Lithospheric Temperature Response to Magmatic Processes in West Bohemia

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The magnitude and timing of the transient thermal anomaly in the lithosphere induced by asthenosphere upwelling and by magma underplating of the crust on the southwestern end of the North Bohemian volcanic line was investigated by means of mathematical modelling. The generation and propagation of the heat pulse was simulated by numerically solving the transient heat conduction equation in the geothermal model of the lithosphere, taking into account the latent heat of the magma crystallization. Four alternative scenarios of magma underplating were considered: the instantaneous formation followed by conductive cooling, a) immediately or, b) after 11 Ma of keeping the magma molten and, c) gradual magma underplating within the period of 11 Ma, or d) of 40 Ma. The thickness and position of magma emplacement was estimated from the geological interpretation of the 9HR seismic reflection profile at 3 km at the depth range of 30–33 km, just below the Moho boundary in the area of the Teplá Upland. The shape of the emplacement was approximated by a vertical cylinder with a diameter of 90 km. The time scale of the process, 10–40 Ma, is based on the age of the volcanics found in the region. The initial magma temperature of 1300 °C was assumed on the basis of petrological and geochemical studies in similar zones in Germany.

We found that the transient heat flow anomaly from the magma emplacements near to the Moho amounts to about 5 mWm^{-2} on the surface and does not account fully for the increase of 10 to 20 mWm^{-2} observed in the area (about 80 mWm^{-2} compared to 60–70 mWm^{-2} in the surroundings). A substantial part of the observed heat flow surplus can be explained by the asthenosphere upwelling in the early stages of the magmatism some 40 Ma ago. Simulation of this process by considering 1300 °C hot asthenosphere upwelling from 100 km to 75 km below the area of the magma underplating yielded, for the considered geothermal model of the lithosphere, the background surface heat flow of 69 mWm^{-2}, increasing to 75 mWm^{-2} towards the central part (axisymmetric geometry) or to 78 mWm^{-2} (2-D geometry) for times of 40 Ma and longer. We conclude that a combined effect of the asthenosphere upwelling and magma underplating near the Moho can raise the surface heat flow to the observed levels. All these results are rather conservative estimates that did not take into account the possible small-scale mantle convection between the mechanical boundary layer and the thermal boundary layer (region between 800–1300 °C).

New Geophysical Contributions to the Geological Structure of the Contact Zone of the Bohemian Massif and the West Carpathians

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The paper presents some results of the project entitled "Structural-Geological Configuration of the West Carpathians and their Basement on the Basis of Geophysical Data from Border Areas with Poland and the Slovak Republic". The area of interest occupies the contact zone of the Bohemian Massif with the West Carpathians in the Czech territory and in the near-frontier areas of Poland and Slovakia. Magnetic, gravity, seismic, well-log and petrophysical data were gathered, reprocessed and newly interpreted regarding the latest methodical and geological knowledge. The following new maps were evaluted: Magnetic ΔT anomalies, Bouguer gravity, Horizontal gradient of gravity, Density boundary indications, Shaded relief of topography and Top of the crystalline basement map. The magnetic and gravity interpretation schemes were elaborated with the lists of anomalous geological sources. Finally, two interpretation cross-sections were outlined: Brno–Hodonín and Šternberk–Lysá pod Makytou.

Gravity field features

As the densities of lithologies in the study area vary within a relatively wide interval of 2.00–2.90 gcm^{-3}, numerous geological structures are emphasized in the gravity maps (eastern edge of the Bohemian Massif, the front line and the inner structure of the Carpathian Flysch Nappes, northeastern limit of the Vienna Basin). The NE–SW density boundary indication lines reflect primarily younger tectonic structures of the West Carpathians while the NW–SE indications reflect structural elements of the Brunovistulian basement and its platform cover. Large positive gravity anomalies correspond to the Metabasite Zone of the Brno pluton and to the huge Paleozoic sedimentary cover of the basement in the eastern part of the Jeseníky Mts. The Outer West Carpathian complexes such as the Flysch Zone, Molasse Zone and the Vienna Basin cause distinct gravity lows.

Magnetics

In general, three different belts of magnetic field can be defined in the area under study. The first positive magnetic belt is developed between the Hrubý Jeseník Mts. (W) and the vicinity of Karviná (E). It continues to Poland and to Slovakia. The second large belt of positive anomalies covers the whole S and SE part of the Czech Republic from the Moldanubian Zone (SW) to the Beskydy Mts.(E). It continues to Austria and Slovakia (S) and also to Slovakia and Poland (NE).

Between the two vast positive belts, a magnetic low is developed covering a substantial part of the areas built by Late Paleozoic rocks of the Drahanská vrchovina and the Oderské vrchy Highlands and the northern piedmont area of the Beskydy Mts. All the three large anomalous belts (two positive and one negative) represent the magnetic response of the mostly buried crystalline basement belonging to the Brunovistulian Unit.

Most of the smaller and near-surface magnetic sources occurring along the W margin of the area studied belong to the Moldanubian (SW) and Sudetic (NW) units. The pattern of the magnetic source rocks is completed by young volcanics such as basalts in the Nízký Jeseník Mts., teschenites in the northern piedmont of the Moravskoslezské Beskydy Mts. and andesites in the Bílé Karpaty Mts.

Seismics

Reprocessing of the 15 seismic lines was focused to the area of two new crucial geological cross-sections; the first one between Šternberk (NW) and Lysá p. Makytou (SE) and the second one between Blansko (NW) and Hodonín (SE). The reprocessed and newly migrated seismic profiles defined reliably the base of both Neogene and Paleogene Formations as well as the top of the crystalline basement. Devonian, Carboniferous and Jurassic, mostly carbonate sequences could be locally reliably fixed, too. The find of several thrust planes within the crystalline basement and in its Paleozoic to Mesozoic cover brought evidence of a complicated structure of the contact zone of the Bohemian Massif and the West Carpathians.

The complex seismic interpretation (together with gravity, magnetic and borehole data) was finally summarized in a map showing the top of the buried crystalline basement (Brunovistulian Unit).

References

GNOJEK I. and HUBATKA F., 2001. Structure of the Brunovistulian Unit (E part of the Czech Republic) on the basis of seismic and magnetic data. *Bull. Czech. Geol. Surv.*, 76: 157-168.

SEDLÁK J., GNOJEK I., HANÁK J., HUBATKA F., KREJČÍ O., FRANCŮ J., ŠIKULA J., and MRLINA J., 2001. Czech National Project to Promote Co-operation among Poland, the Slovak Republic, the Czech Republic and Ukraine in the Carpathians. *Naukovyj visnyk Ivano-Frankivskogo tekhnichnogo universitetu nafty i gazu*, Specvypusk 3, 4: 87-91.

Hydraulic Fracturing Control of Melt Migration in Pervasively Molten and Deformed Crust: AMS Fabric Study, Central Vosges

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The common spatial and also temporal relation between migmatites and crustal scale shear zones led several authors to propose a mechanism of magma ascent by exploiting crustal weaknesses. This deformation enhanced ascent model called also ‘tectonic pumping’ suggests that magma is driven upward by buoyancy, which is assisted by contemporaneous deformation. It is argued that the magma intrudes pervasively, parallel to main anisotropy represented by foliation planes, fold hinges and boudin necks. It is generally accepted that the melt migration rate is compatible with deformation rate, and the duration of the whole process is basically controlled by thermal evolution of the given area. The other mechanisms of tectonically driven melt migration proposed recently is called magma wedging into low viscosity country rocks. This model assumes that the hot and anisotropic country rocks prevented the melts from freezing and allowed its pervasive flow through the country rocks in the form of leucogranite sheets.

Migmatites of the Central Vosges allow to study complex behaviour of solid state rocks including granitic melts in a region of fertile magma segregation in metasedimentary and gneissic