HP Melting and its Relationship to the Granulite Facies Metamorphism – an Example of the "Gföhl Nappe" in the Kutná Hora Crystalline Complex

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The Kutná Hora Crystalline Complex (KHCC) is situated between the internal Variscan Moldanubian zone and the low-grade Upper Proterozoic Bohemicum zone. KHCC consists of three major units: the uppermost Gföhl unit is characteristic of occurrence of anatectic rocks containing HP/HT relics, i.e. granulites, eclogites and garnet peridotites. The underlying parts of the Gföhl unit in the Kutná Hora Complex are represented by the Kouřim nappe with fine-grained leucocratic migmatites and by lowermost Micaschist zone consisted of metapelites intercalated with cpx-amphibolites (Synek and Oliveriová 1993). The Gföhl unit by itself is divided into three formations: The Běstvina formation (Losert 1967) is formed by partly migmatized granulitic gneisses and granulites with lenses of garnet peridotites, eclogites and rare garnet amphibolites and calc-silicates. The Malín formation (Losert 1956 a,b) is consisted mainly of leucocratic kyanite-bearing migmatites accompanied by garnet amphibolites, serpentinized garnet peridotites, eclogites and several skarn bodies. The Plaňany formation (Fišera 1977) is represented by of various migmatites (metsedimentary and mafic) with lenses of amphibolites, serpentinites and pyroxenites.

We present the results of structural and petrological study from gneiss, migmatite and granulite of Malín and Běstvina formation. The structural record indicates three stages of deformation. D_1 deformation is associated with early migmatization and documented by relic granulitic fabrics S_1 rarely preserved in the Běstvina formation. S_1 metamorphic foliation is generally subvertical or steeply dipping to NE, whereas only relics of folded earlier (S_1?) fabric are present in the Malín formation. D2 fabric is also anatectic and reworks older S_1 fabrics into a flat S_2 foliation. The late D_3 reactivation affected all previous fabrics including migmatitic structures and resulted in retrogressive mylonitization.

All studied rocks are characterized by the presence of kyanite, garnet, feldspars and the gneiss additionally contains white mica. Replacement of kyanite by sillimanite has not been observed. Migmatite contains clusters of muscovite and biotite with small grains of garnet and kyanite. Textural relations indicate that biotite was formed during late stage of metamorphism. It replaces or rims muscovite being in textural equilibrium with garnet and kyanite. With exception of granulite, garnet in both migmatite and gneiss is homogeneous. A weak retrograde zoning was observed in garnet rims from granulite. Garnet in migmatitic gneiss is rich in Fe (Alm_{77-83}, Py_{10-13},Grs_{2-6}). Relatively high-Mg garnet is present in granulite (Alm_{56-60}, Py_{28-32}, Grs_{5-11}). Analysed muscovite has relatively high phengite component with Si = 3.2 a.p.f.u. Plagioclase is usually rich in Na and the anorthite content ranges between 6–11 mol% in migmatitic gneiss. Granulite has nearly poor albite with $An_{0.07-0,09}$.

The HP/HT metamorphic conditions of 978 ± 90 °C and 16.9 ± 4 kbar were calculated, using average PT (Powell and Holand 1998), for the assemblage Ky-Grt-Plg-Kfs-Ms-Qtz in Malín and Běstvina migmatitic gneisses. Similar PT conditions of ca 900 °C and 16 kbar for these rocks were obtained by the end-member reactions with white mica, garnet, kyanite, using thermodynamic data of Berman (1988). The Běstvina granulite gave temperature and pressure of 831 ± 53 °C and 16.5 ± 1.8 kbar for garnet core and perhitic feldspars. The conditions of LP/LT metamorphic stage in Malín and Běstvina migmatitic gneisses were calculated from the matrix biotite, garnet rims and the recrystallized grains of plagioclase, K-feldspar and quartz and yield 758 ± 20 °C and 9 ± 2 kbar using average PT (Powell and Holland 1998).

The extensive anatexis in the core of the Bohemian massif is connected with decompression-related increase of temperature during the late stages of the Variscan orogenic root exhumation (Petrakakis 1997). This process resulted in stabilization of LP mineral assemblages (±sill, ±crd) in metasedimentary migmatites, in LP overprint of eclogites and HP granulites (O'Brien and Vrána 1995) and in the intrusion of the youngest granitoid plutons (Finger et al. 1997). In contrast, the Malín and Běstvina migmatites are anomalous due to the presence of kyanite in leucosomes suggesting major anatexis already during the high-pressure stage. Such migmatites do not differ in mineralogy from HP felsic granulites, but they show higher degree of partial melting due to higher primary content of hydrous minerals. The presence of kyanite-bearing migmatites and HP felsic granulites suggests that the Malín and Běstvina formations may represent well-preserved segment of extensively granulitized lower crust of the Variscan orogenic root, which was not affected by late LP/HP overprint probably due to very high exhumation and cooling rates.

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Uplift Phase Deformation Features of the NE Part of the Bükk Mountains, NE Hungary

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The detail geological mapping, meso/microstructural research, deformation analysis and paleopiezomentry brought new data for interpretation of tectonic evolution of Gemericum and Inner Western Carpathians. The interpretation accouns also the published results of further branches of geosciences.

Collision terminating the Hercynian evolution. The Lower Paleozoic rock sequences of Gemericum from the viewpoint of tectonic evolution can be divided into two large groups:

A. The rocks of Gelnica Group, representing the Lower Paleozoic cover of rigid blocks of older crystalline basement of Panafrican? provenience, covering the southern margin of prolonged Lower Paleozoic sedimentary basin during continental rifting.
B. Rocks of Rakovec Group of the mature stage of rifting with gradual origin of oceanic crust. Later these rocks suffered tectonometamorphism in various depths of subduction zone.

The Hercynian convergence terminated with the collision of amalgamated Tatro-Veporic domain (cf. Bezák et al. 2002) with the Gemeric domain during wider time interval between Wesphalian and Stephanian (deformation phase VD). The product of this collision is the Rakovec geosuture (Fig. 1) encompassing the lithology of obducted Paleozoic Rakovec and Klátov Groups and partly Carboniferous rocks.

From the Gelnica Group the obducted suite is separated with ductile shear zone of moderate northern inclination. Microtectonic research of mylonites from the boudary shear zone between Gelnica and Rakovec Groups (Németh 2002, Fig. 1) proved two principal directions of tectonic transport – in autochthonous footwall of ductile shear zone (the upper parts of Gelnica Group) the general vergency of tectonic transport is ESE. In allochthonous hanging wall of shear zone (tectonic mélange of Rakovec Group) the transport directions are generally to the south, locally with wider azimuthal spread. The south-vergent structures are common in the Gemericum, encompassing the fold structures. The general vergency of tectonic transport to ESE, being found by microtectonic study, supports the overall southern vergency of Hercynian tectogenesis in its Variscan branch.

Collision producted by Alpine evolution. The thermal régime during Permian was highly probable related to the presence of prolonged thermal source beneath the collided terrane in the North-Gemeric zone. The position of thermal axis in North-Gemeric zone results also from reconstruction of the whole Western Carpathian Permian sedimentogenesis and magmatic trends (Vozárová and Vozár 1987). The position of this linear convection heat indicates its possible correspondence with the heat causing the Lower Paleozoic continental rifting. Later, during the subduction, this heat source was relatively submerged (by the lithosphere displacement regarding to fixed linear source of heat) beneath active (Tatro-Veporic) margin simultaneously with submerging of mid-oceanic ridge. The convective heat multiplied the thermic effects of subduction, and, mainly, the final collision. Therefore, the geothermal gradient in Inner Western Carpathians is supposed to be extremely high in Permian.

Later Permian evolution in the Inner Western Carpathians is characterized with northward dispacement of lithospheric plates with collisional terrane in relation to thermal source. This is proved by still younger ages of Gemeric granite from the north southward.

After the Permian extension in North-Gemeric zone, the continental crust in South-Gemeric zone was later disintegrated and the prolonged Meliata-Hallstatt basin has originated.