Metamorphic and Microstructural Evolution of Orthogneisses and Granulites of the Eger Complex (NW Bohemian Massif) – Record of Progressive Granulitization of the Lower Crust?

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In contrast to traditional models of the western margin of the Bohemian Massif, migmatitic orthogneisses, granulitic gneises and granulites of the high-grade Eger complex have been recently reinterpreted as a lower-crustal rocks exhumed from the bottom of the Teplá-Barrandian unit during Lower Carboniferous collision (Konopásek and Schulmann 2005). Recent mapping has shown the presence of high-grade mylonitic orthogneisses in the centre of this unit surrounded by large volumes of almost fabric-free felsic granulitic gneisses and granulites. Field and laboratory observations suggest continuous microstructural transition from banded textures to non-foliated granulitic gneisses and granulites. Microstructural evolution of orthogneisses shows progressive destruction of foliated structure via crystallization of new phases within monomineralic bands of K-feldspar, quartz and plagioclase resulting in complete disappearance of macroscopic planar fabric.

Orthogneisses, granulitic gneisses and felsic granulites are often almost identical in the whole-rock chemistry, but they show substantial differences in mineralogy. Prevailing assemblage in orthogneisses and granulitic gneisses is represented by Grt-Bt-Ms-Plg-Kf-Qtz-Melt. Some samples show an assemblage Grt-Ky-Bt-Ms-Plg-Kf-Qtz-Melt and probably document progressive mineralogical evolution of orthogneisses towards felsic granulites with high-pressure association Grt-Ky±Bt-Plg-Kf-Qtz-Melt. Thermodynamic modelling of the stability field of the assemblage Grt-Bt-Ms-Plg-Kf-Qtz-Melt in orthogneisses shows metamorphic conditions of ~700 °C at 9.5 kbar, whereas PT conditions of equilibration of the assemblage Grt-Ky±Bt-Plg-Kf-Qtz-Melt in granulites are higher (~800 °C at 14 kbar).

Field and microstructural observations together with estimates of metamorphic conditions suggest, that the heterogeneity of the Eger complex may be the result of incomplete granulitization of felsic lower crust due to a short time span between maximum burial of the unit and its rapid exhumation during Lower Carboniferous.

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Alpine Tectonometamorphic Evolution of the Uppony and Szendrő Paleozoic (NE Hungary)

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The Szendrő and Uppony Mountains in NE Hungary form two smaller, pre-Tertiary basement exposures in the so-called Gemer-Bükk region which comprises the innermost tectonic units of the Inner Western Carpathians and the neighbouring areas. The known stratigraphic range of these Early Paleozoic sequences extends from the Middle Devonian to the Middle Carboniferous including mostly platform and pelagic carbonates and a flysch-like sequence (Szendrő Mts.), furthermore clastic rocks of unknown age (Ord-Sil?) and strongly altered, basic volcanics and volcano-sediments. (For a more detailed stratigraphical and lithological description see Kovács 1992.)

The ductile tectonic evolution of these Lower Paleozoic sequences was studied by means of classical structural field methods and detailed microtectonic investigations. Structural investigations reveal that both units suffered a complex, polyphase folding. Regarding also available metamorphic petrological and geochronological data (Árkai 1977, 1983, Árkai et al. 1981, 1995), the Cretaceous (Eoalpine) tectonometamorphic evolution of these units could be reconstructed as follows:

D_1: Formation of a bedding-parallel first foliation (S_{0-1}) associated with intensive flattening in the bedding plane as a consequence of an early tectonic event (F_1 folding and/or nappe thrusting?). Since this deformation is preserved mostly in small fabric-relics, its vergency and other structural characteristics are still unclear.

D_{2a}: Folding of the bedding-parallel foliation (S_{0-1}) into upright to moderately inclined, close to tight (locally isoclinal), subhorizontal to gently plunging, NW-vergent F_2 folds. A well-developed, generally SE-dipping, penetrative axial plane foliation (S_2) was formed during this event. Fold axes trend mostly to NE-SW, in the eastern part of the Szendrő Mts. to E-W, as indicated by the orientation of the intersection lineation of S_{0-1} and S_2 as well. The bedding-parallel foliation is heavily transposed into the "main" S_2 foliation in many outcrops, suggesting intensive flattening during progressive deformation. Structures connected to this phase of deformation are predominant in both studied units.

The D_1 and D_{2a} events must have taken place on the prograde stage (at relatively high-temperature) of the Cretaceous metamorphism as indicated by the intensive crystalplastic deformation of calcite and quartz associated with both S_{0-1} and S_2 foliations, and posttectonic chloritoid (with respect both to S_{0-1} and S_2 foliations) which can be related to the thermal peak of metamorphism. Peak metamorphic conditions can be estimated at about 300–350 °C in the Uppony unit, and 400–450 °C in the Szendrő unit. White mica cooling ages are in the range of ca. 110–120 Ma, while zircon FT data yielded ages about 100 Ma.

D_{2b}: Ductile simple shear occurred after/or at the late stage of F_2 folding, resulting in the formation of a well-developed, either dip-slip or nearly horizontal, grain-scale stretching lineation, developed mainly in the carbonate rocks. The resulting N(W)-vergent thrusting (generally with a slight sinistral component) and the coeval NE-SW trending sinistral strike-slip movements suggest a transpressional tectonic regime. However, no large-scale mylonitic zones could be observed in the studied units.

D_3: A second, less intense folding (F_3) produced locally a non-penetrative crenulation cleavage (S_3). F_3 fold axes are generally also NE-SW (E-W) trending, and gently to moderately plunging. This folding event is especially characteristic in the Szendrő unit where map-scale F_3 syn- and antiforms were also formed during this phase. This deformation occurred on the retrograde path of the metamorphic evolution, at significantly lower temperatures (<270–300 °C) than the D_1–$D_{2a\text{-}b}$ events, as indicated by the very minor associated crystalplastic deformation of quartz and calcite.

D_4: Lastly, steeply plunging F_4 kink folds were formed, related mostly to N-S or NW-SE trending, semi-ductile shear zones accompanied frequently by calcite veins with en-echelone geometry. No foliation developed during this deformation phase, which indicates low deformation temperatures (≤200 °C) on the retrograde path. The "anomalous" orientation of all previously formed structures in certain zones can be attributed to the passive rotation during this deformation, or – in certain cases – later Tertiary block rotations.

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New Paleomagnetic and Magnetic Susceptibility (AMS) Data on the Mórágy Granite (SW Hungary) – Implications for Ductile and Brittle Deformation

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The Mórágy Granite is a Variscan granite pluton (~350 Ma, Klötzli et al. 2004) situated in SW Hungary (Mórágy Hills, SE of the Mecsek Mts) built up mainly by metaluminous to slightly peraluminous, K-Mg-rich, microcline megacryst-bearing, medium-grained, biotite-monzogranites, and quartz monzonites (Buda 1985). The monzogranitic rocks contain generally oval-shaped, variably elongated mafic enclaves (predominantly amphibole-biotite monzonites, diorites, and syenites) of various size (from a few cm to several hundred metres) reflecting the mixing and mingling of two magmas. Feldspar-quartz rich leucocratic dykes (at least three generations) belonging to the late-stage magmatic evolution crosscut all of the previously described rock types.

Paleomagnetic measurements were carried out in order to determine the paleomagnetic directions on a large variety of rock types having different positions in the pluton. The major rock types were sampled from boreholes drilled in the frame of the Hungarian National Research Project on the final disposal of low and intermediate level radioactive waste. The orientation of the samples was determined using the ImaGeo corescanning system and the adjoining CoreDump evaluating software developed in the Geological Institute of Hungary (Maros and Palotás