The Association of Geological Surveys of the European Union
(EuroGeoSurveys)
in their position as
custodians to their national natural resources
and
guardians of their terrestrial environment

present their contribution to
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"Towards an urban agenda in the European Union."

The importance of the Geosciences in holistic urban environmental planning

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1. Introduction

EuroGeoSurveys (see Annex A) welcomes the Communication[1] and European Spatial Development Perspective[2] documents published in 1997. It shares the Commission's perception that the cities are the hearts of Europe and agrees that it is timely to set up guidelines for safeguarding the quality of city life and their environments and to preserve their natural and cultural heritage. Such actions are particularly necessary in view of current estimates that the urban population is likely to grow to 83 per cent of the European Union's total population by the year 2025. This paper seeks to give specific examples of urban environmental problems seen from the geoscience viewpoint and to suggest some appropriate practical actions at a European level.

2. Statement of the problem

At the visual level the European cities have an aspect of long-established physical solidity. However key issues which are likely to cause special environmental and socio-economic impacts as urban populations continue to increase and city physical infrastructures age will include:

- The need for greatly increased flows of Earth resources to satisfy the basic needs of Europe's city dwellers for food, water, minerals (including building materials such as stone, sand and gravel which make up 60% of per capita mineral consumption in a 70-year human lifetime[4]) and energy, most of which will have to be extracted from places close to population centres.

- Operations for extracting Earth resources will need to be carefully monitored, regulated and balanced so that on the one hand they do not upset the delicate local balance in Earth systems and on the other do not make economically valuable Earth materials inaccessible through uninformed expansion of the built zone.

- Extraction of groundwater from beneath cities will need to be carefully controlled in order not to cause subsidence or the risk of flooding.

- Increased usage of city water and drainage systems will strain existing ageing underground conduits, resulting in increased leakage and damage to both natural and built structures underground.

- The subsurface structure of building sites will need careful assessment to prevent construction on slopes that are unstable or liable to develop landslides.

- As the present 500 kg of waste produced annually by each city dweller is likely to rise by 3 per cent each year (OECD estimate) the enormous resulting quantities of waste will have to be disposed of safely above or below ground level but not so far away from cities that uneconomic transport costs are incurred.

- Waste disposal sites will need careful selection so that toxic liquids, gases and other harmful materials will not leak into underground water or fracture systems or into the atmosphere.

We remark that like the Dobris Report[3] neither of the two new documents[1,2] addresses the unseen but extremely important dimensions of time or the underground space of European cities. It is unwise for city managements to ignore these dimensions because many of the geological issues involved exert a strong influence on city dwellers in terms of money, health and lives. The subsurface geology of the city and also the hinterland which provides its water, construction materials and other minerals, waste disposal sites and agricultural zones must be understood and monitored in a holistic, four-dimensional context[5].

3. The monetary cost of geo-problems to urban society

Some estimates made for the United States in 1993 (in 1990 US dollars) are given here as indicators of the high monetary cost of certain geo-hazards to society:

Asbestos pollution
A cumulative total of $12-75 billion for remediation of buildings, rising to US$100 billion including litigation and enforcement.
Radon gas
$ 100 billion to reduce exposure to recommended Environmental Protection Agency levels.
Shrinkage and swelling of soils
$ 6-11 billion annually in building and foundation repairs.
Acid drainage
$365 million annually to control; $ 13-54 billion cumulative to repair.
Water quality
$230 million annually to provide drinking water and US$ 42.8 billion annually for surface water quality.
Earthquakes
$230 million per annum in the decade prior to 1989; over US$6 billion in 1989.
Volcanoes
$4 billion in 1980.
Landslides and avalanches.
$ 2 billion to US$0.5 million annually.
Floods
$3-4 billion annually.
Storm surge and coastal hazards:
$700 million annually in coastal erosion;

As will be seen in section 5, the above key issues and others are represented in many European urban environments.

4. The application of sustained geoscience investigation and records

The sixteen member organisations of EuroGeoSurveys have investigated the ground on which the European cities stand and the underground space beneath them continuously in national programmes over many decades. The association is well aware that many of the present **problems** and, on the positive side**, opportunities** in European cities are not exclusively socio-economic in character but have physical causes rooted in the natural geological structures and time-controlled processes of the solid Earth[6]. Although these processes may be unavoidable and their effects can have knock-on socio-economic effects it is possible to monitor them and to limit damage through intelligent planning based on knowledge and risk assessment.

The Geological Surveys of most European countries have already developed their national data archives into GIS-based information systems which provide detailed site information to alert decision makers, planners, insurance companies and individual house-buyers to the relevance of geo-problem scenarios. The basic data total millions of borehole logs and other site-specific geo-information items which provide extensive knowledge of sub-city geology and its processes.

It is however necessary for such relatively inexpensive systems to become routine planning tools at European level in order to standardise regulations and remedial actions and to exchange technological know-how across Europe. Best practice must be established and information exchanged to benefit city managements, planners, the construction and insurance industries, civil defence groups and ultimately individual property owners. Some city administrations (for example in France, Italy, The Netherlands, Spain and the United Kingdom) already include specialist groups which use geoscience information routinely in this way.

EuroGeoSurveys asserts that the European Union needs well-focused project action in this field to implement the aims of the Communication[1] and the ESDP[2]. Technological upgrading of existing databases, information retrieval and the definition of standards are needed rather than new research. Our suggestions are presented in sections 4, 5 and 6 below.

5. A new indicative assessment of European urban geo-problems: the EuroGeoSurveys matrix.

In autumn 1996 EuroGeoSurveys set up a specialist urban geoscience network (GEURBAN) in order to plan the foundation of an interactive electronic database that will link the member Surveys' information and provide ready geo-problem information for public European access by users such as those listed in 4 above.

The first product of GEURBAN is the attached first order matrix compilation (Table 1). This summarises a second-order matrix of more detailed information which is under construction from a very much larger collection of information still to be analysed in the sixteen national databases.

GEURBAN has selected fifteen key issues or geo-problems which can be grouped into three generic groups distinguished by their causes:

- geological and topographical
- human interference
- natural resources.

The network made a qualitative assessment of the relevance of risk which each geo-problem represents to the cities of each member country. This relevance of risk is summarised in the matrix and given an indicative numerical value and colour disk to indicate its risk rating on a scale of: almost none (0 - green), low (1 - blue), medium (2 - purple) or high (3 - red). When the numbers shown in brackets are totalled for each country the sub-totals for each generic group provide a first-order index of relevance for each of the risks assessed in the three generic groups of Key Issues (see sub-totals in red beneath vertical columns).

The blue totals at the foot of each country column therefore give an indicative rating of the relevance of geo-problems in that country's cities. Thus the countries can be listed in decreasing order of risk to their cities: Portugal (37); France (36); Greece, Italy, Spain and Sweden (33 each); Austria, Ireland, Luxembourg (28); Belgium (27); Finland, United Kingdom (25); Germany, The Netherlands (24); and Denmark, Norway (23).

The horizontal bars and black figures on the right edge of the matrix against each of the fifteen key issues represent an average index for each risk and give an indication of the relative risk from each key issue or geo-problem in the cities. Looking for the indices greater than 2 (medium risk), **human interference** (average 2.33 across Europe) is indicated as the most deleterious influence on the urban environment due to geo-problems such as groundwater pollution (2.75), surface water pollution and contaminated land (both 2.5), and urban waste disposal (2.38). The cities of France (15), Greece and Sweden (both 14) and Portugal (13) show the highest risk index from human interference while those of The Netherlands (9) show the lowest index.

In the **geological and topographical** group (average 1.74 across Europe) flooding and coastal inundation are significant risks (2.44), followed by failure of foundations and underground infrastructure (2.00) and ground collapse (1.94). In this group the cities at most risk are in Portugal (17), followed by Italy and Spain (16), Belgium and France (15); Greece and Sweden (14) with Denmark, Germany and the United Kingdom having the least risk (9). The risk of city geo-problems ascribed to **natural resources** is much lower (average 1.65 across Europe) than for the other two groups.

The matrix shows that each country has a different city "risk profile". Thus the cities of Greece, Italy, Portugal and Spain show the greatest risks for earthquakes and volcanic eruptions and those of Belgium, France, Italy, Sweden and the United Kingdom show the greatest risk of ground collapse. Cities in Germany, Spain, France, Finland, Ireland, Italy The Netherlands, Norway and Portugal show a higher risk of flooding or coastal inundation.

Other general trends can be outlined in the first order matrix (Table 1) and the future work being planned by EuroGeoSurveys is expected to enable more detailed and controlled analysis.

6. The competitive and international context

EuroGeoSurveys member organisations work in an international context and are leading members of many specialist scientific networks, including the 105-country International Union of Geological Sciences (IUGS), one of the largest and most active scientific organisations in the world. The IUGS Commission of Geological Sciences for Environmental Planning (COGEOENVIRONMENT) recently developed an innovative system for defining environmental geo-indicators to measure and monitor changes in the solid Earth's environment on human time scales. It has developed a specific sub-set of such geo-indicators for cities which is particularly relevant to current European Union agenda for sustainable city and spatial development planning [1,2,3].

7. Next actions

The information in this paper represents only the first steps in a complex area. Through the GEURBAN network the members of EuroGeoSurveys are keen to assist European Union work by contributing information from their public sector information banks and expertise to actions such as the Urban Audit, the 1998 Urban Forum and the City of Tomorrow. GEURBAN is planning a GIS-based European pilot project as a concerted action leading to definition of a longer-term project and will seek to link to European Commission and European Environment Agency actions and relevant European, national and regional networks in this area. The systems to be developed have already proved to benefit individual cities within the European Union and farther afield; they are also highly exportable and their further development is likely to increase the competitiveness of the European Union in international programmes.

8. Concluding remarks

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9. Background references in the text

1. Towards an urban agenda in the European Union. ***European Commission. COM(97)197 final of 6.05.97.***

2. European Spatial Development Perspective. ***Meeting of Ministers responsible for Spatial Planning of the Member States of the European Union. Noordwijk, 9 and 10 June 1997 (first official draft).***

3. Europe's environment. The Dobris assessment. ***European Environment Agency,Copenhagen, 1995.***

4. Mineralische Rohstoffe: Bausteine für die Wirtschaft. ***BGR Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, 1995.***

5. ***Cook, Peter J.*** The role of the earth sciences in sustaining our life-support system. ***British Geological Survey Technical Report WQ/97/1, 1997.***

6. ***Mulder, E F J de, with McCall, G J H and Marker B R***. Urban geoscience. ***(Rotterdam: Balkema). 1996***.

10 THREE ILLUSTRATIONS OF GEOPROBLEMS (photographs by the British Geological Survey)

1) Ground collapse

The locations of many pre 19th century mine workings in Britain were never recorded and there may have been as many as 100,000 to 200,000 sites at which materials other than coal were mined. The bus in this picture collapsed into an old pit worked for flints in Neolithic times.

Landfill gas
This ruined house was built on sandstone near to an unlined sandstone quarry filled with domestic waste. In March 1986 landfill gas rich in methane moved through the sandstone beds, accumulating beneath the house floor and exploding when ignited by the domestic central heating pilot light. Three people were seriously injured.

Subsidence caused by removal of groundwater
Excessive pumping of groundwater can lead to differential compaction of thick beds of geologically young sands and gravels. The picture shows the resulting structural damage to industrial buildings.

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TABLE 1 Geo-problems of Urban Areas in the European Union and Norway.