Geochemical and Sr-Nd isotopic constraints on the genesis of ultrapotassic plutonic rocks from the Moldanubian zone of the Bohemian Massif

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Various highly potassic to ultrapotassic rocks are rather abundant members of some Carboniferous igneous complexes in the Variscan orogenic belt of Central–Western Europe. In the Moldanubian zone of the Bohemian Massif, relatively large volumes of ultrapotassic (UK) plutonic rocks constitute several plutons and stocks conventionally counted to major granitoid batholiths, the Central Bohemian Plutonic Complex (CBPC) and the South Bohemian (Moldanubian) Batholith (SBB).

These UK rocks comprise two groups with similar chemistry but differing in their mineral assemblages and textures. The durbachite group (the durbachite series *sensu* Holub 1997), commonly referred to as the Čertovo břemeno type in the Czech literature, covers melasyenites (i.e., durbachites *sensu stricto*) to melagranites with a "wet" mineral assemblage Mg-biotite + actinolitic amphibole. These rocks are often coarsely porphyritic with abundant K-feldspar phenocrysts. The second group, termed the Tábor and Jihlava syenites, corresponds to melasyenites–melagranites characterized by an almost "dry" or semi-dry assemblage orthopyroxene + clinopyroxene + Mg-biotite and lacking the apparent porphyritic texture. Late actinolitization of pyroxenes, however, is common namely in marginal parts of these bodies.

The durbachite series covers a wide compositional range from about 51 % SiO_2 and 9 % MgO in the most mafic durbachites up to 66 % SiO_2 and 3.5 % MgO in the most acid melagranites. The compositional variations are, however, very simple and characteristic linear trends can be observed in various element–element plots. High contents of Cr are typical, being >500 ppm in the durbachites and >200 ppm even in the most acid rocks. Geochemical characteristics of the more acid members of the durbachite series, namely the high contents of MgO and Cr, linear trends in simple variation diagrams and only weak decrease in the Mg/(Mg + Fe) values with increasing silica, are compatible with an origin through mixing of the mafic, mantle-derived ultrapotassic magma with (leuco-)granitic melts, generated from the continental crust (Holub 1990, 1997).

Samples for the isotopic study representing the durbachite group came from the Čertovo břemeno intrusion (SE part of CBPC; locality Vepice), Mehelník and Netolice massifs (the Šumava part of the Moldanubian crystalline complex, Southern Bohemia, localities Talín and Netolice) and the Třebíč Pluton (E of the SBB, Western Moravia; localities Petráveč and Kamenná). The biotite–two-pyroxene quartz syenites to melagranites are from the Tábor (CBPC) and Jihlava (MB) intrusions.

The Sr–Nd isotopic compositions have been determined in the laboratories of the Czech Geological Survey, Prague and an additional pair in the Activation Laboratories, Ancaster, Canada. The isotopic data were age corrected to 337 Ma, the age obtained by U–Pb dating of zircons and rutiles from the Tábor intrusion (Janoušek – Gerdes, this volume). As has been shown for the other K-rich suites within the Central European Variscides (Turpin *et al.* 1988; Janoušek *et al.* 1995; Wenzel *et al.* 1997; Hegner *et al.* 1998; Gerdes *et al.* 2000), the studied samples show highly radiogenic Sr ($^{87}Sr/^{86}Sr_{337}$ = 0.71026–0.71254) and strongly unradiogenic Nd (ε^{337}_{Nd} = –6.3 to –7.6) isotopic compositions.

Within the durbachite series, the sample of the most acid melagranite from Kamenná (Třebíč Pluton) gave the least evolved $^{87}Sr/^{86}Sr_{337}$ = 0.71026 and the least negative ε^{337}_{Nd} = –6.3, closely followed by the slightly less acid melagranite from Vepice (CBPC) with $^{87}Sr/^{86}Sr_{337}$ = 0.71048 and ε^{337}_{Nd} = –6.5. Mafic durbachites have appreciably more evolved Sr accompanied by even less radiogenic Nd. The most magnesian durbachite from Netolice (9.3 % MgO) displays the most extreme Sr and Nd isotopic compositions ($^{87}Sr/^{86}Sr_{337}$ = 0.7125; ε^{337}_{Nd} = –7.4).

Within the two-pyroxene syenitoid group, a similar trend is apparent. The most magnesian melasyenite (Dražice, the Tábor intrusion of the CBPC) has the least radiogenic Nd from the whole data set with ε^{337}_{Nd} = –7.6. Those samples that contain relatively high SiO_2 (60–61 %) and lower MgO (4.5–5.5 %) display significantly less evolved isotopic compositions. Minettes from the area of CBPC are isotopically similar to mafic varieties of the ultrapotassic plutonic rocks (Janoušek *et al.* 1995).

As shown previously, the Sr-Nd isotopic signature of the studied K-rich rocks cannot be explained by crustal assimilation. The high contents of radiogenic Sr and unradiogenic Nd render these rocks impervious to contamination by common Moldanubian metasediments. Moreover, extraordinarily primitive major- and trace element geochemistry of the most mafic rock types, in particular durbachites s.s. and minettes (high Cr, Ni and *mg* numbers) argue strongly for their derivation from an enriched lithospheric mantle source (Holub 1990, 1997; Janoušek *et al.* 1995, 2000; Gerdes *et al.* 2000).

Variations in the isotopic compositions as well as correlations of the initial Sr–Nd isotopic ratios with other geochemical parameters (e.g., SiO_2, MgO, mg#, Cr, Sr, Zr, etc.), support the genesis 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): mafic ultrapotassic, that originated by partial melting of enriched mantle domains, and acid, crustally-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 acid 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 had to be similar to each other (~ 6.5–8).

Better approximation still can be obtained from plots involving MgO or Cr, whose concentrations in the acid end-member were estimated by Holub (1997) to 0.2–0.5 % and < 20 ppm, respectively. From the linear extrapolation follows that it had to have $^{87}Sr/^{86}Sr_i$ slightly lower than 0.7095 and ε^i_{Nd} ~ –5.5. This, together with the whole-rock geochemical intervals outlined by Holub (1997), impose severe constraints on the acid member composition.

In the CBPC, e.g., 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). Also some granites of the SBB display isotopic compositions that may approach those of the hypothetical acid end-member. We cannot exclude, however, a possible role of leucogranitic and aplitic rocks spatially associated with durbachites as numerous dykes, whose isotopic compositions remain so far practically unknown.