The Forum of European Geological Surveys Geochemistry Task Group Inventory 1994-1996.

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Abstract
The Forum of European Geological Surveys (FOREGS) includes representatives from 33 European countries and is responsible for co-ordinating Geological Survey activities in Europe. As part of this programme, the FOREGS Geochemistry Task Group was established in 1994 to develop strategies for the preparation of European geochemical maps following the recommendations of the International Geological Correlation Programme (IGCP) Project 259 'International Geochemical Mapping' and the International Union of Geological Sciences (IUGS) /International Association of Geochemistry and Cosmochemistry (IAGC) Working Group on Continental Geochemical Baselines. It is often difficult to compare geochemical datasets across national borders because different survey methods have been used in different countries. However, the distributions of potential contaminants, essential minerals and ore bodies extend across international boundaries and standardised international maps are essential for the effective management of resources and pollutants in the future.

The initial task of the group was to compile an inventory of geochemical data within FOREGS countries, and a questionnaire designed to establish the extent and types of surveys was sent to Geological Surveys and related organisations in the FOREGS region. This paper presents a compilation of the returns from the questionnaire, which show that the most extensive surveys are based on the collection of stream sediment (26% coverage), surface water (19% coverage) and soil (11% coverage) samples.

The future strategy of the Task Group will be to increase compatibility between national geochemical surveys and to compile an initial series of European geochemical maps. These two aims will be aided by the collection of the Global Reference Network of samples according to the methods recommended in the IGCP 259 Final Report (Darnley, et al. 1995).

1. Introduction
In 1988, the International Geological Correlation Programme (IGCP) Project 259 'International Geochemical Mapping' began to address the need for standardised geochemical databases across the globe. Recommendations for standardised methods of geochemical mapping and the preparation of global geochemical maps were published in the final report of the project (Darnley, et al. 1995). The successor project, IGCP 360, entitled ' Global Geochemical Baselines', will terminate in 1997 and the programme will be carried forward by an International Union of Geological Sciences (IUGS)/ International Association of Geochemistry and Cosmochemistry (IAGC) Working Group on Continental Geochemical Baselines chaired by Dr A. Darnley from the Geological Survey of Canada and Prof. J. Plant from the British Geological Survey. European contributions to the international geochemical mapping programme have been provided by the Western European Geological Surveys (WEGS) group and the Forum of European Geological Surveys (FOREGS).

The WEGS group was established in 1971 as an informal forum held annually for Geological Survey directors to discuss topics of mutual interest. One of the programmes organised by WEGS was the Working Group on Regional Geochemical Mapping which carried out a Pilot Project between 1988 and 1990 to compile an inventory of geochemical data in WEGS countries and to investigate methods of wide-spaced regional geochemical sampling in Western Europe. The Working Group reported in 1990 with the main recommendation that geochemical maps of Western Europe should be based on overbank sediment samples (Demetriades et al. 1990). This survey method was pursued only by a small group of countries including, West Germany, Greece and the Benelux countries but was not taken-up by other members of WEGS. In 1993, the WEGS group became FOREGS, increasing in size to include countries such as Slovakia, Hungary, Poland, the Czech Republic and united Germany (Table 1). The FOREGS Geochemistry Task Group, a new initiative to develop geochemical maps of Europe, was launched by the FOREGS group in 1994 with the initial terms of reference to compile an inventory of geochemical data available in FOREGS countries and to direct European geochemical mapping policy following the recommendations of IGCP Project 259. This paper describes the results of the first stage of the project and is concerned principally with the preparation and analysis of an inventory of the geochemical data available on the surface environment of Europe. This information forms a fundamental basis for compiling a series of geochemical maps of Europe with the primary aim of informing policy-makers concerned with the management of contaminants and resources in the environment. European geochemical maps would have a broad range of other applications including geological and metallogenic studies; agricultural, forestry and veterinary studies, epidemiological investigations and coastal pollution studies.

2. Some Geochemical Problems of the European Environment

Europe has a long history of mining, industrialisation, intensive agriculture/forestry and urbanisation, and remains one of the most densely populated and utilised land areas on earth. These factors have led to interrelated problems of land degradation and contamination, which affect both the continent and the coastal zone. There is increasing evidence of deficiency conditions in crops, agricultural animals and possibly man as a result of over-intensive landuse. Throughout Europe, public concern about the environment is growing, and, in response, national governments and the European Union (EU) are endeavouring to develop policies, legislation and infrastructure, such as the European Environment Agency (EEA) to address environmental issues. Attempts are also being made to establish "Safe Levels" of Potentially Harmful Elements and Species (PHES) in the environment, but so far these have often based on limited and/or inadequate information. As a result, the redevelopment of contaminated land is becoming increasingly difficult because of legislative and fiscal controls despite the necessity to reutilise "brown field" sites rather than extend development into "green field" areas.

At the present time, knowledge of the geochemistry of the surface environment of Europe is based on different surveys of variable standards carried out by different organisations in the public and private sectors. Whilst there are exceptions, Geological Surveys have, in the past, provided data on rocks and stream sediments; Soil Surveys on soils; Hydrological Surveys on ground and surface water; and biologists/agriculturists on plant and animal tissue samples. The current situation makes comparison between datasets at an international level very difficult. There is also a failure to recognise that the natural geochemical background is highly variable and that natural levels of PHES (such as As, Cd, Pb, NO_3, the radioelements and organic pollutants) can be as high or higher than those caused by man-made sources of pollution. Even where synthetic pollutants are concerned, it is the natural geology and geochemistry which frequently exert the fundamental controls on the distribution of the PHES and consequently determine their potential to create hazards.

3. Requirements

Systematic baseline environmental geochemical data are necessary to inform policy-makers and provide a sound basis for legislation. For this purpose such data are required to be:

1. Standardised across national boundaries.

2. Available in digital form for use on Geographical Information Systems (GIS) so that they can be viewed interactively with other datasets, such as those for land-use and for animal and human morbidity and mortality data.

3. Comprehensive, to include the majority of PHES and ideally as many harmful chemical species as possible, including synthetic compounds.

4. Based on a full suite of sample types including soil, stream sediment, surface water, groundwater and offshore marine and estuarine sediment in the coastal zone.

4. Why Geological Surveys?

Geological Surveys have an important role in providing environmental baseline data, as the lithosphere is the fundamental base on which soils and crops develop and through which water and fluid pollutants migrate. Many Surveys already have experience of optimum methods of sampling and analysing surface environmental materials and are familiar with the preparation and interpretation of multi-element geochemical maps of rocks, soils, surface waters, groundwaters and stream sediments. In Europe, national geochemical datasets already enable contaminated land to be viewed in the context of naturally occurring high levels of PHES and the natural environment generally (Appleton, 1995). In addition to providing baseline data, many Surveys have programmes concerned with site-specific pollution such as landfill and nuclear waste repositories and have considerable knowledge of the interaction of natural and synthetic pollutants with the natural environment. This information combined with expertise in ore deposits, which provide natural analogues for understanding the distribution and migration of heavy metals, radio-elements and other pollutants in different geological environments, allows more detailed study of contaminant mobility. Geological Surveys generally have the quality control procedures in place, and the expertise in databases and GIS to develop and apply environmental baseline geochemistry effectively.

5. The Inventory

Information was collected using a standard form designed by the FOREGS Geochemistry Task Group. The form comprised 9 sections, each for a particular sample type (Table 2). Detailed information on collection, preparation, analysis and data availability were requested for all sample types with the exception of rock and biological surveys where information on availability only was required. The form was distributed to the organisations detailed in Table 1. Mining and exploration companies and universities were generally not included because the surveys which they carry out tend to cover relatively small areas of less than 5000 km^2, the lower limit considered relevant for the purpose of the inventory. Completed forms were received from 29 of 33 countries (Figure 1). Croatia, Iceland, Latvia and Switzerland have not conducted regional geochemical surveys over the minimum area required for the survey. Results for Sardinia, Bulgaria and for Scottish soils were received too late to be included in the calculations presented in this paper. Unfortunately it was not possible to represent Greenland on the map projections presented in this paper. In general, the form was completed successfully although the recording of UTM coordinates for the boundaries of survey areas presented some difficulties. The coordinates held in the inventory are, therefore, a mixture of UTM coordinates, latitude and longitude and local coordinates.

6. Results

6.1 Regional coverage

The extent of coverage of FOREGS countries by each sample type is shown in Figures 2 to 7. Results for percentage of coverage are based on the total area of the 33 FOREGS countries which extend to 8306516 km^2. Table 3 lists the range of sample types collected by each country.

The coverage of regional geochemical till, organic drainage, rock, lake sediment and biological surveys is largely restricted to Scandinavian, Baltic and some central European countries (Table 3 and Figures 2-6). These surveys do not, therefore, provide a suitable basis for the preparation of European geochemical maps. The use of overbank sediment is also somewhat restricted (Table 3 and Figures 2 and 4). Although the coverage of heavy mineral surveys is more extensive (12%) (Table 3 and Figures 2 and 4), in several cases these samples have undergone qualitative rather than quantitative analysis and are consequently not suitable for the preparation of geochemical maps. Despite increased concern about radioactivity in the environment, only 18% (Table 3 and Figures 2 and 5) of the FOREGS region is covered by radiometric surveys. This contrasts with the situation in North America and Australia where complete coverage of systematic radiometric data is available. There is clearly a need for survey organisations to increase radiometric survey activity if
they are to make a significant contribution to environmental radiometric policy.

Table 1.
Organisations included in the FOREGS Geochemical Inventory

Organisation	Country
Geophysical and Geochemical Centre of Tirana (GGCT)	Albania
Geologische Bundesanstalt (GB)	Austria
Geological Survey of Belgium (GSB)	Belgium
University of Louvain-La-Neuve (UCL)	
University of Leuven (UL)	
Forest Soil Co-ordinating Centre (FSCC)	
Polytechnic Facility of Mors (PFM)	
Institut za Geoloska Istrazivanja (IGI)	Croatia
Geological Survey Department (GS Dept)	Cyprus
Czech Geological Survey (CGS)	Czech Republic
Ministry of Agriculture (Soil Survey)	
Geomineral Coop (Geomin)	
Geofyzika A S (Geofyzika)	
Danmarks Geologiske Undersøgelse (GDU)	Denmark
Ministry of Agriculture and Fisheries (MAF)	
Department of Plant and Soil Science (DPSS)	
Eesti Geoloogiakeskus (EG)	Estonia
Geological Survey of Finland (GSF)	Finland
Bureau de Recherches Géologiques et Minières (BRGM)	France
Geologisches Landesmat North-Rhine-Westphalia (GLNRW)	Germany
Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)	
Institute of Geology and Mineral Exploration (IGME)	Greece
Grønlands Geologiske Undersøgelse (GGU)	Greenland

Geological Institute of Hungary (GIH)	Hungary
Orkustofnun (Ork)	Iceland
Geological Survey of Ireland (GSI)	Irish Republic
Ministry of Industry (MCA)	Italy
University di Napoli (Uni di Napoli)	
Geological Survey of Latvia (GSL)	Latvia
Lietuvos Geologijos Tarnyba (LGT)	Lithuania
Institute of Geology (IG)	
Institute of Forestry (Forest Inst)	
Service Géologique du Luxembourg (See Belgium)	Luxembourg
Rijks Geologische Dienst (RGD)	The Netherlands
Norges Geologiske Undersøkelse (NGU)	Norway
Panstwowy Institut Geologiczny (PIG)	Poland
Aveiro University (Aveiro Uni)	Portugal
Instituto Geológico e Mineiro (IGM)	
Geological Institute of Romania (GIR)	Romania
Geological Survey of the Slovak Republic (GSSR)	Slovakia
Soil Survey of Slovakia (Soil Survey)	
Forestry Research Institute (Forest Res Inst)	
Uranpress (Uranpress)	
Institute for Geology, Geotechnics and Geophysics (GZL)	Slovenia
Instituto Technológico GeoMinero de España (ITGE)	Spain
Empresa Nacional del Uranio SA (ENUSA)	
Sveriges Geologiska Undersokning (SGU)	Sweden
Department of Mineral Resources (NSG)	
Schweizer Landeshydrologie und Geologie (SLG)	Switzerland
Maden Tektik ve Arama (MTA)	Turkey
Inst. of Geochemistry, Mineralogy and Ore Formation (IGMOF)	Ukraine
British Geological Survey (BGS)	UK
Soil Survey of England and Wales (Soil Survey)	
Environmental Geochemistry Research Group, (EGRC,ICL)	
Imperial College London	
Macaulay Land Use Research Institute (MLURI)	

Table 2.
Sample types included in the FOREGS geochemical inventory.

Form Section	Sample Type	Information Required
A	Drainage Sediment	Full survey procedure
B	Lake Sediment	Full survey procedure
C	Overbank Sediment	Full survey procedure
D	Soil and Regolith	Full survey procedure
E	Heavy Mineral	Full survey procedure
F	Surface Water	Full survey procedure
G	Rock Sample	Information available Yes/No
H	Biological Sample	Information available Yes/No
I	Radiometric	Full survey procedure

Many FOREGS countries have surveys based on either stream sediments, surface waters or soils and these materials are considered in more detail in this report as they appear to offer the most valuable basis for the preparation of European geochemical maps. Stream sediment surveys are by far the most extensive and have been carried out in 22 of the 33 countries covering 26% of the FOREGS region (Table 3 and Figures 2 and 6). Complete systematic coverage is available for Albania, Northern Fennoscandia, former West Germany, Lithuania, Poland, Slovakia and Slovenia. Large areas of Austria, the Czech Republic, France, Greece, Greenland, Portugal, Romania and the UK are also covered. Most of these surveys have been carried out for a range of environmental and economic applications, although surveys carried out in France, Greenland and Spain were primarily for mineral exploration .

Surface water surveys covering nearly one fifth of the FOREGS region have generally involved the collection of stream water, although spring and lake water have also been sampled, particularly in Central Europe (Table 3; Figures 2 and 7). Multi-element analysis is available for surveys covering most of the Czech Republic, former West Germany, Poland, Slovakia and Slovenia and for extensive areas of Finland, Norway, Romania and the UK. In addition, data for U, are available for Albania, Greenland and northern UK.

Soils have been collected in 16 of the 33 countries, covering 11% of the FOREGS region (Table 3 and Figures 2 and 3). Belgian, German, Slovenian and Ukrainian surveys have sampled A, B and C horizon soils whereas, Slovakian surveys are based on the collection of A and C horizon soils only. Surveys in the Czech Republic, Estonia, Lithuania, The Netherlands, Norway, Portugal and the UK are based on the collection of A horizon soils although some surveys in the Czech Republic and the UK also sample B horizon soils. Surveys in Albania and France are based on the collection of B horizon soil only.

6.2 Sampling Density

A wide range of sampling densities have been employed across the FOREGS region, reflecting different survey objectives. Stream sediment survey densities range from 1 sample per <0.5 km^2 in France, Greece, Italy, Portugal and Spain for mineral exploration to 1 sample per 200 km^2 in Fennoscandia for geological and metallogenic province mapping, to 1 sample per 2000 km^2 in Romania for rapid reconnaissance mapping (Table 4). Most surveys, however, have been carried out in the range of 1 sample per 1 km^2 to 1 sample per 5 km^2 (Table 4).

Surface water surveys range from relatively high densities (< 1 sample per 2.5 km^2 in Albania, Germany and the UK) to very low densities in Finland and Romania (1 sample per 290 km^2 and 1 sample per 2000 km^2 respectively).

In general, soil survey sampling densities follow similar trends to those of stream sediments ranging from 1 sample per < 1 km^2 in France and Portugal to 1 sample per 3500 km^2 in Estonia. Most soil surveys have been conducted in the range 1 sample per 5 km^2 to 1 sample per 25 km^2.

Table 4.

Sampling densities employed for stream sediment, surface water and soil surveys in FOREGS countries.

	Sampling Density (1 sample per x km^2)								
	0.01-0.30	0.4	0.5	1	1.5	2	2.5	3	4
Stream Sediments	Portugal Spain	Spain	France Greece Italy	Belgium Turkey	Austria Czech UK	Slovakia Turkey UK	Albania	Italy Norway UK	Germany Hungary Ireland Norway
Surface Water					UK	Germany UK	Albania	Germany Slovakia	
Soil	Portugal		France	Czech Ukraine		Germany UK	Albania		
	5	6	7	10-16	25	30	40	50	60

Stream Sediments	Greenland Poland		Spain		Norway Poland	Greenland Norway	Norway	Greenland	Lithuania
Surface Water	Poland	Czech			Poland	Greenland Norway		Greenland Norway	
Soil	Poland Slovakia			Estonia Netherlands	Poland Slovenia UK	Estonia	Norway	Lithuania	
	76-100	180	200	225-290	450	1800	2000	2400	3500
Stream Sediments			Finland Norway Slovenia Sweden	Portugal			Romania		
Surface Water			Slovenia	Finland			Romania		
Soil	Belgium UK	Slovenia		Portugal	Estonia	Estonia		Estonia	Estonia

6.3 Size Fractions

The size fractions analysed for the different stream sediment surveys range from < 63 µm (BSI 240 mesh) in the Czech Republic, Romania and Slovenia to < 1000 µm (BSI 16 mesh) in Lithuania (Table 5). Most stream sediment surveys have, however, been based on the collection and analysis of < 177 to < 200 µm (BSI 80 to 76 mesh) fractions (Figure 8).

All the filtered surface water analyses carried out in the FOREGS region have been based on a filter size of 0.45 µm with the exception of Poland where a hard filter was used (Figure 9 and Table 5).

The range of grain-size fractions collected for soil surveys is bimodal. Some countries collect < 100 to < 180 µm (BSI 150 to 85 mesh) fractions to integrate with stream sediment surveys, while others follow traditional soil survey practice and use < 1000 or < 2000 µm (BSI 16 or 8 mesh) fractions (Table 5 and Figure 9).

Table 5.
Size fractions collected for stream sediment, surface water and soil samples in FOREGS countries.

	Water		Size Fraction								
	Unfiltered	Filtered				< µm					
	None	0.45	63	100	125	150	177	180	200	1000	2000
Stream Sediment	Lithuania	Romania	Czech Hungary Slovenia	Greenland Slovakia	France Ireland	Greenland Greece UK	Belgium Spain Turkey	Austria Poland Finland Norway Portugal	Albania UK	Germany	

						Sweden		
Surface Water	Albania Czech Finland Germany Greenland Norway Romania Slovakia Slovenia UK	Finland Germany Norway Slovakia Slovenia UK						
Soil			Cyprus	France Slovakia	UK	Albania Portugal	Lithuania Norway Poland Ukraine	Belgium Czech Estonia Germany Nethlnds Slovenia UK

6.4 Sieving Techniques

Several countries had difficulty completing the section of the inventory on sieving methods. In some cases it is not clear whether samples were sieved in the field, in the laboratory or both (Table 6). The majority of stream sediment surveys employ sieving techniques in the laboratory after the samples have been dried, but in a significant number of countries sediment is wet sieved in the field. Surveys in Norway and a small area in the north of the UK are based on wet sieving sediment to a relatively coarse size fraction in the field followed by dry sieving to a finer mesh size in the laboratory. With the exception of Belgium and the Ukraine, all soil surveys are based on dry sieving methods. Estonia and Cyprus are the only countries to dry sieve soils in the field.

6.5 Analytical Techniques

A range of techniques have been employed to analyse geochemical samples in FOREGS countries, largely reflecting the years during which the survey was conducted. The abbreviations used to describe each technique are listed in Table 7. The main analytical methods available in FOREGS countries include XRF, ICP-AES, ICP-MS, DC-Arc ES, Flame AAS and NAA (Table 8). Surveys in Ireland, Italy and Luxembourg do not have the facilities to analyse regional geochemical samples, therefore geochemical analyses were carried out in commercial and survey laboratories in other countries in these cases.

Table 6
Sample sieving methods employed in FOREGS countries.

	Field Sieving	Laboratory Sieving		Field Wet then		Field Dry then
	Wet	Dry	Wet	Dry	Lab Dry Sieving	Lab Dry Sieving
Stream Sediments	Finland Ireland	Greece Turkey		Albania Austria	Norway UK (minor area)	

	Norway Sweden Romania Spain UK	Italy		Belgium Czech France Germany Greenland Hungary Lithuania Poland Portugal Slovakia Slovenia Spain UK	
Soils		Estonia	Belgium Ukraine	Albania Czech France Germany Lithuania Netherlands Poland Portugal Slovakia Slovenia Ukraine UK	Cyprus

The range of elements determined appears to reflect the type of analytical method available rather than the economic or environmental aims of the survey (Figures 10-12). Elements such as Sr and Zr which are readily determined by rapid, high-productivity, cost-effective methods have been included in more surveys than elements such as Au and U which are potentially of greater economic significance. There are few data for elements of environmental importance which are difficult to determine by automated analytical methods. Iodine has been determined in only one water survey, for example, and only Greenland, Norway, Slovakia and the UK have data for Se in stream sediments, surface waters or soils. Both total and extractable analytical methods have been employed. The definitions listed in the inventory are those described by each survey organisation.

Table 7.
Abbreviations of analytical techniques employed by FOREGS countries.

Analytical Technique	Abbreviation
DC Arc Emission Spectrometry	DC-Arc ES
Flame Atomic Absorption Spectrometry	Flame AAS
Electro-thermal Vaporisation Atomic Absorption Spectrometry	ETV-AAS
Cold Vapour Atomic Absorption Spectrometry	Cold vapour AAS
Atomic Absorption Spectrometry (unspecified)	AAS
Inductively Coupled Plasma Atomic Emission Spectrometry	ICP-AES
Direct Current Plasma Atomic Emission Spectrometry	DCP-AES
Inductively Coupled Plasma Mass Spectrometry	ICP-MS
Optical Emission Spectrometry	OES
Spectrophotometry	Spectrophotometry
Flame Photometry	Flame Phot
Semi-quantitative Spectral Analysis	Semi quant. Spectral
Instrumental Neutron Activation Analysis	INAA
Delayed Neutron Activation Analysis	DNAA
Neutron Activation Analysis (unspecified)	NAA
Delayed Neutron Counting	DNC
Flow Injection Analysis	FIA
Ion Selective Electrode	ISE
Ion Chromatography	IC
High Precision Liquid Chromatography	HPLC
Gas Chromatography	GC
GSM (Albania)	GSM
X-ray Fluorescence	XRF
Energy Dispersive X-ray Fluorescence	ED-XRF
Fluorimetric	Fluorimetric
X-ray Diffraction	XRD
Colorimetric	Colorimetric
Gravimetric	Gravimetric
LECO	LECO
Kjeldahl	Kjeldahl
Gutzeit Test	Gutzeit
Catalytic	Catalytic

Table 8.
Main analytical techniques employed by FOREGS countries

XRF	DC-Arc ES	ICP-AES	ICP-MS	Flame AAS	NAA
Albania	Albania	Albania	Finland	Austria	Czech
Austria	Austria	Austria	Romania	Belgium	Finland
Belgium	Germany	Belgium	Slovenia	Cyprus	Greece
Czech	Greenland	Czech	UK	Czech	Greenland
Estonia	Lithuania	Finland		Denmark	Ireland
Finland	Ukraine	Germany		Estonia	Norway
Germany	UK	Greece		Finland	Sweden
Greece		Hungary		Germany	UK
Greenland		Norway		Greece	
Lithuania		Poland		Greenland	
Luxembourg		Portugal		Hungary	
Italy		Slovakia		Ireland	
Netherlands		Slovenia		Italy	
Norway		Spain		Luxembourg	
Romania		Sweden		Norway	
Sweden		UK		Spain	
UK				Sweden	
				Turkey	
				UK	

6.6 Quality Control Procedures

All FOREGS countries employ some form of quality control procedure involving inclusion of field and/ or analytical duplicates in analysis, repeat analysis and analysis of internal and/ or international reference materials (Table 9). There are, however, no systematic quality control procedures among countries, highlighting the need for the EU-funded laboratory standardisation project proposed by the FOREGS Geochemistry Task Group. The UK is the only country where national water standards are included in analysis.

Table 9.
Analysis of international standards in FOREGS countries.

International Standards Analysed Yes	No	No Response to Inventory Question
Austria	Albania	Belgium
Cyprus	Germany (seds)	Denmark
Czech	Greece	Italy
Estonia	Poland	Portugal (some surveys)
Finland	Spain (some surveys)	Romania
France	Ukraine	Turkey
Germany (soil)	UK (some surveys)	
Greenland		
Hungary		
Ireland		
Lithuania		
Netherlands		
Norway		
Portugal		
Slovakia		

Slovenia
Spain
Sweden
UK

6.7 Archive Sample Material and Digital Data

Most FOREGS countries retain sample archives for stream sediment and soil samples, although Albania is the only country to report storage of surface water samples (Table 10).
Stream sediment sample archives are available for 14% of the area of FOREGS countries and soil archive material extends to 6% (Figure 13).

Digital data are available for 21% of the FOREGS region for stream sediments, 6% for surface waters and 8% for soils (Figure 13)

Table 10.
Availability of sample archives and digital data in FOREGS countries

	Sample Archives		Digital Data		No Response
	Yes	No	Yes	No	to question
Stream Sediments	Albania France Greece Ireland Italy Lithuania Norway Poland Portugal (some) Slovakia Spain UK	Austria Belgium Germany Greenland Hungary Portugal (some) Turkey	Albania Austria Germany Greece Greenland Hungary Ireland Italy Lithuania Norway Poland Portugal (some) Slovakia Slovenia Spain Turkey UK	Belgium Portugal (some surveys) Romania	Czech France (digital) Norway (some surveys) Romania (archive) Slovenia (archive)
Surface (digital) Water	Albania	Czech Finland Germany Greenland Norway Poland Slovakia Slovenia UK	Albania Czech Germany Norway Slovakia Slovenia UK	Finland Poland Romania	Greenland Romania (archive)
Soil (archive)	Albania Czech Estonia France Germany Lithuania Norway Portugal (some) Slovakia	Belgium Netherlands Poland Portugal (some) UK (some)	Albania Czech Estonia France Germany Lithuania Netherlands Norway Portugal (some)	Belgium Poland Portugal (some surveys) UK (some surveys)	Ukraine

Slovenia	Slovakia
UK	Slovenia
	Ukraine
	UK

7. Conclusions

1. Many FOREGS countries have high-quality multi-element, geochemical data available in digital form at the national level which can be interacted with other geoscience and environmental datasets using GIS.

2. The data have been collected for various purposes including exploration and environmental studies. In several countries multi-purpose surveys are now in progress.

3. This is reflected by the range of sample types collected. Stream sediment, stream water and soil data are available from most surveys. These sample types therefore provide the most appropriate basis for the preparation of environmental geochemical baseline maps of the FOREGS countries.

4. Across the FOREGS countries, stream sediments have been collected using a narrow range of mesh sizes (< 150 to < 200 µm), close to those recommended in the UNESCO report of IGCP 259.

5. In the case of soil surveys conducted for geochemical purposes, however, the range of mesh sizes is bimodal. Some surveys collect fine mesh sizes (close to those recommended in the UNESCO report of IGCP 259) to integrate with stream sediment data while others follow traditional soil survey methods and use < 1000 or < 2000 µm fractions.

6. Various analytical methods have been used, partly reflecting the years in which the survey was performed. Most data have been calibrated using international reference materials.

7. Different suites of chemical elements have been determined in different surveys but data for the PHES are generally available.

8. Sample densities range from 1 sample per 0.5 km^2 to 1 sample per 3500 km^2 .

9. Sample archives are available for re-analysis for up to 14% of the land area of the FOREGS countries.

10. Systematic radiometric data are available for only a small proportion of the land area of the FOREGS countries, despite the Chernobyl accident and increasing concern about natural radioactivity, especially radon gas. This compares very unfavourably with North America, the Former Soviet Union and many developing countries.

8. Recommendations

1. It is recommended that FOREGS organisations prepare or modify their existing geochemical programmes to ensure that their data conform to IGCP 259/360 standards and are suitable for environmental baseline studies as well as other purposes.

2. In terms of national mapping programmes, it is also recommended that a stream sediment and/or soil and one surface water sample if possible be collected at each sample site, in addition to samples such as till, rock or biological material which may be required for national purposes. A minimum density of 1 site per 100 km^2 is recommended (where higher density surveys are available these can be sub-sampled using computer methods). Sampling methods should be those described in Darnley et al. (1995). Collection of < 2000 µm soil samples only is not recommended since they involve the preparation and analysis of a large proportion of quartz and other coarse-grained dilutants. If < 2000 µm soil samples are required for agricultural studies these should be collected in addition to < 150 µm samples.

3. The preparation of European Geochemical Maps should incorporate existing geochemical data. The integration of these datasets will be aided greatly by completion of a geochemical Global Reference Network (GRN) Darnley et al. (1995).

4. Integration of existing data may require some re-analysis and re-sampling especially for for environmentally important trace elements such as Se and I.

5. The collection of GRN samples should be the next priority for FOREGS countries.

6. Implementation of a GRN of samples in Europe also provides a basis for monitoring changes in environmental geochemical baselines through time. In the UK, for example, it is proposed to combine geochemical monitoring with the operation of the seismic network (the UK is served by 70 seismic monitoring stations). The range of remotely-gathered data from selected monitoring sites will be extended to include surface or atmospheric gamma radiation and radon in soil gas. In addition, it is proposed that routine geochemical sampling of stream sediment, surface water and soil should be carried out during maintenance visits to the seismic network sites. The proposed programme will provide information on both short/ medium-term radiometric variation and long-term geochemical change.

7. Analytical methods should be standardised across Europe.

8. A standing group involving geochemists from all FOREGS countries has been established and will take the programme forward and act as the European Regional Committee for the IUGS/IAGC Working Group on Continental Geochemical Baselines.

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Full details of the inventory are available in the FOREGS Geochemistry Task Group 1994-1996 Report, Technical Report WP/95/14 available from the British Geological Survey priced £25.