GEOSCIENCES FOR EUROPE'S ENVIRONMENT IN THE 21ST CENTURY

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Present environmental regulation in Europe

Alarmed by growing public awareness of a deteriorating environment in the 1970s, Europe's national and local governments started to develop environmental policy measures through newly created Ministries of the Environment or similar structures, many of them derived from pre-existing departments of public works. At European level, the Community drafted its first Environmental Action Plan in 1972, and produced 200 items of legislation mostly aimed at defining minimum standards for waste management and pollutant levels in water and air. At first this resulted in some unbalanced decisions on clean-up activities and a coherent overall vision of how to manage the environment developed only slowly. European Community legislators favoured a 'level playing field' standard, insisting for example on the acceptance of a single minimum value for arsenic, nickel or acidification in waters and soils across the entire territory although such features show great geographic variation due to the natural chemical and physical 'geodiversity' of the underlying bedrocks.

Policy makers initially split the environment into three convenient but artificial compartments of air, water and soil and ignored the integrated, cyclical workings of natural environmental processes, particularly the driving geological influences. This approach reflected political and economic sensitivities and resulted in a clear but conservative approach. The EC drafted many different directives on environmental issues, some of which subdivided several related issues within any one of the three main compartments, sometimes causing confusing duplications in a mosaic of legislative texts (e.g. over 60 pieces of onshore water legislation were adopted between 1973 and 1991).

Many countries introduced prohibitions on any infrastructural development that might harm the environment, insisting that clean-up of air, surface water or contaminated soil sites should try to restore the natural background chemical levels – although most officials were not able to define them. These incompletely informed demands did not help the unfavourable economic conditions then prevailing in Europe and much of the new environmental legislation was developed with the help of life-science based lobbyists with little understanding of the influence of natural Earth processes such as for example the evolution of natural soils from underlying rock, the role of groundwater circulation or the causes of natural hazards.

By the early 1990s the maturing Ministries of the Environment in all 12 European Community countries had made their first 'state of the environment' inventories. Environmental policy plans were issued and brave statements were made as to how and when the problems in the various environmental compartments would be solved. To this end, large budgets of public money were made available and the number of environmental consultancy firms grew by the day. The EC Fifth Environmental Action Programme (1992) suggested that the way to resolve many environmental problems was to analyse the activities of the various socio-economic sectors rather than the artificial environmental compartments. In October 1993 the European Environmental Agency (EEA) was launched by the Council of Ministers and European Parliament as an advisory body to "orchestrate, cross-check and put to strategic use information for the protection and improvement of Europe's environment." Based in Copenhagen its area of operation covered the EU, Iceland, Norway and Liechtenstein and this relatively small office (about 80 people) aimed to supply reliable information to enable Member States to take effective measures to protect the environment, to assess impacts and to ensure that the public was adequately informed on environmental issues. The EEA was also directed to publish an assessment of Europe's environment every three years to "describe the present and the foreseeable state of the environment from the following points of view: the quality, the pressures and the sensitivity." In 1995 its founding task force, working within the European Commission Directorate XI (Environment, Civil Protection and Nuclear Safety), published the voluminous Dobris Assessment of 712 pages accompanied by a 455 page statistical annex. The Dobris report aimed to become a baseline reference for periodic updating, based on the best available data.

The report confirmed the poor quality of the European environment, particularly in parts of Central and Eastern Europe, and listed 56 environmental problems (19 of which we note have a geological cause or management solution) and was compressed into 12 prominent European issues in order to define chapter headings in the report: climate change, stratospheric ozone depletion, loss of biodiversity, major accidents, acidification, tropospheric ozone and other photochemical oxidants, the management of fresh water, forest degradation, coastal zone threats and management, waste production and management, urban stress, and chemical risk.

The Dobris report was a bold start, compiled in a short time and had several weaknesses. The influence of geological processes on environment, natural resource and natural disaster issues was not adequately expressed and the EEA admitted that future updates would need to address the issue of non-renewable resources. However the report had important strengths: its catalogue of widespread and unwelcome environmental problems drew political attention in an economically comfortable part of the world. The EEA also established a network of contacts to exchange data between more than 40 countries and strove to keep in mind the criteria of UNEP, the OECD, the EC Fifth Environment Action Programme and the US EPA. It admitted that new issues would be identified in the future and recognised that a multi-media, cross-sectoral integrated approach to environmental problem-solving was necessary. The EEA also recognised that the difficulty of obtaining rapid access to comparable, compatible and verifiable data across Europe made it difficult to define and assess environmental problems.

The first four EU RTD Framework Programmes administered by the Research Directorate General (DG XII) from 1984 to 1998 supported research projects on environmental topics which involved almost all EU universities and research institutes and an 'enabling fund' valued at about 4% of the combined annual research budget of the Member States allowed agreed priority issues of applied research to be tackled at a 'value-adding' EU level. While a fair number of these projects were innovative, few were sustained over more than 2-3 years and few of the results obtained or principles established were directly applicable to the support of forward environmental policy or were even effectively disseminated. Work in the environmental field was also boosted by multimillion national programmes on the feasibility of radioactive waste storage and EU programmes, which sought to orientate the mop-up of the 1986 Chernobyl accident.

However, in the course of the 1990s this promising market stagnated outside the increasing development of the domestic and industrial waste disposal sectors. This was due to several factors: the growing realisation of the complexity of the problems to be solved – many of them inherited from past periods of industrial or war-related damage, and the limitation of the possible range of solutions by over-concentration on surface environmental and ecological processes which were themselves only the end-effects of geological processes. As a consequence of the subsidiarity (or 'localisation') principle which prevents the EU from supplanting legislation applied by national, regional, or local authorities, the EU has rarely addressed soil and subsurface contamination because they are considered to be of a local nature only.

By the end of the 1990s the EU had adopted 315 environmentally related directives. In the research field the EU RTD Fifth Framework Programme (1999-2002) set out its terms of reference and priorities for environmental and sustainable development work in a rather artificial way. The objectives of separate environmental action lines (e.g. within key actions on groundwater, city environments, etc) thus tended to overlap one another in a manner confusing to proposers. The new RTD Framework Programme showed little interest in subsurface issues, and more interest in this dimension had developed within the member states, through research in Holland, the Delft Cluster, SKB and new contracts in UK universities. By the end of the 1990s environmental care was well embedded as a policy issue in many of the traditional policy sectors defined in the EU member states and in many of the non-EU countries in Western and Central Europe. The 'accession candidate' countries strove to align their environmental regulations with those of the EU. In densely populated countries in Northwestern Europe, concern arose about the availability of space necessary to cope with the economic growth during the last half decade of the 20th century. Significant interest in the use of subsurface space was expressed by some governments and media, generating new research programmes to assess its potential and thus creating new opportunities for geoscientists.

In 1998 and 1999 the EEA produced two forward-looking documents on environmental policy. In June 1998 it followed up the 1995 Dobris Report with a Second Assessment. The new report revisited the 12 environmental problems recognised by the Dobris report and analysed their continuing evolution in terms of a 'DPSIR' cycle of driving forces (economic sectors, human activities), pressures (emissions, waste), states (physical, chemical and biological), impacts (on ecosystems, human health and functions) and responses (mostly political – prioritisation, target setting, indicators). It found that little improvement had been initiated because many environmental policies had led to 'end-of-pipe' measures, which were insufficient to address increasing infrastructure development, production and consumption. The report also confirmed the urgency of improving the harmonisation, monitoring and reporting of environmental data across Europe and signalled limitations of funding and time. Importantly - like the 1992 Fifth Environmental Action Programme, the 1995 pan-European Environmental Programme for Europe and the 1997 Treaty of Amsterdam - the report also urged the integration of environmental policies into economic sector activities and the adoption of a coherent forward plan for the European environment.

The second of the two EEA documents was the 1999 'Environment in the European Union at the turn of the century' which attempted to analyse whether the actual sectoral and environmental policies to be developed over the next decade would promote or hinder progress. This report advocated the need for integrated environmental assessment. In 2000 the Director of the EEA stated that although European environmental policy was successful it was still not strong enough and needed to focus more on changing economic policies.

Role of geosciences in the environment in the late 20th century

Up to the late 1980s, geoscientists approached the environment only in a geological context, e.g. the geological environment in which specific deposits were formed. The influence of the biosphere, hydrosphere and lithosphere on human and ecological health became important for geoscientists only during the last 15 years of the 20th century, a development which coincided with the growing public concern about the present state of the environment. The first major confrontation of geoscientists with this concern was the debate on safe, permanent storage of radioactive waste in the (deep) subsurface followed by intensive geoscientific studies. An increasing number of geoscientists became professionally involved in studies on contaminated soils, polluted groundwater resources and other geo-environmental hazards. Faced with a decreasing demand for geoscientific expertise in mineral and hydrocarbon exploration, many geoscientists shifted their attention towards environmentally related issues and moved from multinational companies into the service sector. University curricula were adapted and geological surveys and international scientific bodies shifted their directions following this trend (Cook, 1994; Custodio, 1999). To take up the challenge of applying geosciences to environmentally sustainable development, the International Union of Geological Sciences (IUGS) created a special Commission on Geological Sciences for Environmental Planning in 1990 (de Mulder, 1994). In 1995 the geological surveys of the 15 EU member countries and Norway launched the special association EuroGeoSurveys to focus on the strategic role of geology in EU environment and resource policy (Annells, 1996), and the geological surveys of the non-EU European countries set up the club FOREGS (Forum of Directors of the European Geological Surveys), to focus on similar issues. In general the European geological surveys shifted their orientation from a basic towards a more applied approach aimed at enhancing the benefit of their work to society.

The main environmental fields tackled by geoscientists in the late 1980s and 1990s comprise water, soils, urbanisation, waste disposal, energy, minerals (including the impact of mining) and disaster reduction (de Mulder & Cordani, 1999). Clearly, the cities of Europe are its geo-environmental hotspots. Although not expanding as rapidly as those of Asia and Latin America, European cities are substantially affected by environmental geo-hazards. EuroGeoSurveys conducted a 'first approach' risk matrix survey of such geo-hazards in cities in all EU countries and Norway (de Mulder, 1998) and a comparable matrix was made to show groundwater conditions in European countries (EuroGeoSurveys, 1999a). As contaminated soils were among the main geo-environmental issues, the potential of the subsurface (including its biota) to decontaminate itself became one of the best media-exposed research topics in the late 1990s. In December 1999 the EU-funded GEIXS project completed the development of a significant EU database of geoscience metadata which linked the standardised databases of all EU geological surveys and Norway through a public access Web gateway (http://www.eurogeosurveys.org), making them accessible to a wide field of user groups (EuroGeoSurveys, 1999b). The Nordic countries (Norway, Sweden and Finland) conducted a joint geo-environmental mapping programme for a major part of their area.

Direction of Europe's environmental structure in the 21st century

At the end of the 20th century two new trends had evolved with respect to geographic identity and the level of political responsibility for action. First, the influence of national administrations had declined at the expense of the EU administration and legislation based in Brussels and Luxembourg. Second, the regions had acquired a much stronger localised identity, which could enable them to evolve into separate regional administrations supervised by the EU. The EU is committed to enlarge by admitting new members such as Poland, Hungary, Slovenia and the Czech Republic which are due to enter in 2003 as the first members of a new group of eleven states. Slovakia and Estonia are likely to follow before the end of the first decade of the 21st century and by 2025 the EU could include most countries in the geographic area of Europe west of the Urals.

In May 1999 the Member States and the European Commission released a new intergovernmental 'European Spatial Development Perspective' as a strategic vision or 'Grand Plan' for the entire 'Greater European' territory. This document sets out policy guidelines and objectives for developing a European Union in which urban and rural areas will be better balanced so that excessive economic and population concentrations in the core area of the EU – the 'pentagon' of London, Paris, Milan, Munich and Hamburg - can be avoided and the 236 present regions of Europe can be integrated into the global economy to help the EU to become more competitive. The Commission and Member States are now preparing a medium-term action plan to start implementation of the European Spatial Development Perspective (ESDP), responsibility for which will be shared between the European Commission and appropriate levels of the Member States, their regions and local authorities. Spatial development issues in which geological input will be important at EU, national, regional and local levels will include the control of urban sprawl and improvement of the urban environment, preservation of the natural environment and heritage of rural areas and landscapes, diversification of the economic base by alternative scenarios of natural resource and land use, preservation of natural soils and preservation of the quantity and quality of water resources. All of these issues will require the construction and continual updating of major GIS facilities with information that can be readily compared and exchanged across Europe.

Potential role for geosciences in Europe in 21st century

As a follow-up of the trends displayed in the last few years of the 20th century, geoscientific input into the new Europe during the first quarter of the 21st century will focus on making databases accessible to public and private clients of increasing numbers and sophistication. In addition, national and topic-related databases will become integrated. It is expected that 3D and even 4D images of the subsurface conditions in substantial regions of Europe will be available well before the end of the first quarter of the 21st century. Geo-indicators will then be used for monitoring the state of health of the subsurface environment. Geoscientists will study the Quaternary record even more intensely to reveal very detailed information on the natural climatic development during the last glacial-interglacial cycles which, in turn, will feed the significantly improved global climatic models with reliable data. This development should result in a clear distinction between man-induced and natural climatic change. Towards 2025, new energy resources such as solid methane hydrates will be exploited in remote areas such as sea beds and ocean floors in order to satisfy the demand of 630 Gigajoules/jr of energy anticipated for 2020 (Meadows et al, 1992).

Subsequently, integrated models predicting the subsurface behaviour of such regions for many kinds of development will be accessible not only to geoscientists but also to educated non-geoscientific end-users. Meanwhile, the dominant hydrogeological, biological, geochemical and geological processes in the subsurface will be understood conceptually, described quantitatively and modelled. Significant new, but small-scale processes will be discovered in the subsurface as the geological development of the Earth's crust becomes better understood through the development of integrated and detailed geophysical, hydrogeological and geochemical tomography techniques applicable in the shallow subsurface (down to 100 metres). Particularly interesting new developments are expected in the field of biogeochemistry, a black box so far despite the work of Gold (1999) and others.

By 2050 the geological, geochemical, geo-mechanical and hydrogeological structure and composition of the topmost 25 metres of the entire European continent and its offshore territories will have been assessed at a 1km2 scale (Figure 1). Remote sensing, including improved and extremely sensitive hyperspectral sensors and geophysical techniques, will have played significant roles in this achievement but this will not be the end of geological mapping. Construction utilising subsurface space will become a booming business and the need for sustainable planning and management of subsurface space will become obvious. More advanced simulation models will give specific attention to the quality of the input for such models. Present-day geodata is rough and uncertain in quality in comparison to the upcoming and ever improving, fine-tuned models. After simulation, observation is expected to become more and more relevant: it will be carried out by means of improved observation techniques and by geoscientists better trained in field techniques.

During these developments, the subsurface conditions of any place in Europe will become known and integrated with past and present socio-economic and other conditions. Such information will be accessible to any interested party through the successors of the Web.

By 2050 the world population will have grown to around 10-11 billion (World Bank, 2000) and Europe's population will have grown to some 550 million. The increase in the size of urban populations will concentrate many human activities in space below ground level to dictate new concepts of cities, which will have to be well monitored for the occurrence of geo-hazards. Enormous quantities of fresh water will have to be available, obtained mainly by purification of surface water. Food will be produced almost entirely in greenhouses on artificial substrates. By this time geoscientific expertise will be entirely integrated with other fields of expertise. Our successors in the profession will then focus on the smart and sustainable use of the subsurface through application of the greatly increased knowledge of the small-scale earth processes. New exploration and exploitation techniques will become available and the subsurface will become a target area for the exploitation of new and degradable materials, which will significantly reduce the volumes of waste and present-day basic materials. New ways for utilising the physical, biological and chemical potentials of the earth will become available for sustainable economic growth and further increases in the quality of life, but perhaps also for the development of mass destruction devices.

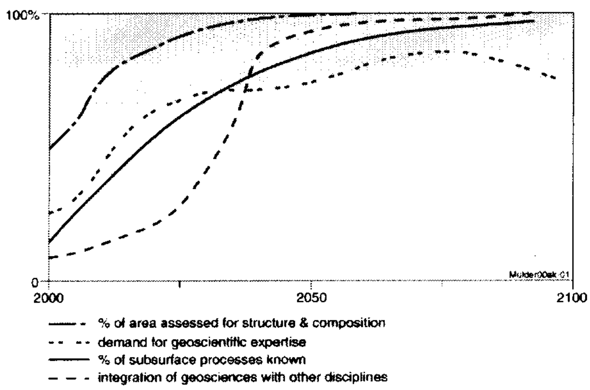

Figure 1: Development of Geosciences in Europe in the 21st century: a tentative approach

With these expectations, it is unlikely that the geosciences will remain unchanged. Some of the European Geological Surveys have already started to develop into public information centres dealing with subsurface problems and opportunities. They are likely to become parts of new clusters of public institutions focused on mitigating societal problems and issues such as the depletion of water resources, natural hazards, and life support systems. The new generations of geoscientists will operate in multidisciplinary teams rather than as 'loners' to resolve societal problems or to discover new materials (Figure 1). And as the subsurface in general and stability of urban centres in particular will become far more relevant issues in European society than today, we expect that the geosciences will also acquire greater value in the pure scientific realm. Earth scientific innovation in universities and other scientific research centres will occur mainly along the fringes of the classical scientific disciplines, particularly at the interfaces of the geo- and biosciences.