Contribution to the Structure of the Crystalline Basement in Eastern Moravia Based on Geomagnetic and Seismic Data

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Geomagnetic field of eastern Moravia consists of several long-wave anomalies reaching up to 500 nT. Geological section of the area investigated by many seismic profiles and deep boreholes revealed the presence of Neogene, Paleogene, Cretaceous, Jurassic, Carboniferous and Devonian rocks, recently also Cambrian rocks and, finally, the crystalline complex comprising plutonic and metamorphic rocks of Proterozoic age.

A detailed study of magnetic properties has shown that the Neogene and Jurassic strata do not embrace any magnetic rocks. Slightly magnetic layers were found in the Paleogene and Carboniferous strata, the magnetic effect of which reaches only some 10–12 nT. Local occurrences of magnetic teschenites and andesites were found within the Cretaceous and Paleogene sequences. These volcanic rocks may produce expressive anomalies where in outcrops, however, effects of deep-seated small bodies is negligible. Frequent occurrences of distinct magnetic rocks were recognized in plutonic and metamorphic rocks of the crystalline basement; therefore, this basement complex is considered to be the major source of the long-wave magnetic anomalies.

Comparison of magnetic maps with the topography of the buried basement obtained by seismic survey revealed a good coincidence of most of magnetic anomalies with elevations of the basement. This fact allowed to outline a new scheme of the composition and structure of the basement with full respect to the results obtained from boreholes.

An extensive continuation of the Brno and Dyje massifs to the S (as far as to NE Austria) and to the E was indicated, with the buried parts of these massifs being mostly situated at a depth of 1 to 2 km in southern Moravia. Another large and completely hidden granite complex lies beneath the NE part of the Ždánicky Les and Chřiby Mts., and beneath the northern extension of the Vienna Basin. Its upper margin is inclined from the depth level of about 1 km in the NW to the depth of 3.5 km in the SE. As shown by seismic sections, its depth reach is 18 km.

The shallowest magnetic granites and metamorphic rocks (at a depth of hundreds of metres or locally even in outcrops) were proved in the faulted area of the Upper Moravian Depression between the towns of Prostějov, Olomouc, Přerov and Hulín. Further east to the Hostýnské vrchy Mts., the easternmost, mostly intermediate to basic magmatic body lies beneath flysch sequences at a depth of about 1 km. The large areal extent of the hidden plutonic rocks from the exhumed Dyje and Brno massifs in the SW to the Hostynske vrchy Mts. in the NE permits us to introduce the term „South Moravian pluton".

The metamorphic envelope mostly represented by paragneisses seems to be – according to the seismic sections – intrafolded among the individual stocks of the pluton to the depth of about 10 km. The most continuous envelope of metamorphites is supposed beneath the Rača flysch unit in the Vizovické and Vsetínskí vrchy Mts. and beneath the Cretaceous Silesic Nappe in the northern foothills of the Beskydy Mts. However, the magnetic field pattern and the seismic sections indicate an another hidden pluton, „Beskydy granite pluton", which may continue further E to Poland and Slovakia.

The whole magnetic complex of plutonic and metamorphic rocks is considered to be a constituent part of the North European Platform consolidated by the Cadomian orogeny. The magnetic field structure and the crystalline basement topography indicate the existence of a regional transpressive zone, in which (during a long-lasting high-pressure and high-temperature conditions) the amount of magnetic minerals increased and where the plutons were squeezed to upper structural positions.

Evolution of the Northern Part of the Paleogene Central-Carpathian Basin, Slovakia

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The fore-arc Central-Carpathian Paleogene Basin (CCP Basin) lies in the northern part of the Central Western Carpathians. The tectonics and sediments of the basin suggest a complex kinematic history with prevailing extensional regime and minor compression mostly occurring in its northern part. The main volume of the CCP Basin fill deposits consists of deep-water turbidite systems mostly elongated in the SE–NW direction in the eastern part of the basin and in the NW–SE and W–E direction in the western part of the basin. Minor volume of the basin fill is composed of transverse, mostly gravity-flow aprons.

The basin fill consists of sedimentary succession divided into 4 units reflecting different stages of the basin evolution. Based on the analysis of the reflection seismics and deep boreholes, the maximum thickness of the sediments is estimated at some 4,000 m. Breccias, conglomerates, sandstones and sandy limestones, originating in a shallow-water environment, comprise the base of the succession (Unit 1). The age of the unit, determined by analysis of nummulite fauna, is the late Middle Eocene and Late Eocene (Bartonian and Priabonian, P14–P15 zones of planktonic foraminifera). The overlying Eocene to Early

Oligocene (NP zones 17–21) deposits of Unit 2 consist of three subunits: Subunit 2-1 is composed of thick conglomerates commonly filling erosional scars cut into Unit 1 and the basement (deep-water canyon); Subunit 2-2 consists of dark shales containing up to 5 m thick bodies of conglomerates and thick sandstone beds (slope deposits); and Subunit 2-3 is composed of dark shales with minor thin sandstone and conglomerate beds (interchannel deposits of deep turbiditic system). Unit 2 gradually passes into Unit 3, mostly showing the Early Rupelian age based on nannoplankton. The alternating sandstone and shale deposits may be divided into two subunits based on sandstone:shale ratio and sandstone bed thickness. Spatial distribution of both subunits varies both vertically and laterally. The deposits are interpreted as proximal and distal overbank deposits of a turbidite system.

The lowermost deposits of Unit 1 were deposited during marine transgression and represent a transgressive systems tract. Coarse-grained deposits of Subunit 2-1 and shales with conglomerates and sandstones of Subunit 2-2 are thought to be deposited during relative sea-level fall, representing a lowstand systems tract. The shales of Subunit 2-3 reflect deposition in a quiet, low-energy environment during rising sea level (transgressive systems tract). The gradual transition into Unit 3, interpreted as turbidite system deposits, suggest lowering of relative sea level. The nannoplankton from these deposits was mostly assigned to nannoplankton zones NP 20–21 suggesting building of this turbidite system on the boundary between the Eocene and Oligocene.

Comparison of the relative sea-level curve constructed from sedimentary record in the study area and the eustatic sea-level curve shows a little fit, suggesting that the eustatic sea-level variation was not the main trigger responsible for the sedimentation in the investigated part of the CCP Basin. Similarly, the climate during the Late Eocene and Early Oligocene was stable and probably did not influence the sedimentation. It seems that the most important factor influencing sedimentation was the tectonic activity. It controlled basin size and shape, canyon-floor gradient, shelf width and local relative sea level determining the type of sedimentation and the resulting sedimentary succession.

R – an Alternative to Spreadsheets and Special Software for Geochemical Calculations and Plotting

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The interpretation of whole-rock geochemical data from igneous and metamorphic rocks often requires complex and time-consuming calculations. Nowadays, these are commonly performed on a personal computer using dedicated software (e.g., MinCalc – Melín and Kunst 1992, NewPet – Clarke 1993, and MinPet – Richard 1995). However, unless either detailed documentation is provided, or the user is skilled in the particular programming language, it is complicated to figure out exactly which algorithm has been employed by the author. Moreover, any modifications to the original program are usually difficult or even impossible as it is not a common practice to make the source code available to the public.

To eliminate these major drawbacks, a freeware QuickBasic 4.5 package for recalculation of major-element analyses, named NORMAN, has been developed (Janoušek 2000). It is capable of computing parameters according to the most common normative calculation schemes and consists of several core modules designed for importing and editing of the input data, selecting an appropriate calculation scheme, display, printing and saving the output data. The calculation algorithms are stored in nearly independent modules with a simple structure. The advantage of the chosen approach is the simplicity, availability and open architecture that enables an average user not only to follow, but also, if need be, to modify the algorithms applied to his data.

However, NORMAN is essentially limited to DOS/WIN 95/98 and QuickBasic is difficult and time-consuming to program, especially for graphic outputs – hence NORMAN lacks these. Writing a system based on a spreadsheet such as MS Excel would not eliminate these setbacks either, as for more complicated calculations the spreadsheet tends to become too complex and prone to errors; moreover, Excel's plotting capabilities are limited and far from being of a publication quality.

A viable alternative seems to be R, a system for statistical computation and graphics (Ihaka and Gentleman 1996) that is based on statistical programming language termed S (Becker et al. 1988). R is a very high-level language, which means that the generated code is short and – compared with other languages – relatively easily understandable. It is also completely platform-independent, as R implementations are available for the most common operating systems (Unix, WIN 95/98/NT). Additionally, R produces high-quality graphic output (e.g., PostScript, HPGL, WMF) and has tools for interaction with the plots that, for instance, make possible identification of the plotted points or their interactive selection. Apart from built-in basic arithmetic, matrix, database and statistical functions, there are numerous add-on packages available (see Hornik 2000 for a complete up-to-date list and further details on R). Last but not least, R is free ☺.

To date, a great majority of the NORMAN modules have been ported into the new environment. In addition, most of the common geochemical plots used for interpretation of igneous rocks (e.g., Harker diagrams, AFM, spider diagrams, REE plots) as well as numerous classification diagrams (e.g., TAS, R_1–R_2, geotectonic diagrams for granitoids and basaltoids) are now ready to use. Functions for forward and reverse modelling of main igneous petrogenetic processes (fractional crystallization, binary mixing, AFC) utilising major- and trace-element data and/or radiogenic (Sr–Nd) isotope compositions were also written as were basic modules to interpret these (calculating initial Sr and Nd compositions, Nd model ages etc.). The aim is to build – partly on the basis of analogous S-based software written for Sun compatible computers by Farrow (1991) – a single,