

The Polish Geological Institute activities in the cross-border geological mapping

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Abstract. Cross-border geological mapping is essential for proper understanding of the Poland's border areas geological setting and their mineral potential. Close co-operation with geological institutions of the neighbouring countries is, therefore, necessary. The joint detailed geological mapping of the cross-border areas was difficult until 1990 because of security reasons. The whole Polish Geological Institute's mapping activity concentrated, until that time, on very general cartographic presentations of the regional, European or world-wide geology, tectonics, palaeogeography, mineral perspectives, and so on, in the adequately small scales. Since the early 1990s the Institute started to develop more systematic, geophysical, geological and geo-environmental mapping of the common cross-border areas with the national geological surveys and other geological institutions of the neighbouring countries. The most systematic and most detailed cartographic surveys have been carried out so far with the German geological surveys. The Czech, Slovak, and Lithuanian surveys co-operated also very actively. A great cartographic effort has been made on the Baltic Sea geology, as well. Geological mapping co-operation with the Ukrainian, Belarusian, and Russian institution is eventually slowly building up, too. This paper presents the up-to-date results of the joint Polish Geological Institute and the neighbouring geological surveys activities in the geological mapping of the cross-border areas, as well as some current, mapping related activities.

Key words: the Polish Geological Institute, cross-border areas, geological mapping, geophysical mapping, geo-environmental mapping

Geological mapping of the country is one of the statutory responsibilities of the National Geological Surveys. Therefore, the Polish Geological Institute, having been founded in 1919 to function as the Geological Survey of Poland, was also designated to carry out mapping of all kind of geological phenomena of Poland. Obviously, the country's territory is the main objective of such an activity. However, geological structures, mineral concentrations or groundwater reservoirs are not limited by the state boundaries but they usually extend further on, across the political boundaries. Besides, to properly understand fragments of geological structures, it is necessary to study the geological units as a whole. For that purpose, it is essential to maintain a close co-operation with specialists from the neighbouring countries, usually to the mutual benefit of all the partners. Cross-border geological mapping is a starting point and, at

the same time, the foundation of all the international geological investigations.

During the first period of the Polish Geological Institute existence, i.e., between 1919 and 1939, its activities concentrated on the organisation of the basic national surveys. As far as mapping was concerned, it was first focused on setting out standards of geophysical and geological mapping, carrying more systematic work on the few chosen fragments of the country's territory, only.

Participation in the international geological investigations and mapping intensified greatly after the World War II, covering also, as far as possible, cross-border geological problems (Ber, 2004). However, the policy of the East European communist countries set down very strict secrecy regulations, including establishment of fairly broad military zones along the state boundaries, even between the communist countries themselves. Those restrictions, additionally worsened by purposely deformed topographic background maps, have made cross-border geological

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mapping of the region hardly possible until the beginning of the 1990s.

Therefore, the Polish Geological Institute participation in geological mapping at the international scale concentrated since late 1950s almost to the end of 1980s on co-operation within such geological organisations as the International Geological Congress (Committee on the Geological Map of the World), International Union of the Geological Sciences, Carpatho-Balkan Geological Association, etc. (Czerwiński, 1970). The co-operation resulted in completion of a series of worldwide or European thematic geological maps in general scales (usually 1 : 1,000,000 – 1 : 2,500,000 scale for Europe, and 1 : 5,000,000 for the whole world), such as geological, tectonic, neotectonic, lithologic-palaeogeographical and metallogenic maps as well as various minerals potential maps, and so on. Those regional geological-cartographic activities are still continuing (e.g., Katzung & Pokorski, 1991).

Independently, another series of thematic maps, usually also in overview scales and concerned mostly with the assessment of the prospecting potential for various strategic minerals such as iron, base metals, and radioactive elements, coal, oil and gas, and other, as well as groundwater resources, covering parts or the whole territory of the East European countries (e.g., Bojarski et al., 1977), were prepared under the auspices of the Permanent Geological Committee of the COMECON (organisation of economic co-operation within the Eastern European communist countries).

Since the 1970s, satellite images were analysed by the Polish Geological Institute (Graniczny, 2004). Some imagery interpretations extended across the Polish borders, as well.

One of the first cross-border co-operation projects on geological mapping concerned metallogeny of the Bohemian Massif and adjacent areas (Lächelt et al., 1973). It was prepared by the geological surveys of East Germany, Czechoslovakia, and Poland, and published in 1973, in 1 : 500,000 scale.

A very special event in the Polish Geological Institute's international cross-border geological cartography of those times was a joint research effort with the Czech and Slovak Geological Surveys leading to compilation of a series of geological maps of the western Outer Carpathians and their foreland in 1 : 500,000 scale, published in 1989 as an atlas, in English (Poprawa & Nemčok, 1989; Bednarczuk et al., 1993).

The problem of the cross-border geological mapping with the neighbours of Poland has been normalised by the early 1990s, and only since then the joint bi- or multi-lateral mapping is developing with various success.

Geological mapping

Mapping of the surface geology as well as its deeper geological structures became the prime objective of the Polish Geological Institute cross-border cartographic co-operation since 1990. Based on the former long-term co-operation with geological surveys and geological research institutions of the neighbouring countries, the Institute started discussions on the joint cross-border geological cartography.

The very first effects of the new over-the-border cartographic arrangement was a close co-operation with the Czech Geological Survey and German (Saxony) Geologi-

cal Survey on the integration of the revised geological map of the Lower Silesia (without Quaternary deposits) in the scale of 1 : 100,000, with geological maps of the adjacent areas of Bohemia and Germany (Sawicki, 1995). The map, prepared by the Lower Silesian Branch of the Polish Geological Institute, was published by the Institute in 1995, in sheets, with explanations in Polish and English. Additionally, the resulting small atlas included a metamorphism map of the Lower Silesia region and a map of the isotopic data from the same region, both in 1 : 750,000 scale.

At almost the same time, in 1995, an uncovered geological map of the Carboniferous formation from the whole Upper Silesia Coal Basin area (both Polish and Czech USCB parts) has been prepared jointly by the Polish Geological Institute (Upper Silesian Branch in Sosnowiec), Vysoká Škola Báňská — Technical University in Ostrava, and the Czech Academy of Sciences (Institute Geonics in Ostrava). The map was published by the Polish Geological Institute in Warsaw, in 1 : 200,000 scale, in English, Polish, and Czech (Jureczka et al., 1995).

That co-operation still continues, and an atlas of special geological maps of the Polish and Czech parts of the Upper Silesia Coal Basin has been prepared in 1 : 200,000 scale, and will soon be published in Polish and English by the Polish Geological Institute in Warsaw (Jureczka et al., 2005). The atlas contains structural maps of several lithostratigraphic units of the Carboniferous formation, maps of the thickness of the economic coal seams at different depth intervals, and maps depicting some other economic factors of coal deposits (e.g., overburden, moisture, volatiles).

In 1998, another Institute's specialists team, closely co-operating with geologists from geological surveys of the eastern neighbours, especially from Lithuania (Geologijos Institutas Lietuva) has prepared a cartographic summary of many years of extensive regional studies on the geological development of the north-eastern Poland and Lithuanian territories. Small portions of the adjacent Belarus and Russia (Kaliningrad region) areas were also included into the resulting atlas, published in English jointly by the Polish Geological Institute and the Lithuanian Geological Institute, in Warsaw (Marek & Grigelis, 1998).

The atlas consists of 14 maps in the scale of 1 : 2,000,000 (geological and structural maps of the Permian–Mesozoic basement, structural maps of Zechstein, Triassic, Lower+Middle Jurassic, Upper Jurassic, and Cretaceous bottoms, and thickness maps of Zechstein, its cyclothem Werra, Buntsandstein, Muschelkalk+Keuper, Lower+Middle Jurassic, Upper Jurassic, and Cretaceous). It provides also a comprehensive introductory text on the tectonic position and geological evolution of the investigated area, and on the geological and structural evolution of the local Permian and Mesozoic basins.

Revolutionary political changes occurring in Central Europe since the end of the 1980s allowed the Polish Geological Institute for new initiatives on the cross-border geological cartography. The most important objective was to correlate and unify standard geological maps in 1 : 200,000 and 1 : 50,000 scales across the borders with all the neighbours of Poland. The fastest and the most fruitful arrangements on that matter have been concluded with German geological surveys.

The first attempts to elaborate jointly the standard geological maps across the Polish–German border have been made with geological surveys of the neighbouring German federal states: Saxony and Brandenburg. Co-operation on

joint standard geological maps started with the Geological Survey of Saxony (Sächsisches Landesamt für Umwelt und Geologie) in Freiberg. It resulted in publication of a geological map without Quaternary deposits, in 1 : 200,000 scale (sheet Cottbus) in German (Lorenz et al., 1997).

As a next step, a geological map (without Cainozoic sediments) of the Lausitz–Jizera–Karkonosze region has been prepared in co-operation with geological surveys of Saxony and Czech Republic (Český geologický ústav), and published in 1 : 100,000 scale, in Polish and English (Brause et al., 2000; see also Kasiński et al., 2004), with comments published separately in 2001, in English (Kozdrój et al., 2001).

Almost simultaneously, the very first joint map in the 1 : 50,000 scale (sheet Frankfurt (Oder)–Ślubice) has been published in German by the Geological Survey of Brandenburg (Landesamt für Geologie und Rohstoffe Brandenburg) in Kleinmachnow (Schultz et al., 2000). Preparation of further 1 : 50,000 scale sheets has been temporarily suspended due to a general reorganisation of the Geological Survey of Brandenburg.

In the 1990s, the long-lasting co-operation with the Federal Geological Survey of Germany (Bundesanstalt für Geowissenschaften und Rohstoffe) has been enriched with a systematic joint work on 1 : 200,000 scale geological maps, covering the whole Polish–German cross-border area. The maps, prepared jointly with geologists from the Pomeranian and Lower Silesian Branches of the Polish Geological Institute, were published (in German) in Hanover, consecutively since 2001: sheet Stralsund in 2001 (Schultz et al., 2001), sheet Görlitz in 2002 (Berger et al., 2002), and sheets Cottbus, Schwedt (Oder), and Frankfurt (Oder) in 2003 (Lippstreu et al., 2003a, 2003b; Hermsdorf et al., 2003).

Systematic cross-border geological mapping at standard 1 : 200,000 and 1 : 50,000 scales with other neighbours of Poland (Czech Republic, Slovak Republic, Ukraine, Belarus, Lithuania, and Russia — Kaliningrad Region) has been delayed, so far, and is awaiting further arrangements and agreements. This also applies to standard geological mapping of the Baltic Sea area across the economic zones of Poland and the neighbouring states.

The Institute has further succeeded in preparation and publication in 2004 of a sequel to the geological maps of 1989, of the western Outer Carpathians and their foreland (Jankowski et al., 2004). That was a more detailed map (1 : 200,000) of the same Outer Carpathian region, covering the borderlands of Poland, Slovakia and Ukraine, and presenting the extent of the main tectonic units. It has been created jointly with the Geological Survey of Slovak Republic, and with the Institute of Geology and Geochemistry of Combustible Minerals, of the National Academy of Sciences of Ukraine, from Lviv, and published in English, in Warsaw.

A thorough studies of the Lublin–Lviv–Volhynia coal-bearing Carboniferous strata were also carried out in close co-operation with the National Academy of Sciences of Ukraine (Institute of Geological Sciences in Kiev), and a resulting geological map of Carboniferous throughout that region has been prepared in the early 2000s in 1 : 1,000,000 scale (Shulga, 2005).

As far as the co-operation with Belarus and Kaliningrad Region of Russia in the geological cartography is concerned, a programme on the geological mapping of the western part of the East European crystalline basement is

being conducted, and a map is being prepared on the regional scale.

The recent sediments mapping of the Baltic Sea bottom have been carried out jointly with the neighbouring countries since the early 1990s (Zachowicz et al., 2004). As a first effect, a map of the western Baltic sediments has been prepared in co-operation of the Polish Geological Institute (Marine Geology Branch in Gdańsk) with the Baltic Sea Research Institute in Warnemünde, in Germany, and the Institute of Oceanology of the Russian Academy of Sciences (Atlantic Branch in Kaliningrad). The map consisted of two plates: (1) first 5 cm of recent surface sediment, (2) Quaternary sediments from beneath 1 m. It was published in 1994, in 1 : 500,000 scale, in English, by the Department of Navigation and Oceanography of the Russian Federation Ministry of Defence, in Sankt Petersburg (Emelyanov et al., 1994a; Emelyanov et al., 1994b).

For the central Baltic Sea area, two maps in 1 : 500,000 scale were prepared with the Lithuanian Geological Institute, Geological Survey of Lithuania, Geological Survey of Sweden, and the Swedish Maritime Administration. First one concerned the bathymetry of the area, and the second one — the bottom sediments. Both maps were published in English in 1998, in Uppsala, (Gelumbauskaite, 1998; Repecka & Cato, 1998).

Recently, a map on sediments of the area located between the Pomeranian Bight and Bornholm island has been prepared jointly with the Baltic Sea Research Institute in Warnemünde, in Germany, and is awaiting publication (Bobertz et al., 2005).

The Institute's co-operation on the broader European regional geology has been lately appended with the publication of a geological map (without the Cainozoic sediments) of Northern Europe in 1 : 4,000,000 scale (Sigmond 2002–2003). The map has covered Scandinavia and Central Europe, including the Baltic Sea. It was a product of co-operation between many European geological surveys and other geological institutions, lead by the Geological Survey of Norway. The map was published in English in Uppsala, Sweden.

Geophysical mapping

Geophysical mapping, especially gravity and magnetic surveys, is the prime objective of the geological investigations. Unfortunately, those geophysical data were long regarded in Poland and the neighbouring communist countries as the top secret information. Therefore, though gravity and magnetic surveys were systematically carried out everywhere there, the Polish Geological Institute succeeded in publishing the results of the cross-border correlation of those surveys from one small border region only.

An atlas of the gravimetric and magnetic maps of the Polish–Lithuanian border area has been published in 1 : 200,000 scale, in English, together with the Geological Survey of Lithuania (Królikowski et al., 1999). It contained maps of the gravimetric Bouguer anomalies and of the total intensity magnetic anomalies from the Suwałki, Sejny, and Grodno sheets. Very concise explanatory notes accompanied the atlas.

Recently, a programme on the construction of the synthetic gravity, magnetic, and geothermal maps of Poland, Czech Republic, Slovakia, Hungary, and Austria, in a regional scale, is being prepared as a follow-up of the

CELEBRATION 2000 international deep seismic sounding project.

Geo-environmental mapping

Since the early 1990., the geo-environmental problems (soil, surface water and groundwater pollution, surface water bottom sediments pollution, environmental impacts of the open cast and underground mining as well as their wastes and tailings, natural hazards, such as floods and landslides, and so on) became an increasingly important part of the Polish Geological Institute's research and development activities. All the investigated geo-environmental phenomena have been recorded in the extensive databases and eventually presented in the published serial maps and thematic atlases.

Those phenomena were studied and surveyed along the borders of Poland, as well. During the last fifteen years, several attempts to co-ordinate the geo-environmental research methods and measurements techniques with the research institutions and geological surveys of the neighbouring countries, have been undertaken. An important idea of the cross-border correlation of the basic geo-environmental maps is still being developed. However, only a single cross-border geo-environmental atlas (Graniczny & Satkunas, 1997) has been published so far (Graniczny, 2004).

It is an atlas presenting geology, geochemistry, radioecology, and some geo-environmental groundwater aspects of an area covering the north-eastern corner of Poland (Suwałki region) and the adjacent south-western corner of Lithuania. The atlas was prepared in English, in 1 : 500,000 scale by the Polish Geological Institute, the Geological Survey of Lithuania, and the Lithuanian Institute of Geology, and published in 1997, in Warsaw. It contains five geological maps, 46 geochemical maps of various chemical elements content in soils and water sediments, five maps on gamma radiation and radioactive elements content, three maps on geopotential and environmental hazards, and one plate of the processed satellite images. A comprehensive explanatory notes concerns geology, geochemical studies, radioecology, groundwater as component of geopotential, and ecology.

Geo-tourist mapping

The constantly growing interest of tourists in geological monuments and, generally, in geo-environmental phenomena in the late 1980s and early 1990s has drawn attention of the national geological surveys and other geological institutions to the construction of geo-tourist maps. Among the neighbouring countries, the Czech Geological Survey (Český geologický ústav) was the first one working on such maps and, therefore, the Polish Geological Institute started with that Survey the joint construction of geological maps for tourists.

The first joint map covered the Śnieżnik Massif from the Sudetes Mts. at the scale of 1 : 50,000. Against fairly detailed geological background, the map shows location of quarries, open cast and underground mines, waste dumps, gold placers, caves, and springs. Besides, boundaries of protected areas are marked, as well as scenic points, nature

monuments and tourist tracks. Additionally, a comprehensive explanatory text on the region's geography, geology, and mineral raw materials has been included, supplemented by a short description of the selected, interesting localities. It was published in Praha, in Czech, Polish and English (Gawlikowska et al., 1997).

Next geological map for tourists was the one covering the Stołowe/Adrspassko-Teplicke Mts., also within the Sudetes Mts., and with similar content. This map (Čech & Gawlikowska, 1999) was also published in 1 : 50,000 scale, in Praha in Czech, Polish, and English. Further geo-tourist maps, covering the Bystrzyckie and Orlickie Mts., and Opawskie Mts., from the Sudetes Mts. area, are still in preparation.

In the meantime, a geo-tourist map in 1 : 200,000 scale, covering the Polish-Lithuanian border area and prepared jointly with the Geological Survey of Lithuania, has been published in Warsaw, in English (Krzywicki et al., 1998). Besides stratigraphic and lithologic units, it contains the main topographic elements (cities and villages, roads and railways, lakes, and so on) and other objects interesting for tourists (nature reserves boundaries, important geological outcrops, architectural monuments, gas stations, motels, camp sites, etc.).

The latest publication of that kind is a geo-tourist map, covering the Euroregion POMERANIA. It was prepared in 1 : 200,000 scale by the Geological Survey of Mecklenburg-Vorpommern, Germany, in co-operation with the Polish Geological Institute (Pomeranian Branch), Archäologisches Landesmuseum, Landesamt für Bodendenkmalpflege Mecklenburg-Vorpommern, the Polish Academy of Sciences (Department of Lowland Geomorphology and Hydrology) and Voivodship Office for Historical Monuments Protection in Szczecin. It was published in 2004 in Güstrow, Germany, in German and Polish (Börner et al., 2004).

Conclusions

1) The cross-border co-operation with neighbours of Poland on the systematic geological mapping started practically at the beginning of the 1990. Previous joint geological research, though fairly intensive, concerned mostly regional geology, general problems of mineral deposits exploration, and construction of review maps.

2) Since 1990, the co-operation on the joint geological mapping has developed mostly with German, Czech, Slovak, and Lithuanian Geological Surveys and Research Institutions. The Baltic Sea bottom geological mapping is also satisfactorily developing. However, cross-border mapping co-operation with Ukraine, Belarus, and Russia (Kaliningrad Region) is still at the initial, regional scale stage, and awaits further arrangements.

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