ENVIRONMENTAL GEOSCIENCE IN THE 21st CENTURY IN SCANDINAVIA

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Environmental geoscience has a long history in the Scandinavian countries. In Scandinavia, environmental work is in the process of transition from repairing damage to preventative activities. Thus, in the environmental sector, geological knowledge will play an increasingly important role. Already in the early 1970s geological surveys in these countries commenced environmental geochemical mapping on a regular scale. At the same time the topic of Geomedicine was developed and especially in Norway this science started early (Låg 1990). Certain future developments can be seen in the 21st century:

Environmental geochemistry will be continuously developed, for example biogeochemistry indicating bioavailable elements in the environment.

Most countries all around the world use inorganic stream sediment samples in environmental geochemistry. This sample medium was originally developed for mineral exploration and is now also used for environmental purposes. However new geochemical sample media have been developed for environmental mapping (Brundin et al 1988). One example is biogeochemistry (Selinus et al 1996). In Sweden the Geological Survey started a nation-wide mapping programme in 1980. A new method is used, whereby metal concentrations are determined in organic material consisting of aquatic mosses and roots of aquatic higher plants. These are barrier-free with respect to trace metal uptake and reflect the metal concentrations in stream water. Aerial parts of many plant species do not generally respond to increasing metal concentrations in the growth medium because of physiological barriers between roots and above-ground parts of plants. These barriers protect them from uptake of toxic levels of metals into the vital reproductive organs. The roots and mosses respond closely to chemical variations in background levels related to different bedrock types in addition to effects of pollution Due to chemical weathering processes, the metal concentrations in the stream water reflect the chemical composition of the surrounding bedrock and soils. The exchange of metals between the water and the roots is a slow process whereby the influence from seasonal variations is of minor importance. The biogeochemical samples also provide information on the time-related bioavailable metal contents in aquatic plants.

The biogeochemical mapping programme is and will be of great use in the work going on in Medical Geology and also in other environmental studies.

Medical Geology will be continuously developed in cooperation with medics and veterinarians.

"Medical Geology" is defined as the science dealing with the relationship between natural geological factors and health problems in man and animals, and understanding the influence of ordinary environmental factors on the geographical distribution of such health problems. Medical Geology is therefore a broad and complicated subject which requires interdisciplinary contributions from different scientific fields if the problems are to be understood, mitigated or resolved. Earth science research can identify how geologic processes transport and store substances that are toxic to humans, including both naturally occurring materials and those produced by human activities. By understanding these processes, improved strategies for pollution prevention, mitigation, and remediation can be developed. The presence of toxic elements in soil or rocks, whether due to natural geochemistry or human activities, including pollution, usually influences human health indirectly ingested via food or drinking water..

Significant scientific advancements will result from increased collaboration between geoscientists and specialists from the medical and biological. Earth scientists can provide crucial geological and geochemical insights into epidemiological studies examining the elevated regional occurrences of some diseases. All the Scandinavian countries are actively working with medical geology and this will be further increased in the 21st century.

Because of the importance of geological factors on health, and the general lack of appreciation an

understanding of the importance of geology in such relationships, COGEOENVIRONMENT

decided in 1996 to establish an international Working Group on Medical Geology with the primary aim of increasing awareness of this issue among scientists, medical specialists, and the general public.

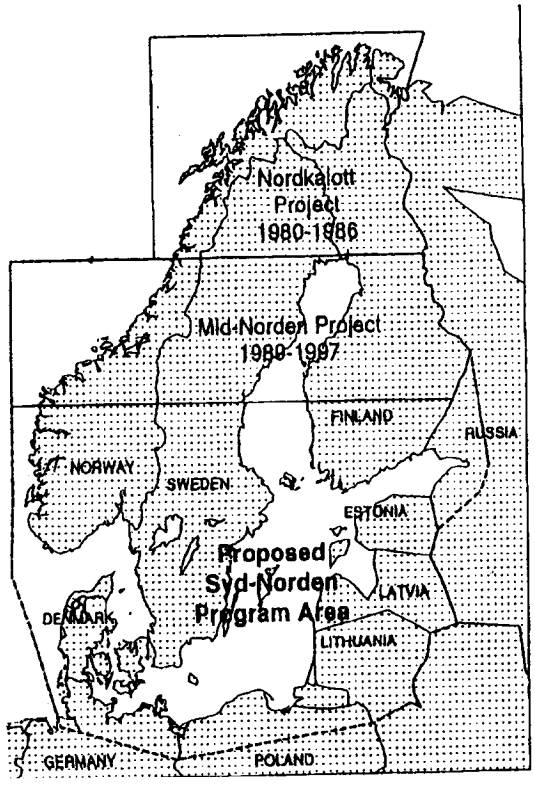
USGS presented in 1999 a Science Strategy for the Geologic Division of USGS, 2000-2010. 7 goals were presented and one of these goals was to "Interpret the links between human health and geologic processes". This reflects the importance worldwide of this subject. The specific targets are to : Increase cooperative research efforts with specialists in human health, toxicity, epidemiology, and other life sciences, continue research on the geologic occurrence, geoavailability,

environmental mobility and degradation, and health effects of potential toxins, determine the transport mechanisms and ultimate fate of sediment-associated contaminants.

Sydnorden

The Nordkalott and Mid-Norden projects, carried out by the Geological Surveys of Finland, Norway and Sweden, have attracted important international interest and recognition because of the far-reaching results and the very successful cooperation between countries (Wolff et al 1990, Neeb, 1996). The projects covered a large part of Finland, Sweden, and Norway and produced a vast amount of primary and compiled geoscientific information, which - from a users point of view - has proved to be useful in relation to economic and general Geological aspects in the region. The results were exhibited at international congresses and attracted great interest, and emphasised the importance of this type of co-operation between national institutions. In the northern part of the Fennoscandian Shield, geoscientific questions related to mineral deposits were the most important issues. In the planned Syd-Norden area, this aspect is still important. However, this region is more densely populated and industrialised, therefore more emphasis will be placed on compiling regional geological data necessary to understand problems related to environmental management.

As a continuation of the Nordkalott and Midnorden programmes a Syd-Norden Programme is planned by the geological surveys of the Nordic countries in order to support the Economic and Environmental development in the Baltic and Skagerrak regions by the integrated use of the combined geoscientific knowledge base in the participating countries. It will be extended to all the countries surrounding the Baltic Sea and the Skagerrak. Today, all the geological surveys in the Greater Baltic region wish to contribute to an environmentally sustainable development along the lines indicated by the Rio Conference (1992) in the "Agenda 21" and the regional Agenda 21 for the Baltic Sea Region. Important items for this agenda has been identified by the intergovernmental programme: "Visions and Strategies around the Baltic Sea 2010", "The Stockholm Declaration on Sustainable Spatial Development, Policy in the Baltic Sea Region" from the Fourth Conference of Ministers for Spatial Planning, and Development 1996 in Stockholm, the 11th meeting in the Committee for Land Use Planning and the Development of the Baltic Region 1997 in Riga, by The Danish Energy Agency Baltic Agenda 21 Action Plan for Energy, and by the Baltic Sea Council meeting 1998 in Riga



The programme is initiated by the geological surveys of the countries surrounding the Baltic Sea and the Skagerrak: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia and Sweden. In contrast to the Nordkalott and Midnorden projects the Syd-Norden Programme, however, is a framework under which several individual projects will be launched

Three project proposals are stipulated:
BRIG - Baltic Region Information on Geology. A metadata base on Skagerrak-Baltic region geological data
TECHA - Neotectonics and its role in geohazards.
MEREA - Mineral and energy resources, and environmental aspects in the Baltic and Skagerrak region.
- This is supposed to be an important project/ programme with many sub-project, such as:
Basin evolution and models, Surface geology, Marine geology and environment.
Environment - Environmental geochemistry: Natural and antropogenic harmful elements, background levels, groundwater quality, sediment/water interface processes. A basin wide integrated view of the interaction between natural conditions and the impacts of human activities;
Minerals and energy

Urban geoscience is gaining an increasing importance in Scandinavia.

One of the more important topics in the future is urban geology. The Geological Survey of Sweden is now directing certain resources to urban geological mapping. The first main project started in 1998 in Gothenburg in

cooperation with the Gothenburg City Council. All types of geological information will be mapped and used in this programme and the results will be adapted to the needs of the planners. The city planners and city environmental authorities are involved in the project. New urban areas under consideration are located in east central Sweden and will be started in year 2000. In Norway and Finland great efforts are also put in urban geology. Some examples are Trondheim and certain cities in Finland.

Environmental geology in general and evaluation of risk areas of different kinds will be further developed as well as waste deposits and contaminated soils.

In Scandinavia there are many land and water areas contaminated by previous industrial activities. There are thousands of areas where soil, groundwater, sediments are polluted to such an extent that there could be risks for humans and animals. Examples of pollutants are heavy metals, organic pollutants etc. Geoscience in Scandinavia will increasingly work with such problems in the future, mapping, monitoring, risc classification, remediation etc.

Contamination from mining, waste landfills and shooting ranges is assessed by detailed soil and ground water sampling. Soil profiles are studied in acidification research.

Other topics of interest in the future are:
The study of anthropogenic influences on acidic loadings focused on element leachability and podzol weathering and sensitivities of soils to acidification.
Improve understanding of the effect of natural and manmade environmental factors on the quality of groundwater.
Use of moss to show airborne sources of metals
Contamination from mining, both closed and operating mines
Natural contamination, concentrations of toxic or 'harmful' elements due to high natural concentrations of these elements in the underlying bedrock.

Nuclear waste disposal and applied geology

The safe disposal of nuclear waste requires a thorough understanding of the properties of the bedrock and the quality and movements of bedrock groundwater. In Sweden the solution favoured is to make use of the stable and sound environment found deep down in the bedrock. The rock is between 600 million and two billion years old. The main idea is to store the fuel in canisters embedded in clay at a depth of 500 metres in the bedrock. The repository will keep the fuel isolated for a period of 100,000 years. Sweden and Finland are also currently participating in a research programme, to find a safe repository for nuclear waste. The geological surveys of Sweden and Finland are involved in the activities concerning nuclear waste disposal and this topic will be of still greater importance in the coming years.

Monitoring and remediation activities in former Eastern Europe and Russia.

In the 1990s a large international project was carried out in the northernmost part of Europe, the Kola Ecogeochemistry project. The primary aims to the Kola Ecogeochemistry Project were: to map the extent of contamination by inorganic elements in various media around industrial centres, to map the content of radionuclides in topsoil throughout the Project area, to shed light on the process and the dynamics of trace element cycling in catchments, to establish a soil sample bank for future investigations, to determine the natural or background geochemical variability of sampled media, to investigate how deep the atmospherically transported pollutants have penetrated the soil cover, to analyse the effect of pollution on erosion patterns, e.g. by studying overbank sediment profiles, to test the usefulness of environmental sulphur isotopes in the region, to undertake international co-operation with partners, and collaboration with other national and international institutions

At the end of the last century a new atlas was produced. This atlas presents the results of the large international (Finland-Norway-Russia) multi-medium (terrestrial moss, humus, topsoil, B- and C-horizons of podzol profiles), multi-element (more than 60 chemical elements, radioisotopes and other parameters) geochemical mapping project covering 188,000 km^2 in the European Arctic. The Russian part of the area is heavily industrialised (nickel smelters, huge open cast mines of various ores, power plants) while N-Finland is one of the most pristine regions in Europe. Comparison between different media and results from different chemical extraction techniques allows a better understanding of the levels, sources, cycling and fate of chemical elements in the environment.

As a continutaion of the Kola Project The Geological Survey of Norway, the Geological Survey of Finland, North West Regional Centre Geological Centre in St Petersburg and Arkangelskgeologiya in Archangelsk will carry out an environmental geochemical mapping of northwestern Russia. This geochemical mapping will cover over one million square kilometres and consist of sampling of moss, soils, rain, snow, stream sediments and stream water. The samples will be analysed for heavy metals and organic pollutants.

Also other detailed environmental investigations will be carried out in Scandinavia in polluted areas. One now ongoing example is environmental investigations in Ämari, a former heavily polluted Soviet military airbase in Estonia. Other localities of the same kind will in the future be studied by geoscentists.

FOREGS

Within the framework of FOREGS, Forum of Geological Surveys of Europe, an environmental geochemical mapping programme is carried out all over Europe. The Geochemistry Working Group of FOREGS was established in 1996 and aims to collect, store and analyse sampled materials, to standardise national geochemical mapping data sets and to visualise the concentration of selected elements. Twenty six countries are involved including Albania, Latvia, Luxembourg, Russia and Switzerland. The objectives is to publish a Geochemical Atlas of Europe in 2001. The aim of this mapping is to collect, store and analyse several sampling materials from the Global Terrestrial Network (GTN) cells. These reference materials will be used to combine national geochemical mapping results into a European wide or even a global scale geochemical atlas. The sampling is totally randomised, and it will not display the lowest natural background concentrations, but it will show the actual situation within Europe. The materials to be sampled are stream water (filtered and unfiltered), stream sediment, residual soil, upper horizon, lower horizon, humus where present, floodplain sediment. During the next decade after presentation of the results of the project, implementation will be carried out by all the participating countries.

EuroGeoSurveys

A new European geoscientific body which is becoming increasingly important in Europe and Scandinavia is EuroGeoSurveys with an office in Brussels. EuroGeoSurveys is a European non-profit association constituted by the Directors of the national Geological Surveys of all fifteen member states of the European Union plus Norway. The association's main aim is to provide the entire range of European institutions with expert, balanced and practical pan-European advice and information as an aid to problem-solving and policy formulation in areas such as the use of natural resources (minerals, water, energy and soils) and the sustainable management of environmental issues and natural hazards. The Association of the Geological Surveys of the European Union aims: To bring together the Geological Surveys enabling them to jointly address European issues of common interest, to provide a permanent network between the Geological Surveys and a common, but not unique, gateway to each of the Surveys and their national networks, to assist the European Union to obtain joint technical advice from the Geological Surveys of the Member States, to promote, wherever appropriate, the contribution of geoscience to European Union affairs and action programmes and to initiate, develop, and promote geoscience inputs to co-ordinated bilateral and multilateral programmes within European and other countries.

EuroGeoSurveys will provide assistance in: gathering the technical data and advice necessary for the formulation of policy or for solving problems in the fields of the sustainable development of water, mineral and energy resources; land-use planning, conservation and management of the environment and infrastructure development, coastal zone management and prediction and mitigation of geohazards. EuroGeoSurveys will during the 21st century be increasingly important for the geological surveys in Europe including the Scandinavian countries.

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