Evolution of the Déva orthogneiss (Tisza block, Hungary) and its geodynamic consequences

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Introduction

Variscan basement of the Tisza block is a composite of different terrains, which got juxtaposed during subsequent tectonic events from the Paleozoic ages up to present. Details of the inherited Variscan structural elements as well as the conditions of the post-Variscan exhumation of the metamorphic basement are rather obscure yet. There is firm evidence for a large-scale nappe formation during the Cretaceous. It was followed by opening of the Pannonian Basin during the Neogene, which coincided with significant horizontal and vertical movements even in the basement. As a result, the current structure of the basement is characterized by co-existence of metamorphic blocks of incompatible lithology and P-T-t evolution.

In the present study key localities from the metamorphic basement of the central Tisza block are compared. We present petrological data from orthogneiss bodies representing a close to 100 km long WSW-ENE profile and attempt interpreting them in a consistent geodynamic scenario. On this basis we define the Déva orthogneiss unit, and mention the rock bodies, previously studied separately, under the same name.

Geological setting

The topography of metamorphic basement of the Tisza block is characterized by uplifted basement highs, which are located around 500–2000 metres below the present surface and deep (up to –7000 m) sub-basins among them. There is any information about the petrography of the metamorphic rocks exclusively from the highs, where hydrocarbon exploration wells penetrated the basement.

The main rock types of the study area are HT paragneiss with sillimanite and migmatitic texture; orthogneiss and diverse amphibolite varieties. Some of the metabasic rocks contain relics of an early HP metamorphic event, while another subset is clearly of MP-MT origin. Previous studies showed, that metamorphic evolutions, as well as isotopic ages of these lithologies differ significantly, and so they represent diverse portions of the Variscan crust. At present, lithologies of different evolutions can be found in large blocks separated mainly by tectonic zones of the Neogene movements (M Tóth et al., 2000). Most of these lines are also shown by seismic methods.

Although, orthogneiss is an important constituent of most neighbouring metamorphic highs, there only is a little information about this rock type. Common myrmekitic texture was shown as an important indicator of igneous origin by Zachar and M Tóth (2001); Schubert and M Tóth (2001) described the widespread post-metamorphic mylonitic deformation in detail.

Petrography

Rock forming minerals of the orthogneiss in each studied localities are identical; K-feldspar, plagioclase quartz and biotite with a subordinate role of muscovite. Matrix feldspars are usually myrmekitic and at several places form polygonal texture. Accessory phases are idiomorphic in shape; elongated laths of zircon and apatite occur. Based on these features, gneiss samples studied are classified as metagranitoids. Mica determines two foliation planes (S1, S2) that are typical for the orthogneisses in each locality.

The main petrographic characteristic of gneiss is presence of various types of xenoliths and xenocrysts of exotic origin. Most xenoliths are mafic in chemistry; they represent eclogite, garnet amphibolite, amphibolite with or without igneous relics. Additionally also ultramafic and felsic xenoliths occur, while many xenocrysts represent different felsic protoliths. Their classification and petrological interpretation is presented separately (Zachar, M Tóth, this volume).

Geochemistry

Based on the discrimination schemes of Debon, Le Fort (1983), Pearce et al. (1984) and Maniar és Piccoli (1989), orthogneiss samples are of peraluminous character and represent volcanic arc granodiorite, tonalite.

Mineral chemistry, thermobarometry

Because of the rather simple mineralogy, there is a little possibility to estimate conditions of the metamorphism of the orthogneiss. To do so, we used matrix plagioclase – recrystallized amphibole xenocrystal equilibria for several cases. In addition to these calculations, also thermodynamic modelling was applied (Domino/Theriak) using bulk rock chemical compositions. The results show a peak metamorphism in the range of 550–600 °C for each locality.

Xenoliths of different origin exhibit a wide range of metamorphic evolutions (Zachar, M Tóth, this volume).

Ages

K/Ar data of matrix biotite and amphibole xenocrystals give an average of 300 Ma. Amphibole ages from the mafic xenoliths (amphibolite) are significantly older being around 330 Ma.

Discussion

Metamorphic basement of the Tisza block in the study area consists essentially of orthogneiss with identical mineralogy, peraluminous chemical character, similar metamorphic evolution and age constraints. Gneiss in each locality contains various amounts of xenoliths of different origin and evolution. On this basis the separated crystalline highs are thought representing an identical gneiss terrane and will be mentioned as Déva orthogneiss.

Predominant amounts of orthogneiss of peraluminous composition and of MT-HT metamorphism, as well as presence of xenoliths representing both subducting oceanic slab and felsic material of various P conditions are the basic characteristics of subduction-accretionary complexes or Alaskan-type orogenic belts (Ochsner, 1993). According to such a scenario at the initial phase of subduction, mantle derived magmas intrude the margin of the craton. Continuous continental sediment supply during subduction of the oceanic crust causes development of accretionary prism since sediments deposited in the subduction trench do not subduct as deep as the oceanic crust. They rather tend to be cocked and accreted to the edge of the continental crust. In an advanced state of the subduction, accretionary prism forms landwards dipping thrust wedges as older sedimentary packages progressively rotate upwards. Crustal shortening thus accompanies with gradual steepening of the inner structure of the accretionary prism. As a consequence of the continuous external sediment supply, uploading of the subduction trench generates the accretionary prism to grow oceanwards thus subduction zone retreats oceanwards too. From a critical moment on, mantle derived magmas intrude directly to the lower part of the accretionary prism that causes granulite facies metamorphism and melting of the sedimentary beds of the accretionary prism. These sedimentary derived granitoids rise along the steep dipping inner structures to the upper part of the prism causing high T metamorphism (and initial anatexis) of the surrounding sedimentary rocks. During upwelling, these intrusions may drag slabs of different rock types from different depths with them that are present as xenoliths in the magmatic body. Since uplift of sedimentary derived magmas can be regarded as almost pure mass transfer within the crust downflow of the country rocks must compensate to maintain equilibrium. This reorganization of the whole crust (synmagmatic D2 tectonics) makes possible to the deeply buried eclogite facies rocks to get next to lower grade rocks of the shallower part of the crust.

Although there is no indication of the presence of steep dipping slices of the accretionary prism in the mentioned area, occurrences of xenoliths of diverse metamorphic pressures in the orthogneiss implies that a process similar to the subduction accretionary complexes took place. According to the abovementioned results one may conclude that the study area may represent metamorphic equivalent of intrusions that were emplaced in an Alaskan-type orogenic belt in an advanced state of subduction when mantle derived magmas intruded into the downmost segment of the accretionary prism.