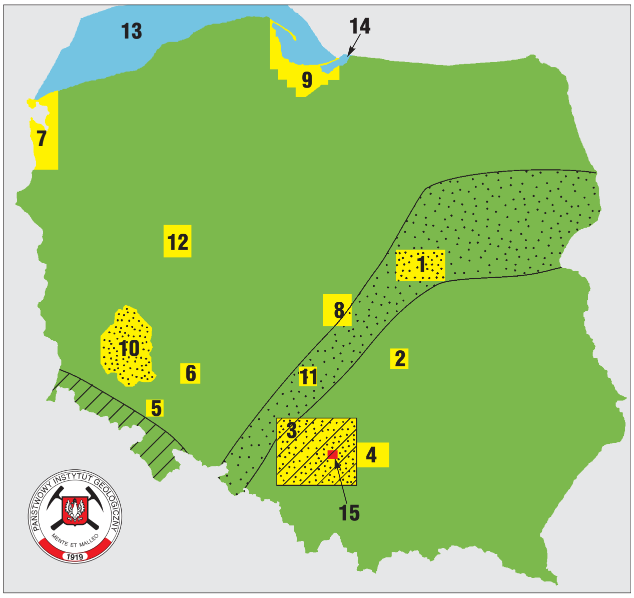
Directions and problems of abiotic environment research in Poland conducted by the State Geological Survey

Ryszard Strzelecki*

Abiotic environment in Poland is a subject of research by the Polish Geological Institute (PGI), performing the duties of a State Geological Survey, since more than 20 years. At first, the studies dealt mostly with protection of mineral deposits, rational exploitation of the main usable mineral and accompanying resources, as well as managing the mining wastes. Then, especially since the 1990s, grew the importance of ground surface studies, aimed at identifying environmental hazards and health risk of the local inhabitants. This direction of research was imposed not only by the changing laws, but also by growing ecological conscience of the society. Consequently, one of the principal considerations of such research is their utility, allowing to implement the results by public administration, business and all citizens seeking reliable information about the environmental conditions.

Firstly, geochemical cartography projects were launched, because there were no reliable data on soil contamination in Poland, and published fragmentary results suggested strong pollution of the country, especially with heavy metals. Basic survey of the area of Poland in 5 x 5 km grid was taken first (Lis & Pasieczna, 1995). In each grid square a soil sample was taken from the depth of 0–20 cm (soil level A), while from surface waters both water and bottom sediments were sampled. In the samples, pH was determined, as well as content of more than 20 chemical elements and compounds, measured with the ICP-OES method, using samples leached with nitrohydrochloric acid. The results were presented graphically in the *Geochemical Atlas of Poland*. Generally, the pattern of surface distribution of particular elements in soils depends on geological structure. Postglacial Quaternary strata covering more than 70% of the country area, reveal lower geochemical backgrounds than outcropping older rocks, especially Palaeozoic formations of the Sudetes and Triassic carbonates in the Silesia-Cracow area. Soils polluted due to anthropopressure of industry and urbanisation cover about 3% of the territory of Poland and concentrate in industrial areas of the Upper Silesia and major city agglomerations. The widest extent was documented for lead, zinc and copper pollution.

The next stage of geochemical studies by the PGI involved semidetailed survey in 1 : 100,000 scale — one sample of soil (ground), water and bottom sediments per each 1 x 1 km square — for major Polish city agglomerations: Warsaw, Wrocław, Łódź, Gdańsk, Kraków, Szczecin, and this year for Poznań. For some agglomerations, additional studies on the first underground aquifer were performed. Besides, similar projects were done for the Upper Silesian Coal Basin (1 : 200,000 scale) and for the Lubin-Głogów Copper Basin (Lis et al., 1997). The results



Geochemical Atlas of Poland (1 : 2,500,000), 1995

radon potential studies — gamma-spectrometric survey (1:100,000),

Detailed atlases:

1 Geochemical Atlas of Warsaw and Environs (1 : 100,000), 1992
2 Geochemical Atlas of Kielce (1 : 50,000), 1994
3 Geochemical Atlas of Upper Silesia (1 : 200,000), 1995
4 Geochemical Atlas of Kraków and Environs (1 : 100,000), 1995
5 Geochemical Atlas of Wałbrzych and Environs (1 : 50,000), 1997
6 Geochemical Atlas of Wrocław and Environs (1 : 100,000), 1998
7 Geochemical Atlas of Szczecin Agglomeration (1 : 200,000), 1998
8 Geochemical Atlas of Łódź Agglomeration (1 : 100,000), 1998
9 Geochemical Atlas of Gdańsk Region (1 : 250,000), 1999
10 Geochemical Atlas of Legnica-Głogów Copper District (1 : 100,000), 1999
11 Geochemical Atlas of Częstochowa and Environs (1 : 100,000), 2001
12 Geochemical Atlas of Poznań and Environs (1 : 100,000), in preparation (2005),
13 Geochemical Atlas of the Southern Baltic (1 : 500,000), 1994
14 Geochemical Atlas of the Vistula Lagoon (1 : 150,000), 1996
15 Detailed Geochemical Map of Upper Silesia (1 : 25,000),; pilot sheet Sławków, 1999

Fig. 1. Monitoring natural radiation and radon potential

are available as printed atlases and in electronic form. Currently, for areas with highest heavy metal concentrations in the Upper Silesia a detailed survey is under way, in 1 : 25,000 scale (Fig. 1). Because the carbonate Triassic basement rocks have very high geochemical background content of zinc. Lead, cadmium (zinc and lead ores have been exploited in the area), the samples are taken from two depths: surface layer (0–20 cm) and deeper level (80–100 cm). This allows to assess whether high surface concentrations result from industrial pollution or from high

*Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; ryszard.strzelecki@pgi.gov.pl

natural geochemical background. In the latter case, the area is not designated as land needing recultivation work.

An important element of geochemical studies is the monitoring of changes in the geochemistry of Polish rivers and lakes, continued yearly since 1991. During the last several years the water sediments purity greatly improved, largely due to reduced amount of toxic wastes dumped to the surface waters, especially by the industry.

In recent years work started on determining the conditions of bottom sediments in artificial reservoirs. These reservoirs are often used as sources of potable water for large cities. In their catchment areas industrial activity is conducted. Thus, the degree of pollution of their bottom sediments is important, as they may be a source of contaminants for waters in the reservoir, as well as for its fauna and flora. The research was completed for the Włocławek Reservoir on Vistula River, while soon projects will commence for reservoirs in the upper parts of Vistula and Odra rivers.

In 1992–1994 geochemical research on radioactive elements were also conducted. For this purpose, a ground-based gamma spectrometric survey was taken, to reveal the patterns of surface distribution of natural isotopes of uranium, thorium and potassium, total dose of gamma radiation, as well as of caesium 137, an isotope deposited over the territory of Poland after the Chernobyl nuclear disaster (Strzelecki et al., 1994, 1993). The maps, based upon results of almost 19,000 measurements, revealed that the concentrations of natural radionuclides depend on geological structure, and the highest contents of uranium, thorium and potassium are related to the outcrops of Palaeozoic igneous and metamorphic rocks in Sudetes. The highest concentrations of the post-Chernobyl caesium in Poland were found in SW Poland, near Opole. The pattern of distribution of caesium concentrations in soils reflects the meteorological conditions in Poland in April/May 1996, at the time when the radioactive cloud from the damaged nuclear power plant in Chernobyl passed over the country. The so-called Opole anomaly, where maximum concentrations of caesium reached 100 kBq/m^2, was subject to detailed geochemical and biogeochemical studies, that demonstrated adsorption of caesium 137 and 134 isotopes in the humus layer of soil. The vertical migration of caesium is very slow, in the range of 2–3 cm per year, and do not pose hazards to aquifers. Studies on plants have shown that the caesium is absorbed most effectively by grasses, forest berries, fungi and some root plants. The concentrations found, however, do not exceed the UE phytosanitary standards.

More detailed gamma spectrometric measurements were taken for the Warsaw and Upper Silesian agglomerations, Lubin-Głogoów Copper Basin and zone of elevated caesium content between Warsaw and Piotrków Trybunalski (Fig. 1).

Assessing health hazards involves research on gas emissions of radioactive radon from the geological environment and its concentrations in groundwaters. The studies were performed in areas of Poland, that according to their geological structure were regarded as potentially hazardous in this respect. Detailed studies based upon measurements of emissions of Rn in soils (measured at 80 cm depth) and in municipal water intakes were performed for structural and stratigraphic units of the Sudetes and their foreland (SW Poland) and for the Upper Silesian Coal Basin.

The measurement revealed that highest radon hazard is presented by the Variscan granitoid massifs, such as the Karkonosze and Strzegom massifs, as well as their metamorphic envelopes, such as the Izera Massif (Kusyk et al., 1999). Much lower radon potential is exhibited by sedimentary rocks, both in the Sudetes and in the Upper Silesian Coal Basin (Wołkowicz & Strzelecki, 2000a). The subsequent stage included indoor measurements, which demonstrated that the highest amounts, exceeding the Polish maximum allowable concentration of Rn, i.e., 200 Bq/m^3 of air, occurs in buildings located in areas with the highest geological radon potential. The influence of building materials used for construction of the buildings is of secondary importance for the Rn concentrations. The results are available as maps printed in 1 : 50,000 scale.

In 1997, after several years of methodological preparations, production of a serial digital *Geonevironmental Map of Poland* (GIS format, Geomedia) in 1 : 50,000 scale has begun. The map covers a wide spectrum of information, several dozens of thematic layers, pertaining to elements of abiotic environment: mineral resources, soils, protected areas, selected aspects of water managements, building substrate conditions and anthropopressure. The latter includes mining and its environmental impact (depression sinks, mining damages, mining wastes). The map shows natural hazards such as maximum extents of floods in the 20th century or land mass movements. Besides, a database of mineral deposits and an extensive explanatory text are in preparation. All information shown on the map (and in the database) are presented in a way compatible with Polish legal standards.

The map is produced according to administrative provinces — the voivodeships. By the end of 2004, about 850 sheets covering the area of 13 voivodeships, i.e., around 80% of the country area, will be finished (Sikorska-Maykowska & Strzelecki, 2000). The edition will be completed by 2007 (Fig. 2). At the same time, since 2003 the map is being updated. The information should not be older than 4–5 years. Under preparation is a system of annual updates for selected thematic layers. The map database is now being expanded with a new layer, pertaining to the land surface protection and radon hazard (Sikorska-Maykowska & Strzelecki, 2001; Sikorska-Maykowska et al., 2003). Another one — using existing geological, hydrogeological and geoenvironmental databases — presents a possibility of locating waste storage sites according to the Directive 99/31/UE, and soon a layer presenting the European system NATURA 2000 will be introduced.

Like the whole map, the new thematic layers are addressed to a wide spectrum of users, including administrative organs preparing studies on conditions and directions of land use in communities, as well as planners at the level of communities, counties and voivodeships. The areas marked in the thematic layer "Waste storage" should be taken into consideration not only when proposing variants of situating waste dumps, but also at the stage of negotiating conditions of construction and land use of objects especially arduous for the environment and human health and objects potentially damaging to the environment.

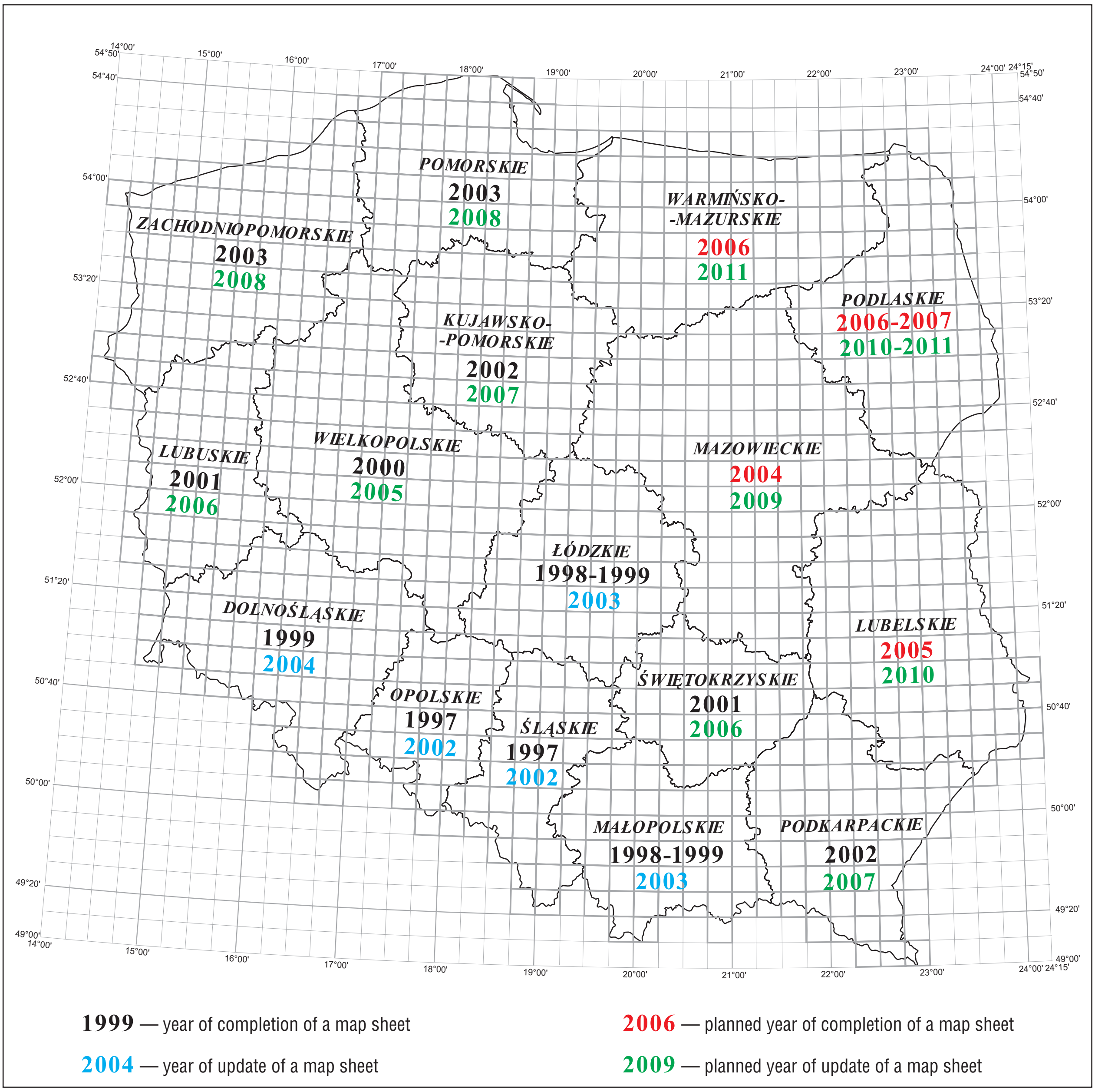


Fig. 2. Schedule of publishing and updating the *Geoenvironmental Map of Poland* (1 : 50,000 scale)

Another element of great importance in rational choice of land function during spatial planning is the information on soil and water sediment pollution, also belonging to that layer of the map.

Our current experience indicates that the map is mostly used by the public administration, architects and urban planners, companies interested in exploitation of natural resources, as well as persons seeking information on the resources and conditions of the environment. The completed sheets, as continuous layers for particular voivodeships, are successively introduced to the voivodeship systems of spatial information.

Because the scale (1 : 50,000) is not sufficient for local planning, it is planned for the years 2004–2006 to begin work on a more detailed map for areas with especially great accumulation of environmental problems. At first, four pilot sheets of a geoenvironmental *Map of Degraded Areas and of Elevated Natural Risks* in 1 : 10,000 scale will be prepared. The number and order of sheets will be decided in arrangement with the regional (voivodeship) authorities. It can be estimated that about 10 to 30% of the area of particular voivodeships will be covered by these maps. This project will necessitate a cooperation of specialists from various branches of geology, such as, e.g., environmental geology, hydrogeology, engineering geology or geochemistry.

It is assumed that the main criterion in choosing the areas to be included in the map will be a presence of areas in need of detailed geoenvironmental survey, such as:

- ❏ urbanized areas or areas designated for major infrastructural or industrial investments;
- ❏ areas degraded by underground and strip mining, as well as by other industrial activities;
- ❏ areas of high risk of natural disasters, such as floods or landslides.

One of the more important research projects of the State Geological Survey is the survey and environmental impact assessment of storage sites for expired crop protection chemicals. Between 1960 and 1985, more than 330 such sites in Poland were designated, where no longer usable pesticides were stored in quantities ranging from few tonnes to several hundred tonnes. A total amount of some 18,000 tonnes of environmentally toxic wastes was thus stored (Wołkowicz & Strzelecki, 2000b). After a few decades, due to action of the chemicals stored and improper construction of the "tombs", many of them have begun to leak chlororganic compounds, including DDT, organophosphorous compounds and other toxic substances to soils and groundwaters. The PGI made an inventory of all the sites, assessed their environmental impact and compiled a priority list, indicating the order of liquidation of particular objects. Thermal method of waste disposal was proposed, together with a comprehensive recultivation procedure for the sites, as well as establishing a groundwater monitoring network. The "pesticide and herbicide tombs" are systematically liquidated since 1999, and almost half of them already ceased to exist by now.

In 2002, the PGI participated in preparing the first National Plan of Waste Management in Poland. This document presenting the strategy of waste management and disposal, and the PGI produced the diagnosis and proposals concerning mining and industrial wastes, as well as storing municipal wastes.

A specific problem for environmental protection and land management in Poland are closed down industrial plants and mines. After 1990, the restructuring of Polish mining and industry caused shutdown of hundreds of large industrial facilities. For example, in 1989 in Poland there were 106 underground mines, mostly of coal, as well as of lead and zinc ores. In 2003, the number of active mines dropped to 53. Assuming that an average mine extends over an area of 1,000 ha, the closed mines alone occupy some 50,000 ha. Usually, the closed down objects are located within cities that engulfed their former industrial suburbs. For example, there are three decommissioned mines the within the city of Sosnowiec. Revitalizing the postindustrial areas goes far beyond the problems of environmental protection; it is also a social problem. The working program for postindustrial areas should include, most of all, the inventory of the objects together with the assessment of ground and groundwater pollution, presence of wastes and environmental impact of abandoned industrial installations.

A separate group of research conducted at the PGI is devoted to geodiversity protection. Their concept is based upon the currently introduced network NATURA 2000, being the most thoroughly prepared (legally, logistically and scientifically) European ecological network, aimed at securing long-term survival of ecosystems. Within the scope of this research topic, several regional studies were made, such as "Geodiversity protection in the Lower Silesia" (Gawlikowska, 2000). Besides an educational message, their major goal is protection of valuable geological and geomorphological sites. The care of geological heritage is achieved mostly through protecting such objects as outcrops, geological profiles, surface forms including important stratigraphic sequences, interesting lithologic, tectonic or karstic features, or containing animal or plant fossils or traces of old mining activities. The results serve as a basis for establishing a hierarchy of importance in formulating conclusions for a detailed documentation of various objects of inanimate nature, such as Geoparks, to provide them legal protection.

The directions of research conducted at the Polish Geological Institute in the coming years will largely follow the document proclaimed by the Polish Parliament in 2003, called *The Second Ecological Policy of the State*. The aim of the ecological policy, *is providing the Polish society ecological security throughout the 21st century and implementing the strategy of sustainable development of the country.* The *Policy...* designates the areas of the state's strategic interests. Their effective treatment will obviously involve a wide array of geological work. Among them worth mentioning are:

❑ adjusting sector policies (= ecologizing sector policies) for sustainable economy and protection of natural resources, especially water, mineral, land surface, soil, and air resources as well as farm and forest goods;

❑ improving the quality of environment in all aspects (air, water, soil, ecosystems, species and habitats, climate, landscape) and in all specific kinds of the country's territory (cities and settlements, especially degraded areas, farmlands, areas with high biodiversity, forests and wetlands, mountains and their foothills, seashore zone, territorial waters, state border zones;

❑ providing information on the environment to the society;

❑ promoting sustainable development in international contacts, cooperation with Poland's neighbours and other countries in solving transnational issues, especially in reducing the cross-border migration of pollutants and establishing prevention and warning networks, as well as aid to neighbours and other countries of Central and Eastern Europe in solving their environmental problems through export of Polish scientific knowledge and technological know-how.

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