

## GEOLOGICAL MAPS PRODUCTION TECHNIQUES

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### INTRODUCTION

Polish Geological Institute - National Research Institute (PGI-NRI) is an author and coordinator of all the fundamentally detailed and reviewed geological cartographic elaborations in Poland. PGI-NRI acts as Polish Geological Survey. Performing cartographical elaboration for Poland is one of the tasks of Polish Geological Institute - National Research Institute.

Fundamental polish geological map data is being developed at a scale of 1:50 000. This is the base to thematic case studies and maps in smaller scales. Based on this data, areas for more in depth analysis are being selected. All these resources are digitalized and becoming a part of the Spatial Data Infrastructure.

Surface Geological Mapping Department (SGMD) of PGI-NRI has long experience in development of digital serial maps, covering wide range of aspects from geology, hydrogeology, engineering geology, environmental geology, geophysics and geochemistry.

Currently SGMD is realizing the following maps:

- Detailed Geological Map of Poland at a scale of 1:50 000
- Litogenetic Map of Poland at a scale of 1:50 000
- Geological Map of Poland at a scale of 1:200 000
- Geological Map of Poland at a scale of 1:500 000
- Geological map of Tatry Mountains at a scale of 1:10 000

as well as many others elaborations.

### SUBJECT AREA

Detailed Geological Map of Poland at a scale of 1:50 000

The Detailed Geological Map of Poland at a scale of 1:50 000 (DGMP) is the fundamental geological map of Poland. The whole territory of Poland is covered by 1085 map sheets. The map has been published since 1954.

The map is constructed by qualified scientists from the Polish Geological Institute, Polish Academy of Sciences, high schools, and geological enterprises. DGMP is created based on field work, exploratory drilling, geophysical surveys (geo-electrical and gravimetric methods), and in-house and laboratory studies. Detailed Geological Map of Poland is being constructed as on the basis of the detailed geological mapping program realized at a scale of 1:25 000. It presents information about the geological structure of the country including stratigraphy, petrography, and tectonic features and their origin. Detailed Geological Map of Poland presents the near-surface geological structure, as well as some information about the subsurface.

The map allows to determine prospects for mineral resources and future trends in exploration and production. It also provides essential information about economic geology, paleontology, dynamic geology, geomorphology, paleogeography, archaeology etc. Its wide topical range allows to construct other series maps, such as hydro-geological and geological-economic maps. These maps are a compendium of knowledge about the resources, quality of ground-waters and about reserves of mineral deposits, shown against the background of geological engineering and geo-environmental problems. Detailed Geological Map of Poland is addressed to all geologists and it meets practical needs of miners, drainage engineers, farmers, foresters and builders, satisfying requirements of specialists in site planning, environmental protection and even military fields. This map can be a basis for a preparation of different geological and environmental protection reports, as well as for site planning works and local investment programs. Edition of this map is also supplemented with a common explanation in text brochure.

Since 1996, the DGMP is digitalized using ESRI software. The development team includes: scientists collecting data from groundwork, employees performing digitalization, a substantive editorial team, and a team of technical editors. The technical editors complete the process of creating and sharing maps. Old sheets of DGMP have also been digitalized. Dedicated software has been developed for the needs of the digitalizing team and technical editors, have enabled partial automation and verification of work.

Currently, the author's case study stage is finished. Most of these sheets are available in the digital version. DGMP is available in printed form and digital (file in formats \*.pdf, \*.jpg or \*.shp).

Data from the DGMP will be the reference layer for Poland, in accordance to Annex II Directive INSPIRE. The digital version of DGMP is created based on the Instruction published in 1996, and has been updated a few times. The architecture of the database for a single sheet is very complicated and have got many connections between the data. The database includes polygons, lines and point layers with information about surface geological structure, hydrogeology phenomena, tectonic, localization of drillings, documentation areas, etc., and also additional raster layers with topography, hydrography, and hypsometry. The main layers in database: polygons with geological structure and stratigraphy, geological cross-sections, localization of drillings with stratigraphy and depth, geological profiles with all map formations. Whole edition for this map has the same colours based on age, lithology and their origin. At this moment we have got about 1400 colours using patterns in our database.

Work is currently being done on integrating all 1085 sheets into a continuous geodatabase, enforcing necessary comparisons, and harmonizing the borders between older, traditionally made sheets, into new sheets. Dedicated software has been created for the partial automation of this adjustment. The necessity of harmonized borders between the sheets of DGMP enforces the renewal of old map sheets. Finally, all DGMP sheets will be available as continuous layers through the IKAR geoportál of our Institute (<http://ikar2.pgi.gov.pl>)

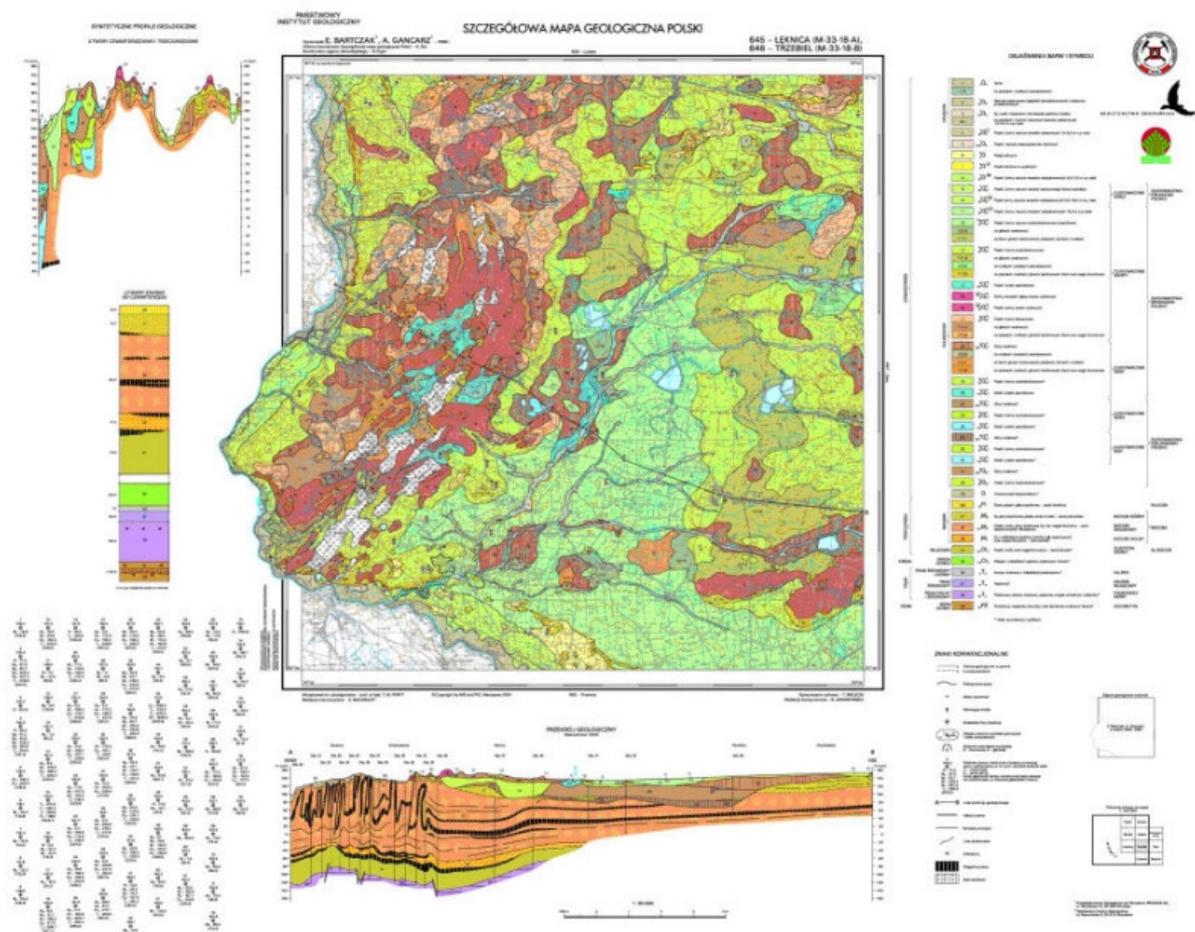


Figure 1. Sample DGMP sheet at scale of 1:50 000, digitalized and published Geological Map of Poland at a scale of 1:200 000

Whole edition of this map covers 77 sheets. First map sheet: Radom was printed in 1969. It was constructed in 1971 and published systematically in 1973, in accordance with the approved instruction. The whole edition, made with tradition manual method, was completed in 1998.

The map covers the entire territory of Poland. It was published in colour and in two versions: A – covered and B – uncovered (without Quaternary sediments). Each map sheet also contains a geological cross-section, typical for the area, and stratigraphical-lithological profiles.

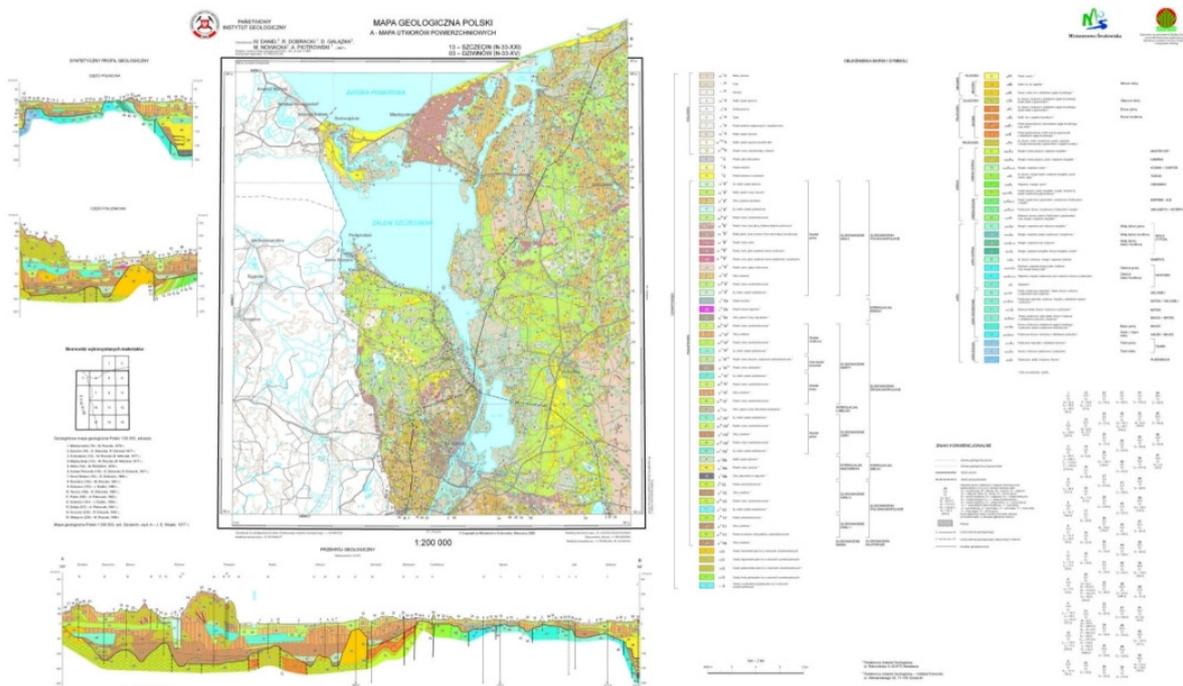
Each map sheet of both versions is also supplemented with a common explanation text brochure, containing, among other things, deep borehole logs, geological cross-sections, description of tectonics, lithology, and results of cartographic investigations, performed in more detailed scales. Together with explanatory notes, is very useful in the presentation of general geological structures and the distribution of mineral resources of the area. It may be the basis for mineral prospecting, as well as for regional geological, engineering-geological, hydro geological, geomorphologic and ecological studies.

Since 2006, the GMP at a scale of 1:200 000 is being renewed. It is based on updated DGMP at a scale of 1:50 000, in the process of its generalization, and also based on old sheets of that map. One sheet of GMP includes 16 sheets of DGMP. Groundwork's are also being performed in order to renew its contents.

The map is being developed with state of the art technology, information knowledge and other tools. In 2009, new instructions for map renovation were created, including guidelines for digital elaborations. The map is being developed using ESRI software, with supporting customized software.

As a derivation of the DGMP, this map is being created by the same team, with the same standards implemented. Such processes enable us to utilize experience gathered while developing DGMP at scale of 1:50 000. Currently 10 sheets have been finished (edition A and B). We are in the process of gathering data and developing the following ten sheets of this map. GMP is combined with additional layers with topography, hydrography and hypsometry from Vmap L1.

Version A



Version B

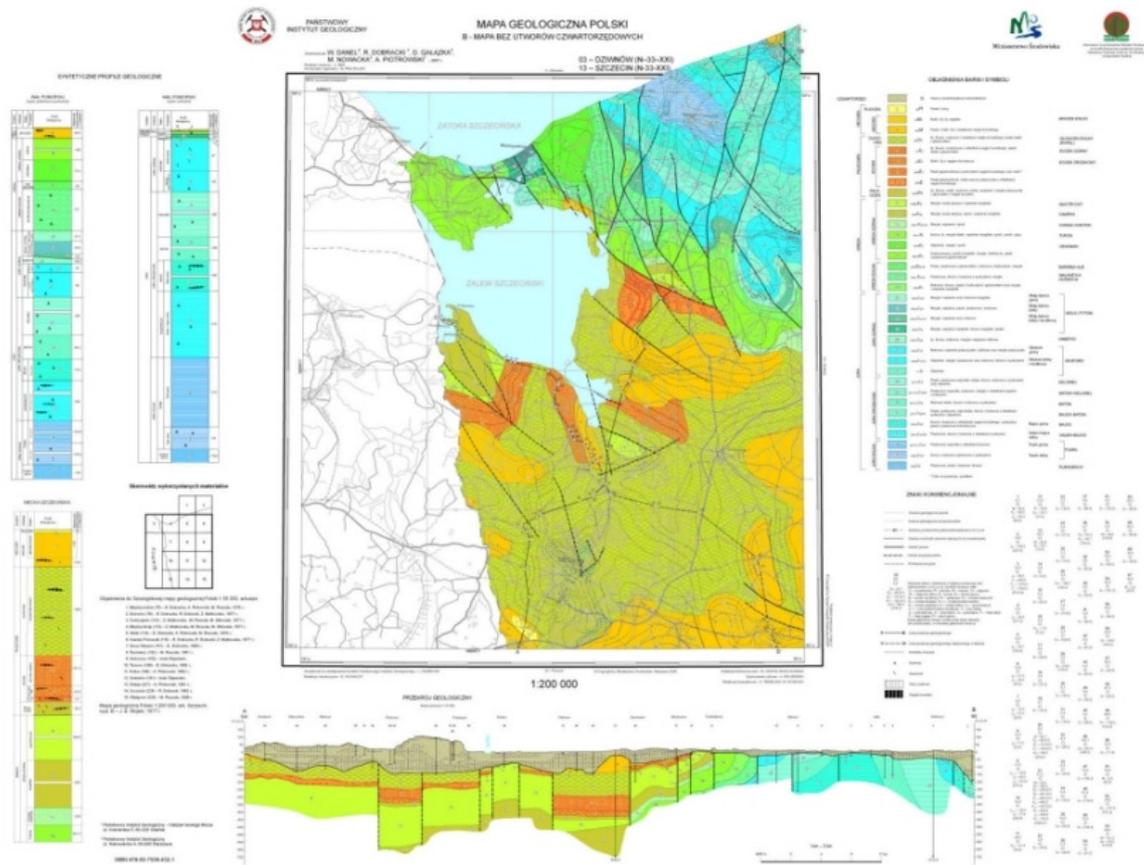


Figure 2. Sample GMP sheet at scale of 1:200 000, digitalized and published in analog form: version A – covered, version B - uncovered

#### Geological Map of Poland at 1:500 000 scale

In 2005, the Geological Map of Poland at a scale of 1:500 000 (GMP) was created based on generalized DGMP sheets at a scale of 1:50 000 also using GMP at a scale of 1:200 000. This map presents the surface geological structure of Poland. It covers the following numerical thematic layers: geological structures, tectonic, glacial limits, eskers, drumlins, moraines, lines of geological cross-sections and base topographic layers (administrative borders, rivers, cities). Whole edition of this map covers four sheets.

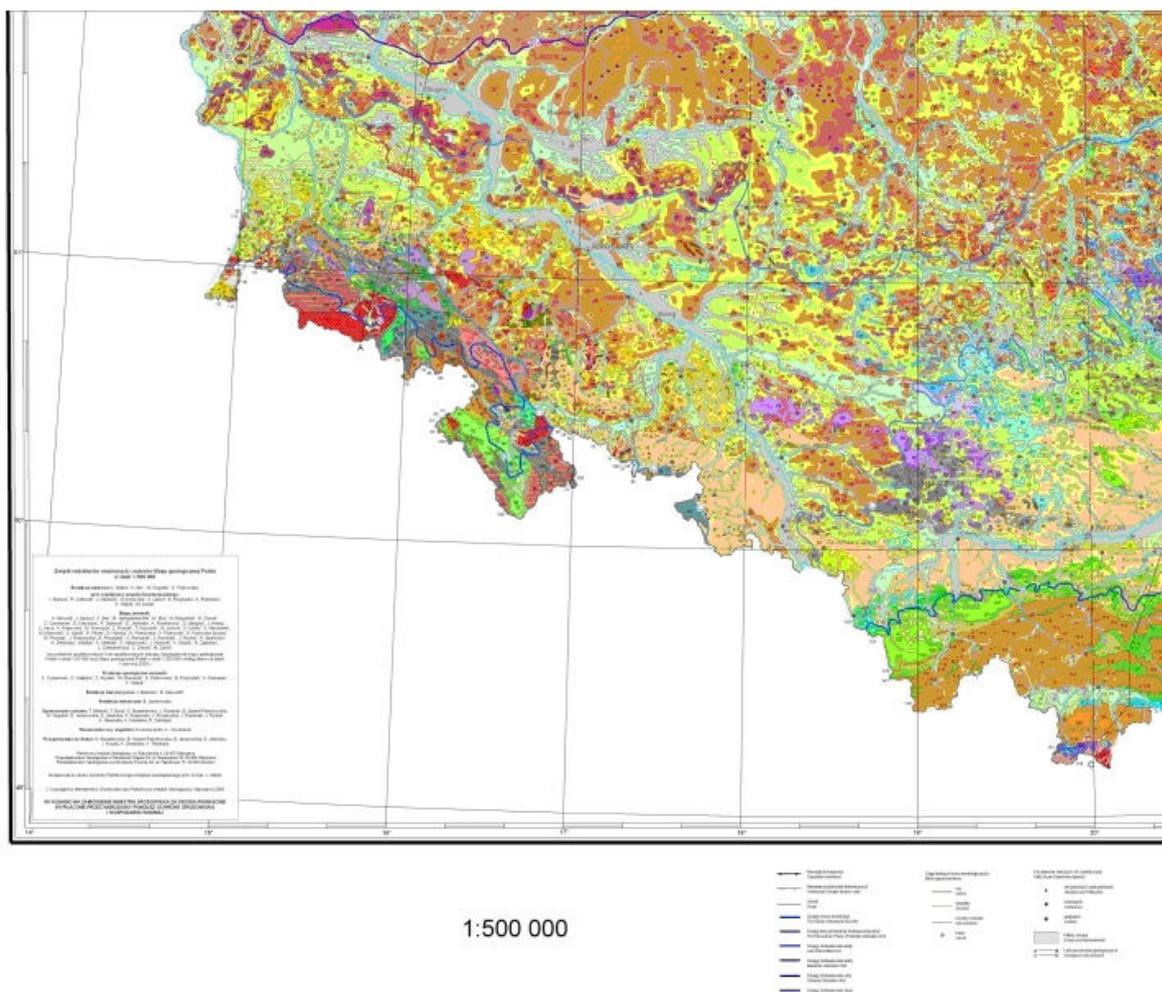


Figure 3. One of four sheets of GMP at a scale of 1:500 000

The GMP at a scale of 1: 500 000 is presented on the geoportal site, <http://ikar2.pgi.gov.pl/cms/>

#### Lithogenetic Map of Poland at 1:50 000 scale

The source of DGMP, at a scale of 1:50 000 is LMP at the same scale. LMP is designed for common use, including individuals without geological knowledge. The aim of LMP is to present the varied lithology for the area of Poland and to provide data for land use, planning, and geotouristic purposes. It will also be used in the process of initial evaluation, future investments, and evaluation of ground for further detailed analysis.

LMP is based primarily on digital conversions, selection and generalization of information from the DGMP database utilizing ArcGIS tools. LMP presents lithology and genesis of formations covering surface, and chosen geodynamical, hydrogeological, and anthropogenic phenomena. LMP is accomplished using the digital elevation model.

Each sheet of LMP is prepared in an personal geodatabase. At first the coordinator assigns sheets of DGMP to authors, and stores this information in LMP sheets . The db.Author develops the single map and verifies the correctness using tools. The finished map is sent for technical approval. If everything is correct, the map is uploaded to a temporary geodatabase. The Technical Editor downloads the map from this temporary database and generates a mock version of the map, and prepares it for publishing. The map is then uploaded to the IKAR database. Dedicated software has been specially created for this map. It allows partial automation of technical control and preparation of map sheets for publication.

At present, we have finished the first part of 400 map sheets. The plan is to create 1085 sheets of that map, just like DGMP. LMP is available in analogue form – plotter print, digital – raster files (\*.pdf) and ArcView files (\*.shp). It is possible to visualize them in a variety of free GIS software.

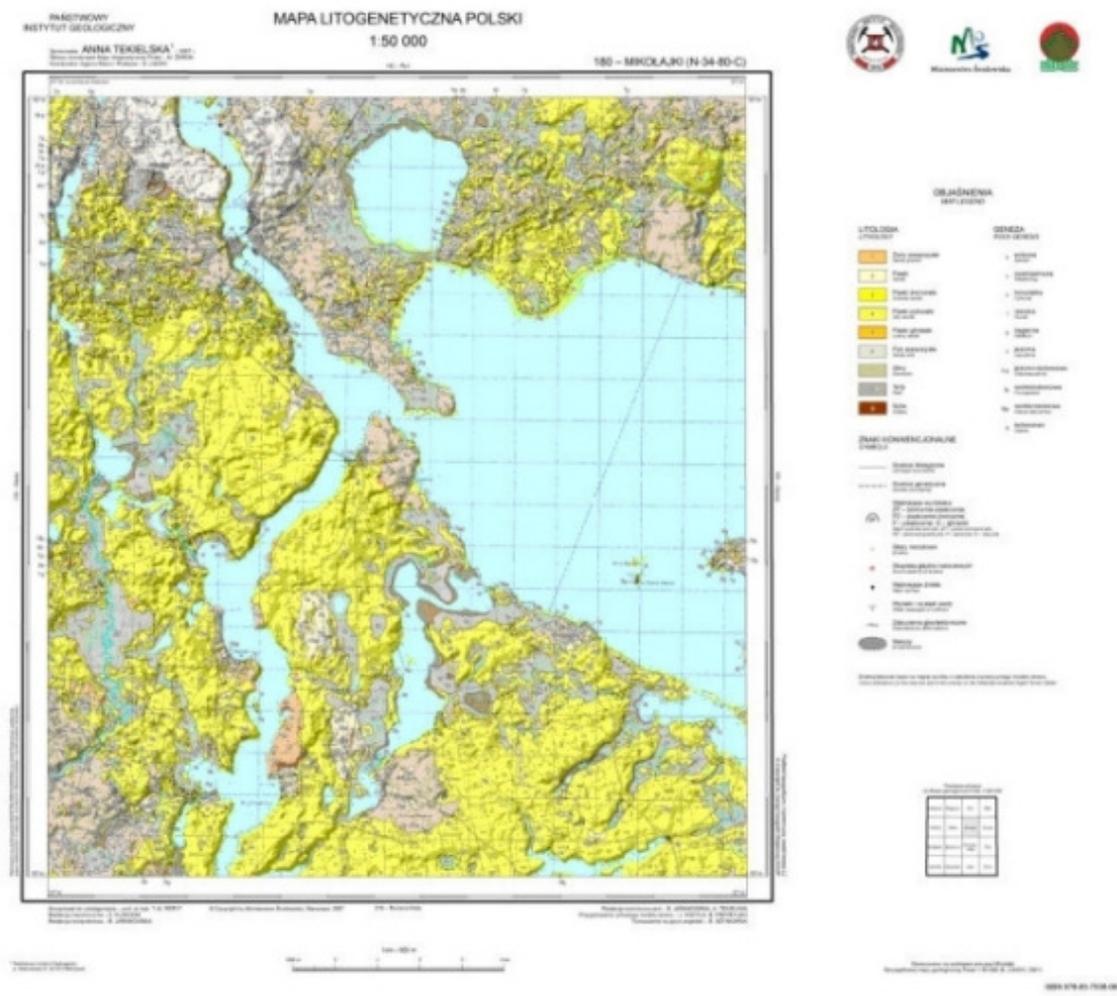


Figure 4. Sample LMP sheet at scale 1:50 000, digitalized and published in analog form  
 Geological Map of the Tatra Mountains at 1:10 000 scale

The most detailed serial maps developed in the Surface Geological Mapping Department is the Geological map of the Tatra Mountains at 1:10 000 scale. Elaboration at this scale due to a very complicated structure of this part of our country. To create this map using ArcGIS software, we needed to have documentation from field works and laboratory works. It is created in cooperate with Slovakian Geological Survey, which is why the geological information is continuous cross the border line. At this moment we have nine sheets of this map in our database.

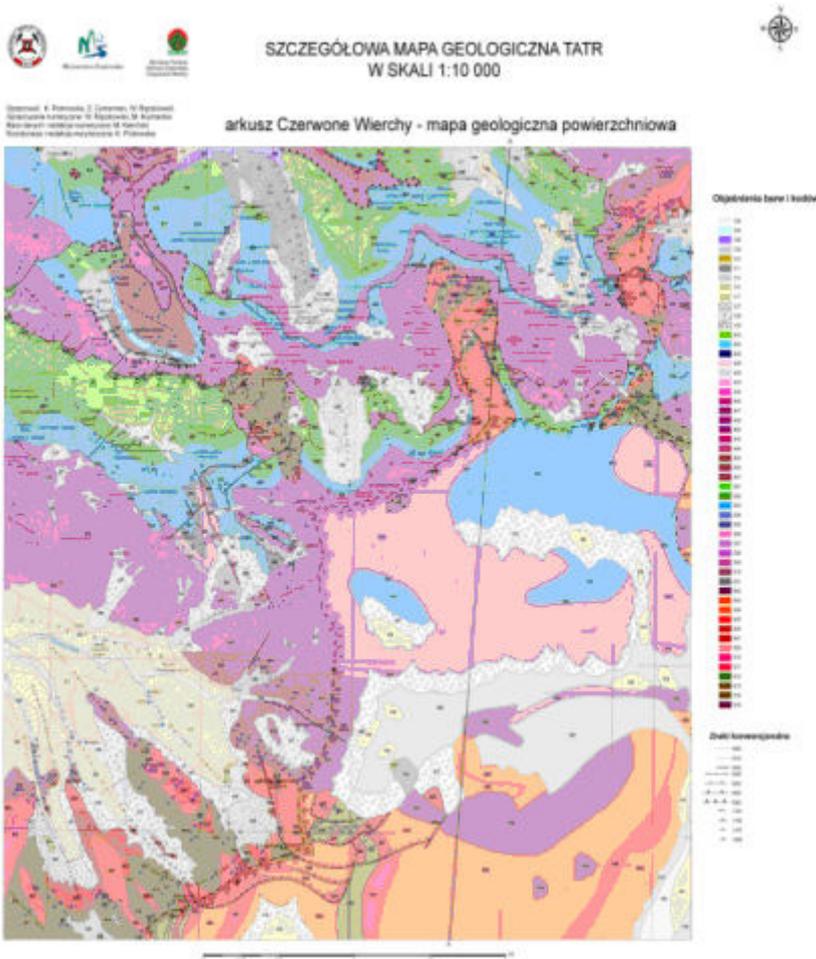


Figure 5. Sample of Geological Map of the Tatra Mountains at 1:10 000 scale (in work)

## CONCLUSION AND FUTURE PLANS

Data included in DGMP at a scale of 1:50 000 is used in creating other serial maps at a scale of 1:50 000. In other departments of PGI-NRI, hydrogeologic, geo-environmental, and geo-economical maps are being developed, including information about the geological structure from DGMP. Those maps are developed in digital form. All thematic maps at a scale of 1:50 000 will be available through the IKAR geoportal as map services. Geospatial data about the geological structure of Poland, stored in PGI-NRI databases is the base for different elaborations at different scales.

The Glacitectonic Map of Poland at a scale of 1:1 000 000, displaying glacitectonic processes for the territory of Poland has been created. Currently it is being prepared for publishing through the IKAR geoportal. Data is being used in the process of planning and localizing the linear objects of transport infrastructure.

Maps at a scale of 1:100 000, of planned routes, including protected areas and surface geological structures, have been created.

Geo-touristic maps of Polish National Parks, presenting tourist information and protected areas against the geological structure of selected areas are developed. They will be integrated into the IKAR geoportal.

We are taking many initiatives in the area of digital development of geological maps in cooperation with other countries. As a research institute we develop standards for creating the geological maps and share this knowledge with other countries.

One example of such cooperation is the creation of the Geological map of Angola at a scale of 1:1 000 000. The creation of the map initiated the process of creating digital maps in the Republic of Angola. PGI-NRI holds many training sessions in ArcGIS use for geologists of Angola.

On the basis of our developed methods, together with geologists from Belorussia, we are creating a geological map of Poland and Belorussia borderline at a scale of 1:250 000. The aim of this project is to develop a continuous geological map without divisions through countries borders. The map will be in a digital version, with similar spatial data structure to that which was verified during previous realizations of

a geological map series. The documentation prepared to create each map sheet was juxtaposed from DGMP data, which is part of the PGI-NRI database. They are the base for generalization of data. This project is in the initial stage of realization.

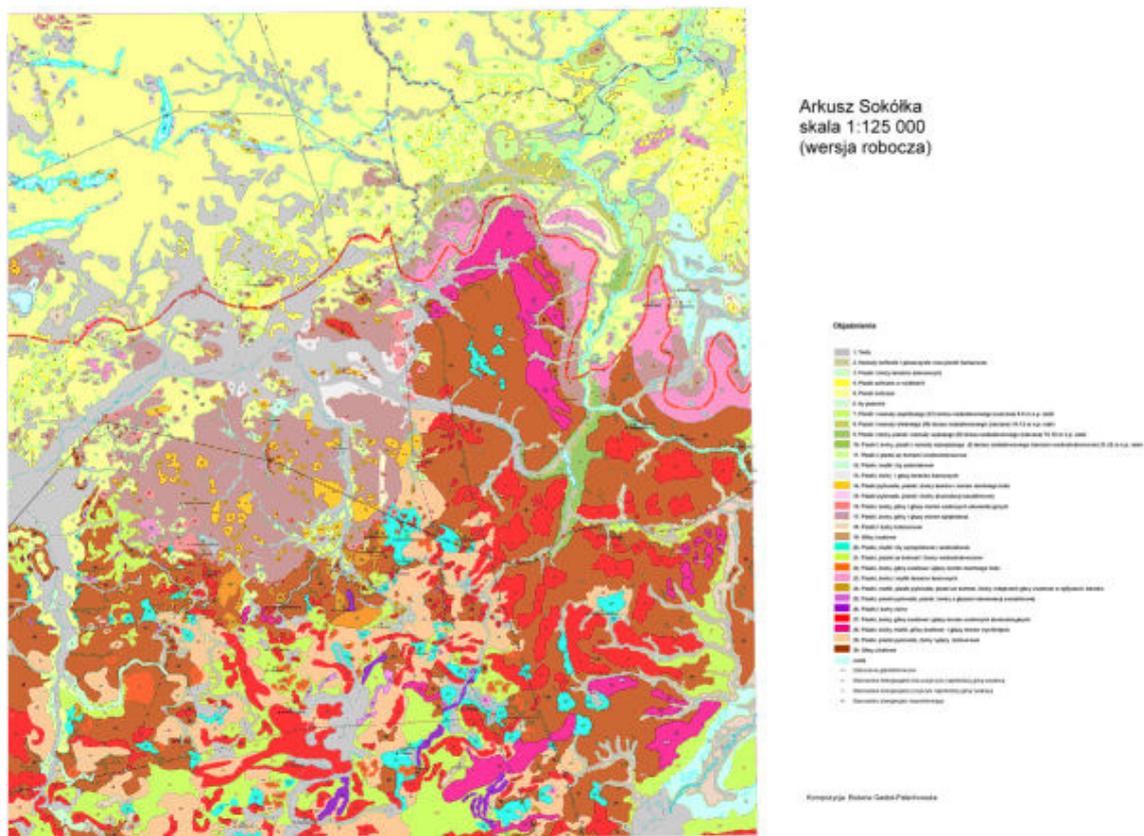


Figure 6. Cross-border map of Poland and Bialorus at a scale 1:250 000 (version in work)

In accordance with the directive set by the Infrastructure for Spatial Information in the European Community (INSPIRE), this will serve as the reference data for Poland. Each cartographic project is built on technical assumptions for each stage of work. Maps are based on databases with well defined, coherent structure.

In connection with INSPIRE guidelines the process of adjusting cartographical geological data to meet required standards has been started with the creation and publishing of metadata. The process is supported by PGI-NRI which is taking part in the international initiative OneGeology with the accompanying European project OneGeology-Europe. All geological cartographic elaborations are being prepared for publishing in the geoportal of Integrated Cartographic Geological System (IKAR).

Case studies above are only a small part of PGI-NRI activities, but it is difficult to present all activities we take part in such a short article.