this geological model will be based (see figure 2). GSI3D (Geological Surveying and Investigation in 3 dimensions) is a methodology and associated software tool for 3D geologic modelling developed initially by INSIGHT GmbH and now by the BGS in conjunction with the GSI3D Research Consortium (www.gsi3d.org.uk). GSI3D utilizes a digital elevation model, surface geological linework and downhole borehole data to enable the geologist to construct cross sections by correlating boreholes and the outcrops to produce a geological fence diagram and corresponding coverage maps of geological units (outcrop plus subcrop). Scientists draw their sections based on facts such as borehole logs correlated by intuition - the shape 'looks right' to a geologist. This 'looks right' element pulls on the geologists' wealth of understanding of earth processes, examination of exposures and theoretical knowledge gathered over a career in geology

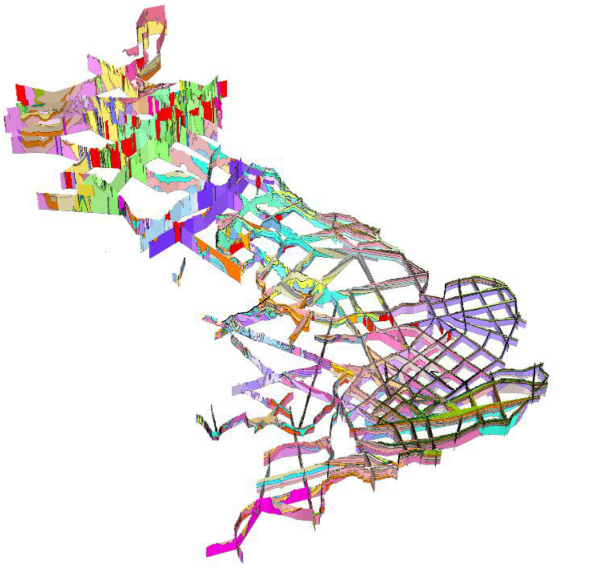

Figure 1 Current progress on developing the cross sections required to create a GSI3D framework model of onshore Britain. Note the scale differences and depths included, between Scotland and England and Wales

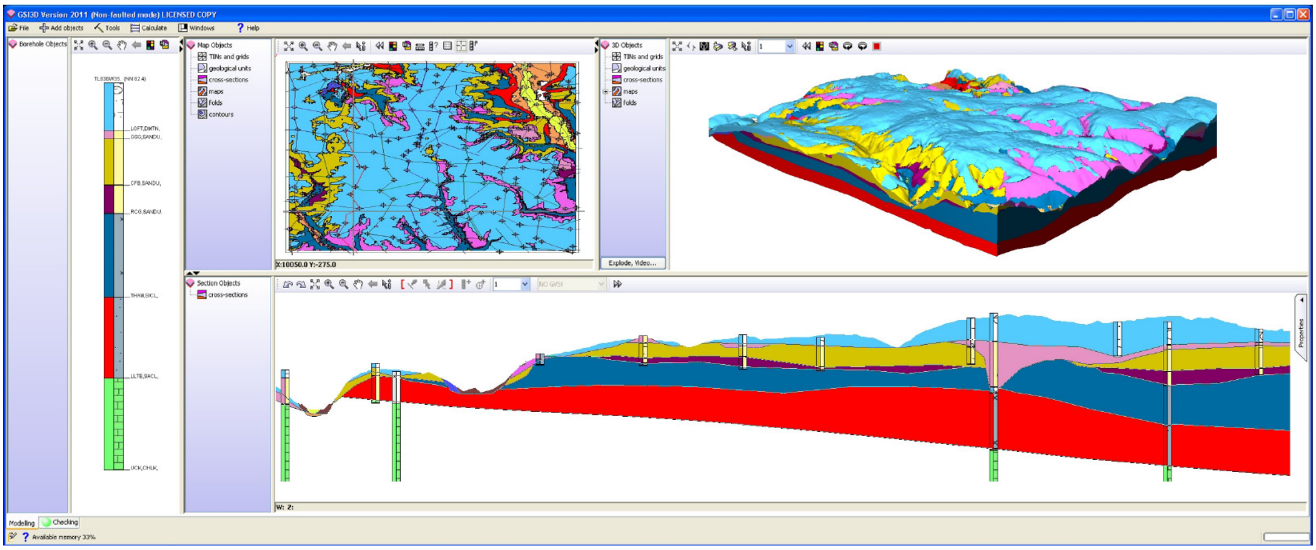

Figure 2 The GSI3D software interface

## 15.7

# Provision of 3D GIS (model GMS) for geospatial hydrogeologic modeling of Mio-Plio-Quaternary groundwater of Foussana (Central Tunisia)

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Water is essential for all forms of life and crucial for human development. Water systems, including surface waters and aquifers, provide a vast majority of human needing including drinking water, irrigation and industry. However, water resources are unequally distributed in space and time and therefore requiring an appropriate management especially in countries under arid and semi arid climate such as Tunisia where, an unlimited increasing of exploitation of the non-renewable water resources has been noted in the recent years. In this regard, irrigated agriculture, industry and energy supply consume the great part.

The aquifer of Foussana in central Tunisia constitutes an example showing signs of such over exploitation. The intensive exploitation of groundwater representing the mainstay of the Foussana area is becoming more pronounced and critical in the recent years resulting in over exploitation which requires a rigorous control of the management of groundwater resources. For tackling this problem and to properly ensure the management of groundwater resources, a good knowledge of both the quality and quantity of water is essential which requires a deep understanding of the evolution of the reservoir geometry and the characteristics of permeable formations.

In the present work we have used a new technique of interpretation and interpolations called “3D GIS”. It allow a good management of the drilling data and help in the establishment of 3D schemes of the hydrostratigraphy and the aquifers with a simulated three-dimensional geometric which is very close to its actual condition.

Also, the understanding of the aquifer and its geometry was apprehended for the study of lithostratigraphic columns of wells and piezometers supported by GIS through the 3D model ‘’Ground Modeling System” or “GMS”. GMS is a geodatabase design for representing datasets in ArcGIS groundwater under the module’’ ArcHydro Groundwater” or AHGW. The data model allows storing, view and analyzing multidimensional data of groundwater, and includes several components to represent different types of datasets including representations of the aquifers, wells, boreholes, 3D hydrogeological models, timing information, and data from simulation models.

This model can explicitly represent the geological features highlighted in the interpretation of data in the form of hydrogeological horizons, so the form of solid or mesh Voxel.

The specific objectives of the intervention, corresponding to the expected results of the modeling can be formulated as follows:

- Assessment of regional patterns of flows in the area
- Identification of hydro reservoirs and their geometry;
- Evaluation of flow directions within the reservoirs identified, and quantification of groundwater flow in these tanks;
- Estimation of the regional distribution of hydrogeological parameters;
- Predictions of the effects of changes in groundwater recharge and the piezometric groundwater flow;
- Tool for decision support for the implementation of measures for monitoring and for the management and exploitation of groundwater;

The results of this intervention offers interesting perspectives for further developments in modeling of groundwater, both for the geometry contribution to the assessment of the renewable resource, and evaluation of its potential for exploitation; for the groundwater flow

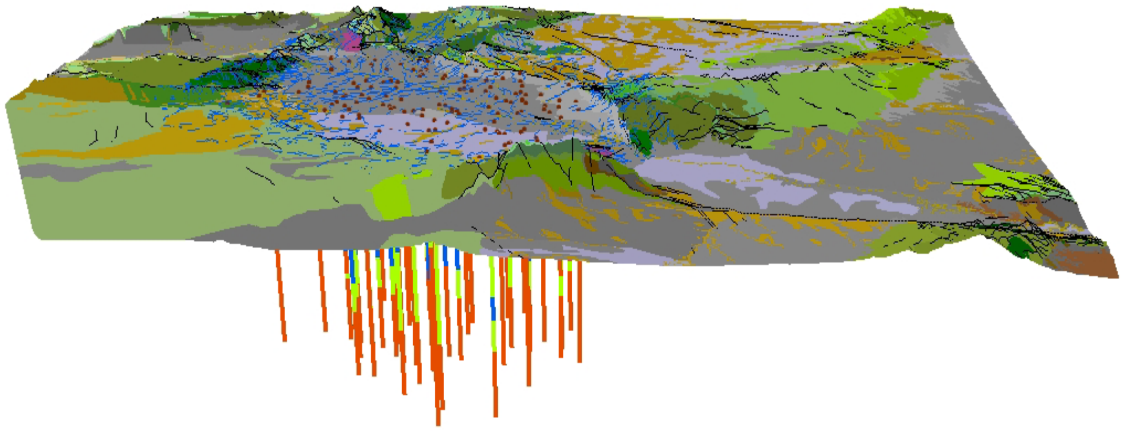

Fig.1: Numerical Model of the basin associated with the drilling of Foussana available

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# 15.8

# Geological 3D modelling of Quaternary sequences using GSI3D – an example of the surroundings of Berne

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swisstopo / Swiss Geological Survey (SGS) wants to build up geological 3D models at different scales and resolutions. These models visualise the structure of the earth's crust. Such information is important for many topics such as 3D urban planning, resource management etc. and can be easily understood by professional geologists as well as laymen.
A geological 3D model can comprise bedrock as well as superficial Quaternary formations. For modelling bedrock formations the SGS uses the Move software suite (Midland Valley Exploration) which provides various tools for model verification such as cross section balancing, kinematic forward and reverse modelling etc. In order to model the Quaternary sequences, the SGS applies in addition to Move the software GSI3D (Geological Surveying and Investigation in three dimensions) developed by the British Geological Survey (BGS). In GSI3D, especially the capability of vertical exaggeration while modelling is useful to build up Quaternary 3D models, because the shape of straticulate sequences can be visualised.

The following data has been used to build up the geological 3D model of Quaternary sequences of the surroundings of Berne:

- geological surface map of the Geological Atlas of Switzerland 1:25'000 (GA25) and its lithostratigraphic units
- Digital Elevation Model (DEM) of the earth surface
- borehole data (with two quality standards)
- cross sections
- DEM of the bedrock surface

All data has been combined within GSI3D and the 3D model has been constructed according to the following method:

- Construction of a geological fence diagram, based on the geological surface map (GA25)
- Refinement by adding further cross sections based on the data in GSI3D (correlation of boreholes, map and cross sectional data)
- Construction of geological unit maps with their area-wide extensions (subcrops) at the same time
- Construction of helper sections for specific areas, as proposed by Mathers et al. (2011)
- Topology check while digitising sections and geological units (snapping to intersections, outcrops and subcrops)

Combining the input data, the geological units are created in GSI3D in their lithostratigraphic order. Output is a 3D block model of the Quaternary units; they could also be displayed in an exploded layer view. For a general geological 3D model, this Quaternary block model is imported into Move and therein combined with a bedrock model.

Because the construction of a geological 3D model is always linked with a good deal of interpretation, the accuracy of such a model varies as a function of the distance to the trusted data, its quality and distribution. For a good quality control of a geological 3D model, it is useful to have a quality map of the trusted data, where the two-dimensional reliability of the model is represented. As the available borehole data in the surroundings of Berne, used in the introduced Quaternary 3D model, has a heterogeneous distribution and two different quality standards, the SGS created as a first approach a quality map with the inverse distance weighting (IDW) interpolation method. However for a final quality assessment further investigations are required.

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# 15.9

# Numerical modelling for risk scenarios generation

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MIARIA (Adaptive Hydrogeological Monitoring supporting the Area Integrated Risk Plan) INTERREG project foresees, among other activities, the numerical modelling of instability phenomena.

The Swiss case study is located in Val Canaria (Tessin): a region particularly susceptible to landslides. In particular, the modelled landslide is of complex type. Its failure could generate an accumulation that may block the main river flow causing a temporary dam. Successive dam break would likely produce a flooding that could damage the buildings and the trasport infrastructures of North-South axis of San Gottardo.

In 2009, an important event involving 350'000 $m^3$ occurred: fortunately, even though the risk scenario presented above took place, the damages were limited because the flood didn't reach the critical infrastructures.

The availability of terrestrial laser-scanning data just before and after the event allows to generate detailed digital terrain models which are invaluable information in models set-up. In this study the authors applied MassMov2D (Begueria et al., 2009): a dynamic model that describes terrain movements by combining mass and momentum balance equations with rheological formulas able to characterize the material involved.

A three dimensional description of a phenomenon both in terms of run-out area and deposit heights can be obtained.
This work illustrates *(i)* the phases of sensitivity analysis and calibration of the model on the 2009 event and, based on the parameters obtained from the calibration, *(ii)* the generation of a new hypothetical hazard scenario. Moreover, the implementation of the model within a GIS environment (GRASS) will be presented.

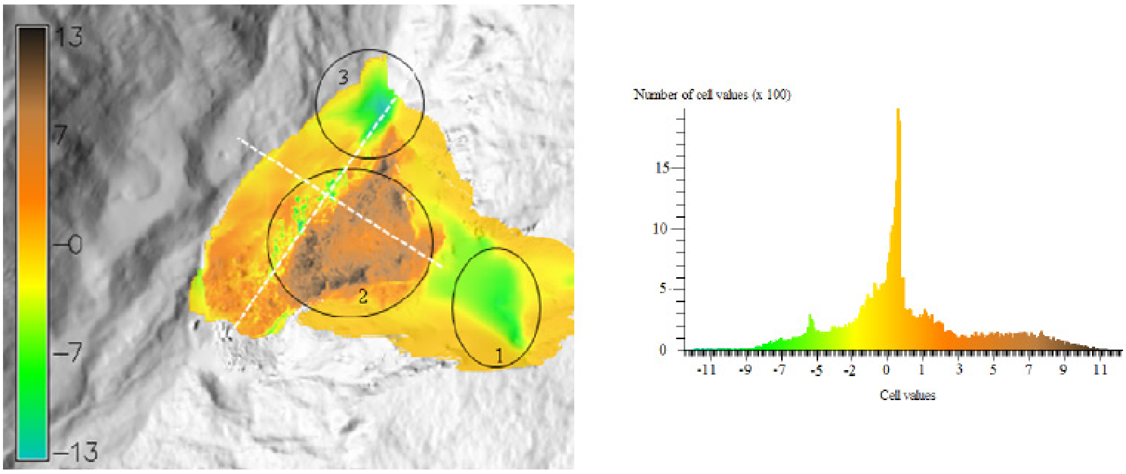


Figure 1. Difference map between observed and modelled deposit and histogram of the cell values

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# 15.10

# Modeling of the “Plan da Mattun” archeological site using a combination of different sensors

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Deep in the Tasna valley, finds dating back to the time of Ötzi, where discovered by archaeologists of University Zürich. The finds derive from early alpine dwellers, taking shelter below the overhanging boulders at Plan da Mattun, while they were hunting or before they crossed the mountain pass at the end of the valley. For expanded investigations of this archeological site, digital models of the terrain and of certain boulders were of lager interest. Additionally the digital models will be used for documentation and visualizations.

Figure 1 the archeological site “Plan da Mattun”

The goal was to obtain a digital terrain model of the rock stream located at the end of the valley, as well as detailed models of four larger boulders. The larger boulders are up to 15 meters high and the smaller rocks still average to about 2 meters in height and in diameter. The roughness of terrain (see Figure 1) makes it difficult to access certain areas and requires using multiple measuring techniques in order to cover all the objects of interest. That is why the digital terrain model was acquired using a combination of laser scanning (Leica Scanstation C10) and unmanned aerial vehicle (UAV) photogrammetry. The larger boulders were reconstructed with a Zoller&Fröhlich Imager 5006 laser scanner, terrestrial and UAV photogrammetry.

**Georeferencing of the measured data**

To georeference the obtained scans and images, a geodetic reference system had to be set up within the Swiss coordinate system LV95. Because of the lack of mobile phone reception at the end of the valley, the Swipos service could not be used. Therefore three reference points were measured by static GNSS and corrected with a virtual reference station (VRS) in advance. One of these was used to set up a local GNSS reference. Hence it was possible to measure the ground control points for the photogrammetry in real time. Accordingly to the GNSS accuracy, the control points had a horizontal accuracy of 2 cm and 5 cm in height. To georeference the scans done by the Scanstation, the scanner position was measured by GPS, force centered on the same tripod. The Scanstation C10 allows to directly setting the orientation by measuring a known sphere target. In contrast the scans done by the Zoller&Fröhlich Scanner, were georeferenced by using several sphere targets whose coordinates were measured before. For terrestrial photogrammetry, reflective targets were placed on the boulders and referenced with tacheometry.

**Data processing**

The scans from the Scanstation were edited in Cyclone and afterwards exported into Geomagic to edit the dataset. The UAV images were first processed with Photomodeler Scanner to obtain approximate camera positions and orientations. These orientations were then imported into Leica Photogrammetry Suite (LPS) and used to automatically measure tie points. The ground control points were measured manually. The digital terrain model was generated automatically and edited in Geomagic. Afterwards, the final orthophoto has been generated automatically using the mosaic tool from LPS. For the Z&F scanner the same processing chain as in the C10 case was performed. The terrestrial images as well as the UAV images were oriented and georeferenced in Photomodeler Scanner. The same software has been used in order to generate a dense point cloud. All the datasets used in this project were edited in Geomagic.

**Results**

The resulting dataset includes a coarse digital terrain model with a resolution of 10 cm and a relative accuracy of 2 cm in flat terrain. The larger boulders feature a resolution of 10 mm and a relative accuracy of 5 mm.

The datasets will be used for visualization purposes by the archaeologists and for analyzing purposes of the rock stream by geologists.

Figure 2. Orthophoto mosaic draped over DTM.

## 15.11

# Determining archaeological potential in the Pennine Alps using GIS tools

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The accelerated melting of glaciers in the Alps is freeing up many archaeological relics which demonstrate the use of high altitude passes since prehistoric times. Until recently, scholars have neglected the study of these high altitude passes due to the fact that these areas were seen as marginal and uninhabitable by humans. There is an urgency to collect and conserve these archaeological findings as most objects consist of perishable material and, once exposed to the environment, they rapidly degrade and decompose. The disappearance of this prehistoric and/or historic material is an inestimable loss which would impede the understanding of how people have used these glaciated high altitude passages throughout history.

This project, which is funded by the Swiss National Science Foundation (SNSF) with the support of the Musée d'Histoire du Valais and the Service des Bâtiments, Monuments et Archéologie in Sion, proposes to develop methods using GIS tools to localize sites with the highest potential of artefact discovery in high altitude passes and trails in the Pennine Alps. This study area is one of the most glaciated territories of the whole Alpine arc and is located between the Canton of Valais (Switzerland) and the Italian border. We will use a multidisciplinary approach to develop a predictive model based on geographic, historic and cultural inputs. Some geographic inputs include: a 25 m digital elevation model (DEM), historic glacier delineations (since 1850), aerial photographs, trails and topographic maps. An archival text analysis is being conducted along with a critical analysis of historic publications to obtain more information about ancient trails and passes through these mountains. Archaeological find location information has been provided by the archaeological department in the Canton of Valais.

The theory behind our model is based on the model used by Dixon *et al.* (2005) for determining archaeological potential in glaciers and ice patches in Alaska's Wrangell-St. Elias National Park and Preserve. We will create potential 'influence' and 'restriction' layers, assign weights to each layer based on its importance for archaeological potential, and multiply 'influences' by 'restrictions' to create a model for archaeological potential.

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## 15.12

# Vp-Vs measurements of shallow formations in Chémery (FR): comparison between laboratory and field data and integration within a 3D geological model

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Object of this study is an underground gas storage facility located in the south-western border of the Paris Basin. The geology of the site is well known and it is characterized by an anticlinal structure affected by a dense fault network (Fleury, 1997). This structural trap is exploited since late '70s as an artificial gas reservoir at a depth of 1200 m. The reservoir is located in Triassic strata of fluvial sandstones (Hamon and Merzeraud, 2001).

A passive seismic acquisition campaign was held in the area to record low frequency seismic waves above the reservoir (Artman et al 2011). The technique allows to define the areal extension of the gas cushion, detecting anomalies in the microtremor wavefield presumably caused by hydrocarbon (Saenger et al., 2009). Passive seismic can additionally be used to understand the influence of the near surface on the major wavefield. Therefore, a good knowledge of the velocity distribution within shallow formations is essential to understand possible anomalies in the seismic record.

Velocities of the shallow formations can be found in a public dataset which collects up-hole seismic data (BRGM online catalog: infoterre.brgm.fr/viewer). However, the velocity model can be better defined integrating laboratory measurements. We collected 24 hand specimen from which we drilled out core plugs. The sampled lithologies are 6 different sedimentary rocks, mostly calcarenites. The core plugs are 25 mm diameter and the length ranges from 23 to 50 mm. The measurements were conducted employing the pulse transmission method for compression (Vp) and shear (Vs) waves in dry and ~fully water saturated conditions. The samples were weighted, and the volume was measured accurately in order to obtain the density value in both saturation conditions. The porosity was measured with two different methods: (1) with a helium pycnometer, and (2) measuring the variation of weight for dry and fully saturated conditions. Porosity ranges between 45% and 0%.

The results obtained for dry samples are:

- Cretacic calcarenites exhibit Vp ranging between 1400 and 4700 m/s and Vs ranging 800 - 2800 m/s. Turonian Tuffeau Blanche and Tuffeau Jaune have average Vp ~2025 m/s and Vs ~1300 m/s, while the Senonian Craie Blanche à Silex has average Vp ~3600 m/s and Vs ~2000 m /s. Such differences were also observed by Hanot & Renoux (1991).
- Low cemented sample from the Palaeocenic-Eocenic Formation Détritique Continentale has Vp of ~1600 m/s and Vs of ~1050 m/s, while a sample from the same formation which is strongly cemented and silicified shows Vp of ~5600 m/s and Vs of ~3000 m/s.
- The Miocenic Calcaire de Beauce and the Falunian marine sands show Vp around 4500 m/s and Vs of ~2450 m/s.

In fully saturated conditions, Vp values increase on average by 10% while the Vs values decrease on average by 15%. Similar trends have been observed in the literature (Cadoret et al., 1992). Alteration of outcrop samples can affect the elastic modules of the materials significantly and has to be taken into account.

The velocities measured in the laboratory were then compared with the uphole velocity logs and the data were used to build a 3D model of elastic properties for the lithological units in the study area. This last task was performed employing the modeling software Petrel.

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# 15.13

# The Swiss Geologic Data Model

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Behind each geologic map is a concept that is visualised in its map legend. When converting a printed map into a Geographic Information System (GIS) dataset, the map legend is used to further extend this initial concept to meet the requirements of digital datasets. Although the concept for digital geologic datasets (database, structure and semantics) is often ignored by geologists, it turns out to be very important when putting data from different authors / sources together.

To facilitate the handling of different geologic datasets in a GIS-environment, the Swiss Geological Survey has established a data model (Strasky et al. 2011), which describes the structure of the geologic data and defines the specific objects and its attributes. A working group consisting of eleven members from various institutions of the Swiss Geological Community has contributed significantly to achieve a final draft version, which was then submitted to an external review board. Feedbacks from 22 external reviewers from federal and cantonal institutions (including the Swiss Geological Commission SGK, the Swiss Geotechnical Commission SGTK and the Swiss Association of Geologists CHGEOL) as well as private companies were included in the current version of the geologic data model. Today the model consists of 49 classes which organise the different geologic object types. The classes are further grouped into eight major topics. The documentation gives a detailed description of the content of the data model in French and German as well as UML-diagrams and the corresponding INTERLIS 2.3 code. Furthermore a standardised vocabulary for rock types, tectonic units and the geological time scale is provided. The data model is applicable for two-dimensional geologic data at any scale. The first official version of the Swiss geologic data model will be available by the end of 2011.

With the Swiss geologic data model we supply the basis for well-structured, homogenous geologic GIS data and we provide the standard for a future seamless, semantically harmonised, nationwide digital geologic map of Switzerland.

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