Geo-Resources and Geo-Hazards

Areas for settlements and industrial plants as well as infrastructure occupy high percentages of the available ground in many countries. In Germany, the amount of sealed land exceeds 12% of the space available in the country already and reached a high of more than 17% in the Rhine-Main area, one of Germany’s urban centres. Such sealing spreads fast, so that officials recognised that there is a problem at hand and they intend to reduce the sealing of soil from 130 to 30 hectares per day in Germany.

The use of land in urban and metropolitan areas and their surroundings poses a serious problem in many countries, especially as resources which are vital for these fast growing settlements are sealed off. Groundwater, soils valuable for agriculture and mineral deposits including raw materials (sand, gravel, limestone) may be at risk. As a result, the access to clean drinking water becomes difficult in many areas and large amounts of construction material have to be hauled over long distances. Dense population also increases the possibilities that natural hazards (earthquakes and tsunamis, mass transports on steep slopes or by subrosion of evaporites in the underground as well as volcanism) may turn into risks and may eventually lead to catastrophes.

However, areas containing geo-resources or posing geo-hazards cannot be “moved” to a more favourable spot by man. They usually have longer cycles of regeneration than a human lifetime and may affect the interests of several generations. As a consequence, all land use planning – especially in growing communities – should take a close look into the geo-potentials. The sealing of, for instance, a thick deposit of economically extractable gravel may force a community to use another deposit of less thickness and thus increase the impact on land use even further. However, extraction of raw material and other forms of land use are not necessarily a contradiction. There are many examples, where former gravel pits or quarries developed into spheres rich in biota and are now defended fiercely by environmentalists for their high biodiversity.

In recent years, the consensus is that a thoughtful treatment of the natural environment is of vital importance. The numerous debates on the necessity of sustainable development resulted in many new regulations and laws (for instance in article 20a of the German Constitution). However, geology is neglected in many planning processes using the argument that the results are too complex to be considered. While it may - in some cases - be true that geologists have problems to explain the relevance of the geological evolution of a certain area for planning purposes, it is also true that the geosciences have undergone substantial change: Coming from a qualitative approach, they reached quantitative and modelling approaches in the last few decades, and they are now capable of making geo-resources and geo-hazards visual.

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Research projects

We concentrate on research on the outskirts of urban centres where land use triggers conflicts of interest (e.g. extraction of groundwater vs. extraction of raw material vs. agriculture vs. conservation of nature etc.). These metropolitan areas are:

- the Cenozoic terrestrial Hanau-Seligenstadt Basin between the Odenwald and Spessart Mts., which serves as a lab in the vicinity of our university and has been investigated by Stefan Lang and Christian Lerch since 2001; the latter defended his doctoral thesis successfully at the end of November 2005.
- the surroundings of the city of Zaragoza (northern Spain), where the solution of Tertiary evaporates led and still leads to numerous dolines in the Quaternary sediments of the Ebro River (investigated by Teresa Lamelas Gracia in cooperation with Prof. Dr. Juan de la Riva of the University of Zaragoza; a DFG-project since 2003);
- the northern outskirts of Belo Horizonte (Minas Gerais, Brazil), a fast growing city having more than 4.5 million inhabitants at the time being. The area’s geo-resources as well as its geo-hazards are investigated and evaluated by Monika Hofmann (supported by the DAAD) in cooperation with Prof. Dr. Joachim Karfunkel (Universidade Federal de Minas Gerais).

In cooperation with the “Bundeszentrale für politische Bildung”, a visit of Israel and the West Banks was organized for a group of experts on water issues and journalists. Together with local scientists and the water authorities, the group looked into and discussed the water issue with respect to availability, demand and socio-economic consequences (see the short article at the end of this volume).

Supported by Thomas Utter, Honorarprofessor (honorary professor) to our institute, four students were doing field work in the Sierra Madre Occidental in north-western Mexico. They mapped part of a gold-bearing porphyry copper district (iron oxide-gold-copper subtype) in detail. The ore is bounded to metasomatosis and local brecciation (“skarn”) during the Laramide Orogenesis which generated tonalities, diorites and andesites intruding folded ?Ordovician quartzites, discordantly overlain by Triassic arkoses.
For a few months, the excavation for the future Science and Congress Centre of Darmstadt, the “darmstadtium”, revealed the eastern master fault of the Upper Rhine Graben which separates granodiorite from Cenozoic sediments. A 3D visualisation and a facies model for the areas of denudation and accumulation were elaborated (see the short article at the end of this volume).

**Publications**


The eastern master fault of the Upper Rhine Graben below the Science and Congress Centre “darmstadtium” at Darmstadt, Germany

Stefan Lang and Andreas Hoppe

The Upper Rhine Graben is part of an active rift system crossing Europe from Scandinavia to the Mediterranean Sea (Fig. 1). Since the Eocene, it has received sediments up to 4 kilometres in thickness. The eastern master fault of the Graben was visible in the excavation pit of the future Science and Conference Centre of the University and the City of Darmstadt, the “darmstadtium”, in 2005. During the excavation process, the fault and the adjacent units were documented in detail including lithofacies profiles, outcrop maps, photographic panels, measurement of the tectonic inventory, soil sampling and palynologic analysis. Geophysical logs (spectral natural gamma radiation, magnetic susceptibility) and ground penetrating radar profiles were contributed by Jens Hornung and Nils Lenhardt. The project was funded by the Wissenschafts- und Kongresszentrum Darmstadt GmbH & Co. KG.

Fig. 1: The outline of the future congress centre (right) shows that the building is situated on top of the eastern master fault of the Rhine Graben which is part of a European rift system (left, slightly modified after Pflug 1982: Bau und Entwicklung des Oberrheingrabens, Darmstadt, Wiss. Buchges.).

To the southeast of the master fault granodiorites of the Variscian basement are exposed, while to the northwest Cenozoic graben sediments were accumulated (Fig. 1). Where depth and distance to the master fault decrease, the rock is increasingly decomposed. In a zone 1 to 2 metres wide along the master fault, the granodiorite is largely desilificated and transformed into clay minerals. The Cenozoic sediments
include mud, clay, silt and sand, partially containing clasts of gravel size. Rooted floodplain intervals are interbedded with mudflows showing proximal-distal trends such as decrease in thickness, sand-sheet flows, local gravity deposits and small-scale channels, some of them filled with lacustrine deposits. These architectural elements indicate an interfingering of a floodplain or levee environment with an alluvial fan formed in front of the master fault. A large fluvial channel - several hundred meters wide and about 10 meters deep - is incised in this succession. The channel sediments consist of crossbedded sand with gravel beds of a braided river environment which is indicated by sedimentary structures such as abundant scour pools. The rocks and sediments are covered by cultural deposits of different ages including remains of former buildings such as a medieval city wall and historic wells that were filled in.

The bedding of the fluvial sediments is inclined to the southeast with a dip of 10-20° below an angular unconformity and almost horizontally above. The inclination was measured on the southern limb of a low amplitude anticline which probably developed during antithetic flexuring. The strike of the master normal fault is about 53° and its dip 70-80° NW. Several normal, thrust and overthrust faults of similar strikes with throws of centimetres or decimetres are related to the master fault. Fracture planes with horizontal slickensides within the granodiorite show north-eastern and south-eastern strikes. Maxima of joint strikes within the granodiorite are north, northeast and less obvious southeast according to the regional major tectonic strike directions.

In this study the master fault of the Upper Rhine Graben within the city centre of Darmstadt was traced in more detail and the first facies models for the Cenozoic fluvial sediments of this area were given. Further work focussing on the stratigraphic age of the sediments, such as luminescence dating, is currently carried out. An information point inside the “darmstadtium” will inform visitors about the special geologic conditions of the site. Furthermore a long-term levelling device will be installed to detect of relative movements along the master fault.
Will scarcity of water lead to war in the Near East?

Andreas Hoppe

In the Near East, rain is most likely from November to February. It is brought by the clouds and western winds from the Mediterranean, falls down on the mountains of Israel and the West Bank and its amount decreases rapidly further east and from the north to the south. Following these directions, a close succession of green plains and hills and the deserts of the Negev and the Dead Sea is the result. The majority of surface water is stored in Lake Kinneret (Sea of Galilee) which contributes quantities between 90 and (in 2004) 500 MCM (million cubic metres) to the water consumption in Israel. Israel’s water is supplied by the “National Water Carrier,” which is responsible all over the country (Fig. 1).

Fig. 1: Israel and the Occupied Territories (left), the mean annual rainfall (in the middle; in mm/year) and the water distribution system (right).

The annual rainfall also controls the recharge of the groundwater basins. These are mainly Cretaceous and Early Tertiary karstic limestone aquifers in the mountains, Plio-/Pleistocene porous aquifers in the coastal plain and joint aquifers in the Cenozoic volcanic rocks of the northeast (Fig. 2). They contribute more than 65% to the water consumption storing a mean annual groundwater recharge of approx. 1500 MCM.
Fig. 2: The geological development resulted in the porous aquifer of the coastal plain, the joint aquifers in the mountain area (mainly karstic limestone) and the joint aquifer in the northeast (in volcanic rocks). The numbers in the upper right give rough estimates for annual groundwater recharge (in MCM) for the various groundwater reservoirs.

In a politically difficult area, like the Near East, water is a sensitive question and some politicians already speculated that it may be the reason for a future war. This implies that data on water production and consumption are not always easy to get. When confronted with data from other sources, some experts simply state: “I would not believe him a word”. This was one of the manifold experiences of two information tours of the German Federal Agency for Political Education (“Bundeszentrale für politische Bildung”) in 2001 and 2005 to Israel and the West Bank. It brought a group of German experts and journalists into contact with Israeli and Palestinian experts (coming from universities, water authorities, politics, NGOs, kibbutzim, settlers, and Mekorot, the Israeli water supplier who is in charge, whenever questions related to water come up). The information given by these experts and considerations on the geology of the region, like groundwater basins and the annual precipitation, led to a rough estimate of the water exploitable from the different groundwater basins as shown in Fig. 2.
The annual consumption in Israel and the Occupied Territories of approx. 2000 MCM already uses the exploitable reserves of water up. Water is delivered by Mekorot for a price of approx. 0,30 Euro/m³ to the communities which in turn calculate their own prices for the consumer. Currently, Israel uses more than 60 % of its water for agricultural purposes, and officials state that this practice will continue. Therefore, new sources of water are necessary. Israel recently reacted by constructing sewage treatment plants. In 2005, these plants made 340 MCM of water available which is given to agricultural producers at a price of approx. 0,16 Euro/m³. In addition, six desalination plants are planned (two of them are already under construction) which will produce more than 500 MCM per year at a price ranging between 0,38 and 0,45 Euro/m³ in the near future.

This demonstrates that the water shortage does not necessarily lead to war. Surface and groundwater reservoirs added by water from desalinisation and sewage treatment can meet the water demand. And it shows that the natural conditions are not to be blamed for the rise of militant actions - the way decision makers distribute water or prevent the access to it would be the real cause.