Europe's geochemical cartography

Pinning Down the Background

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Being able to effectively protect our environment hinges upon first having a good understanding of the condition of its various elements and the mechanisms involved, and then taking any necessary steps to prevent and repair damage

Geological services in European countries have been doing joint geochemical research since the 1990s. This includes collecting samples from various surface environments, determining their chemical composition in laboratories, calculating statistical parameters of the data sets, and presenting distributions of components on geochemical maps. The statistical parameters (mainly medians and percentiles) are used to determine the content classes used in creating the maps.

Steady improvement in chemical analysis methods has resulted in the generation of increasingly extensive and precise data on the content of individual elements in the natural environment. However, purely numerical information (reflecting concentrations of a given element) is only useful when compared against the baseline "geochemical background," which according to traditional definitions refers to the concentration range of a given element characteristic for the geological structure of a given region and country. It shows variability depending on region (resulting from differences in lithology and climate) and time (caused by the migration of components within a given medium), as well as between different elements of the environment. Beyond the upper and lower boundaries, there lie certain negative and positive anomalies. Numerically speaking, the geochemical background is expressed as an individual value (median, arithmetical mean, geometric mean); it is determined using statistical methods which require representative data sets and an understanding of the distribution of results.

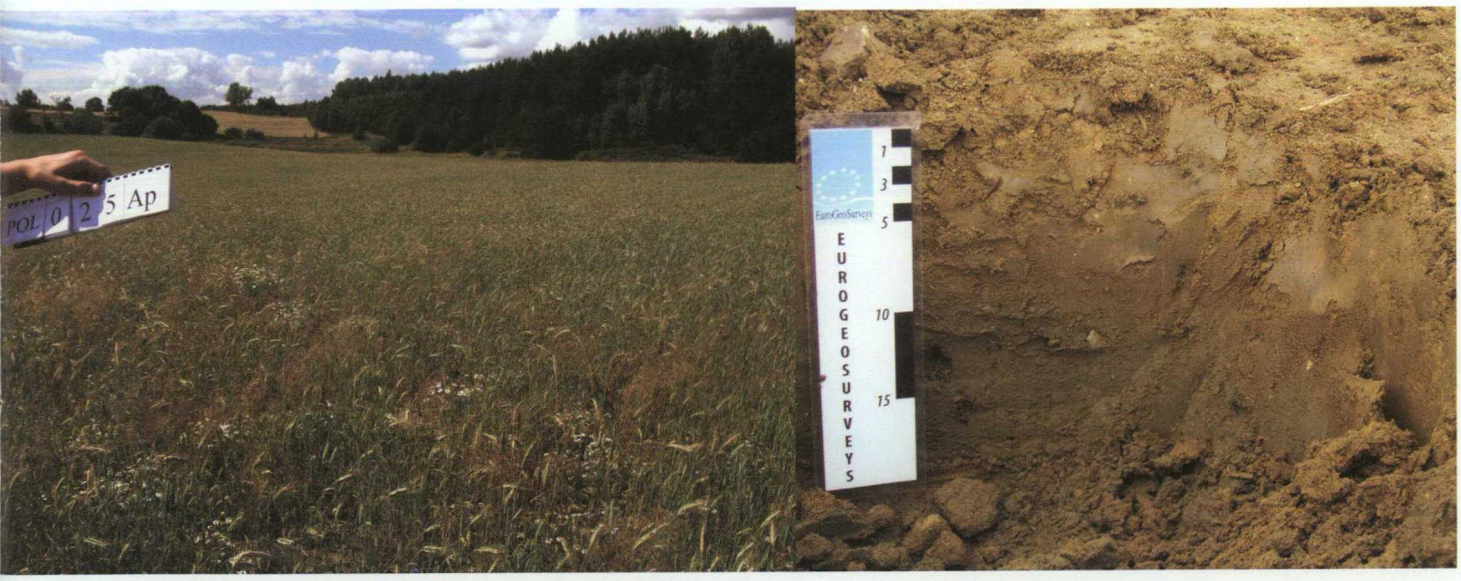
Ongoing research conducted in various countries shows that on the European scale, values of the geochemical background for individual elements in soil show significant variation, up to several orders of magnitude. Until recently, the absence of a coherent and reliable database for the entire continent has posed a major obstacle in the consistent assessment of environmental condition. Combining databases and geochemical maps created in individual countries was impossible, since they were created using different testing and analytical methods, with different ways of interpreting results.

A Single European Map

National geochemical databases can be useful if they are normalized correctly and the reference material is a set of geochemical samples collected, analyzed, and interpreted using the same methods across the entire continent.

The first attempt at making European data uniform was the extensive international cartography program EuroGeoSurveys - FOREGS Geochemical Baseline Mapping of Europe, conducted between 1999-2006. Its results are gathered in the two-volume Geochemical Atlas of Europe, prepared by the geological services in 26 countries and at selected universities. In Poland, the atlas is distributed by the National Geological Institute. The main purpose of the atlas is to define the natural concentrations of heavy metals and other elements in natural surface environments in the late 20th century, and to estimate the effects of human activity on natural variability. The atlas presents the geochemical background of over 50 elements in soils and subsoil, in stream settlements and surface waters. Results show that geochemical variability of chemical elements reflects the natural conditions (type of bedrock, climate, decay and soil-forming processes, and biological processes), which have been disturbed by human activity on a local or regional scale.

Following the success of that pioneering project, Europe's geological services started their next joint enterprise, GEMAS (Geochemical Mapping of Agricultural Soils and Grazing Lands in Europe), in 2008; its aim is to define the content of selected elements and certain physicochemical parameters of soils in arable lands, meadows and grazing lands. The research involves defining total content and content following acid mineralization of numerous chemical elements.



Tomasz Gliwicz

Sample photos presenting field work (general overview, profile)

In as much as possible, the results will be used to create international standards for the assessment of contamination of soils in agricultural lands. This is an extremely important issue, since the quality and quantity of food depends on the condition of agricultural soil. The project also aims to generate comparable data for the entire continent, and to define factors that determine bioavailability and toxicity of elements to plants. Information gathered in a single database will be used in the preparation and implementation of a Soil Protection Directive of the European Union.

Chemical studies of agricultural soils conducted by experts have mainly focused on assessing the content of elements important for the optimal functioning of plants and the toxic concentrations of trace elements in soils. For many of them, maximum permitted content in arable land and effluents used as fertilizer have been defined. However, a deficiency of certain elements can have just as much of a negative effect on the function of plants and animals and human health as a surplus.

From Field to Lab

The scale and terms of the GEMAS project were agreed during several meetings of the EuroGeoSurveys working groups. Geological services of individual countries cover the costs of field studies in their own territory, transport of samples to laboratories conducting assays (geological services in Slovakia), and analysis of results. Chemical analysis was financed by the Eurometaux industrial consortium.

Samples from across Europe (over 2000 in total, including 270 from Poland) were collected in the summer of 2008 at a regular density of 1 sample per 2500 km2. Range size was defined as 50x50km. Samples collected near the centre of the range represented the predominant type of soil within it. In general, arable lands and meadows selected for sample collection were as flat as possible, excluded valleys and basins, and were not exposed to anthropogenic factors. Locations were disqualified if anthropogenic modifications were present, such as landfill sites, mining sites, or sewage discharges that were visible or perceived by smell.

The first data is recorded while a sample is being collected. The field card contains information such as serial number, description of location, coordinates, type of surface, size of area, and cultivation. Field work is documented by a series of photos taken at each location where samples are collected, in the following order: first, a close-up of the sample number on a type of a clapperboard, followed by a soil profile with scale, then a close-up of soil surface showing the type of cultivation, and finally a view over the landscape (in all directions of the compass).

After the soil samples are dried, they are delivered to the laboratory of the Slovak geological service, where they are split into a series of "subsamples," four of which are archived, and two 100 ml samples and four 50 ml samples subjected to chemical analysis. Fifty-three main and trace elements have been marked thus far at the ACME Laboratories in Canada. Other completed analysis includes the assessment of granulometry and pH, and the content of organic carbon, total sulfur, carbon, lead isotopes, and organic components.

Following statistical analysis of the results, geochemical maps presenting spatial distribution of elements on a simplified topographic background are prepared, with an extensive commentary. The completion of the atlas is projected for 2013.

Results will be made available to public administration and planning departments, agricultural institutions, universities, and non-governmental institutions working in ecology. ■

Further reading:

Salminen R. (ed.) (2005) - Geochemical Atlas of Europe. Part 1. *Geol. Survey of Finland*, Espoo. http://www.gtk.fi/publ/foregsatlas.

De Vos W., Tarvainen T., (eds), 2006 - Geochemical atlas of Europe. Part 2, *Geological Survey of Finland*, Espoo. http://www.gtk.fi/publ/foregsatlas

Field manual (2008) - EuroGeoSurveys Gochemical mapping of agricultural and grazing land soil of Europe (GEMAS) - NGU Report 2008.038. *Geological Survey of Norway*, Trondheim.