GEOLOGICAL MAPS

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FÖLDTANI TÉRKÉPEK

Összefoglalás

A földtani térképek a tematikus térképek csoportjába tartoznak. Céltérképek, mert egy-egy terület földtani megismerésének eszközei, ugyanakkor hivatástérképek is, mert újabb, sokirányú kutatás alapját képezhetik. A térképek tematikus információ tartalmát terepi felvételezések, térképezés során szakemberek, geológusok gyűjtik össze. Az adatbázisokba rendezett tematikus információ tartalom a tudományos feldolgozást követően térképi alapra kerül, amelynek részletessége, topográfiai pontossága nagymértékben meghatározza a térkép használhatóságát. A földtani tematikus tartalmat kartográfiai módszerekkel, meghatározott jelrendszer segítségével ábrázoljuk. A térképi információ értelmezése a jelmagyarázat segítségével történik. A jelmagyarázat tartalma és részletessége egyértelműen kifejezi a geológiai ismereteknek a térképezés időpontjára jellemző szintjét. A részletes földtani információ, ami a földtani térkép segítségével bemutatja egy terület földtani természetét eredetét, nagyon lényeges az információn alapuló társadalmi, közösségi, politikai döntéshozatal és gazdasági fejlesztés területén.

Summary

Geological maps belong to the group of thematic maps. They are regarded as special-purpose maps, since they are tools of the geological cognition of a certain area. At the same time they are profession maps, as they make up the basis of further multi-purpose researches. The thematic information content of the maps are gathered by specialists, geologists during field surveying (mapping). The thematic information content ordered in databases, after their scientific elaboration, is superimposed over a base map, the detailness and topographic accuracy of which considerably determines the usability of the map. Geological thematic content is represented by cartographic methods, by using a system of specific symbols. The information provided by the map can be interpreted by using the map legend. The content and detaileness of the legend unambiguously reflect the geological knowledge characteristic of the time period when the field mapping was done. The detailed geologic information represented on geological maps, introducing the geologic features and the origin of an area, is very useful from the point of view of social, communal and political decision-making, based on information, and it is playing an important role on the field of economical development.

Definition of the geological map

Roadmaps, city and tourist maps, atlases, which show the surface of the Earth and the location of artificial features, are well-known for all of us, and used for orientation. Unlike these variants, which are called topographic maps, the geologic maps show the distribution of geologic features of the area, including the composition and structure of rocks at and under the land surface, and are represented by the combination of colours, lines, and special symbols unique to geologic maps. Other characteristics of geologic maps are the following: colours and symbols represent the age of rocks, so users can have a look into the processes of the history of Earth, into the fourth dimension: time.

From a cartographic point of view, a geologic map is the scaled graphic representation of the characteristics, occurrence and the relationship of geologic formations, which represents the spatial position and age of geologic phenomena and structures, and it reflects the time when the mapping was done.

Geologic maps belong to the group of the thematic maps. They are regarded as purpose-maps, since they are the tools of the geological orientation in a certain area. At the same time, they are profession maps, as they constitute the basis of every further multi-purpose research. The professional information based on observations are collected by specialists, geologists. The observed and interpreted information are superimposed over a base map, the detailness, topographic accuracy and authenticity of which determine the value of the whole mass of information. The geologic content is visualized through an adequate coding in generalised form according to the scale or topics of the representation (KLINGHAMMER–PAPP-VÁRY 1991).

Consequently, the geologic map is a graphic representation of the geologic information that contains descriptive information about the solid Earth. The geologic map identifies the spatial distribution of the essential rocks, e.g. granite, limestone, sandstone or aleurolite; the formations on the surface deposited by wind, water and ice; and geological structures, such as faults, fractures and folds. Geologic maps give an interpretation of the relationship between these rocks and phenomena in space and time.

Making geological maps

Geologic information basically refers to the structure of the Earth's crust, the location of the phenomena and their chronological order. The traditional tool for its visual representation is the geologic map. The geological information content of the map reflects to the state of development of the discipline. The production, treatment, maintenance and publication of information are basically a governmental task because of its national, economical and educational aspects. In our country the Geological Institute of Hungary is the institution that is destined for this task, being the only establishment that carries out regular geologic mapping, and publishes summarizing maps for regions and for the country.

It is in the nature of the thing that information concerning the structure of the Earth is a spatial information. The gathering, classification and interpretation of geologic information concerning an area, the geological exploration/survey of the area can be divided into several phases, and every phase has its special importance and expenses.

The process begins with (1) capturing data in the field, and continues with (2) summarizing and interpreting the data. This is followed by (3) the visualising of data and the creation of databases. The process ends with (4) the publishing of the information. The whole process is labour intensive and needs a highly-qualified team. Thus, producing properly detailed geologic information covering the whole area or a part of a country, which is sufficient for every prospective field of application, is extremely expensive, therefore its realization must be a long-term, nation-wide strategic plan.

Calculating the prospective costs of the certain phases of the above-mentioned process, it is unambiguous, that the acquisition of data, i.e. the gathering of field information, is the most expensive stage. The reduction of the expenses of the phase comprising data-acquisition and gathering new information, can be achieved by using remote sensing and by using aerial photographs and satellite images. At the same time, these methods guarantee the spatial continuity of the information, and, due to the rapidity of data acquisition, the relative simultaneity of the field mapping. Moreover, due to the exact definability of parameters, they guarantee the possibility of the repeated comparability and monitoring.

Scientific information content of a geologic map

The geologic map contains a wide range of scientific information.

Physical features: geologic maps provide information about all the geologic formations and structures including such physical characteristics of rocks as mineral composition, as well as weathering and chemical alteration of rocks, or solidity, relative density, thickness, consolidation, moreover the orientation of fractures, faults and folds. These features are important, since they determine the continuity of the certain rock-types, geologic formations and structures and the boundary lines between them.

Three-dimensional geometry: based on information that descript the geometric orientation of geologic materials and structures, which occur on the surface, and with the help of the geologic map, the three-dimensional, subsurface image of geologic formations can be interpreted. This means the interpretation of the lateral and vertical distribution of rock bodies, and the changes in orientation and bedding between the individual spots of observations and measurements.

Relative ages: geologic maps provide information of the age of geologic formations and the date and succession of geologic events, which are represented on a particular map, and which form the geologic structures shown by the maps. The determination of the relative age of a geologic event compared to another one is important because a lot of applied researches are based on a certain geologic unit or structure. Research work depends on the age of the formations of the unit or structure, or on the relationship between these and other structures or units.

Relation between geologic forms and geologic processes: a geologic map lets the user understand geologic processes that created the formations and structures, which are represented on the map. If the user understood the genetic processes that played role in the formation of physical characteristics of the units or structures of the geologic map, the usability of the geologic map significantly increases for him.

Cartographic visualisation

Geological map is a depiction of the spatial distribution of various lithological units. At the same time it gives information about the age of rock bodies and the mappable units, and about their role in Earth history. The representation of the thematic content of a two-dimensional (2-D) geologic map needs a solution that can make the geological four-dimensional (4-D) information (space + time) picturesque and interpretable (BOULTER 1991).

This specific problem must be solved by the process of making a geologic map, from the surficial geologic mapping to map compilation. To the visualization of geologic observations and interpretations adequate cartographic methods, provided by the thematic cartography, can be assigned (BREZSNYÁNSZKY 1971). The simplified framework of the cartographic visualization of space-time (4-D) thematic content, which consists of remarkably diverse and complicated internal relationships, is the following:

- 2-D thematic content: separating rock bodies, cartographic, lithostratigraphic or mappable units; determining their spatial extension, and marking the boundaries between them. Visualization: by using area cartographic methods of absolute or relative graphical accuracy and encircling.
- 3-D thematic content: determining the position of rock bodies, lithostratigraphic or cartographic units and defining the relationship between them (position of beds, strike and dip, faults, folds, deformation). Visualization: by using accurate or draft vectorial data, by using the flow line map method.
- 4-D thematic content: the determination of the age of rock bodies, lithostratigraphic or cartographic units. Depiction: areal cartography with the help of surface colouring, hachures, schematic symbols, letters and numbers (indexes).

Managing digital data

Geologic research is supported by the continuously developing base of basic and interpreted data, and by the summarizing of these data. In this data processing course a geologic map – as an integrated and efficient 'data carrier' of space-time data (4-D) – plays a distinguished role (BREZSNYÁNSZKY–TURCZI 1998).
A model of the process (*Fig. 1*) has been compiled, which can help to get to achieve the projected knowledge set of the geologic objects, starting from spatial geologic objects of the real world using the means of the geologic surveying (mapping). The essence of the scientific elaboration (research) that follows the above-mentioned stage is the classification of the information, the exploration of the system of relationships and symbolization (legend). The (abstracted) mass of information, which is concentrated in the legend, is replaced to a 2-dimensional projection of space by the cartographic processing, and this processing – using the proper depiction methods and conventional symbols – produces the geologic map, which contains space-time data.

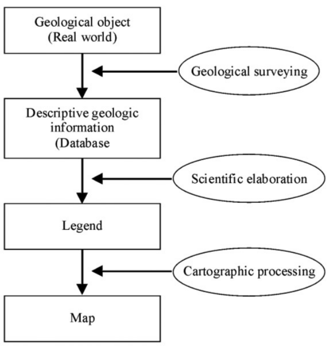

Fig. 1. Model of the geologic map elaboration process

Geologic information is a localized information. The development of the digital technology involved the development of geographic information systems (GIS) which is system capable of capturing, storing, processing, updating, analyzing, and displaying geographically referenced information. Digital storing, managing and processing of geologic data derived from field mapping, and the continuous increase of the mass of data, which are suitable for computer processing, need fundamental changes compared to the data management of the mass of information of traditional, printed, paper maps. The differences are summarized under three headings by ZENTAI (2000):

– The digitally stored system of data must be converted into a code, which can be interpreted by the computer. The data of geologic objects should be stored in a frame of reference.
– In the interest of digital visualization, the certain elements on the map, the thematic content must be provided with an explicit coding (attribute assigning).
– The digital data format requires the clearly unfolded (explicit) and unambiguous coding of the spatial relations among the individual data (map elements, objects).

If our data system matches the above-mentioned criteria, we can create the unique data model of the digital geologic map (*Fig. 2*). On the figure each cycle represents a part of the data model. The *geological object* is an observed and mapped element of the real world. The *descriptive data* are regarded as the set of attributes linked to the geological objects. With the help of the *legend*, the geologic object can be equipped by individual features and symbols. According to the illustration of the data model, the *geologic map* is an overlapping intersection of the geologic objects and their characteristic descriptive data and the legend. The figure shows the phenomena: *data standard*, *geologic nomenclature* and *GIS*, which mean the classification, denomination and spatial location of the geologic objects.

A numerous criteria can be assigned to the development of the data model of the geologic map according to JOHNSON et al. (1997):

– Data model should be attainable and should make less demand on the person or organization that prepares the digital geologic map.
– Data model should contain a minimal information set that is needed by every digital map.
– Data model should be ready for the reception of new information.
– Data model must have mechanisms, with the help of which the source of information, concerning every geologic object, can be queried.
– Data model must be appropriate to apply the standardized terminology related to geologic objects and to develop them, if it is necessary.
– Data model should be capable to register the spatial and temporal relationship system of the geologic objects.
– Data model should contain the explicit identification mechanism of each geologic object.
– Data model must be adequately flexible to satisfy the demands on the variable thematic of data in the future.

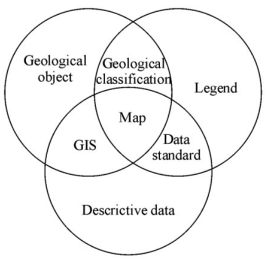

Fig. 2. Data model of the digtal geologic map

The basis of the data model of a geologic map, as it was explained previously, is the following: each geologic object of the real world is represented as a different geometric shape, element of space, as a surface, line or dot. In the two-dimensional world of maps the representation of geologic objects is restricted to areal, linear and dot elements. By the combination of them, any geologic object can be represented, depending on the type of the map and the scale of the map.

Consequently, the basis of producing digital geologic maps is the elaboration of data models, which makes the management of data structures possible, as well as the flexible adaptation to computer orientated thematic methods.

Using geologic maps

People usually consider the land as a static system, since landscape-forming mountains and rivers and, especially, subsurface rocks slightly change during the life-span of a generation. Nevertheless, geological and hydrological processes are dynamic. Earthquakes, volcanic eruptions, landslides, floods and inland waters – to mention only some of them – have an effect on the society that suffers from them. At the same time the human society, which lives together with the living environment, can change the geological features of an area and can influence the appearance and impacts of certain natural catastrophes. E.g.: the changes in the development/exploitation of an area may change erosion, sedimentation and ground water supply. As the environmental system changes due to natural and human activity, the reactivity of the system against the changes may also change. In the treatment of regional development and environmental problems, information describing the changes of the physical world are crucial. In this respect, geologic maps can provide useful information.

Decisions on economical developments – on every level (from local to global) – are influenced by their characteristics that have an effect on environmental changes. Decision-makers face with choices due to environmental changes, which have considerable social consequences. Decisions, which are directed towards the protection of certain characteristics of a land, may restrict the possibilities of the development of the neighbouring area. On the other hand, an improper development, which does not take the natural conditions into consideration, may be profitable in the near future, but may generate problems in a longer time, and these charge the future's generations with extraordinary expenses.

The detailed geologic information, which introduce the geologic features and the origin of an area, is very important from the point of view of social, communal and political decision-making, based on information, and is very important on the field of economical development. A lot of communal-political decisions and economic enterprises need special geonomic information, which are spatial information and belong to geological structures and materials characterized by physical parameters. The tool that collects and shows these information best of all, is the general-purpose geologic map.

Information recorded on geologic maps constitute the primary database of practically every applied and basic research, which belong to geosciences, including the followings:

- the exploration and excavation of raw materials, fuels and water supplies,
- the selection of places for depositing communal and hazardous waste,
- regional development and environmental planning,
- the decrease of earthquake danger,
- forecasting dangers of natural origin,
- planning and building of infrastructural investments, roads, routes of public utilities and reservoirs,
- the decrease of damages due to landslides and surface movements,
- the decrease of the impacts caused by soil degradation and erosion,
- building special establishments,
- basic geologic research
- education.

It is generally accepted that geologic information is useful for the society. In case of land use planning, the extent of benefit increases if decisions are made based on a higher information level. In order to provide this higher information level, the application of the most up-to-date and effective tools and methods are needed.

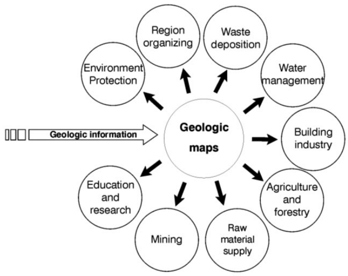

Fig.3. Geologic maps and their fields of utilization

Geologic data are regarded as information of public utility; their most general form of representation is the geologic map, their utilization happens in a real interdisciplinary medium (*Fig. 3*). Geologic information are needed for land-use planning, regional development, and for the risk analysis of regional development. They are essential in agricultural land-use planning. Geologic information are increasingly used by environmental protection, especially in the following fields: environmental impact studies, the safe deposition of waste, the prevention of possible environmental damages and the planning of water supply protection. Geologic information are indispensable for the research of fuel raw materials, building materials, clay, gravel, sand and building rocks, and for inventory adjustment. The economy of subsurface waters, or medical and social utilizations, such as the research on determining the harmful concentration of natural toxic matters, can also be mentioned.

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