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Structure and dynamics of the lithosphere in the Western Carpathians: multidisciplinary geophysical and geological study

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Introduction

The present lithosphere of the Western is a result of repeating compressional and extensional processes in the space between two continental megablocks (Laurasia, Gondwana, and Africa, Europe respectively) during Palaeozoic, Mesozoic and Tertiary. The region provides an opportunity to study not only how the crust on the southern margin of Europe varies in thickness due to passive margin development, continental collision and later extension, but also how the depth of the lithosphere-asthenosphere boundary has been affected by these processes.

Method

The understanding of geological processes in such complicated region, as the Western Carpathians are, can be benefit only from multidisciplinary study. Our study utilises existing geophysical and geological observations to interpret the crustal and lithospheric structure of the Western Carpathians and its vicinity. Geological-geophysical models of the Western Carpathian lithosphere were based on synthesis of deep refraction and reflection seismic; seismological, gravity, magnetic, magnetotelluric and temperature observations.

Seismic interpretation

The Atlas of Deep Seismic Profiles of the Western Carpathians has just published in Slovakia (Vozár and Šantavý 2000). It was prepared by the Geological Survey of Slovak Republic in Bratislava, the Geocomplex Inc. Bratislava, the Environmental Agency of the Slovak Republic with cooperation with the ELGI Budapest, and the KAPPA Ltd. Brno. The interpretation represents a final form of processing of all available data from the previous research stages dealing with crustal reflection-seismic profiles. Selected crustal profiles with a time registration of 12 and more seconds, which have more than 1 250 km in length, were accompanied by geologic interpretations.

Gravity interpretation

Based on the results of deep seismic transects 3T, 6HR, 2T and G, four gravity models were calculated by means of the 2D density modelling method (Šantavý 1999). In this study we have already presented re-interpretation of these density models. The re-interpretation consists of taking into account the lithosphere-asthenosphere boundary, as Lillie et al. (1994) found out that this boundary plays very important role for interpretation of long-wavelength gravity anomalies in the Carpatho-pannonian region.

Sesmological and Magnetotelluric observations

The data related to the lithosphere-asthenosphere boundary and its course were taken from two sources. The first data refer to teleseismic P-wave delay times (Babuška et al. 1987, Spakman et al. 1993). The second source comes from magnetotelluric sounding (Červ et al. 1994, Praus et al. 1990, Ádám et al. 1989, Varga et al. 1993)

Magnetic observations

Map of the total vector T of the geomagnetic field intensity (Gnojek in Vozár and Šantavý 2000) was used for interpretation of magnetic field in the Western Carpathians This map was compiled using the measurements of the detailed airborne proton magnetics. Locally, mostly in lowland areas, detailed ground magnetic measurements were utilized.

Temperature observations

For integrated study a map of the surface heat flow density of the Western Carpathians-Pannonian basin region and their vicinity (according to Král 1995 and Čermák 1994) was used.

Conclusion

The Western Carpathians structure is characterised by nappe structure and zoning. They are classified according to the age of development of the Alpine nappe structure as the Outer with Neo-Alpine nappes and the Inner with Paleo-Alpine – Pre-Paleogene nappe structure. The Klippen belt marks the boundary between the two.

Outer Western Carpathians (Flysch belt) represent an external part of the Western Carpathians. They are made up of the Tertiary series of rootless nappes, i.e. of sedimentary sequences detached from their basement an thrusted over the North-European platform.

Klippen belt is the most complicated belt of the Western Carpathians. It represents a transform Tertiary fault zone at the tectonic contact between the units of central and External Western Carpathians.

Central and Inner Western Carpathians are dominant features in presented seismic and gravimetric section. The Central Western Carpathians are represented by Tatricum, Veporicum and higher rootless nappes of Hronicum. The Inner Western Carpathians consist of Gemericum, Meliaticum and nappes of Turnaicum, Silicicum. The Alpine tectonic units are characterized by a northern vergency. Evidence of the variscan tectonic structures are very sporadic in the crystalline basement.

Postnappe formations of the Inner Carpathians are represented by Paleogene sediments. Their position colmate the stack of the Inner Carpathian nappes, is essentially tabular. However, tectonism has deformed the rocks within a narrow zone along the Klippen belt and resulted in a formation of scales and folds.

Basin and graben Development of basins and grabens in the Western Carpathian falls within the framework of the geodynamic processes, which controlled the development of the Carpathian arc at the close of Paleogene and during Neogene periods. Present day scenario is generally the result of the developments after Middle Miocene times, when the pre-arc basins, such as the Vienna Basin, the inter-arc basins, such as the intramontane depressions and the Eastern Slovakian Basin and the backarc basins, e.g. Danube and Southern Slovakian Basins, have formed.

Neogene volcanics cropping out mainly in the areas of central, southern and eastern Slovakia are a part of an extensive volcanic region of the Carpathian arc and Pannonian Basin. Their origin we relate to processes of subduction and back-arc extension during Neogene evolution of the arc.

The results contribute to a more complete picture of the lithosphere structure, slab evolution, collision and extension in the Carpathian mountain arc.

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