Slovak Geol. Mag., 7, 2(2001),197–200

DANREG Programme – a set of geophysical of geophysical, geological and geoenvironmental maps of the Danube region

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*Abstract.*Three countries linked by the Danube river agreed to produce a map series of unified approach and methodology. The DANREG Programme was initiated on bilateral (Slovak-Hungarian) basis in 1989. In 1990, the representatives of the national geological surveys of Slovakia, Hungary and Austria and two geophysical institutions, namely Geocomplex (Bratislava) and Etvös Loránd Geophysical Institute - ELGI (Budapest) signed the agreement about the cooperation in regional and environmental geology and in geophysics. The basic objective of the international co-operation was to integrate the available geophysical, geological and geoenvironmental data of this territory (Császar et al., 1996). The knowledge and the detailness on natural conditions was not steady over the whole area and had to be completed with the new investigations. The aim of the study was to adjust the national geological and geophysical data bases, different in systems, approaches and detailedness and to compile various thematic maps assisted by GIS approach supplemented by explanatory notes and by a study of water quality.

Key words: Danube region, geophysics, geology, environmental geology, GIS

1. Introduction

The region of the DANREG Programme is divided by borders into three independent states - Austria, Slovakia and Hungary. The geoscientific questions can not be solved isolately, as well as cross-border problems of the environment. The answers needs multinational co-operation. The DANREG Programme was an attempt to create a set of unified thematic maps in the field of geoscience and applied geology.

The extension of the study was roughly 20 000 km^2, situated between the capitals - Vienna, Bratislava and Budapest (Fig.1). The Danube river represents the centre line of the entire area.

The following maps were compiled:

Maps in the scale of l:100 000: Surface geology map, Map of environmental geohazards. These two maps are regarded as the most important maps of the project.

Maps and geological profiles in the scale of 1:200 000: Map of the pre-Tertiary basement, Lithofacies and thickness map of the Pontian and the Pliocene, Lithofacies and thickness map of the Pannonian, Map of genetic types and thickness of Quaternary sediments, Tectonic map, Neotectonic map, Hydrogeological map, Engineering-geological map, Geothermal potential map, Bouguer anomaly map and two cross border geological profiles.

Maps in the scale of 1:500 000: Stripped gravity anomaly map, Magnetic ΔT anomaly map, Gravity linea-

Fig. 1

ment map (calculated by Blakely-method), Results of the magnetotelluric measurements, Contour map of the pre - Tertiary basement, Contour map of the Pannonian basement, Thickness of the Quaternary sediments (based on Schlumberger DC soundings), Apparent resistivity maps for AB=200 m, 600 m and 1000 m (based on Schlumberger DC soundings).

2. The DANREG programme

The DANREG Programme (*DAN*ube *R*egion *E*nvironmental *G*eology) was launched in 1989, originally on bilateral (Slovak-Hungarian) basis. Later, in 1990, after the fundamental political changes in Central and Eastern Europe, the representatives of the national geological surveys of Austria (Geologische Bundesanstalt), Hungary (Magyar Állami Földtani Intézet) and Slovakia (Geologický ústav Dionýza Štúra, later on Geologická služba Slovenskej republiky) signed the agreement. Since then work has been going on in 14 working groups, in which the geophysical maps were compiled by two collaborating institutions: Geocomplex (Bratislava) and Eötvös Loránd Geophysical Institute (Budapest). The results and things to be done were reviewed by a Co-ordinating board which held its meetings every 3-4 months (Császar et al., 2000). The basic objective of this co-operative effort was to integrate the existing knowledge that was inadequated along the borders and in the deep Neogene basins and should be completed with new investigations. In 1994 the DANREG Programme was officially accepted as one of the projects of the Central European Initiative (CEI). In 1995 the Federal Ministry of Science and Transport (Austria) has decided to support the publishing the maps and their explanatory notes. The Geological Institute of Hungary (MÁFI) was selected for GIS work and for coordinating the printing procedure. The maps and explanatory notes incl. a study on water quality were published in 2000-2001.

3. Pattern of the DANREG achievements

3.1 Geological maps

The ***Surface geological map*** served as the base for all the other maps of ther DANREG Programme with special regard to the Quaternary map, to the Engineering-geological map and to the Map of environmental geohazards. The complicated geological setting of the area is reflected in the number of elements of the legend that exceeded 300 originally. A special attention is paid to the Quaternary sediments and the Neogene sedimentary and volcanic formations which covers the great majority of the area. Besides Quaternary and Neogene sediments, smaller areas are built by a pre-tertiary basement (Tatricum and Veporicum units).

The ***Map of genetic types and thickness of Quaternary sediments*** summarizes the main genetic types of sediments and their cumulative thickness. In the deepest part of the basin the thickness values are based mainly on geoelectric measurements. The isopach lines separate territories of fast subsidence from the uplifting or slowly subsiding areas. The process of fast subsidence that is going on even today was restricted to the western part of the Little Hungarian Plain in the Quaternary (where even some 600 m thick deposit was accumulated during a period of some 2 million years). The separation of subsidence and uplift is indicating the most mobile zones along which one can expect earthquakes and tectonic movements even today.

The ***Lithofacies and thickness maps of the Pannonian and the Pliocene*** show a differentiation (particularly, subsidence) of the terrain that started at the beginning of the Miocene, as well as an intensive acceleration of this process during the Pannonian (the accumulation of 6000 to 7000 m deposits over a period of some 8 milllion years). The Little Hungarian Plain - the Danube Lowland area is the deepest Neogene basin within the Carpathian arc. The thickness lines were estimated on the basis of geophysical measurements, wells and borehole data. The very mighty sequence is composed of two sedimentary cycles that are illustrated on two maps: the Lower Pannonian and the Upper Pannonian - Pontian ones.

The ***Map of the pre-Tertiary basement*** documents the differences in depth and age of the basement and also the origin of the individual tectonic units. The last data can be used for palaeogeographic reconstruction and for distinguishing the tectonic movements of a great number of tectonic lines indicated on the surface of the pre-Tertiary basement. In addition to the wells and boreholes indicated in the maps, the geophysical data are also used for the setting of the isolines. Due to irregular distribution of basement data in boreholes there are areas with great uncertainty in age, in rock type and even in depth of the basement.

The ***Tectonic map*** excluding the Quaternary formations represents units according to the successive deformation phases. The main Alpine tectonic phases are as follows: Cretaceous, Palaeogene, Early to Middle Miocene, Late Miocene to Pliocene. The present-day tectonic outline of the region was developed during the Early to Middle Miocene. This corresponds with the volcanic activity and the formation of the deep basins. There is clear evidence for the rejuvenation of the movements along some tectonic lines. The following tectonic elements are distinguished: axes of synclines and anticlines, nappes, overthrusts, strike slip faults and normal faults. Separating the Pelso unit from the Veporic unit, among many important tectonic lines the Rába - Hurbanovo - Diósjenő Line is considered to be the most important one.

The ***Neotectonic map*** is based mainly on the seismic activity and on the thickness differences in the sediments of the Upper Pliocene to Recent. The tectonic lines and structures active this time separate faults of basinal structure (Gabčíkovo Basin) and faults of other structures. The most intensive young tectonic activity in the region has been observed on the contact of the Little Carpathian Mts. (with Hainburg Hills) to the basinal part of the Danube Lowland.

3.2 Geoenvironmental maps

The ***Engineering-geological map*** belongs to the group of zoning maps. Altogether about 30 zones (lithologic-genetic units) and more than 10 lithological types of solid rocks and soils were delineated in the map. Other data important for the engineering geology were taken from other maps (tectonics and neotectonics, selected hydrogeological data). The geodynamic phenomena - like slope deformations, erosional features, karst phenomena, hydrocompaction in loess, underminings, places of minings and sources of possible pollution - like waste disposals are also presented in the map.

The ***Hydrogeological map*** expresses the permeability and lithology of the aquifers. Primary (pores), secondary (fissures) and karst permeability have been distinguished in the map, with seven categories according to their value. The lithology of the aquifers is displayed identifying 21 types.

The ***Geothermal potencial map*** indicates the distribution of temperature recorded at 1500 m depth. Due to their geothermal potential two main areas have been delineated: the Vienna Basin and the Little Hungarian Plain - Danube Lowland. A study with several cross sections is attached to the map.

The ***Map of environmental geohazards*** is intended to show some phenomena of natural impact on the geological environment and the risk factors associated with the man-made hazardous establishments. The methodology is new and has been developed specially for the DANREG Programme. The mapped area was divided into five zones according to the sensitivity of the area to pollution. Another data which represent some types of natural or man-induced environmental hazards are also presented (active tectonic faults, epicentres of recorded earthquakes, boundaries of floods, sites of waste disposals, quarries and mines, areas of high level of pollution of soils, etc.). The main philosophy of this map is to show the sensitivity of rocks to contamination (thus, the protection level of groundwater, some confined groundwaters and karst water).

3.3 Geophysical maps

The common ***Bouguer anomaly map*** has been constructed using a density value of 2.67 g/cm^3. The interval of isolines is 1 mGal. A characteristic feature of the map is an elevation strip with axis oriented to SW-NE in the NW part of the project area, corresponding to the "heavier" Little Carpathian Mts. and Hainburg Hills. The large distinct depression in the Dunakiliti-Senec region represents the deepest part of the pre-Tertiary basement. The Vienna Basin shows similar gravity values, although its depth is considerably less than that of the previous depression. The gravity maps are usually compiled for two reasons: - to obtain information on the depth of basins; - to obtain information on the internal structure of the crust. However, in the DANREG area the gravity method could not deliver the above information entirely because of the distortion of the Bouguer anomalies by crustal and upper mantle effects. Therefore in addition to the Bouguer anomaly map, the map of residual anomalies, indication map of density contrasts by Blakely and stripped gravity map have been compiled.

The common ***Magnetic ΔT anomaly map*** has been constructed in the project area in order to clarify the extent, shape, depth and distribution of the sources of magnetic anomalies, i.e. mafic and ultramafic rocks. Prior to the start of the DANREG project, the magnetic maps for Slovakia and Hungary could not be fitted together along the border, therefore some special problems had to be solved for the compilation of the common map. Their reason was that the previous measurements had not been agreed between the countries (measurement of ΔZ in Hungary, ΔT in Austria, ΔZ and ΔT in Slovakia, ground and airborne surveys, different altitudes in the airborne surveys, etc.). The connecting profile lines have been measured between Slovakia and Austria and between Hungary and Slovakia, after which the Geological Survey of Austria compiled the common ΔT map. Many magnetic anomalies have been detected in the project area. According to the seismic and magnetotelluric measurements, the sources of major magnetic anomalies are surely situated within the pre-Tertiary basement.

As one version of the geoelectrical maps, ***Apparent resistivity maps*** have been compiled to assess the lithology of the Quaternary sediments, which represent one of the most important freshwater reservoires in Central Europe. Three resistivity maps have been compiled for different AB distances, (for AB = 200 m, 600 m and 1000 m), corresponding to approximate depth levels of 50 m, 150 m and 250 m. The maps show extensive accumulation of coarse to medium grained Quaternary sediments (gravel and sand) occuring in the central depression of the Danube Basin and the Little Hungarian Plain.

On the basis of electrical soundings, the ***Thickness map of the Quaternary sediments*** has also been compiled, showing that the thickness reaches even 600-700 m.

Among other geophysical activities in the DANREG Programme it should be mentioned that **magnetotelluric and seismic measurements** have been performed in the region for the investigation of deep structures. Their most important result is located of the Rába-Hurbanovo structural line. It is, in fact, a contact zone between two microplates of different origin. The results of the DANREG Programme allow a new interpretation of the structure of the crust and the upper mantle.

All three ***cross sections*** cut the Rába - Hurbanovo tectonic line(s) separating the Lower Austro-Alpine-Carpathian units from the Pelso unit. In addition to this the Vienna Basin - Little Hungarian Plain section shows the relation between the Austro-Alpine units and the Bohemian massive.

The ***Study of water quality*** evaluates the quality of surface water, ground water and precipitation water. The natural and anthropogenic factors that influence the quality of water are described and evaluated. The study is based mainly on archive data. Some new sampling and laboratory testing have been performed within the project. The present

situation and prognosis for the future of the quality of water is presented in the study.

4. Conclusions

The region of the DANREG Programme is divided by borders into three independent states, but geoscientific questions can not be solved isolately, as well as problems of the environment cross the borders and their answers needs multinational co-operation. The DANREG Programme was an attempt to create a set of unified thematic maps in the field of geoscience and applied geology. These maps and the connected data base should function as an unanimously accepted basis for decision makers for land use planning.

References

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