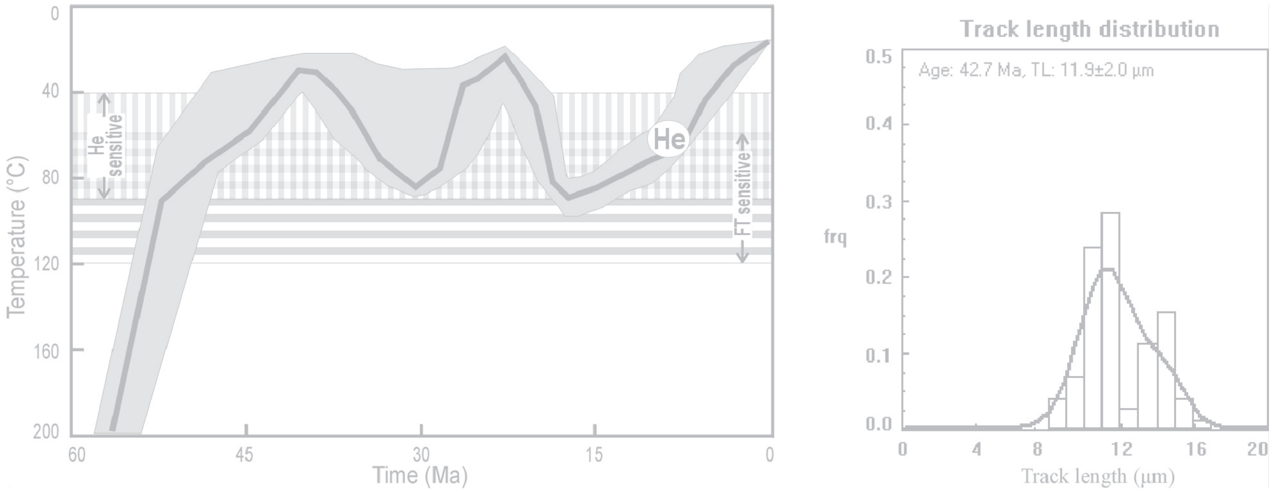


■ **Fig. 2.** Thermal history modeling results based on FT and He data (for explanation and interpretation see the text).

bimodal track length distributions suggest a complex thermal history. To date, He analyses were successfully carried out on 2 samples, yielding (Ft -corrected) ages in the range from 13.4 to 13.8 Ma (Fig. 1). Thermal history modeling results based on FT and He data and constrained by geological evidences, revealed the following thermal evolution (Fig. 2):

- cooling during Late Cretaceous – Early Paleogene times, indicating exhumation after Eoalpine metamorphism and nappe stacking;
- reheating during Middle Eocene – Oligocene times, interpreted as temperature increase induced by burial beneath sediments of the Central Carpathian Paleogene Basin (CCPB);
- cooling at Oligocene-Miocene boundary, reflecting inversion and disintegration of the CCPB;
- reheating period at ~17 Ma, interpreted as reflecting increased thermal gradient during Miocene volcanic activity in the Western Carpathian realm;
- final cooling to present-day conditions.

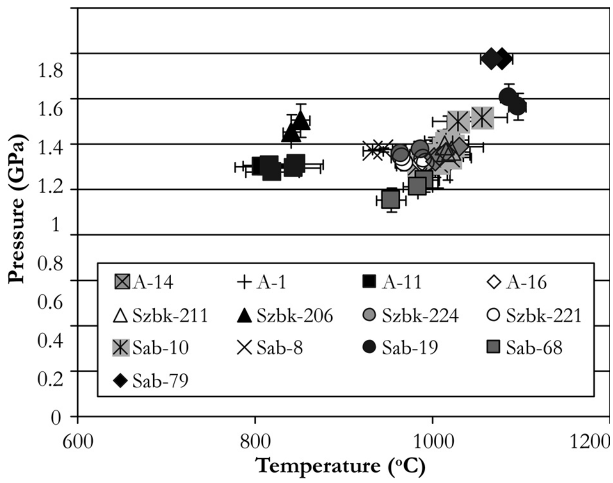
Thermo-Barometry of Garnet Granulite Xenoliths from the Bakony Balaton Highland Volcanic Field (BBHVF)

Júlia DÉGI, János KODOLÁNYI, Eszter BADENSZKI and Kálmán TÖRÖK

Eötvös Loránd University, Lithosphere Research Group, Department of Petrology and Geochemistry, 1117 Budapest, Pázmány Péter Sétány 1/C, Hungary

Granulite xenoliths are known at several localities in the BBHVF (Szigliget, Sabar-hegy, Mindszentkálla, Szentbékkálla and Kapolcs) where they occur along with upper mantle xenoliths in Neogene alkaline basaltic tuffs and lavas. The importance of the granulite xenoliths is that they have sampled the lower crust and, thus, provide a unique possibility to study the chemical and physico-chemical properties. The study of samples from the whole region can give a comprehensive picture about the structure and processes of the lower crust. Each locality has its own peculiarity, hence at each locality different process predominate.

We have studied mafic granulite xenoliths from Sabar-hegy, Szentbékkálla and Kapolcs by means of petrography, mineral chemistry, mineral equilibria and thermobarometry to reveal geological processes in the lower crust of the Pannonian Basin. Although, petrography reveals reactions referring to different stages of the metamorphic history of the xenoliths, in this paper we deal only with the equilibrium pressure and temperature conditions of the garnet granulite xenoliths from the above localities. The



■ **Fig. 1.** Equilibrium temperatures and pressures of garnet granulite xenoliths from the BBHVF.

equilibrium mineral assemblage of the xenoliths is clinopyroxene, plagioclase, garnet, ± orthopyroxene, ± amphibole ± quartz.

The garnet-clinopyroxene thermometer of Krogh (1988) have been used to obtain the equilibrium temperature. The pressure has been calculated with the PT Mafic program (Soto and Soto 1995) using the Holland and Powell (1988) calibration of the garnet-clinopyroxene-plagioclase-quartz barometer. The results with their error bars (two sigma deviation) are illustrated in Fig. 1. The p-T diagram shows two different arrays of data points. Most data plot along a certain band between approximately 900 °C, 0.9 GPa and 1100 °C, 1.6 GPa. This group may represent the geothermal gradient existing in the lower crust during the equilibration of the garnet granulites. It also shows that the thickness of the mafic lower crust was at least about 20 km before the extension of the Pannonian Basin. Sporadic occurrence of garnet free, clinopyroxene-orthopyroxene-plagioclase granulite xenoliths also point to the fact that this estimate should be treated as minimum for the mafic lower crust prior to extension. Two samples (Szbk-206 and A-11) show significantly lower temperatures (760–840 °C) than the other group. However, their pressure data (1.1–1.4 GPa) are similar to those of the "main group". These two samples differ from all other in their mineral chemistry. They contain less plagioclase and orthopyroxene but more garnet and clinopyroxene than other samples. Plagioclase is richer in albite component, and garnet contains more almandine in these two samples. The differing P-T conditions of formation of the two garnet granulite groups show that the lower crust cannot be treated as a wholly equilibrated rock column, but consists of two parts equilibrated at different P-T conditions. The "main group" represents garnet granulites equilibrated at high temperatures and the two xenoliths showing lower temperatures represent rocks equilibrated at similar depths, but at the amphibolite-granulite facies boundary.

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Variscan Structure of Hranice Paleozoic Area (Moravosilesian Paleozoic Zone)

Vojtěch DVOŘÁK, Jiří KALVODA and Rostislav MELICHAR

Institute of Geological Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

The Hranice Paleozoic belongs to the Rhenohercynian belt of the Middle European Variscides (Bohemian Massif). Although the mobilistic model of this area was proposed in fifties (Homola 1950) the fixistic interpretation prevailed. Dvořák and Friáková (1978) interpreted different sedimentary facies in tectonic blocks as the result of synsedimentary tectonic movements of the blocks.

The "laminated" limestones occurring in different stratigraphic levels in the different blocks were considered as sedimentary slope facie (e.g. Dvořák 1991). The first problem with these limestones is in stratigraphy: the age was not based on biostratigraphy but only on superposition. The lateral changes to limestones of different type and age are important for solving this problem. The second problem is in their structure: the lamination with strong lineation is not sedimentary structure but the result of tectonic strain under ductile to semiductile conditions (foliation, cleavage). Hence, the "laminated" limestones represent high-strained limestones (carbonate mylonites); their precursors are either the limestones of the Líšeň Fm. (nodular limestones, intraclast breccias, limestone turbidites with shales) or the reefoid limestones of the Macocha Fm.

Different strain indicators (Špaček et al. 2001) were used to distinguishing tectonic limestones facies, which include weakly recrystalized protoliths, protoblastomylonites and blastomylonites. Mylonites are forming wide shear zones, which were localized in geological maps as well as in boreholes (V501-V503, V504, V505, LV60). The thickness of the shear zone in the V501 borehole is 92 m, for example. These ductile shear zones dip in 45° to the WNW and lineation is trending to the WNW. Microstructures (boudinage, book-shelf structures, stretched peloides etc.) indicate minimal elongation up to 1000% parallel to foliation across shear zones. The kinematic markers indicate the top-to-ESE thrusting.

Stratigraphic sequences are usually duplicated in association with the shear zones, which is evident in geological maps as well as in some boreholes. Based on microfacies study and lithostratigraphy, significant thrust planes were usually localized in central parts of shear zones. Three main thrusts were recognized:

1. Thrust between Hranice and Černotín (Frasnian reefoid limestones of the Macocha Fm. thrusted over Famenian limestones of the Líšeň Fm. and/or over the Culmian siliciclastic rocks);
2. Thrust in the Ústí surroundings (Famenian limestones thrusted over upper Tournaisian–lower Visean limestones);
3. Thrust East of Hluzov (duplication of the Macocha Fm.).