INTRODUCTION

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General Background

The FOREGS Geochemical Baseline Mapping Programme's main aim is to provide high quality, multi-purpose environmental geochemical baseline data for Europe. The need for this type of data was justified by the first Working Group on Regional Geochemical Mapping immediately after the Chernobyl accident in 1986, when it was realised that a baseline for radioactive and other polluting elements could not be defined (Bølviken *et al*. 1990, 1993, 1996). Subsequent compilation of inventories of existing regional geochemical databases in Europe revealed the existence of some 120 separate geochemical databases based on up to seven different sample media. Although a wide range of element concentrations were determined by 13 different analytical methods, many environmentally essential elements were, however, not measured. (Plant and Ridgeway, 1990; Plant *et al*. 1996, 1997). Because it was impossible to compile a homogeneous data set for the whole of Europe from these data, it was clear that the establishment of a harmonised European wide geochemical database was essential. This database could then be used for levelling older national geochemical databases in order to produce more detailed European wide maps to satisfy the needs of present day national and European Union legislation. Plant *et al*. (1997) made the case thus:

> *"Throughout Europe public concern about the environment is growing. In response, national governments and the European Union (EU) are attempting to develop policies, legislation and infrastructure, such as the European Environment Agency (EEA). Attempts are also being made to establish 'Safe Levels' of Potentially Harmful Elements and Species (PHES), but these are often based on limited and/or inadequate information.*
>
> *The available data on environmental geochemical baselines and radioactivity are not systematic in coverage or quality and, therefore, are not of the standard required to quantify the distribution of PHEs at the European scale as a basis for policy-making and monitoring future change to the environment.*
>
> *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 organizations in the public and private sectors. Whilst there are exceptions, Geological Surveys have, in the past, provided data on rock and stream sediments; soil surveys on soils; hydrological surveys on ground and surface water and biologists/agriculturists on plant and animal tissue samples.*
>
> *In general, there is a failure to recognise that the natural geochemical background is highly variable and the natural levels of PHEs (such as As, Cd, Pb, NO_3^-, the radioactive elements 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."*

Data on geochemical baselines are urgently needed in Europe, because environmental authorities in most countries are defining limits for contaminants in soils for different land use purposes. At the same time, the Commission of the European Union (EU) is preparing the Soil Protection Directive. As geochemists know, the natural concentrations of elements are different in the different constituents of overburden, and vary markedly between geologically disparate areas. State authorities, however, are not always aware of these significant natural variations, which should be taken into account in defining action limits. There are already examples of action limits that are lower than natural concentrations.

The data produced by the FOREGS Geochemical Baseline Mapping programme should make a significant contribution to the EU Soil Protection Directive, especially as a basis for defining action limits. Older national geochemical data sets in Europe, as it has already been pointed out (Plant and Ridgeway 1990; Plant *et al.* 1996, 1997), are not in a form that can be readily used for this purpose. It is not possible to define the present day European geochemical baseline for a single element on the basis of old geochemical data.

Systematic baseline environmental geochemical data are necessary to inform policy makers and to provide a sound basis for legislation. According to Plant *et al.* (1996), for this purpose such data are required to be:

1. *Standardised across national boundaries.*
2. *Available in digital form for use in 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 off-shore marine and estuarine sediment in the coastal zone.*

The report by Plant *et al.* (1996) also gives reasons why Geological Surveys, or equivalent governmental institutions, are particularly well suited to provide the data needed to establish systematic environmental geochemical baseline databases for Europe.

In Europe, the geochemical results of the Global Terrestrial Network sampling (GTN) - also called the Global Reference Network (GRN) - as recommended by the UNESCO International Geological Correlation Programmes IGCP 259, "*International Geochemical Mapping*", and its successor, IGCP 360, "*Global Geochemical Baselines*" (Darnley *et al.* 1995), will be used as a reference to normalise national baseline datasets in Europe.

The FOREGS programme is also the European contribution, and a practical example, to the International Union of Geological Sciences (IUGS) - International Association of Geochemistry and Cosmochemistry (IAGC) Working Group on "Global Geochemical Baselines".

The FOREGS Geochemical Baseline Mapping Programme was approved in 1996 by the Forum of European Geological Surveys' Directors (FOREGS). In 1996, the Working Group representatives were nominated by each country and by the end of 1997 the principles of field and analytical methodologies were agreed. The field methodology was subsequently tested and modified during a practical field course in the Slovak Republic in June 1997, and the "FOREGS Geochemical Field Manual" was published in 1998 (Salminen, Tarvainen *et al.* 1998).

The geochemical data are based on the analysis of samples of stream water, stream sediment, floodplain sediment (or alluvial soil), residual soil, and humus collected from 26 European countries. High quality and consistency of the data were ensured by using standardised sampling methods (Salminen, Tarvainen *et al.* 1998), and by applying rigorous, harmonised quality assurance measures during chemical analysis and subsequent data handling stages.

Sampling Media

The choice of sampling media has been made in accordance with the recommendations of the IUGS/IAGC Working Group on Global Geochemical Baselines (Darnley *et al*. 1995). These media, described below, are considered to be the most representative of the Earth's surface environment, and are the most commonly used in past and current environmental geochemical investigations:

- Stream water (filtered and unfiltered);

- Stream sediment – mineral sediment (<0.150 mm);
- Residual soil – upper 0–25 cm horizon (topsoil) without the top organic layer (<2 mm);
- Residual soil – lower (C) horizon (subsoil); a 25 cm layer within a depth range of 50–200 cm (<2 mm);
- Humus (where present);
- Overbank sediment – upper 0–25 cm horizon (<0.150 mm, optional);
- Overbank sediment – bottom layer (<0.150 mm, optional);
- Floodplain sediment – upper 0–25 cm horizon (<2 mm), and
- Floodplain sediment – bottom layer (<2 mm, optional).

Stream and floodplain sediment samples generally reflect the average geogenic composition of a catchment basin for most elements, although they are sensitive to pollution. Since most national Geological Surveys have undertaken national stream sediment studies, the FOREGS stream sediment baseline data will be used to level these more detailed national datasets, and to link the results across Europe.

Stream waters reflect the interplay between geosphere/hydrosphere and pollution. At the same time, they can be a major source of drinking water. Many surveys have completed local studies, so the FOREGS data can be used to link results across Europe.

Soil samples reflect variations in the geogenic composition of the uppermost layers of the Earth's crust. Because of this, it was important to avoid soil sampling at locations that had visible or known contamination. Priority for site selection was given to:

1. forested and unused lands;
2. greenland and pastures; and
3. non-cultivated parts of agricultural land (in very special cases, where residual soil could not be found).

Comparison of topsoil and subsoil data gives information about enrichment or depletion processes between the layers. One such process is anthropogenic contamination of the top layer. The <2 mm fraction was taken according to environmental standards. The <0.18 mm and finer fractions have been widely used in mineral exploration programmes, and the FOREGS data will be used to create a link between environmental and mineral exploration databases.

Humus samples can be used to determine the atmospheric (anthropogenic) input of elements to the ecosystem. To reach this aim, samples were collected in forested areas as near as possible to the residual soil sampling sites. To reflect the atmospheric input, the uppermost few centimetres of the organic layer were collected immediately under the green vegetation and litter (max. 3 cm).

GTN sampling locations were totally randomised, and are not designed to show the lowest natural background concentrations in the European environment, but to demonstrate the geochemistry of the surface environment at the end of the 20th century.

Organisation and Time Frame of the Programme

The work was carried out by the FOREGS Geochemistry Working Group. To this group belonged representatives of the following 26 European countries (see table at end of chapter). An executive group was nominated to lead different activities as described below:

<u>Executive group:</u>

Chair	Prof. R Salminen (Finland)
Secretary	Ms Fiona Fordyce (UK) 1996-1998
	Ms Lorraine Williams (UK) 1998-1999
	Mr S Reeder (UK) 2000-

Co-ordinating Committees:

Sample Preparation & Storage	Dr K Marsina (Slovak Republic)
Analytical	Dr H Sandström (Finland)
Data Management	Dr T Tarvainen (Finland)
Publishing	Dr P Klein (Austria)
Scientific Interpretation	Prof. J Plant (UK) 1996-2004
	Dr W De Vos (Belgium) 2004-
Public Relations (including public understanding of science)	Mr A Demetriades (Greece)
GIS and background data	Lorraine Williams (UK) 1998-1999

Work started with the preparation of the Field Manual (Salminen, Tarvainen *et al* 1998), which was accepted by each participating country. The sampling was carried out as national projects by the geological institutions of the FOREGS countries. Sampling started in 1998 and was completed in November 2001.

Nine laboratories from participating Geological Surveys were selected to carry out the analysis. In order to ensure the homogeneity of the data and to avoid any bias between laboratories or analytical methods, each laboratory was nominated to take responsibility for carrying out analysis by a particular analytical technique or techniques on all samples of a certain type. Analytical work was carried out from 1999 to 2003. All applied methods are described in detail in the analytical manual (see chapter on Analysis). A sample archive was established in the Slovak Republic and samples will be available for future analysis at the discretion of the FOREGS Geochemistry working group.

The Geological Survey of Finland (GTK) coordinated the sampling, analytical work and data management. GTK provided detailed sampling instructions (also on web pages), sent all maps of random sampling sites within GTN cells, created the project database, and gave further information whenever needed.

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