Thermomechanical Modeling of Variscan Orogenic Root System: Possible Sources for Moldanubian Metamorphism

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The crustal age and composition in the Bohemian Massif and in the Variscan belt in general are extremely heterogeneous containing both Cadomian crustal segments (Barrandian section) as well as relics of Cambro–Ordovician magmatism and rifting. The building of the Variscan orogenic root is undoubtedly controlled by pre-Variscan inherited pre-Paleozoic lithological heterogeneities and vertical distribution of lithological/rheological layers. More importantly, the Devonian subduction of the Saxothuringian belt below easterly situated precursor of the Moldanubian Zone strongly influenced the thermal and mechanical evolution of further development of the orogenic root system. Numerous geochronological studies document that Saxothuringian subduction pre-dates the development of deep and hot Carboniferous eclogites and high-pressure granulites within the Moldanubian root system. Also, massive calc-akaline potassium-rich magmatism in the area of the Central Bohemian pluton of Devonian to lower Carboniferous age antedates the 340 Ma old paroxysm of Moldanubian metamorphism and may be related to major subduction event. We suggest that the Early Devonian Saxothuringian subduction, in conjunction with possible back-arc type magmatism in the foreland of mechanically weakened lithosphere by Cambro–Ordovician thermomechanical events are the best candidates for development of deep and exceptionally hot orogenic root in the Moldanubian Zone.

Metamorphic petrology, geochronology of metamorphic and igneous rocks are combined in a thermomechanical model which emphasizes the role of Devonian to Carboniferous magmatism in the development of exceptionally hot and soft orogenic root system. We show that the progressive thickening and hardening of thermally weakened crustal rocks led to the development of stiff orogenic root floored by relatively thin, rigid sub-root mantle. The modelling shows the limitations of maximum thickening of the Moldanubian root system controlled by external heat supply during Devonian magmatism and lithological composition of the root. Finally, we suggest conditions favourable for rheological collapse of thickened crust.

We correlate metamorphism of the Gföhl eclogites and granulites with respect to maximum possible burial of the Moldanubian root system. In addition, peak pressure conditions of eclogites from Montonous and Varied groups are used to depict complete field geotherm for the thickening period. Both Gföhl high-pressure rocks and HP rocks from the Montonous Group are re-equilibrated at mid-crustal depths and granulite facies conditions. These metamorphic conditions were achieved during extensional tectonics, i.e., are related with flat fabrics and subvertical compression. Further thermo-rheological modelling is carried out to correlate these data with exhumation of lower crustal rocks under lateral compressional regime. Soft material was further extruded over rigid continental shoulders in the form of far-travelling crustal nappes in Carboniferous times.

Geochemistry and Petrogenesis of the Klatovy Granodiorite, SW Part of the Central Bohemian Pluton

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The extreme SW part of the Central Bohemian Plutonic Complex (CBPC) is built by the Klatovy apophysis (c. 197 km^2). It is strongly elongated in the NE–SW direction following the Klatovy Deep-seated Fault that forms the first-order tectonic boundary between the Barrandian block in the NW and the Moldanubian block in the SE.

Most of the Klatovy apophysis is composed of highly inhomogeneous granitoids of the so-called Klatovy type (c. 85 km^2). The following rock varieties can be distinguished here:

(1) Relatively fine-grained porphyritic amphibole–biotite granodiorite, frequently with clinopyroxene and abundant plagioclase megacrysts. This variety is the most common one.
(2) Medium-grained light porphyritic amphibole-bearing biotite granodiorite to monzogranite, commonly with large K-feldspar megacrysts (up to 7 cm across).
(3) More mafic rocks and mafic enclaves, petrographically defined as melagranodiorite, quartz monzodiorite, quartz diorite and rarely tonalite. The enclaves are present in both of the two granitoid varieties and display typical microstructural features of mafic microgranular enclaves (MME; Didier and Barbarin 1991). Most of them show evidence pointing to their hybrid origin (such as the presence of ocellar quartz, acicular apatite, oikocrysts of K-feldspar and blade-shaped biotite).

The Klatovy intrusion belongs to the high-K calc-alkaline series (HK group of Holub et al. 1997). The three main rock varieties distinguished on petrologic grounds in this intrusion also markedly differ in their major-element contents. The first, most abundant variety has 63–66 wt.% SiO_2 and A/CNK of 0.93–1.14, the lighter granodiorite (of the second variety) contains 69–71 wt.% SiO_2 and displays metaluminous to slightly peraluminous chemistry (A/CNK = 0.85–1.16). More mafic rocks and enclaves have 57–61 wt.% SiO_2 and metaluminous character (A/CNK = 0.9). In many variation diagrams (e.g., the Harker plots) all these rocks exhibit relatively good linear correlations.

The studied rocks show initial strontium ratios between 0.708 and 0.709, i.e. within the range characteristic for the HKCA group (Janoušek et al. 1995), see Fig. 1. Whole-rock ä^{18}O values are low (+6.8 to +7.2 ‰ SMOW), likewise in magmas with major mantle component. Oxygen thermometers yielded temperatures in the range of 470–600 °C indicating some type of subsolidus diffusional exchange of O isotopes between rock-forming minerals. However, the studied rocks seems to show no evidence of interaction with meteoric water fluids. Trace sulphur in the Klatovy granodiorite has concentration of max. 0.04 wt.% and its isotope composition falls in the range of -1.5 to -2.5 ‰ (CDT).

Taken together, the observed whole-rock geochemical variations cannot be explained by a closed-system differentiation of a single granitoid magma. Instead, several sources of different isotope compositions must have been involved. Moreover, an important role for hybridization with more mafic magma batches is assumed.

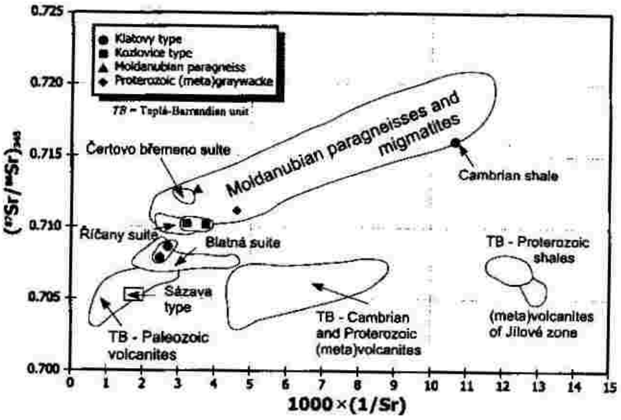

Fig. 1. A diagram of initial strontium ratio (345 Ma) vs. 1/Sr with fields for CBPC granitoids, adjacent geological units and new rock samples. Data sources are cited in Šmíd (1999).

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Detachment Control of Core Complex Exhumation and Back-arc Extension: Case Study from the East Slovak Basin

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The East Slovak Neogene Basin is also floored by the metamorphic series of the Iňačovce–Krichevo Unit (IKU). This unit appears to be the Lower Miocene core complex, exhumed jointly with back-arc extension of the East Slovak Basin. Petrological, structural and geochronological data allow to interpret the processes of core complex updoming and basin downfaulting.

The estimation of the physical conditions of metamorphism in the IKU is based on the study of mineral assemblages. The peak metamorphic conditions are documented by assemblages: (1) biotite + actinolite and/or magnesioriebeckite + chlorite + titanite + epidote (metabasalts), (2) muscovite + quartz + pyrophyllite + paragonite + intermediate Na-K micas + chloritoid (Al-metapelites), which are indicative of metamorphic temperatures between 350 and 400 °C. Co-existence of Na and Ca amphibols is considered here as a relic of earlier, higher-pressure metamorphic event (greenschist to blueschist transition zone, p » 7–8 kbar). During decompressional phase of metamorphism, normal greenschist assemblages occurred (chloritoid in metapelites and biotite in metabasalts) at a pressures <5 kbar. The youngest sediments of the IKU are represented by the Middle Eocene formations composed of black phyllites and metasandstones. Using phyllosilicate "crystallinity" and coal rank data, their degree of metamorphism corresponds to the higher anchizone or lower epizone, respectively (IC = 0.31°D2Q, ChC$_{(002)}$ = 0.26°D2Q, R$_{o\ max}$ = 5.75 %).

The IKU reveals a complex polydeformational history. Progressive deformation proceeded from (1) underthrusting – soft sediment deformation, stratal disruption and boudinage of high-competent layers, overpressured conditions, (2) underplating and deep tectonic burial – high flattening strain, F$_1$ foliation, synkinematic crystallization, intrafolial folding, diffusional mass transfer, crystalplastic deformation, (3) subcretion and intra-wedge shortening – crenulation cleavage as F$_2$, transpositional foliation, high-strain zones, ultramylonites, d-type porphyroclasts, open to tight F$_2$ folds, dynamic recrystallization, etc., and (4) updoming and extensional unroofing – shear bands, SC foliation fabric, kink bands, en-echelon structures, extensive veining, cataclastic deformation, brecciation, normal faulting, etc.

The FT dating of the IKU gave significantly younger ages