K-rich Magmatism in the Moldanubian Unit, Bohemian Massif – a Complex Story Featuring Variably Enriched Lithospheric Mantle Melts and their Interaction with the Crust

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The petrogenesis of (ultra-)potassic plutonic rocks that form conspicuous and widespread suites in the European Variscan Belt has been a matter of a passionate debate. This is mainly due to the fact that the mafic members of these suites have a mixed geochemical character. While their high contents of Cr, Ni and mg# point to derivation from an olivine-rich source (i.e., a mantle peridotite), the elevated concentrations of Pb, LREE, LILE (Cs, Rb, K, U, Th), a pronounced TNT anomaly (depletion in Ti, Nb, and Ta) as well as high K_2O/Na_2O and Rb/Sr ratios apparently contradict the mantle origin. This led several authors (e.g., Turpin 1988; Holub 1990, 1997; Janoušek et al. 1995, 2000; Wenzel et al. 1997, 2000; Hegner et al. 1998; Gerdes et al. 2000) to assume an origin by partial melting of anomalous (LILE- and LREE enriched) mantle domains.

New integrated geochemical and Sr–Nd isotopic data for renown K-rich rocks occurring in the Moldanubian Zone of the Bohemian Massif contribute to the understanding of their petrogenesis. The suite comprises two important rock types: (1) coarse Kfs porphyritic amphibole–biotite melasyenite (durbachite *sensu stricto*) to melagranite of the Čertovo břemeno type (the "durbachite series" of Holub 1997), and (2) biotite–two-pyroxene melasyenites to melagranites devoid of Kfs phenocrysts (Tábor or Jihlava type).

In the absence of sufficiently precise ages, we have performed conventional U–Pb dating of one of the prominent K-rich massifs, the two-pyroxene Tábor syenite. Three zircon fractions, each consisting of 1–3 abraded grains, yield a concordia age of 336.6 ± 1.0 Ma (Janoušek and Gerdes, in print). The Pb–Pb age (336.3 ± 0.8 Ma) of a multigrain rutile fraction is identical within error, which argues strongly for a rapid cooling below c. 600 °C (closure temperature of the U–Pb system in rutile: Cherniak, 2000).

Accordingly, the Sr–Nd isotopic data, acquired in the laboratories of the Czech Geological Survey and the Activation Laboratories, Ancaster (Holub and Janoušek, in print), were age-corrected to 337 Ma. All show highly radiogenic Sr ($^{87}Sr/^{86}Sr_i$ = 0.71026–0.71272) coupled with unradiogenic Nd (ε^i_{Nd} = −6.1 to −7.6). As shown previously, this cannot be ascribed to crustal assimilation as the high contents of radiogenic Sr and unradiogenic Nd render these rocks impervious to contamination by common Moldanubian lithologies. Moreover, primitive whole-rock geochemistry of the mafic rock types (high Cr, Ni and mg#) requires their derivation from a mantle source (Holub 1990, 1997; Janoušek et al. 1995).

The $^{87}Sr/^{86}Sr_i$–ε^i_{Nd} plot shows a linear trend spanning two extreme compositions: (1) mafic ultrapotassic, corresponding to minettes (Janoušek et al., 1995), most mafic variety of the biotite-poor two-pyroxene melasyenite from Tábor and durbachites from the Mehelník and Netolice massifs ($^{87}Sr/^{86}Sr_i$ = 0.7119–0.7128; ε^i_{Nd} = −7.4 to −7.5), and (2) more felsic, equivalent to the light facies (melagranite) of the Čertovo břemeno type from the Central Bohemian plutonic complex and the Třebíč pluton ($^{87}Sr/^{86}Sr_i$ < 0.7105; ε^i_{Nd} −6.3 to −6.5). Analogous correlations observed between other geochemical parameters (e.g., SiO_2, Cr, MgO, mg#) and initial Sr–Nd isotopic ratios, support the origin of the whole spectrum of the studied K-rich plutonic rocks as well as the associated minettes by mixing of two distinct magma types proposed by Holub (1990, 1997) and Gerdes et al. (2000): ultrapotassic, originated by partial melting of enriched mantle domains, and acid, crustal-derived.

Even though the isotopic composition of the mafic end-member is constrained well at $^{87}Sr/^{86}Sr_i$ > 0.712 and ε^i_{Nd} ~ −7.5, the nature of the acid end-member is more problematic as its proportions in the felsic durbachitic rocks can be only estimated. The limits are provided by the most silicic (66 % SiO_2), least magnesian and, at the same time, isotopically most primitive durbachitic melagranite from the Třebíč pluton ($^{87}Sr/^{86}Sr_i$ < 0.7103 and ε^i_{Nd} < −6.3). Moreover, the fact that the trend fitted to the $^{87}Sr/^{86}Sr_i$ – ε^i_{Nd} data is linear (i.e., hyperbola with curvature equalling unity) shows that the elemental Sr/Nd ratios of both end-members must have been similar to each other (~ 6.5–8). Better approximation can be still obtained from plots of MgO or Cr, whose concentrations in the acid end-member were estimated by Holub (1997) at 0.2–0.5 % and < 20 ppm, respectively. As indicated by linear extrapolation, the $^{87}Sr/^{86}Sr_i$ ratio must have been slightly lower than 0.7095 and ε^i_{Nd} ~ −5.5. This, together with the whole-rock geochemical intervals outlined by Holub (1997), imposes severe constraints on the acid member composition. In the Central Bohemian plutonic complex, for instance, some aplite dykes associated with the Blatná intrusion display an appropriate isotopic composition (see van Breemen et al., 1982; Košler, 1993; $^{87}Sr/^{86}Sr_{337}$ = 0.7085 and ε^{337}_{Nd} = −5.8). We cannot exclude a possible role of leucogranitic and aplitic rocks spatially associated with durbachites as numerous dykes, whose isotopic compositions are still unknown.

The U–Pb age for the Tábor intrusion indicates a narrow time gap between the high-grade metamorphism (c. 340 Ma: Kröner et al., 2000), the emplacement of the granulite-bearing Gföhl nappe and intrusion of K-rich magmas cutting it. The obtained age is comparable with the data from analogous rock types penetrating the Variscan high-grade nappe units (Massif Central, Vosges, Schwarzwald, Bohemian Massif, Alps and Corsica – see the reviews in Wenzel et al., 1997; Schaltegger, 1997) and suggests a nearly synchronous melting of the variously enriched subcontinental mantle along the Variscan Belt.

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P-T-d Evolution of Marbles and Mica Schists in the Krowiarki Range, the Lądek-Śnieżnik Metamorphic Unit, West Sudetes

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The Krowiarki Range occurs in a convergence zone of the Lądek-Śnieżnik Metamorphic Unit (LŚMU) fan-like feature. It is composed of polyphase anticlinorial and synclinorial macrostructures – their converging axes plunge to the NW (Don, 1964). Along the NW-trending Krowiarki Range, from the vicinity of Stronie Śląskie in the SE to Żelazno in the NW, structural and petrological studies of interlayered marbles and mica schists were carried out in order to establish the P-T-d path of their tectono-metamorphic evolution and to provide data for a more detailed geodynamic reconstruction of the LŚMU.

The earliest deformation structures in marbles are scarce, small-scale, isoclinal, intrafolial F_1 folds, with the axial plane foliation S_1 mostly parallel to the folded bedding planes. The D_2 tight, asymmetric folds in the S_1 are more evident in marbles, especially in their impure variants, than in mica schists where the S_2 axial plane foliation is a predominant tectonic feature. The D_2 fold axes plunge at low angles to the NW. The S_2 metamorphic foliation generally dips towards NE, N or NW, usually at low and rarely at high angles. Penetrative L_{2i} intersection lineation parallel to F_2 axes and occasional L_{2s} stretching linea-