WE LOVE GEOLOGICAL MAPS -
A REVIEW OF THE CHOSEN GIS BASED PRODUCTS
COMPiled by the Polish Geological Institute -
National Research Institute

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Abstract
The Polish Geological Institute - National Research Institute has been a main provider of geological maps in Poland for many decades. The basic developed product is the Detailed Geological Map of Poland which starting from the year 1996 has been compiled using an especially designed GIS based application. The system with later updates is still in use and provides data for many other cartographic products. The PGI-NRI also takes part in various regional and international initiatives as well as follows a considerably new direction in geological cartography and publishes series of geological-tourist maps of the chosen national and landscape parks. The digital geological and geological-tourist data is stored in the Central Geological Database and available on the Internet.

Keywords: geological maps, geological cartography, Detailed Geological Map of Poland, GeoLOG application

INTRODUCTION

The Polish Geological Institute - National Research Institute (PGI-NRI) acts as a geological survey in Poland. According to the Geological and Mining Law, one of the main tasks of the Polish Geological Survey is to conduct and coordinate geological mapping in the territory of our country. Therefore the Polish Geological Institute has been a chief provider of geological maps in Poland for many decades. Although our products have been the subject of many previous papers and presentations in the past, during the International Map Year it is worth to remind our major achievements in the field of geological cartography. It has to be stress out that this paper focuses on maps compiled in the Geological Mapping Program that is on geological and geological-tourist maps. All of these maps are developed by the use of ArcGIS software where additional dedicated extensions as well as cartographic tools originally provided by ESRI are applied. Most of the geological and geological-tourist data is available on the Internet.

NATIONAL GEOLOGICAL MAPS

The long tradition of geological maps compilation in the Polish Geological Institute reaches 1950s. Over the course of years the production techniques have been constantly improved and updated, what has led to establishment of coherent GIS based production process. Details and principles of the construction procedures are defined in the appropriate instructions, developed and published beforehand. A consistent system for data storage as well as a unified nomenclature of thematic layers have been introduced for all of the maps (Instrukcja… 2004, 2008, 2009). Digital data is loaded to the Central Geological Database which is an Oracle database developed and maintained by the PGI-NRI. At the same time each of maps has its own repository with data grouped into folders and geodatabases accordingly to the sheet division. A unique situation exists in case of the Detailed Geological Map of Poland where apart from the above mentioned solutions there is a separate dedicated database.
The following national maps are compiled in the Geological Mapping Program of the PGI-NRI:

- Detailed Geological Map of Poland to a scale of 1:50 000
- Lithogenetic Map of Poland to a scale of 1:50 000
- Geological Map of Poland to a scale of 1:200 000
- Geological Map of Poland to a scale of 1:500 000

Figure 1. National geological maps – availability of the digital data

Table 1. Structure and nomenclature of the data

<table>
<thead>
<tr>
<th>Name of the layer</th>
<th>Stored data</th>
</tr>
</thead>
<tbody>
<tr>
<td>geo1</td>
<td>Geological/lithogenetic units, linear structures of surface geology</td>
</tr>
<tr>
<td>geo2</td>
<td>Anthropogenic forms</td>
</tr>
<tr>
<td>geo3</td>
<td>Conventional signs like erratic boulders, groundwater seepages, mineral appearances, accumulation of mineral resources and fossil fuels, fossil flora and fauna occurrences, archeological findings etc.</td>
</tr>
<tr>
<td>geo4</td>
<td>Open pit mines and quarries</td>
</tr>
</tbody>
</table>
Detailed Geological Map of Poland to a scale of 1:50 000 (DGMP)

The whole edition of the Detailed Geological Map of Poland comprises 1069 sheets (plus 16 partial sheets published together with the adjacent ones). It has been published by the Polish Geological Institute since 1954. The map combines information gathered from: a field work of mapping, exploratory drillings, geophysical surveys, laboratory studies as well as archival results of geological researches (Jóźwik 2013). It is the most complex geological compilation in our country and, to be proven later in this paper, provides the fundamental data for geological maps in different scales. It is also the base for other thematic compilations like hydrogeological or environmental maps.

Process of compiling each DGMP sheet is divided into several stages (Instrukcja… 2004). Part of them such as preparation of a geological design, field and indoor works were (they are already finished, except few map sheets that are being renovated) performed by an author of the map. To ensure a high quality of the product, there is a group of specialists involved in the remaining stages of the process. Three cooperating teams handle scientific editing, digitalization and technical editing. They base on the Instruction issued by the director of the Polish Geological Institute. Not only does the document describe the construction procedures on every single stage but it also defines all of the obligatory map elements. Since each map sheet is a separate study consisting of: a geological map to a scale of 1:50 000, a geological cross-section, synthetic geological profiles, key of colors and symbols, boreholes’ profiles etc. It is published together with an explanatory text, which describes geology of the particular area in details and includes thematic sketches, results of laboratory analyses and other attachments (Instrukcja… 2004).

Starting from the year 1996 map sheets have been digitally compiled using an especially written (in Arc Macro Language) ArcSMGP application that has been awarded many times as one of the first digital systems for data storage and cartographic editing in Poland. Designed in the cooperation with specialists from the PGI-NRI, it was created by the Neokart GIS on the basis of ArcInfo Workstation and Oracle database and became the main tool for maintaining and managing the DGMP database. The ArcSMGP application comprises of several different modules (Jóźwik 2013).

Table 2. Moduls of the ArcSMGP application

<table>
<thead>
<tr>
<th>Name of the modul</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin</td>
<td>Manages users’ accounts</td>
</tr>
<tr>
<td>Verification and loading</td>
<td>Enables automatic verification of data compliance with the dictionaries and loading data to the database</td>
</tr>
<tr>
<td>Tools</td>
<td>Generates workspaces for maps, cross-sections and profiles, extracts data from the database</td>
</tr>
<tr>
<td>Dictionaries</td>
<td>Color symbols selection, generating and printing reports</td>
</tr>
</tbody>
</table>

Table 2. Moduls of the ArcSMGP application
To these days the same technology is applied for digitalization, verification, data storage as well as for updating color symbols and other map elements. In other words, from the above mentioned modules all, apart from the technical editing module, are still in use and provide basic data for other cartographic products. The technical editing process has been transferred to ArcGIS 9.3.1. It has been done by preparing suitable dictionaries and styles’ libraries next to creating and adding to ArcToolbox new tool boxes with the appropriate Python scripts and new tool bars to ArcMap application.

The first of the added tool boxes is used directly for the technical editing and comprises the following scripts:

- Generate boreholes’ legend
- Generate boreholes’ profiles
- Generate frames of map sheets
- Generate scale bars for geological profiles
- Download map sheet for the editing process
- Change order of the stratigraphic legend items
- Check the stratigraphic legend items

The basic script here is “Download map sheet for the editing process”. This tool downloads data for the chosen map sheet from the DGMP database and automatically converts it from coverages to an ESRI personal geodatabase. The geodatabase contains appropriate thematic layers, rasters, tables with legend items and inner datasets for geological cross-section and geological profile or profiles. The first of the mentioned new ArcMap’s tool bars enables configuration (defining paths to appropriate templates and dictionaries) and automatic generation of a map layout, in particular: placing data frames with the specific map elements in defined areas, creating joins with dictionaries, symbolization of layers, drawing key of color and symbols as well as other graphic elements. The latter toolbox contains one main script (Export_MDB_TILES) and is designed for loading revised data back to the DGMP database what is done by converting it again from geodatabase to coverage format so that all the data can be stored in the same format creating a coherent database.

As of the end of 2015, there is 659 revised and completed map sheets but the whole number of the sheets in the database (including those that are already digitized but still need revision) exceeds 900. Data coming from the geodatabases of the completed map sheets (after suitable simplification) is loaded to the Central Geological Database as well.

**Lithogenetic Map of Poland to a scale of 1:50 000 (LMP)**

The whole map edition consists of 1069 sheets (plus 16 partial sheets published together with the adjacent ones) and is designed for common use including people who do not have detailed geological knowledge. It is compiled on the basis of the Detailed Geological Map of Poland but it focuses on lithology and genesis of surface formations and does not include stratigraphic division. Therefore units distinguished here are highly simplified (Instrukcja… 2008). To enhance the quality of the cartographic transmission, apart from layers with hydrography and topography, a digital elevation model is added to the map. Furthermore, explanations of colors and symbols presented on the map are bilingual, written in Polish and English.

The detailed rules of creating, checking and editing the LMP are described in the Instruction issued by the PGI-NRI director. The whole process takes place in ArcGIS 9.3.1. environment, where new tools (Python scripts) for data management as well as for map layout configuration and generation have been added (Jaranowska 2007). They are available from a toolbar level in ArcMap and are also used for the series of the Geological Map of Poland to a scale of 1:200 000 (GM200).
### Table 3. Dedicated ArcMap tools for the LMP and the GM200 map series

<table>
<thead>
<tr>
<th>Name of the tool</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification</td>
<td>Checks the structure and content of the geodatabase with applied rules</td>
</tr>
<tr>
<td>Configuration</td>
<td>Defines map series and connections with templates and dictionaries</td>
</tr>
<tr>
<td>Download</td>
<td>Downloads data from the preliminary repository and creates a geodatabase</td>
</tr>
<tr>
<td>Load</td>
<td>Loads data from the geodatabase to the Central Geological Database</td>
</tr>
<tr>
<td>Generate a map layout</td>
<td>Generates a map layout, creates joins with dictionaries, matches to styles’ libraries</td>
</tr>
</tbody>
</table>

700 map sheets of the Lithogenetic Map of Poland have been published by the PGI-NRI in the years 2006-2013. The next 50 map sheets are being prepared, they will be completed till the end of 2016.

**Geological Map of Poland to a scale of 1:200 000 (GM200)**

The analogue version of the Geological Map of Poland to a scale of 1:200 000 covers the entire country. The compilation of the map started in 1955, the first map sheet (Radom) was published in 1969, the next map sheets in the years 1971–1998. The map presented the state of geological recognition from the 1970s and after the completion of the field work for the DGMP, turned out to be obsolete. Hence, the map renovation project was set up in 2005. Simultaneously the new instruction including guidelines for the digital compilation was created. The territory of Poland has been divided into 77 map sheets. Each map sheet is published in two versions: “covered” (presenting surface geology) and “uncovered” (bedrock geology), together with a shared explanatory text (Instrukcja… 2009). The process of map compilation mostly base on joined and generalized data from the 16 appropriate DGMP sheets to a scale of 1:50 000 and is handled in ArcGIS 9. Applied dedicated solutions as well as the way of data management are exactly the same as for the LMP series.

There is 21 map sheets digitally elaborated so far. Another 13 will be compiled in the years 2016-2019.

**Geological Map of Poland to a scale of 1:500 000 (GMS500)**

The map covers the whole territory of Poland and consists of 4 sheets plus one sheet with the geological cross-sections. It was compiled in the years 2003-2005 on the basis of the Detailed Geological Map of Poland to a scale of 1:50 000 and the Geological Map of Poland to a scale of 1:200 000. After completing and updating accordingly to the contemporary geological knowledge, the map was published by the PGI-NRI in 2006. It shows geology of surface formations in Poland. Information on lithology, stratigraphy and genesis is available in two languages: Polish and English. The map, like all previous mentioned, was compiled in ArcGIS. The data is stored in a common ESRI personal geodatabase. It has been loaded to the Central Geological Database as well.

**REGIONAL GEOLOGICAL MAPS AND INTERNATIONAL COOPERATION**

**Detailed Geological Map of Tatra Mountains to a scale of 1:10 000**

The Detailed Geological Map of Tatra Mountains to a scale of 1:10 000 is a serial map comprising 25 map sheets. All of them have been completed in the years 2005-2015. The map has been compiled in the cooperation with Slovak geologists (Piotrowska 2013) on the basis of old paper (both Polish and Slovak) maps of this region as well as on current geological field work and geophysical surveys. Similarly to the Geological Map of Poland to a scale of 1:200 000 the map is published in two versions: “covered” (presenting surface geology ) and “uncovered” (bedrock geology).

Like the other cartographic products, it has been developed in ArcGIS 9 software but, what is worth to underline, it is the first one where advanced solutions origially provided by ESRI have been introduced (Piotrowska 2013).
The DS Map Book was applied for the purposes of a map series creation. The application enabled generation of the unified layouts for all of the map sheets and made the process of technical editing partly automated. The advanced symbolization technique has been implemented as well (Piotrowska 2013). The background colors of geological units are defined as simple symbols whereas all patterns come from representations’ rules (Cartographic Representation extension). To control the quality of text data the so-called attribute domains have been used. They constrain the values allowed in any particular attribute and so enforce data integrity.

Although the map edition consists of 25 map sheets published separately, the data altogether composes a coherent database and is stored on the server of the Central Geological Database.

Geological Map of the Northern part of the Polish-Belarusian cross-border area

The map was compiled in the frame of an international project, financed by the Ministry of Science and Higher Education (in accordance to the Agreement on Scientific-Technical Cooperation between Poland and Belarus), regarding correlation between main lithostratigraphic units in the North part of the Polish-Belarusian cross-border area (Marks 2011). Pilot sheets of Quaternary (“covered”) and bedrock (“uncovered”) geological map to a scale 1:250 000 were published together with an explanatory text in 2011. They were developed on the basis of the available sheets of the Detailed Geological Map of Poland as well as on the Belarusian geological map of Quaternary deposits and (in the North area) the Quaternary Geological Map of Lithuania (both to a scale 1:200 000). First stage of digital map compilation was performed in the ArcInfo Workstation software, further stages as well as preparation of final map layouts – in ArcGIS 9.3.1. The data was finally gathered in an ESRI personal geodatabase with inner division to feature classes imitating the structure of compilations such as the DGMP and the GM200 (Marks 2011). All of the map sheets’ explanations are bilingual and include Polish and English version. There is also a CD being attached to the disseminated copies of the compilation.

OneGeology

The Polish Geological Institute – National Research Institute has been involved in the OneGeology initiative since the very beginning that is since the Brighton agreement concluded in March 2007. Among other things, our contribution to the project consisted in creation of a geological map of Poland to a scale of 1:1000 000 that would be semantically and technically conformant with the introduced OneGeology standards. The compilation has been done on the basis of the Geological Map of Poland to a scale of 1:500 000 and concerned geometrical and substantial generalization and verification of geological units as well as revision of vocabulary on lithology and stratigraphy. This is the first geological map fully prepared in GeoSciML 3.2 (Stępień 2011). The first one that truly deserves to be called a GIS compilation because (unlikely to other maps where polygons are coded with strings of digits and have to be linked to dictionaries) each polygon here is directly described with a name of a geological unit. The map presents surface geology of Poland and is published as a WMS service on the OneGeology (as well as OneGeologyEurope) portal. Specialists from the PGI-NRI are responsible for maintaining the service.

It is worth to remind that the PGI-NRI has also supported the SRDE Geoinform of Ukraine in the process of standardization and adaptation of their geological map to the OneGeology software. The Ukrainian map of bedrock geology to a scale of 1:1000 000 was published on our server as a Web Map Service (WMS) in order to test its compatibility with the OneGeology geoportal. Currently the service is maintained by the SRDE Geoinform of Ukraine themselves.

According to the EGDI Bridge project all of the national maps being served by the OneGeologyEurope geoportal are supposed to be converted to the INSPIRE conformant form and move to the EGDI portal (as the current OneGeologyEurope portal is going to be terminated in June 2016).

Apart from the adaptation of the Polish Geological Superficial Map that is currently presented on the OneGeologyEurope geoportal, the related works in the PGI-NRI will also include the following maps:

- Glaciotectonic Map of Poland to a scale of 1:1 000 000
- Bedrock Horizontal Cutting Map of Poland to a scale of 1:1 000 000 (6 levels of horizontal cutting)
- Bedrock Geological Map to a scale of 1:1 000 000

They have been compiled in the GeoSciML 3.2 in the frame of an additional national project. Although they have not been served on the OneGeologyEurope portal before, they are fully compliant with the required standards and so after transformation to the GeoSciML 4.0 will be included in the EGDI project.
GEOLOGICAL-TOURIST MAPS

Apart from traditional geological maps the PGI-NRI publishes series of geological-tourist maps of the chosen national as well as landscape parks. Not only do these maps present tourist attractions and topography of the given areas but they also show simplified geology and the most interesting geosites. Although it is a considerably new direction in geological cartography it wins appreciation among wide range of users.

The same production techniques were applied for both kind of protected areas’ maps. They were compiled in ArcGIS software, where advanced cartographic solutions like the Cartographic Representation extension as well as the Selective Masking tool were used. The first one enables full modification of point, line or polygon features without changing their factual structure and location. The latter makes possible masking certain map elements and so enhances the cartographic transmission of the map. Thanks to these solutions it was possible to legibly present the wealth content of the maps on printed versions and at the same time to prepare interactive versions to be shared on CDIses or published on the Internet (Jóźwik 2015). The paper edition includes a traditional folded map with a geological-tourist map on the one side and a description of geosites on the other. It has been disseminated together with the CD.

According to the technical guidelines for both series, data is stored in ESRI personal geodatabases. Each of maps has its own database with internal datasets for geology, tourism and topography (Przasnyska, Tekielska 2008-2009, Przasnyska 2013, Jóźwik 2015). Likewise in case of geological maps, data is eventually loaded to the Central Geological Database.

The following geological-tourist maps of the national parks were published by the PGI-NRI in the years 2010-2013:

- Białowieża National Park to a scale of 1:25 000
- Babia Góra National Park to a scale of 1:13 000
- Polesie National Park to a scale of 1:30 000
- Roztocze National Park to a scale of 1:30 000
- Wigry National Park to a scale of 1:30 000
- Ojców National Park to a scale of 1:25 000
- Pieniny National Park to a scale of 1:25 000
- Gorce National Park to a scale of 1:25 000
- Drawa National Park to a scale of 1:40 000
- Warta Mouth National Park to a scale of 1:25 000
- The following geological-tourist maps of the landscape parks were published by the PGI-NRI in 2014:
  - Gostynin-Włocławek Landscape Park to a scale of 1:60 000
  - Suwalki Landscape Park to a scale of 1:25 000
  - Vistula Spit Landscape Park to a scale of 1:60 000
  - The Coastal Landscape Park to a scale of 1:60 000
  - Masurian Landscape Park to a scale of 1:60 000
  - Wel Landscape Park to a scale of 1:40 000
  - The Romincka Forest Landscape Park to a scale of 1:40 000

AVAILABILITY OF THE DATA ON THE INTERNET

The geological and geological-tourist data can be viewed on a computer using classic map browser available on the PGI –NRI web site or they can be accessed directly from a mobile device by the use of the GeoLOG application. Both solutions are provided by the Central Geological Database. From the technical point of view, the latter one is not exactly a mobile application but a modern webGIS site supporting mobile devices. The whole set of the accessible data comprises not only the previous mentioned geological and geological-tourist maps but much wider range of the Central Geological Database’s resources. Apart from displaying and browsing data, the GeoLOG offers many additional functionalities, among the others: defining one’s exact location and registering the route as well as loading WMS
services from other servers, compiling your own maps’ compositions and saving them on the device or sharing via social media. The application’s language is Polish but it can be easily changed to English.

The geological and geological-tourist data is also available as WMS services, whose addresses as well as metadata can be found on the Central Geological Database portal.

There is a team in the PGI-NRI consisting of specialists from various domains who work on making our services fully compliant with the INSPIRE directive.

CONCLUSION

The Geological Mapping Program of the Polish Geological Institute – National Research Institute has great accomplishments in the field of geological cartography. All of the basic geological maps are compiled here, under the watchful eye of qualified specialists. Experience gathered in the course of years has allowed them to develop the optimal, unified GIS based techniques of map production as well as the coherent system of data storage and dissemination. Eventually all of the data coming from the described geological and geological-tourist maps (apart from the exception of the Polish-Belarusian cross-border map) goes to the Central Geological Database which is the largest collection of digital data on natural sciences in Poland. The data is available on the Internet via desktop or mobile map browser as well as in form of WMS services. Specialists from the PGI-NRI Geological Mapping Program take part in many regional as well as international initiatives and stay current with new GIS solutions.

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Instrukcja reambulacji Mapy geologicznej Polski w skali 1:200 000. Wydanie II uzupełnione. Państwowy Instytut Geologiczny, Warszawa, 2009


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