Cost-Benefit-Analysis of Geological Expertise

International Symposium
October 15-16, 2005
Vienna, Austria

Programme Abstracts Excursions

Geological Survey of Austria

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International Symposium
Cost-Benefit Analysis of Geological Expertise

Programme

Saturday, October 15th

09:00–09:30 **Arrival and Registration** of participants

09:30–09:45 **Welcome and Opening of the Meeting**: SCHÖNLAUB, Hans P. (Director of the Geological Survey of Austria).

09:45–10:15 **Chances and Risks, Trials and Errors Resulting from Measures to Increase Flexibility of Public Institutions i.e. Geological Surveys**: MENTE, Michael (Germany).

10:15–10:45 **Products, Costs and Benefits of State-Provided Geological Information in Switzerland**: SPINATSCH, Markus (Switzerland).

10:45–11:15 **Benefit and Limit of Underground Investigation**: KLIMA, Kurt & SWOBODA, Gerfried (Austria).

11:15–11:45 Coffee break

11:45–12:15 **Methods to Determine Speciation and Importance for Risk Assessment: Case Study from Port-Romano Albania**: SHTIZA, Aurela & SWENNEN, Rudy (Belgium).

12:15–12:45 **The R&D-Programme GEOTECHNOLOGIEN – Interface between Science and Application**: STROINK, Ludwig (Germany).

12:45–14:15 Lunch at the “Alter Heller” – a typical Viennese restaurant nearby.

14:15–14:45 **Geology as Cultural Mission and Economic Amortization Calculations: a Stress-Field**: KRENMAYR, Hans-Georg (Austria).

14:45–15:15 **Cost-Benefit Maps in Prevention of Geobiological Risks: a Methodology Based on GIS Techniques**: SEPÚLVEDA, Joel, RETOLAZA, Jose Luis & MENDIZABAL, Maddalen (Spain).

15:15–15:45 **Convincing Society to Fund and Use Geoscience Expertise**: McARDLE Peadar & O’CONNOR, Patrick J. (Ireland).

15:45-16:15 **Translating Geological Data into Information for Land and Property Owners** by FALVEY, David A. & WESTHEAD, Keith (United Kingdom)

16:15–16:40 Coffeebreak

16:40–17:00 Postersession

- **Study on the Sustainability Evaluation System of Natural Resources: Environmental & Economic & Scio impacts of Gas Hydrate R&D**: KIM Yu-Jeong & DEA Gi-Huh (Korea).
- **Economic Impacts on Generic R&D Projects Performed by Government-supported Research Institutes (GRIs) in Korea**: KIM Seong-Yong & AHN Eun-Young (Korea).
- **Academic Spillover of Geological Information**: AHN Eun-Young, KIM Seong-Yong & SON Byeong-Kook (Korea).

17:00–17:30 **Final Discussion – Conclusion**

19:30 **Visit of a “Heuriger”** in the outskirts of Vienna.

Sunday, October 16th

Excursion day

09:00 **Departure (by tram) from the Geological Survey** to Taborstraße (tunnel site under construction of the Viennese metro line U2 with geothermal utilization)

12.00–14.00 **Lunch and Official End of Symposium**

Afternoon

Sightseeing and / or

“The reef on the roof” – a “geological” walk through the city of Vienna (from the Opera to the Museum of Natural History).

Welcome and Opening of the Meeting

Hans P. SCHÖNLAUB
Geological Survey of Austria

Although the numbers of participants at this Symposium is rather small, the organizers are very pleased that representatives from as many countries as Germany, Switzerland, Belgium, Spain, Luxemburg, Korea, Ireland, The United Kingdom, Austria and even the Secretary General of EuroGeoSurveys are able to attend this important meeting.

In our opinion there is a clear connection between the activities of a Geological Survey and the economy. In the past earth science, politics and economy have been regarded as distinct spheres of human endeavour. However, time has come to start a more profound discussion on the interconnected relationships of these spheres and the benefits the geoscientific sector provides to the society. To date, the public at large is neither well informed about their activities nor about the services they provide for their well-being and economic growth. The lack of information concerns

- the products and services for planning and decision support systems
- the principal users and the economic sector who need these products
- the customers appraisal of the costs they have to pay for the data and
- the total costs incurring from their activities and finally,
- the added value of geoscientific expertise to the national economy.

The actual value of the benefits the geoscientific sector provides to the society can be measured in two approaches:

1. In a **qualitative approach** the value of geological expertise is reflected both on a long-term and mostly intangible basis. There are a few case studies available, e.g. from Ireland, UK and Austria which address different issues ranging from geology and society, water, natural hazards, raw materials, urban geology and infrastructure, land-use planning, nature protection, geoinformation, research and education, foreign aid and development and geotourism.

   In such studies the services of the geoscientific sector are listed, the potential users are identified and the risks in case such products and services were not available[1].

   Moreover, in our opinion, the intrinsic value of geological maps has long been underestimated. At GBA newly published maps are the results of combined efforts focusing on geological field studies, the documentation of geological hazards, hydrogeology, economic geology and airborne geophysical surveys. Hence, they represent a very comprehensive data source which acknowledges most demands from very different clients, let alone the extensive knowledge basis of complementary research and data storage activities.
2. The **quantitative approach** aims to measure potential Earth Science related benefits to society. In this approach, the economic value of different services that make significant contributions to the national economy are calculated or estimated, e.g., the value of specific landscapes, forests, water, protected areas, flood control etc.[2] In such cases, the economic relevance of a project is mainly determined by clients from the private or public sectors.

   The proper method to determine the economic relevance of an investment is to apply a cost-benefit-analysis (C/B). However, it is not easy to quantify the costs and benefits of collecting, managing and providing geodata in relation to the annual governmental investment to a Geological Survey or any other stakeholder. Most important benefits result from

- savings due to already existing data sets
- savings on running costs of a project [3]
- saving time on a project (e.g. for the planned Brenner railway tunnel in Tyrol or the Semmering tunnel in the eastern part of the Alps)
- improving the success rate achieved by exploration activities
- avoiding poor decisions, limiting liabilities and future costs.

Another approach to quantify the value of geological expertise is the application of the "Value Added Approach" developed by "Oxford Economic Research Ass. Ltd." (OXERA). This method aims to calculate the contribution of products and services of Geological Surveys to the gross national product (GNP). To date, two Geological Surveys have applied this method:

According to the Executive Summary of Roger Tym & Partners on "The Economic Benefit of the BGS" (NERC 2003) and the Annual Report of the National Geological Survey of the Netherlands for 2003 in a first step the different economic sectors were identified and subdivided according to the national statistics office. It is followed by the definition of the degree of dependence on a survey's products and services for each relevant industry sector as a source of input for production or operation.

At the end, this approach concluded a contribution between 5 and 8% of BGS to the GNP of Great Britain and between 3 and 7% of NITG-TNO in the Netherlands [4, 5].

In Austria two institutions specialized in socio-economic impact assessment of certain activities were contacted, i.e. the Department of Quantitative Economics at the Vienna University of Economics and Business Administration and the Institute of Technology Assessment at the Austrian Academy of Science, respectively, to comment on these proposed values. In short, they do not believe in such a high contribution to the GNP. Instead, they rather prefer Intellectual Capital (IC) Reports summarizing the outreach and output of a public entity.

Whether or not these numbers really reflect the actual contribution of Geological Surveys to the GNP of a country, it demonstrates the obvious value of geological expertise for the economy of a country, the need to promote applied geoscientific research and, finally, to establish a closer link between the Earth Science sector and the economy.

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[4] ROGER TYM & PARNERS, 2003: The Economic Benefit of the BGS. Executive Summary, 1-8, Natural Environment Research Council (NERC), London 2003.

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Chances and Risks, Trials and Errors Resulting from Measures to Increase Flexibility of Public Institutions, i.e. Geological Surveys

Michael MENTE
Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany

What are the procedures to sell geological expertise? What is the legal framework? What products could be sold? What are the existing markets? What are the cost drivers?

Some years ago the Curatorium of the BGR raised the question, whether BGR's business procedures, behaviour of staff and adopted legally flexible structures under the view of closer cooperation with industry. Additionally it was asked, if BGR with its own products, skills and know-how in addition with other consultants will be in the position to follow the international demand presented by international donor organisations.

To answer the above questions, in 2002 BGR prepared a concept for testing various marketing functions including implementation of a marketing office and the establishment of essential marketing procedures such as:

1. Evaluation of core competences and their balance with the global demand on geoscientific skills and know how
2. Identification of the legal framework and the consequences on a marketing function
3. Go ahead signal for further advancement
4. Implementation of a working group for execution of all work and for implementation of the adopted functions, definition of administrational and organisational framework following strictly the conditions of a change management plan, assignation of the responsibility to the Vice President, implementation of a Marketing Manager
5. Execution of a marketing analysis and identification of the global demand by donor organisations
6. Evaluation of quality and availability of BGR's products, skills, competences and know how
7. Assessment of offered performance and demand
8. Preparation of a detailed implementation plan and suggestions for further advancement
9. Preparation and execution of internal training courses to raise marketing skills and business acumen.
10. Commissioning a contract for a consultant to support BGR in the implementation process (step 5 to 9)

Forwarded by the ministry, a working group chaired by a former Director of one of the most important geological services performed the general evaluation of the BGR (see above step 1). In the results it was stated, that BGR with its skills follows demand in various cases and growing markets.

The 10 above mentioned steps were finalised with the following results:

- Specific potentials (unique selling points, i.e. know how related to final repository work) could cover clear requests easily and could be sold slightly without additional efforts. Recent publications and efficient lobby work will help to sell these products.
- For bigger strategic long term projects or global connected phenomena i.e. to assess global geo-systems or projects for climatic research a reduced commercial demand is estimated. But for BGR's potential for the realisation of short or medium term projects in various areas (ground water, emergency help, regional planning, natural resources, institution building aso.) there will be a raised demand by donor organisations.
- The existing framework allows participation in tendering procedures only under specific conditions, postulating, that the prices will be fixed on a raised level and no negotiations are allowed. Because of high prices, the market position will be slightly poor. What are the reasons:
  - Following the full cost principle incl. overhead (only under specific conditions staff cost without overhead are accepted)
  - No splitting related of average cost regarding divisions, departments, units.
  - Benefits have to be transferred to ministry
  - No budget for acquisition of contracts
  - Projects within a consortium are not eligible because of assurance problems (jointly and severally liability)
  - It will be not allowed to sign assurance contracts (i.e. for foreign currency projects)
  - Contracts in foreign currency are not allowed (assurance problem)
  - In specific cases intellectual property rights do not allow broad dissemination of results. Normally geological surveys (i.e. USGS) have to spread results and data worldwide and without charge
- Because of decreasing benefits (reduced allowance, if complete camp will be arranged), reduced or no abroad payments (in the case of short term projects) or reduced or no stimulation fee, public servants will not be attracted to join project teams (divided from family, extreme climatic conditions, health risks, logistic risks, security problems aso.)

Recommendations

- The geological survey should concentrate acquisition in the sectors of unique selling point, where a market leadership or a market control could easily be maintained.
- The role of the geological survey has to be adopted to each contract. The survey will join projects preferably as a subcontractor or as a leader without consortium (only possible in smaller projects).

Products, Costs and Benefits of State-Provided Geological Information in Switzerland

Markus SPINATSCH
Beratung für Politik und Verwaltung, Bern, Switzerland

Since the middle of the nineteenth century the Swiss state has been promoting the production of geological maps, and since the nineteen seventies there also has existed a systematic observation of ground-water occurrences. In former times, these activities served above all the interests of academic research. Today, as in many other European countries, they are considered as indispensable tasks of the state.

Products

Today the Swiss Geological Survey produces information and knowledge of the underground with three core products:

- the Geological Atlas of Switzerland, consisting of geological maps at a scale of 1 : 25,000, currently covering about half of the country's surface
- the systematic, continuous surveying and processing of information about the quality and quantity of underground water
- the supply of archived, but not published geological information.

Within the context of these core products, the service also offers additional products like geological and hydrogeological maps at other scales, academic publications and consulting services or the national coordination of tracer tests in groundwater.

Costs

The total annual costs of the Swiss Geological Survey total about 5 million Euros. About half of this amount is spent for the production of maps, one third is used for groundwater observation and for the archive of geological information.

Utilization and main users

The geological information and knowledge provided by the Swiss Geological Survey serve primarily for the (early) detection of problems and the planning and evaluation of construction projects like e.g. the construction of roads and tunnels, drinking water supply, environmental protection (water, refuse dumps), the exploitation of raw materials, such as sand or gravel, the storage of radioactive waste, the prevention of natural hazards (earthquake, rockslides) or the assessment of the consequences of the climatic change. The most important primary beneficiaries of this information and knowledge are different agencies of the federal and the cantonal administrations, the power supply industry, the universities as well as private geology and engineer's bureaus.

Societal and economic usefulness

The products of the Swiss Geological Survey contribute substantially to the early detection and prevention of natural hazards. They can help to prevent great human disasters and large material damages. The ground-water observation is an indispensable element of the implementation of the federal law of water protection. The costs to produce this information is by far exceeded by the multiple economic benefits. With the in all probability increasing climate change and a continuing intensive use and exploitation of the underground, the need for geological information and expertise will without doubt further increase in future.

Benefit and Limit of Underground Investigation

Kurt KLIMA & Gerfried SWOBODA
Institute for Applied Geosciences, University of Technology, Graz, Austria

For tunnel projects, many different investigation methods e.g. aerial photo interpretation, geophysical methods, core drilling, geological mapping, are used. All of the site investigation methods are intimately connected among each another. Due to this network it is difficult to express the benefit of individual methods objectively. Exploratory drilling and geological field mapping are the most important methods for the site investigation. Therefore these two methods were selected to analyze the cost-benefit relation.

Four simplified geological models, derived from a real geological documentation of a 2340 m long tunnel with a mean overburden of 166 m, were used.

The delineated geological models differ in the geological complexity of the ground. The most complex model is made up of 25 types of rock and with 91 changes of rock type along the tunnel. The simple model uses 4 types of rock and 8 changes of rock types within the total tunnel length. To keep the cost-benefit analysis manageable, only the lithological sequence at tunnel level was considered.

The underground investigations, for detecting the ground conditions of these models, are simulated by a certain number of randomly situated drillings. The number of drillings was chosen within the range from 2 to 65.

Based on the information on the lithological sequence at tunnel level, accomplished by simulated drillings, new geological models are created and compared with the original model. The result is expressed as percentage of match of the new model compared to the original model.

The obtainable “theoretical prediction result” is established on the basis of this comparison. The simple computing procedure is repeated 10000 times in order to obtain statistical reliable and representative results.

The statistical evaluation of the data gives a general tendency of a cost-benefit relation: For a low number of drill holes the level of information is increasing with the amount of drill holes. With rising number of drillings, costs are increasing not in proportion to the gain of new information, expressed as percentage of match, depending on the geological complexity.

The comparison of the “theoretical prediction result” from randomly arranged drillings with drilling arranged on basis of a geological model demonstrates the importance of geological field mapping: subsurface investigation by randomly arranged drillings, under certain geological conditions, may cause a substantial increase in costs of the drilling program compared to the gain of geological information.

A most economical optimization of the underground investigation program can only be achieved on basis of geological field mapping.

Methods to Determine Speciation and Importance for Risk Assessment: Case Study from Port-Romano Albania

Aurela SHTIZA & Rudy SWENNEN
University Leuven, Belgium

Chromium ore has been treated to produce chromate and bichromate salts from 1972 till 1993 in the chemical plant of Porto-Romano. During the manufacturing of these salts huge quantities of Chromate Ore Processing Residue (COPR) were released in a nearby field yielding a yellow color to surface "soils". Continuous leaching of this waste results in yellow-colored surface water runoff and yellow "chromate blooms" on the site. The basement of the polluted site is composed of silty clay quaternary swamp sediments rich in iron oxides and organic matter.

Deciphering the background (naturally occurring) from anthropogenic (man-made) signals is a first step in the risk assessment study. The Cr background values 5–7 km distant from the study area vary around 200 mg/kg. Sediment profiles at a depth of >1 m within the yellow field were carried out in an attempt to reconstruct the pollution through time. The total concentration of Cr in the profiles varied between 1311–12198 mg/kg. However is not the total concentration of Cr but rather its valence state (VI) and (III) that is of primary importance in environmental studies.

Different ways exist to determine the valence state of chromium: mineralogy (sediments), colorimetry (water samples) and for pH long time changes the pH_{stat} tests.

The mineralogy consisted in the determination of the clays, pollutant phases and the association of the pollutants with the sediments.

The determination of the total content of Cr^{VI} was made with a 5-five step extraction, the so called Cascade Leaching Test (CLT). Approximately 70–90% of the total content of Cr in the pond sediments is present as Cr^{III}, while 30–10% of it occurs as Cr^{VI}. The water leaching the COPR from the samples taken from pond profiles in the study area is alarming, with maximum ~2400 mg/kg Cr^{VI} leached from a sample containing a total concentration of Cr 12200 mg/kg (profile D).

As deduced from the pH_{stat}, acidification at pH<4 will enhance the leaching of both Cr species Cr^{VI} and Cr^{III}, while in basic pH values (respectively 8 and 10) the concentration of Cr(VI) released in solutions increased. This results emphasize that remediation of this industrial site is urgent.

The R&D-Programme GEOTECHNOLOGIEN – Interface Between Science and Application

Ludwig STROINK
GEOTECHNOLOGIEN Coordination Office, Potsdam, Germany

GEOTECHNOLOGIEN is a multidisciplinary German R&D programme started in 2000 and funded by the Federal Ministry for Education and Research (BMBF) and the German Research Council (DFG). The Programme designed to run over a 10 year period comprises 13 thematic priority areas of major scientific, societal and economic significance. Overall aim is a better understanding of the complex processes underlying the system Earth and the development of new prevention strategies and negotiation options for a sustainable management of "Planet Earth". Consequently research mainly focuses on applied and interdisciplinary topics, like

"Earth Observation from Space", "The Development of Early Warning Systems","The evaluation and sustainable utilization of the underground", or "Gashydrates in the Geo-Biosystem".

Seven topics with more than 120 research projects are already funded. Of high national and international acceptance are for example those projects which focus on the participation in international satellite missions, like CHAMP, GRACE or GOCE or on activities dealing with the chances and risks of gashydrates. In summer 2005 a portfolio of 10 research projects between academia and industry has been started, dealing with the ecologic and economic perspectives of the underground storage of the greenhouse gas CO_2. Overall aim of these integrated joint projects – incorporating universities, research institutions and SMEs – is an assessment of the various options for underground CO_2-storage in Germany. Forthcoming research activities of the GEOTECHNOLOGIEN programme deal with the development and application of early warning systems and technological aspects of mineral surfaces. Without doubt, scientific excellence is the most important demand for funded projects of the R&D-Programme GEOTECHNOLOGIEN. However, due to the high potential of the scientific topics for application, a strong cooperation between research institutions and companies is expected. GEOTECHNOLOGIEN offers a broad platform for joint projects with the industry.

The talk gives an overview on some successful co-operations between science and application, presents some new technological product developments in the frame of the R&D-Programme GEOTECHNOLOGIEN and presents the different efforts of the Programme-Management to integrate small and medium enterprises. Beyond that, it will show how stakeholders, politicians and the broad public can be informed about the value of geoscientific competence and their relevance for society.

Geology as Cultural Mission and Economic Amortization Calculations: a Stress-Field

H.G. KRENMAYR
Geological Survey of Austria

The conventional semantic content of the term "Cost-Benefit-Analysis (CBA)" seems to mirror a widespread shortening of argumentation in respect to financial coverage of scientific institutions.

The term "costs" on the input side may be more or less clearly defined, even though changing rates of inflation and the fluctuating level of interest prevent us from knowing exactly which effort we are truly investing by spending a certain amount of money, or say rather, which effort we will have to invest later on when paying back our debts.

On the output side the same goal is being strived for: the "benefit" should be expressed in numbers as clearly as possible, in order to compare it to the costs. This may be more or less possible for a certain portion of the benefit in the case of earth sciences and of course it is very important to try! However for a rather substantial portion of the benefit this trial is doomed to fail from the beginning.

That substantial portion, not suitable for monetary rating, is endangered to be completely forgotten. The final aim, which is financial coverage of our scientific institutions, will of course suffer from this truncation of arguments. Moreover this strategy suggests (or at least seems to silently accept) that monetary input in any case is only acceptable if it is followed by a direct or indirect monetary output.

In order to provide for a rationale of these statements a closer view into the structure of motivation of involved stakeholders might help.

According to J. Mittelstraß (speech on the occasion of the opening ceremony of the new building of the Geological Survey, Vienna, 2005), professor of philosophy at the University of Konstanz, curiosity is the main driving force of science. From a historical viewpoint this might be less clear for the earth sciences than for other disciplines, as the demand of raw materials frequently was (and still is) a prime motivation of research activities.

But also in a historic context we should distinguish between those who pay for science, those who carry out scientific research and those who apply its findings. In case of the researchers themselves, curiosity may in fact be regarded as the most important motivation factor.

The structure of motivation behind all kinds of men's actions however, is highly complex and is itself an object of extensive research work. A first attempt to analyze the motivation structure of the three stakeholders involved in the earth sciences is given below. The order of enumeration is random and no ethic validation or quantitative estimation is given here:

1. Politicians and public servants within ministries as money lenders:
    - public and institutional pressure
    - awareness of responsibility – insight into the importance of earth sciences
    - personal interest and curiosity
    - goals of structural policy
    - connections – human personal relations with money receivers
    - possibility to expand the own sphere of control
    - habit

2. Scientists at geological surveys:
   - institutional pressure
   - awareness of responsibility – insight into the importance of own work
   - scientific interest and curiosity
   - career interest
   - appreciation by colleagues
   - salary
3. Consumers of services of geological surveys:
   - practical need to fulfil legal requirements
   - practical need out of economic interests
   - personal interest and curiosity

Maximum benefit for all stakeholders who are connected in a system can be achieved, if the different motifs are mutually recognized and taken into account. This includes the awareness of the power of each stakeholder to be able to even influence the motivation structure of the others up to some degree.

If we, as representatives of scientific institutions, use CBAs of only monetary implication as our arguments, we miss the opportunity to present our services primarily as outstanding cultural achievements, symbolized by geological maps. However, in doing so we also fail to address the complete motivation structure of our system partners.

Isn't it much nicer to spend money on something we enjoy than on something which we rationally shouldn't foregoe?

So is it true then, that geology as cultural mission and CBAs of public geological services represent two poles of a stress field? I would rather suggest, that these two aspects build up a powerful synergetic unit. However, this unit can develop its full potential only if we seize up the chance and argue on the basis of both of these aspects.

Cost-Benefit Maps in Prevention of Geobiological Risks: a Methodology Based on GIS Techniques

J. SEPÚLVEDA[1], J.L. RETOLAZA[2] & M. MENDIZABAL[3]
[1]GIS-TELEDEK, [2] UPV/EHU, Facultad de Economia y Ciencias Empresariales,
[3] UPV/EHU, Facultad de Ciencias y Tecnología. All: Bilbao, Spain.

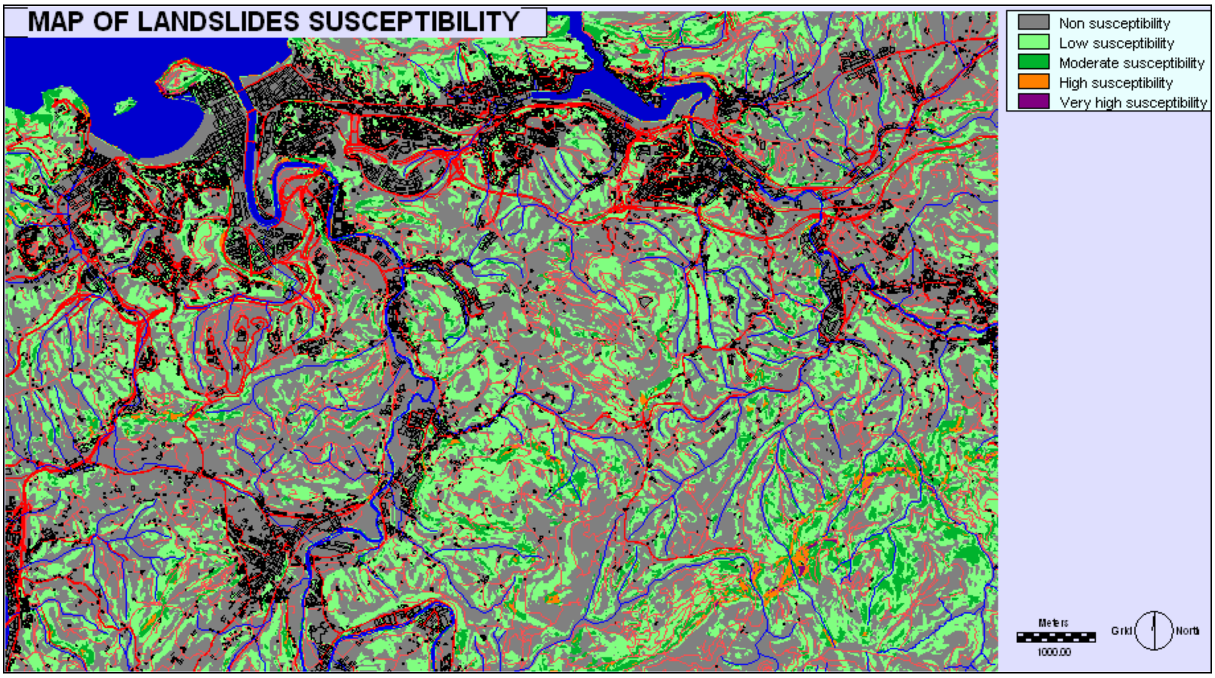
The spectacular development experienced in the last years of the applications based on GIS technology (Geografical Information System) and its extension to the civil scope, has allowed a qualitative jump in studies of natural risks. In this sense we can review (MORA-VHARSON, 1984; WU, YIN & LIU, 2000; VARNES, 1984; ALZATE, J.B. & ESCOBAR, A.E 1992). Nevertheless the advance in identification of risks is only part, important but partial, in the prevention of such; this implies, not only the detection, but also the application of preventive measures, or in their case restrictive measures with respect to the detected risk. In this sense and in general, since the resources required for affronting the totality of identified risks exceed the resources available, it becomes necessary to complement the mentioned Maps of Risks Identification of (MRI) with some instrument that allows to decide upon the usable resources in the prevention, as well as the priority in the sequence of measures to adopt. In this line, the methods of cost-benefit analysis, widely developed in economic sciences for the valuation of public investments, suppose a methodology, proven and complementary, that developed of joint form with the Maps of Risks Identification, allows to make authentic Maps of Risks Prevention (MRP). In the present communication we approached in a systematic form the process of conjunction of both methodologies, illustrating it in the concrete case of San Sebastian city where we have made the experimental study to validate the methodology.

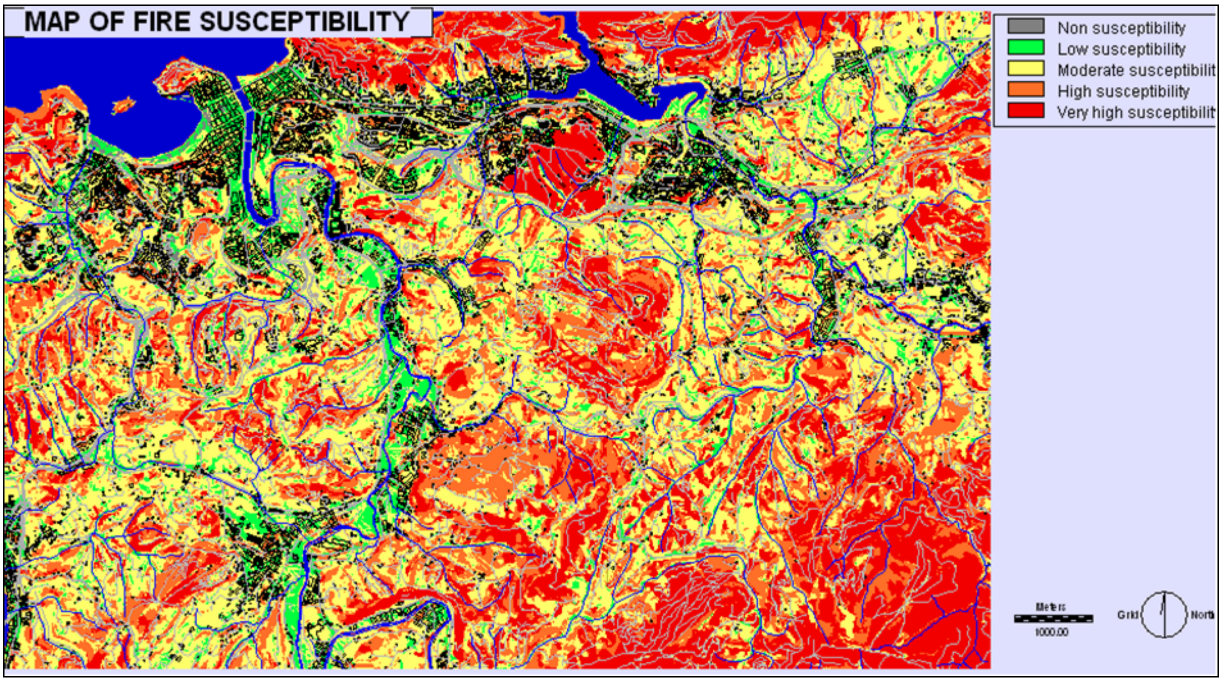
Maps of Risks Identification (MRI)

In the following maps it is possible to evaluate the degree of susceptibility in relation to two possible dangers: landslides and fires.The risk has been classified in five categories, assigning to them a rank from 1 to 5 based on the degree of danger; 1) without risk, 2) low risk, 3) moderate risk, 4) high risk, and 5) very high risk.

With regard to the vulnerability of the different affected potential zones, a ranking from 1–5 has been developed, that classifies the risk in: 1) non vulnerability, 2) low, 3) moderate, 4) high, 5) very high, based on the score obtained by the multiplication of the percentage of ground – occupied by each type of use – and the values assigned to each one of them, based on the addition of the three used factors of weighting, which are: 1) type of construction, 2) type of infrastructures, 3) density of population.

On the other hand the risk (VERNES, 1984) will be defin,ded by the degree of loss attributable to particular phenomena of natural character, and it would be the product of weighted risk and vulnerability. This would allow us to define a matrix of 15 squares, based on the relation established between risk and vulnerability.





Vulnerability	Null (1)	Low (2)	Moderate (3)	High (4)	Very high (5)
Null (1)	1	2	3	4	5
Low (2)	2	4	6	8	10
Moderate (3)	3	6	9	12	15
High (4)	4	8	12	16	20
Very high (5)	5	10	15	20	25

Up to here, we have seen that the analysis of risks can be presented in graphical form (GIS) or in a numerical matrix, both being complementary; however, as we have indicated, for being able to make decisions on investments in the prevention or restriction from risks, the work done until now is insufficient, making necessary a cost-benefit analysis.

In this analysis, first we must choose the unit of calculation: meter, streets, districts, areas ... We have selected the m^2, considering that it is the minimum unit in which all the units of calculation can be divided of mathematical form, making possible a measurement of objective comparison among other possible units of calculation with greater ecological meaning.

We have attributed an unitary value of 2,800 € per meter to the square meter constructed in a maximun weighted zone, whereas to lands without advantage we have attributed a minimun value of 50 € per meter. The rest of values is obtained multiplying by 36^2 the assigned weighed factor. From this data it is necessary to multiply the square meter of land by the index of constructed meters, obtained like a function between the index of advantage of the land and the average number of levels of the buildings of the zone. Obtaining the value of replacement per square meter, multiplying it by the existing meters in a certain zone, district or area, we could calculate the value of restoration of the same, and therefore the benefit obtained by the preventive measures in case the predicted risks materialized.

Despite the calculation of the obtained benefit thanks to the saving, we introduce a factor of uncertainty in relation to the probability of occurrence of risk update; in this sense the GISACOBE methodology proposes to calculate the probability for a disaster to happen in the area of maximum risk, and by an operation of investment, to calculate in an infinite series, the average period of years of phenomenon occurrence. The benefit will be obtained by dividing the restoration value of the study area between the average value of the risk update. From this form we will have one of the values of the cost-benefit equation.

The other value, relative to the cost of the investment in preventive measures or in the advance payment of palliatives measures, is obtained by calculating those investments that can be specific in each situation; despite this differential analysis of unitary character it would have a very high study cost; therefore we propose to carry out standard measures in prevention of risks, in which specific high cost studies are contemplated in areas of maximum risk only (susceptibility * vulnerability). On the other four levels of risk we propose an accumulative process based on the successive detected levels of risk.

The general solutions proposed would be:

1) precise campaigns of citizen information,
2) informative installation of posters and panels with permanent character,
3) prevention and damages minimizing courses,
4) realization of preventive measures of general character (fire-resistance, establishment of slopes ...) and installation of accesses and infrastructures for the aid services.

The standard cost of these performances is divided by the square meters that the predicted performance covers, obtaining the cost of investment by square meter based on the risk. From this cost we subtract the benefit obtained previously by the saving in the replacement, which is going to give a numerical result to us, which, if positive, will indicate the saving attributed to the execution of the propose preventive measures, and if negative, would indicate the saving obtained with the non realization of performances, although in this equation only the material costs and not personal cost attributable to the affected people are included. Thus even in case of a negative result preventive measures can be interesting.

Complementarily, but equally important, the obtained results allow a classification ordered in relation to the different risks and prevention zones, which allows us, in case of limited resources, to optimize these resources using them in the best relation of obtained benefit.

Convincing Society to Fund and Use Geoscience Expertise

Peadar McARDLE & Patrick J. O'CONNOR
Geological Survey of Ireland, Dublin

A resource and environmental survey of Ireland

In 2000 GSI and the Geological Survey of Northern Ireland (GSNI) developed (with the support of the British Geological Survey and the United States Geological Survey) a proposal for systematic geophysical and geochemical surveys of Ireland and Northern Ireland. The proposal was known as the Resource and Environmental Survey of Ireland (RESI). The Environmental Institute of University College Dublin was commissioned to undertake a CBA of the proposal (BULLOCK & CLINCH, 2001). The purpose of the CBA was to measure the proposal's net benefits to society. BULLOCK & CLINCH (2001) reported that few similar CBA case studies were available and equally that relevant data were scarce, especially in relation to Ireland. This may reflect the fact that benefits tend to be both long-term and indirect.

The CBA identified a wide range of potential benefits, spanning mineral exploration, health, water quality, land use, environmental management and infrastructure. The Net Present Value (NPV) of each benefit (Table 1) is based on the middle estimate using a discount rate of 5%.

Table 1: Summary of RESI benefits:

		€ million
Mining and Exploration		
Exploration	24.1	
Minerals	34.3	
Aggregates	10.2	68.6
Infrastructure		
Water supply	22.7	
Landfill siting	14.5	
Electricity substations	3.2	40.4
Land Management		
Toxicity and deficiency in beef output	17.8	
Acidification and forestry siting	13.0	
Nitrate-vulnerable zones	2.5	33.3
Water		
Water Framework Directive	4.7	
Clean water supplies	11.2	15.9
Radiation		5.3
Contaminated Land		3.3
Total		**€ 166.8 million**

BULLOCK & CLINCH (2001) identified a benefit-cost ratio for RESI of 5 : 1. This was considered a very attractive ratio in comparison with those of other environmental proposals. Subsequently the Government of Northern Ireland approved the TELLUS project through which GSNI is implementing the components of RESI within Northern Ireland. GSI has not received funding to implement RESI within the Republic of Ireland. The failure to get funding for RESI caused GSI to review how it was evaluating its project proposals and to address issues which would ensure that Irish society would benefit from them.

Beyond CBAs

The qualitative approach may be equally powerful to the quantified outcomes of a CBA. For example, GSI recently published a brochure (ANON, 2005) to demonstrate the value of its geological services. It lists the issues that the services of GSI are intended to address. It documents the reduced risks enjoyed by society in Ireland as a result of these services and it identifies the specific sectors that benefit from them.

Sponsor confidence: It is important that potential funders have confidence that a particular proposal, if implemented, will have a successful outcome. This can be ensured by applying project management techniques to proposals and ensuring that they are adequately costed, scoped, scheduled and planned. This will reduce the project risks and ensure that funders have realistic expectations.

A major issue facing database managers is the establishment of an appropriate data release policy. There tend to be two opposing policy drivers. One seeks to maximise the societal benefit from data generated by Exchequer funding and wishes to see data provided freely and easily to the largest number of users. The second driver seeks a revenue return on Exchequer investments and would encourage database managers to focus on potential customers who are willing to pay economic rates for access. There is a prevailing view that the former is more appropriate for geoscience databases but that national governments would favour the latter. In practice, free access is provided for the third level sector where it is engaged in research, while charges apply in the case of commercial users.

New customers and needs

Catching attention may be much easier when geoscience activities are presented as one dimension of a geoscience sector which has considerable economic impact. The geoscience sector comprises the customers and stakeholders for, as well as the providers of, geoscience services, research and education. In Ireland it is estimated that industry associated with the sector has an annual turnover of at least € 2 billion while geoscience services generate turnover of € 130 million with 1,000 employees. The more the sector is recognised as contributing to national wealth and quality of life, the more easily will it be funded.

Public sector organisations, like national geological surveys, can ensure they have maximum societal impact through the manner in which they manage their databases. For example, it is now widely recognised that users of geoscience databases prefer to access them in digital format and online, and that their content should, as far as possible, include real-time monitoring data and not just legacy baseline data. Society now requires that changes in baseline data on geological processes be measured and this involves regular monitoring.

This prompts the question as to what sort of databases will be useful in the future. Firstly, the type of customer is likely to change, with fewer expert geoscientists involved and a higher proportion of end-users without geological expertise. Instead of the expert-to-expert dialogue of the past, we will engage increasingly with businesses and members of the public who require processed and interpreted information or, preferably, information customised to their specific needs. We must involve the customer as fully as possible.
Outreach is a final factor that is important for funding, which can be assured only when there is improved societal awareness. There is a "Ladder of Awareness" which has the following steps:

Discovery: Persons who are not engaged with geoscience can experience the excitement of discovering new insights, i.e. captures the widest public and a flurry of media attention.
Leisure activities: There is increased engagement with a smaller audience when geoscience is linked to leisure activities.Only the committed media will take note.
Utility: At this level of awareness, we are seeking customers to commission geoscience services. For many geological surveys this will be the most valuable form of marketing, but media will not be interested.

All three levels of awareness are important and are necessary in order to ensure adequate awareness of the benefit of geoscience.

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Translating Geological Data into Information for Land and Property Owners

David FALVEY & Keith WESTHEAD
British Geological Survey*, Nottingham

Through its *GeoReports* service, the BGS has found a way to deliver comprehensible and usable information on a range of land stability issues that effect individual homeowners and developers. Customers can choose from a range of affordable reports tailored to their chosen location, which they can order online and have delivered quickly in digital form, doing away with the need for them to interpret paper maps, books and databases.

GeoReports uses innovative technologies and workflows to extract information from BGS digital environmental datasets and deliver this, alongside individually tailored advice from scientists if required, all within the rapid turnarounds required by the modern environmental business.

GeoReports serves several high value market sectors in the UK. These sectors include the new home building sector (worth €15 billion per year), existing house conveyancing sector (worth €200 billion per year), and the commercial construction sector (worth €30 billion per year).

There are many individual examples of how *GeoReports* saves people time and money:

- Wind farm projects can reduce their environmental impact and save many €1000s by using *GeoReports* to predict hazards, such as unstable peaty slopes, and minimise the need for invasive site surveys.
- Commercial developers for road schemes, supermarkets, etc, can save many €10,000s by using *GeoReports* to advise them on site geology rather than drilling many expensive boreholes.
- House builders can save many €100,000s per development by using *GeoReports* to predict ground conditions or radon hazards and prevent over-design of foundations.
- Farmers can save many €1000s by using *GeoReports* to predict where best to find groundwater and saving on wasted drilling.
- Commercial businesses or home owners can save many €1000s by using *GeoReports* to advise them on the most appropriate ground source heat pump design.
- Homebuyers can save many €1000s by learning from *GeoReports* about potential subsidence hazards before they buy a house.

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* The British Geological Survey (BGS) is a component body of the Natural Environment Research Council (NERC) and is the primary source for national geological information and knowledge in the UK.

Study on a Sustainability Evaluation System of Natural Resources: Environmental & Economic & Scio impacts of Gas Hydrate R&D (Poster)

KIM Yu-Jeong & DEA GI-Huh
Korea Institute of Geoscience and mineral Resources (KIGAM), Daejeon, Korea

Gas hydrates draw great attention recently as a new energy being able to replace conventional oil and gas hydrates, their presumed huge amount of volume reaching 10 trillion tons of gas with environmentally friendly characteristics. Gas hydrates can compensate the rapidly increasing consumption of natural gas in Korea and achieve the self support target by 2010 which is 30% of the total natural gas demand. This paper shows the importance and benefit of Gas hydrates compared with new & renewable energy in Korea.

1. Economic Benefit

The improvement of Energy Security

In Korea, the energy production volume from solar, wind and biomass is very small, corresponding to about 1–2% of the total energy supply, due to regional limitations like narrow land and climate conditions.

The estimated amount of gas hydrate deposits is about six hundred millions of tons in the east coast of Korea. It helps to improve the reliability of the energy supply by reducing the Community's growing dependence on imported energy sources.

The development cost

Although the development cost of gas hydrate is high at present, it is expected to be economically competitive with conventional energy sources in the medium to long term.

2. Environmental Benefit

The reduction of CO_2 emission

The diversity of demand sectors

Solar energy and wind energy are used mainly to generate electricity or to operate cooling and heating systems.

As gas hydrate can substitute petroleum and natural gas, it has very broad demand sectors as residential, industrial and commercial and transport. Specially, it is very important that gas hydrate can be used as vehicle fuel covering a large portion of the energy demand. Vehicle emissions have an impact on air quality. Conventional Vehicle fossil fuel like petroleum produces many harmful gases as CO_2, SO_x, NO_x. Gas hydrate emits a little NO_x and no SO_x. Other new and renewable energy resources cannot reach this effect except hydrogen energy.

3. Scio Benefit

Energy intensity
As energy intensities of new and renewable energies (wind energy, biomass, solar thermal photovoltaic) are very low, these energies require land for producing energy.
Gas hydrate is gained from the ocean, its production does not need land.

Low resident resistance
Biomass has the problem of foul smell, the production ofwind energy makes noise, an eco-system problem. These problems lead to resident resistance when the development plants are established. In the case of gas hydrate the number of civil petition is little because it is developed and explored in the ocean.

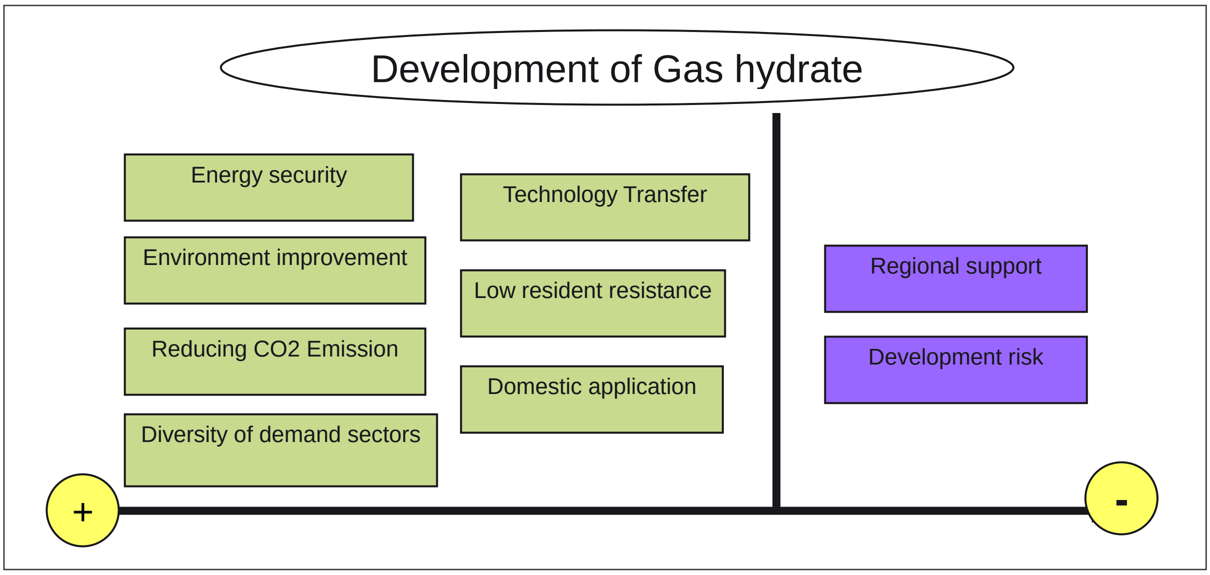

Fig. 1: The strength and weakness of gas hydrate development compared to other energy resources

Economic Impacts on Generic R&D Projects Performed by Government-Supported Research Institutes (GRIs) in Korea (Poster)

KIM Seong-Yong & AHN Eun-Young
Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Korea

In order to improve the efficiency and the effectiveness of Korea's R&D programs and to establish the successful implementation of performance-based R&D management systems, the measurement of economic impacts on generic R&D projects has been enhanced by government-supported research institutes (GRIs). Recently, the increase in demand for the assessment of economic impacts is to promote better resource allocation through well-informed decision-making by the Korean government and its respective agencies.

In this study, a comparative analysis was conducted on the economic impacts from the generic technology projects of the 8 GRIs including the Korea Institute of Geoscience and Mineral Resources (KIGAM). The economic impact characteristics of each of the technologies from the GRIs were analyzed and compared with benefit/cost ratio (BCR), net present value (NPV) and social rate of return (SRR).

The benefit assessment was calculated by the contingent valuation method (CVM) with respect to the projects of KIGAM, KORDI and KISTI, by the counter-factual evaluation model (CEM) with respect to the projects of KRRI and KRISS, by the CEM and market value approach with respect to the project in KARI, by the market value approach with respect to the project of KIER, and by the life cycle assessment (LCA) with respect to the project of KICT. As a result, a measurement of economic impact was identified as the different benefit assessment and valuation method according to the characteristics of the generic technologies.

In the case study of KIGAM, the project's economic impacts in present value of the year 2003, with applying a discount rate of 10.0%, were identified and estimated as 13.3 points in BCR, 67.7 million USD in benefit, 62.6 million USD in NPV, and 152 percent in SRR, respectively. As the case study project carried out by KIGAM, benefit indices of *groundwater remediation of the metropolitan cities in Korea* show a setup using drinking water facilities, groundwater and geological information itself, and use of information by Korea local governments.

It was revealed that the assessment of economic impacts from Korea's generic R&D projects varied with the value assessment method in BCR, NPV and SRR. Therefore, it is unreasonable to make a comparison with arithmetic values calculated from different methods, because their values depend on the analysts, research cost and duration, and characteristics and industrial environments of technology. Still, their values will be used to understand the trends and characteristics of the technology itself.

To more effectively analyze the economic impacts on generic R&D projects, a roadmap describing the input-output-outcome relationships is required to reflect the characteristics of the concerned technology.

Academic Spillover of Geological Information
(Poster)

AHN Eun-Young*, KIM Seong-Yong & SON Byeong-Kook
Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Korea.

Key words: Geological maps, Spillover, Duration, Bibliographical method

To analyze the whole-time effects of research and development (R&D) and public works, estimations of the duration of the related benefits and costs is needed. In many cases, the amounts of the costs and the related time periods are visible, but determining their benefits is problematic. Furthermore, although R&D and public works in geology are expected to derive long-term benefits, the period of the benefits is not easily measured. In this research, we propose using the bibliographical method to quantify the academic spillover of geological maps.

1. Academic Spillover

The recent interest in outcomes of R&D provides the motivation for the empirical study of the social and private effects of R&D on geological information. GRILICHES (2001) writes that new-growth economics has re-emphasized two points: technical change is the result of conscious economic investments and explicit decisions by many different economic units. Unless there are significant externalities, spillover or other sources of increasing social returns, it is unlikely that economic growth can proceed at a constant, undiminished rate in the future. Spillover is defined as a side effect arising from (or as if from) an unpredicted source. Following this definition, the academic spillover of geological information can be defined as the side effects sustained by academe, arising from geological mapping and geological maps.

2. Method

Academic spillover of geological information can be measured via the bibliographical method, by examining researchers' papers in geological mapping programs and papers that contain geological maps. Researchers' papers in geological mapping programs are usually counted and evaluated by authorities during the mapping, so we have focused in our own study on quantifying papers that contribute geological maps. LEE (2002) measured the academic spillover of a public work exchanging high technology equipment by counting papers with contributions to public work; in this research, we assume that papers that contribute geological maps also have references citing geological maps, enabling one to find maps through the papers' respective reference lists. Publications in geology using this analysis include the *Journal of the Geology Society of Korea*, the *Journal of the Korean Society of Economic and Environmental Geology* and the *Journal of the Petrological Society of Korea*.

3. Results

Amount of Academic Spillover

The total number of cited geological maps from the years 2000 to 2004 is 377, with the annual average being 75. Ratios of citation are 2.11 maps per citation paper and 0.68 per total paper; furthermore, the ratio within the citation paper is 0.32 maps per paper. Because of this result, we expect that 0.7 geological maps would be contributed to each paper in the geology field.

Table 1: Results of the citation index

	2000	2001	2002	2003	2004	Total	Annual Average
Cited number (A)	100	77	82	45	73	377	75
(per citation paper) (A/B)	(2.56)	(1.75)	(2.10)	(2.14)	(2.03)	(2.11)	–
(per total paper) (A/C)	(1.02)	(0.64)	(0.71)	(0.42)	(0.62)	(0.68)	–
Citation paper # (B)	39	44	39	21	36	179	36
(per total paper) (B/C)	(0.40)	(0.37)	(0.34)	(0.20)	(0.31)	(0.32)	–
Total paper # (C)	98	120	115	106	117	556	111

Duration of Academic Spillover

In the total data (2000 to 2004), the first quartile is 18 years and the third quartile 35 years, with the mean and mode being 27 and 37 years respectively. With these results, we can assume that the duration of the academic spillover of geological information is 18 to 35 years, with the average being 27 years.

Table 2: Result of the duration

	2000	2001	2002	2003	2004	Total	Average
Mean	27.8	24.1	27.9	25.6	28.9	27.0	26.9
Mode	37	38	39	35	30	37	–
Min	2	1	4	3	4	1	2.8
Q1	20	18	18.5	10	21	18	17.5
Q2	27	26	29	28	30	28	28.0
Q3	33	34	36.8	35	37	35	35.2
Max	76	39	77	85	80	85	71.4
Standard deviation	13.6	11.1	12.8	16.8	14.36	13.6	–
Kurtosis	4.67	-0.70	2.71	2.99	2.88	3.25	–
Skewness	1.66	-0.60	0.71	1.16	1.04	1.01	–

This research could have long-reaching implications, in that it proposes a bibliographical method and quantifies the long-term effects of geological information via academic spillover. However, quantified academic spillover of geological information can differ in terms of their effects on industry and public works.

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Excursion 1

and

Excursion 2

List of Participants

AHN Eun-Young
Korea Institute of Geoscience and Mineral Resources (KIGAM)
Policy Research Group
30 Kajung-dong Yuseong-gu
305-350 Daejeon
Korea
Tel.: +82-42-868-3062
eyahn@kigam.re.kr
www.kigam.re.kr

Patrice CHRISTMANN
EuroGeoSurveys
Rue du Luxembourg 3, B-1000 Bruxelles
Belgium
p.christmann@eurogeosurveys.org
www.eurogeosurveys.org

Godwin E. EBOH
Universität Hamburg
Inst. f. Geologie u. Paläontologie
Bundesstraße 55, D-20146 Hamburg
Germany
eboh@geowiss.uni-hamburg.de
www.geowiss.uni-hamburg.de

David A. FALVEY
British Geological Survey
Kingsley Dunham Centre
Keyworth, Nottingham NG12 5GG.
United Kingdom
dfalvey@bgs.ac.uk
www.bgs.ac.uk

Eckart GEISSLER
Landesamt für Umwelt und Geologie
PF 80 01 32, D-01101 Dresden
Germany
Eckart.Geissler@lfug.smul.sachsen.de
www.umwelt.sachsen.de/lfug

Hansruedi GRAF
MBN AG
Mäderstraße 8
Postfach, CH-5401 Baden
Switzerland
h.graf@mbn.ch
www.mbn.ch

Thomas HOFMANN
Geological Survey of Austria
Neulinggasse 38, A-1030 Vienna
Austria
thomas.hofmann@geologie.ac.at
www.geologie.ac.at

KIM Yu-Jeong
Korea Institute of Geoscience and Mineral Resources (KIGAM)
R&D Policy Research Group
30 Kajung-dong Yuseong-gu,
305-350 Daejeon
Korea
Tel.: +82-42-868-3025
kyj@kigam.re.kr
www.kigam.re.kr

Kurt KLIMA
Institute of Applied Geosciences
Graz University of Technology
Rechbauerstraße 12, A-8010 Graz
Austria
k.klima@tugraz.at
www.egam.tugraz.at

Hans-Georg KRENMAYR
Geological Survey of Austria
Neulinggasse 38, A-1030 Vienna
Austria
hg.krenmayr@geologie.ac.at
www.geologie.ac.at

Robert MAQUIL
Service Géologique du Luxembourg
43 Boulevard Grande Duchesse Charlotte
1331 Luxemburg
Luxemburg
robert.maquil@pch.etat.lu
www.pch.public.lu/administration/organigramme/dss/geo/

Peadar MCARDLE
Geological Survey of Ireland
Beggars Bush
Haddington Road, Dublin 4
Ireland
Peadar.McArdle@gsi.ie

www.gsi.ie
Maddalen MENDIZABAL
UPV/EHU
Facultad de Ciencias y Tecnología Apto 644
E-48080 Bilbao
Spain
mail: gvbmezum@lg.ehu.es
www.ehu.es

Michael MENTE
Bundesanstalt für Geowissenschaften und Rohstoffe
Stilleweg 2, D-30655 Hannover
Germany
M.Mente@bgr.de
www.bgr.de

Hans Peter SCHÖNLAUB
Geological Survey of Austria
Neulinggasse 38, A-1030 Vienna
Austria
hp.schoenlaub@geologie.ac.at
www.geologie.ac.at

Joel SEPÚLVEDA
GIS-TELEDEK
C/Nicolás Alcorta 2, 3º. Dpto: 24/25
E-48003 Bilbao
Spain
mail:oidui@hotmail.com

Aurela SHTIZA
Katholieke Universiteit Leuven
Fysico-chemische Geologie
Celestijnenlaan 200C, B-3001 Heverlee
Belgium
aurela.shtiza@geo.kuleuven.ac.be
www.kuleuven.ac.be

Markus SPINATSCH
Beratung für Politik und Verwaltung
Spitalgasse 14, CH-3011 Bern
Switzerland
ms@m-spinatsch.ch
www.m-spinatsch.ch

Ludwig STROINK
GEOTECHNOLOGIEN Coordination Office
Wissenschaftspark "Albert Einstein"
Telegrafenberg A6, D-14473 Potsdam
Germany
stroink@gfz-potsdam.de
www.geotechnologien.de

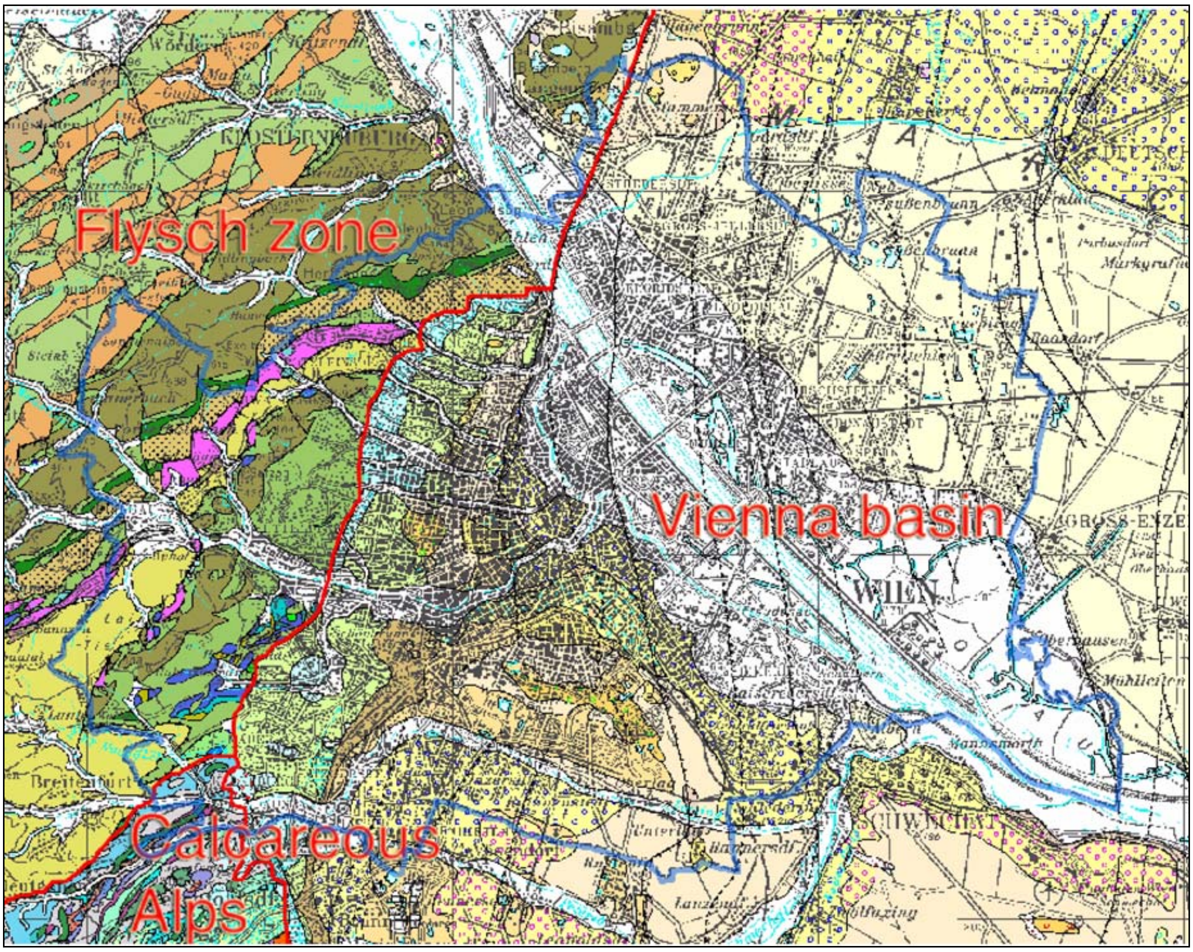
Gillian TIDEY
Nottingham
United Kingdom
gillian.tidey@ntlworld.com

Excursion 2

The reef on the roof
- a „geological" walk through the city of Vienna

guided by

Thomas Hofmann
Geological Survey of Austria
Neulinggasse 38
A-1030 Wien
Austria
thomas.hofmann@geologie.ac.at



Geological map of the city of Vienna (from W. Schnabel, 2002: Geological Map of Lower Austria 1:200.000); city limits in blue, tectonic units in red.

Vienna: geography and geology

Location:

48°07' - 48°19' northern latitude

16°11' - 16°34' eastern longitude

Dimensions:

North-South-extension: 22.4 km; East-West-extension: 29.2 km

Highest Point: 543 m Peak of Hermannskogel

Lowest Point: 151 m Lobau at the River Danube

Total Area: 414.90 km² (95,33 % land; 4,67 % water)

Population: 1,550,123 inhabitants (May 15, 2001), i.e. 3,736 / km²

Vienna is situated at the western margin of the Vienna basin, a tectonic depression existing since the Miocene. The western edge of the city area overlaps the Flysch zone which consists mainly of sandstones and marls (Cretaceous - Paleogene), the most south-western corner of Vienna includes limestones and dolomites of the Northern Calcareous Alps (Triassic - Jurassic). These two units display the most pronounced relief with high peaks and deep, narrow valleys. To the East, Neogene sediments overly the older tectonic units. They were deposited in a marine environment and form a narrow band of outcrops stretching North-South. Further to the East, Vienna displays the characteristic topography of fluvial terraces resulting from alternating erosion and deposition by the river Danube during the Pleistocene.

Meeting Point: The Opera at the „Ringstraße"

The Opera

The architects Eduard van der Nüll (1812-1868) and August Sicard von Sicardsburg (1813-1868), awarded with the first prize by the reviewing committee, had chosen for their prize-winning project the motto: „Fais ce que dois, advient que pourra." It was especially tragic, that criticism of the building, which started in the autumn of 1868, only came to an end after the untimely deaths of the two architects. Criticised was the style: for in 1861 the opera house had been started in a romantic concept, which however, at the latest in 1865 had been replaced by the monumental conceptions of the strict style of historicism. Finally some Viennese people said, that the Opera looks rather like a turtle; despite all those troubles the new house was opened on 25th May 1869 with Mozart's *Don Giovanni.*

Following the destruction of the opera house on 12th March 1945 due to the effects of war, the facade was restored, whereas a faithful restoration of the interior gave rise to differences. The reopening of the opera house was celebrated on 5th November 1955 with Beethoven's *Fidelio* with Karl Böhm conducting.

<u>Building material:</u> The building stands partly in the former moat in front of the fortification wall, partly on the fundaments of the fortification, as well as in a mediaeval clay pit. The fundament is built of reused material (bricks, etc) from the old fortifications.

Most parts of the facade are made of Mid Miocene (Badenium) „Leithakalk" coming from Wöllersdorf situated at the western margin of the southern Vienna Basin.

The material of Wöllersdorf is a coralline algal limestone with distinct sedimentary layers. This material is rather common in late 19th and early 20th century. At this period up to 900 men worked in the quarries of Wöllersdorf to get enough stones for several buildings of the „Ringstraße", like the „Burgtheater", the „Rathaus" and so on.

The facade of the Opera: sedimentary layers characterise the miocene „Leithakalk" from Wöllersdorf.

Thinsections can be classified as rudstone/grainstone – packstones, having a rich foraminferal fauna (58% benthonic elements versus 42% planktonic elements) representing a shallow marine environment.

The „Ringstraße"

The Opera, like many other prominent buildings in the centre of Vienna, are part of the „Ringstraße". The architecture of the „Ringstraße" is dominated by historicism. In Historicism various stylistic elements of the past were combined into a style in its own right. Nowadays the „Ringstraße" together with the „Franz-Josefs-Kai" surrounds the city of Vienna. The city or „Innere Stadt" with an area of 2.88 km² is the 1^{st} of 23 districts of Vienna. The 1^{st} district is situated on the whole on the „Stadtterrasse" (Riss-age), only the „Franz-Josefs-Kai" is at the lower level of the „Praterterrasse" (Würm-age).

Geology: The top of the „Stadtterasse" lies between 190 and 163 meters above sea level, the bottom varies between 182 and 146 m. Pleistocene sediments are overlying Pannonian sediments (blue and grey clay and silt with some intercalations of fine sandlenses). At the bottom of the sequence there are coarse gravels („Rundschotter") transported by the Danube during the Riss-period. There are also some rare crystalline blocks up to the size of one m³ which were transported embedded in some larger iceblocks coming down the Danube from the Bohemian massif. This 6 or 7m thick layer of gravels is covered by a more or less continuous layer (4-6m) of silt and clay which some sandy intercalations („Zwischenlehm"). The next higher level is the level (6-7m) of the so called „Plattelschotter". These platy gravels are derived from the Flyschzone at the western border of Vienna. This upper layer of gravels is covered by Loess and or Loam and/or anthropogene deposits.

First Stop: Albertina and Hrdlicka's „Monument against War and Fascism"

The Albertina

The Albertina is nowadays a museum housing one of the largest and most important graphic arts collections in the world with approximately 70,000 designs and approximately one million pressure graphic sheets. There are works by artists like Leonardo da Vinci, Michelangelo, Raffael, Dürer, Rembrandt, Rubens but also works by Lorrain, Delacroix, Manet and Cézanne. Among the artists of the 20th century Schiele, Klimt and Kokoschka from Austria should be mentioned as well as Warhol, Rauschenberg and Baselitz.

The Albertina Palais is 12m higher than the pavement. This „Augustiner Bastei" (= bastion) is one of the last relics of the fortification which surrounded the City of Vienna; all other parts of the fortification were destroyed in 1857/58. After the 1st siege of the Turkish Army in 1529 the fortification was extended.

The „Danubius-Brunnen" covers the „Augustiner Bastei" (= bastion), part of the old fortification.

The Fountain („Danubius-Brunnen") has been designed by Moritz von Löhrs (1810-1874) and was built between 1864 and 1869. The figures show allegories of Austrian rivers (Mur, Salzach, March, Raab, Enns and Traun).

Monument against War and Fascism

This walk-in monument was carried out by the famous Austrian sculptor Alfred Hrdlicka (*1928) to preserve the memory of one of the darkest periods in history. It is dedicated to all victims of war and facism. The monument was ordered by the city council of Vienna in 1983 and uncurtained in 1988, the Austrian commemorative year.

The place of the monument is the former place of the „Philippshof", a prestigious apartment house of the late 19th century. The object was destroyed on the same day like the Opera (March, 12th 1945), when hundreds of people had taken refuge in the cellars of the building. Their bodies were never recovered and even their exact number is still unknown.

Monument against War and Fascism: Granodiorite from Neuhaus (Upper Austria).

Building material: The two basal blocks of the „Gate of Violence" as well as the „Stone of the Republic" and the Block of „Orpheus entering Hades" are made of granite from the Bohemian Massif coming from the quarry (Fa. Poschacher) of Neuhaus (St. Martin) in Upper Austria.

This granite (Typus: Neuhausen) is a granodiorite belonging to the Southern Bohemian Pluton as part of the Moldanubian tectonic unit. The intrusion during the Carboniferous corresponds with the Variscan orogenesis.

The statues are made from white marble from Carrara.

Second Stop: The Hofburg, Michaelerplatz

The „Michaeler Platz” is dominated on the one side by the Hofburg, on the other side by the Looshaus and finally by the Michaelerkirche. In the centre is an excavation complex which was planned and laid out by the architect Hans Hollein (*1934) in 1991. It shows the relics of several time levels.

The Hofburg

The Hofburg originates from a medieval castle, which was enlarged step by step up to the 19th century, so the complex of the Hofburg is nowadays rather a conglomerate. Today only the castle chapel ('Burgkapelle') is left as oldest part from a medieval past.
The Hofburg was extended over the centuries as a magnificent residence when the Habsburg's power increased. This is reflected in various architectural styles from gothic to art nouveau. Nowadays in this enormous complex is the home of many collections and institutions, such as the National Library, the Imperial Treasury („Schatzkammer“), and several collections, like the one of musical instruments or another collection of weapons. The Museum of Ethnography as well as the famous Spanish Riding School with its renaissance architecture are also incorporated in the complex of the Hofburg. Until 1918 the Hofburg Palace was the seat of the Habsburg dynasty.

Michaelerplatz: The four Hercules statues at the entrance („Äußeres Burgtor”) of the Hofburg.

Building material: Various dimension stones were used in the Hofburg, one of them, the „Zogelsdorfer Kalksandstein” (Zogelsdorfer calcareous limestone) is of special interest. This bioclastic limestone from the Lower Miocene (Upper Eggenburgium) comes from several localities near Eggenburg, a medieval town in the north of Lower Austria. This dimension stone is together with the „Leithakalk" the most important decoration stone in the eastern parts of Austria, southern Moravia and even in western Hungary. During the baroque period „Zogelsdorfer Kalksandstein" was very important for sculptors; hundreds of statutes, especially those of Saint Nepomuc and other saints are made of this stone. Whereas „Leithakalk" is still quarried, there has not been an active quarry of „Zogelsdorfer Kalksandstein" for many decades.

The four Hercules statues by Edmund Hofmann, Josef Lax, Johann Scherpe and Anton Wagner at the Michaelertor originate from the „Johannesbruch" in Zogelsdorf. This quarry was at the late 19th century property of the famous female writer, pacifist and 1905 Nobel Peace Prize laureate Bertha von Suttner (1843-1914) who had her domicile in the neighbouring Harmannsdorf. One reason for using this stone was the excellent preservation of Lorenzo Matielli´s (1688-1748) statues of Herakles (1727-1729) at the „Reichskanzlei" – a part of the Hofburg.

The „Johannesbruch"-quarry, the type locality of the Zogelsdorf Formation, is positioned on the northwestern margin of Zogelsdorf, about 2.5 km southwards from Eggenburg. The stone production here began around 1870 when the intensive building activities triggered an outstanding demand for building materials. The „Johannesbruch" shows a bryozoan dominated facies. Moreover monospecific pectinid layers bearing disarticulated and articulated, horizontally oriented shells of *Pecten hornensis* are characteristic. Among echinoderm remains the representatives of Echinoidea, Asterozoa, Ophiuroidea as well as Crinoidea can be found.

The „Johannesbruch" is located in the southern part of the Eggenburg Bay that was originally sheltered from the influence of the open sea of the Molassezone by roughly north-south striking submarine, crystalline swells, islands and peninsulas. In consequence the Zogelsdorf Fomation, topping therein the basal Late Eggenburgian siliciclastics is developed in a typical terrigenous poor, bryozoan rich facies.

The archeological site

There are the remains of walls and a floor heating system as well as building foundations from the seventeenth, eighteenth and nineteenth centuries visible. Red gravel now marks two roman roads crossing here.

<u>Building Material:</u> Some of the exposed bricks show the letters **H** and **D** standing for **H**einrich von **D**rasche-Wartinberg (1811-1880). As an industrialist he was head of many clay-pits south of Vienna; the later „Wienerberger Baustoffindustrie AG". Today this company is the world's largest producer of bricks with more than 230 plants in 24 countries.

The material of millions of bricks having these initials derives from southern regions of Vienna, where numerous large pits of middle Pannonian clay existed. They date back to the mid of the 18th century, when the first brick-kiln was erected at the „Wiener Berg". So already in 1780 one million bricks were made. 1820 some nearby places of production were integrated thus being able to produce 30 millions of bricks per year (1849). 1865 the first circular kilns were erected. Two years later, 10.000 people, men, women and even children were producing bricks for the rapidly growing city of Vienna. At the end of the 19th century the annual production could be increased to up to 225 million bricks per year.

H and **D** stand for **H**einrich von **D**rasche-Wartinberg, an industrialist famous for brick production.

The material, a blue, to grey silty clay is known in the old geological literature as „Congerientegel" due to the occurrence of the bivalve *Congeria subglobosa*. A common name is also „Inzersdorfer Tegel", due to the locality of Inzersdorf in southern Vienna, close to the southern slopes of Wiener Berg and Hennersdorf, the only active clay pit. The terminus „Tegel", derived from the Latin word „tegulum" which stand for bricks, is commonly used for fine sediments (clays, marls) in the Vienna Basin.
Nowadays all former clay pits are recultivated, except the one of Hennersdorf, south of Vienna. According to recent investigations the sediments represent a deep bottom lake setting environment. Based on bivalves a repeated chance in the oxygenation could be described. Analysing the clay minerals there is a dominance of smectite in Pannonian sediments reflecting dry conditions and seasonal variations in the climatic environment of Lake Pannon. The predominantly smectitic composition documents gentle erosion of smectite-rich soils on a relatively stable, distant source area.

The Looshaus

When Adolf Loos (1870-1933) was building his famous „Loos-Haus" (1909-1911) the Emperor of Austria, Franz Josef (1830-1916), was outraged, because he was confronted with a „house without eyebrows" – a modern monstrosity directly opposite the Imperial Palace. It was like an architectural declaration of war. Adolf Loos, not only a famous architect but also an aesthetician and cultural philosopher, formed an alliance together with the writer Karl Kraus (1874-1936), founder of the polemic periodical „Die Fackel" (1899), to attack the overblown style of Historism and the decorative style of the Secession. Loos advocated buildings that were plain, honest, and functional. Loos was then obliged to add the ten window boxes to calm the critics.

Building Material: The entrance with the columns is covered with green Cipolino Marble from Euböa (Greece), whereas the basis is made of „Light Lambrador” from Norway (Oslo Fjord).

Third Stop: The Heldenplatz

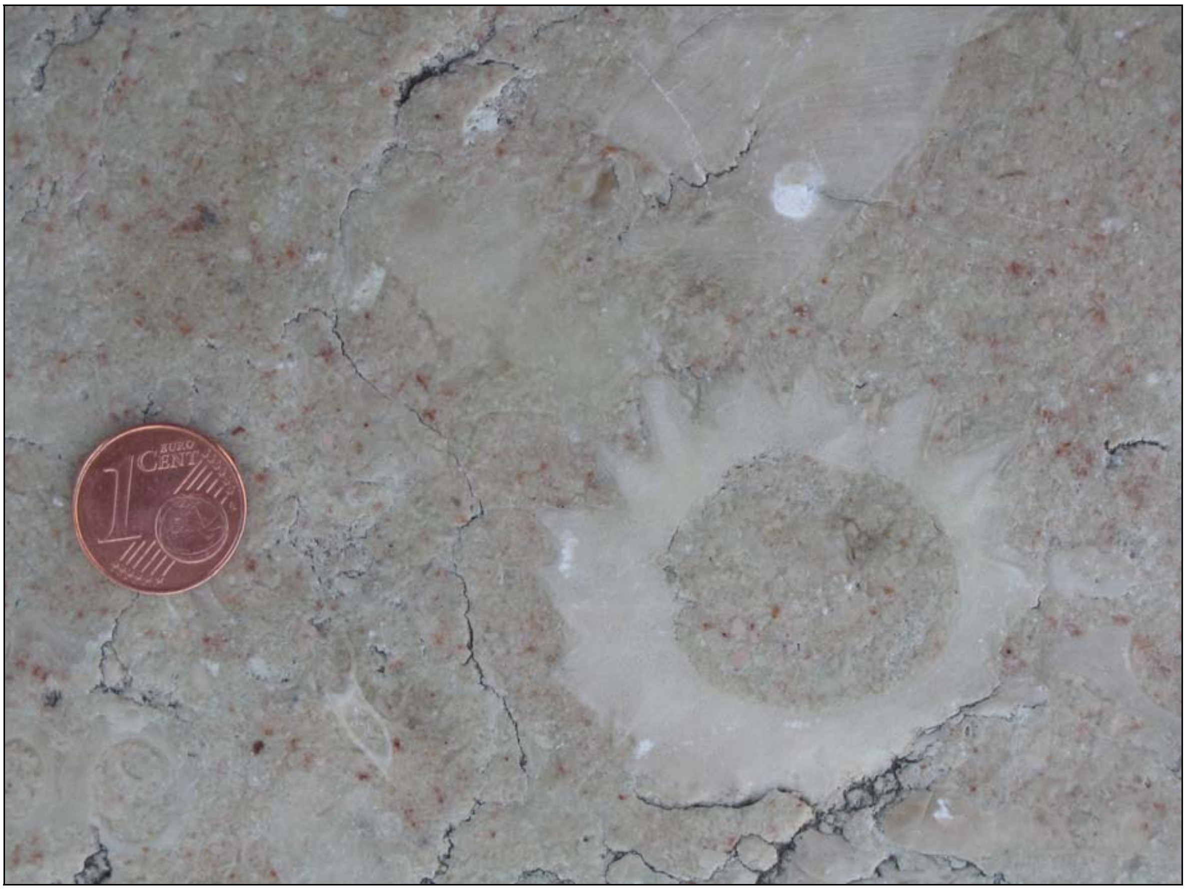
The Heldenplatz

The great „Heldenplatz“ with its two Equestrian statues of Archduke Karl (1771-1847), who won the battle of Aspern against Napoleon's troops (1809), and Prince Eugene of Savoy (1663-1736), who defeated the Turks, is a tribute to Austria's glorious past. The „Heldenplatz” is more than just a square, it is one of Austria's symbols of national identity and gives also the title to the drama „Heldenplatz” (1988) by the famous Austrian writer Thomas Bernhard (1931-1989).

The „Heldenplatz” is part of the „Kaiserforum” a large project by the two architects Gottfried Semper (1803-1879) and Carl von Hasenauer (1833-1894) dating back to 1869, which was never completed. However the symmetry of the two museums (Museum of Natural History and the Kunsthistorisches Museum Vienna) on the other side of the “Ringstraße” as well as the two great Equestrian statues together with the “Neue Burg”, the newest part of the Hofburg, give an impression of how the “Kaiserforum” could have looked liked.

The statue of Archduke Karl first carried out by Dominik von Fernkorn between 1853 and 1859.

The sculptor Anton Dominik von Fernkorn (1813-1878) created the statue Archduke Karl (1853-1859), before he started the monument of Prince Eugene of Savoy (1860-65).



„Untersberger Marmor”: Rudists and tiny bauxite clasts are typical for this cretaceous slope sediment.

Building Material: The basis of both monuments is made of “Untersberger Marmor”; this is not a marble in the petrographic sense, it is a limestone with initial stages of nodular limestone formation. The “Untersberger Marmor” (Late Turonian to Coniacian - Santonian) is part of the Gosau-Group within the Northern Calcareous Alps. This limestone represents one of most traditional decoration stones, which is still quarried in the Salzburg region. It was deposited on a slope or represents a toe-of-the-slope development. Geopetal fabrics indicate an original inclination of the slope of 10-15°. The typical “Untersberger Marmor” is a detritic carbonate sediment-mixture derived from the Gosau carbonate-platform and from the slope, with a considerable share of extraclasts; the latter consist predominantly of Upper Triassic Dachstein and Upper Jurassic Plassen Limestone. Ubiquitous recrystallization renders determination of biota difficult. Due to staining by fine-dispersed bauxite-mud the basal part of the Untersberg Marmor is characterized by pink colour and tiny bauxite clasts and ore grains. The most important bioclasts are rudists, more scarcely corals, bryozoans, hydrozoans, coralline algae and foraminifera.

Fourth Stop: The Theseustemple

The Theseustempel, in the “Volksgarten“ was built 1820-23 by Peter von Nobile (1774-1854) a leading architect of the late classicism in Vienna. Another object of Nobile is the nearby “Äußeres Burgtor“

(1821-1824), a memorial to the "Battle of the Nations" in Leipzig (1813), part of the "Kaiserforum", connecting the "Heldenplatz" with the "Ringstraße".

The Theseustemple is a replica of the antique Theseion in Athens. It was originally built for the statue "Theseus fighting the centaur" by Antonio Canova (1757-1822), which since 1890 has been in the foyer of the Kunsthistorisches Museum Vienna.

Building Material: The columns are made of Mid Miocene (Badenium) "Leithakalk" showing large rhodoliths. These rhodoliths are typical for the quarrys of St. Margareten in Burgenland. In contrary to the "Leithakalk" coming from Wöllersdorf (western border of the southern Vienna Basin), this "Leithakalk" comes from the Eisenstadt Basin, a subbasin of the Vienna Basin east of the Leithagebirge, a crystalline ridge, which is part of the southeastern border of the Vienna Basin.

One quarry of St. Margareten, the "Römersteinbruch" (Roman Quarry), has been active as Steinbruch "Hummel" since of the Roman times.

Large rhodoliths are typical for the miocene "Leithakalk" of St. Margareten in Burgenland.

The "Leithakalk" of St. Margareten represents several microfacial types ranging from foraminiferal facies, foraminiferal algal debris facies and foraminiferal rhodolite facies to pavement facies. Generally, foraminifers, echinoids, bryozoans, and coralline algae are the dominant sediment constituents. The pavement facies is developed in layers with rhodoliths up to 10 cm in diameter. Molluscs are represented mainly by oysters - in some layers enriched - and pectinids. The large rhodoliths of the pavement facies are multispecies aggregates, however pre-dominantly built by crustose coralline algae. Foraminifera, bryozoans and serpulids are of subordinate importance. The sandy carbonates can be interpreted as shallow water sands, where, in shallow depressions, an accumulation of rhodoliths (pavement facies) occurred. The laminated marls and marly limestones may be interpreted as deposits in depressions inside a lagoonal environment.

Fifth Stop: The Burgtheater and Rathaus

The Burgtheater

The Burgtheater (1874-1888), the most important theatre in Austria, is the work of the famous architects Gottfried Semper (1803-1879) and Carl von Hasenauer (1833-1894).

Building Material: The light facade looks rather homogenous, but going into details it becomes evident, that this is a mosaic of various stones, like "Leithakalk" from Wöllersdorf or some cretaceous Limestones from Istria with remains of rudists. This situation results from the great need of masses of stones. After the destruction of the fortification many great buildings at the "Ringstraße" were built at the same time.

The Rathaus or Vienna City Hall

The City Hall is one of the most splendid buildings at the "Ringstraße". Designed by Friedrich Schmidt (1825-1891), it was erected between 1872 and 1883. The City Hall was built in gothic style, with a tower similar to gothic cathedrals. Today the City Hall is the head office of Vienna's municipal administration. More than 2000 people work in the building.

Building material: The City Hall is built of about 30 millions of bricks, which are covered with "Leithakalk" coming from different localities such as Wöllersdorf (Vienna Basin), Mannersdorf, Oslip, St. Margarethen and Breitenbrunn (all coming from Eisenstadt Basin), as well as some parts with the "Zogelsdorfer Kalksandstein" from the Lower Miocene (Upper Eggenburgium) of the Molassezone.

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