MITT.ÖSTERR.MINER.GES. 148 (2003)

WHOLE-ROCK GEOCHEMISTRY OF FELSIC GRANULITES FROM THE GFÖHL UNIT (MOLDANUBIAN ZONE, AUSTRIA AND CZECH REPUBLIC): PETROGENETIC IMPLICATIONS

V. Janoušek & F. Finger

Institut für Mineralogie
Universität Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria

The presumed root of the Variscan orogen in the Bohemian Massif, the Moldanubian Zone, represents a tectonic assemblage of medium- to high-grade metamorphic rocks, intruded by numerous granitoid masses. Its uppermost, allochtonous Gföhl Unit consists of anatectic gneisses, HP–HT granulites (minimum P ~ 1.5 GPa, 950–1050°C), Grt/Spl peridotites, pyroxenites and eclogites [1-4]. The age of the HP granulite metamorphism is constrained at ~ 340 Ma [2 and references therein]. Among the granulites prevail leucocratic types with the assemblage Grt + Ky + Qtz + mesoperthite (former ternary feldspar); mafic-intermediate pyroxene-bearing types are subordinate.

The felsic granulites (SiO_2 > 70 %) are acidic (SiO_2 = 74.5, median), slightly peraluminous (A/CNK ~ 1.1), potassium- (K_2O/Na_2O = 1.5) and rather iron-rich (FeO_t = 1.9, mg# ~ 30). At given SiO_2 the CaO (1.0 %) is fairly high. No significant regional trends in the whole-rock geochemistry are apparent. The felsic granulites show variably low ΣREE, slight LREE enrichments (Ce_N/Yb_N = 1.5–8.7) and pronounced negative Eu anomalies (Eu/Eu* = 0.11–0.72), deepening with increasing acidity. Compared to the average upper crust, Cs, U and Th are depleted, perhaps indicating some element mobility during the high-pressure metamorphism [5-6]. On the other hand, Rb and K as well as MREE and HREE (+Y) seem to be in the upper crustal range and much of the trace-element signature (e.g. variable depletions in Nb, Ti, Ba and Sr) can be explained in the terms of the protolith composition. High concentration ranges of these elements, resulting from closed-system evolution, are typical of many acid volcanic rocks [7]. Trends of rapidly falling Sr and Ba with rising Rb are also common in evolved granites crystallizing Kfs-dominated assemblages. The sharp drop in Zr, Y and P indicates crystallization of zircon and apatite, characteristic of fractionated I-type granite suites [8].

According to [6, 9-10] and our data, the felsic granulites contain radiogenic Sr ($^{87}Sr/^{86}Sr_{340}$ = 0.7106–0.7706, median 0.7283) and unradiogenic Nd (ε^{340}_{Nd} = -4.2 to -7.5, median -6.0). In the $^{87}Sr/^{86}Sr_{340}$ – ε^{340}_{Nd} plot the analyses from Austria and Czechia form subparallel, partly overlapping fields, with the former apparently shifted to lower (i.e. more negative) ε^{340}_{Nd} values. These fields run diagonally from the less to more felsic rocks, the latter with considerably more radiogenic Sr-Nd isotopic compositions. Apparently, the whole-rock Rb-Sr system failed to equilibrate, on a large scale, in Variscan times. Likewise some zircons it may preserve memory of the igneous protolith age (?Silurian–Ordovician: see SHRIMP data of [2, 11]. In the Ab-Qz-Or ternary, the normative compositions of felsic granulites fall close to the low-pressure minimum. This further reinforces the argument for origin from upper crustal acid igneous rocks (rhyolites/fractionated granites) [5] subducted into the mantle during the Variscan collision [4].

The remarkable compositional uniformity of the felsic granulites requires an unusually siliceous and rather homogeneous metaigneous protolith, widely available in the pre-Variscan crust. As noted already by [6], the major- and trace-element chemistry together with the Sr-Nd isotopic compositions of the Gföhl gneisses match almost perfectly those of the felsic granulites. Subtle differences are in the U and Th (that are generally undepleted), also Nb, Sr, Zr and Hf tend to be slightly higher. The Gföhl gneisses, whose igneous protolith has been dated by SHRIMP at 482 ± 6 Ma [12], may in part represent retrogressed granulites [13].

For instance, analogous whole-rock geochemistry show orthogneisses and metarhyolites from the Fichtelgebirge, dated at 455–480 Ma [14 and references therein], i.e. falling within the spectrum of inherited ages observed in the granulites. The Sr isotopic system many of the Fichtelgebirge samples has been disturbed, but the Wunsiedel orthogneiss gave a whole-rock Rb-Sr age of 480 ± 4 Ma with $^{87}Sr/^{86}Sr_i = 0.7095$ [14] that compares well with the mean of the felsic granulites recalculated to 480 Ma (0.7086 ± 0.010, 1s). Moreover, the ε^{480}_{Nd} values for samples from Fichtelgebirge with $SiO_2 > 70$ % (orthogneisses: -3.5 ± 0.4, metarhyolites: -4.8 ± 1.1) are also matching the mean ε^{480}_{Nd} (-4.9 ± 1.9) for the felsic Moldanubian granulites.

Taken together, the bulk of the South Bohemian granulites does not seem to represent HP melts separated in Variscan times from the unmelted residua (cf. [15-17]) but rather metamorphosed (even though in part anatectic) equivalents of an older igneous complex.

This work was financed by the FWF project 15133--GEO that is gratefully acknowledged.

References

[1] CARSWELL, D. A. & O'BRIEN, P. J. (1993): Thermobarometry and geotectonic significance of high-pressure granulites: examples from the Moldanubian zone of the Bohemian Massif in Lower Austria. - Journal of Petrology, 34, 427-459.

[2] KRÖNER, A. ET AL. (2000): Zircon ages for high pressure granulites from South Bohemia, Czech Republic, and their connection to Carboniferous high temperature processes. - Contributions to Mineralogy and Petrology, 138, 127-142.

[3] COOKE, R. A. (2000): High-pressure/temperature metamorphism in the St. Leonhard Granulite Massif, Austria: evidence from intermediate pyroxene-bearing granulites. - International Journal of Earth Sciences, 89, 631-651.

[4] O'BRIEN, P. J. & RÖTZLER, J. (2003): High-pressure granulites: formation, recovery of peak conditions and implications for tectonics. - Journal of Metamorphic Geology, 21, 3–20.

[5] FIALA, J. ET AL. (1987): Moldanubian granulites and related rocks: petrology, geochemistry, and radioactivity. - Rozpravy Československé akademie věd, řada matematických a přírodních věd, 97, 1-102.

[6] VELLMER, C. (1992): Stoffbestand und Petrogenese von Granuliten und granitischen Gesteinen der südlichen Böhmischen Masse in Niederösterreich. - PhD. thesis, Georg-August-Universität, Göttingen.

[7] HILDRETH, W. (1979): The Bishop Tuff: evidence for the origin of compositional zonation in silicic magma chambers. - Geological Society of America Special Paper 180, 43-75.

[8] CHAPPELL, B. W. & WHITE, A. J. R. (1992): I- and S-type granites in the Lachlan Fold Belt. - Transactions of the Royal Society of Edinburgh, Earth Sciences, 83, 1-26.

[9] VALBRACHT, P. J. ET AL. (1994): Sr and Nd isotopic determinations in three Moldanubian granulite massifs in southern Bohemia. - Journal of the Czech Geological Society, 39, 114.

[10] BECKER, H. ET AL. (1999): Geochemistry of glimmerite veins in peridotites from Lower Austria - implications for the origin of K-rich magmas in collision zones. - Journal of Petrology, 40, 315-338.

[11] FRIEDL, G. ET AL. (2003): U-Pb SHRIMP dating and trace element investigations on multiple zoned zircons from a South-Bohemian granulite. - Journal of the Czech Geological Society, in print.

[12] FRIEDL, G. ET AL. (1998): New SHRIMP-zircon ages for orthogneisses from the south-eastern part of the Bohemian Massif (Lower Austria). - Acta Universitatis Carolinae, Geologica, 42, 251-252.

[13] COOKE, R. A. & O'BRIEN, P. J. (2001): Resolving the relationship between high P-T rocks and gneisses in collisional terranes: an example from the Gföhl gneiss-granulite association in the Moldanubian Zone, Austria. - Lithos, 58, 33-54.

[14] SIEBEL, W. ET AL. (1997): Early Palaeozoic acid magmatism in the Saxothuringian belt: new insights from a geochemical and isotopic study of orthogneisses and metavolcanic rocks from the Fichtelgebirge, SE Germany. - Journal of Petrology, 38, 203-230.

[15] VRANA, S. & JAKEŠ, P. (1982): Orthopyroxene and two-pyroxene granulites from a segment of charnockitic crust in southern Bohemia. - Věstník Českého geologického ústavu, 57, 129-143.

[16] JAKEŠ, P. (1997): Melting in high-P region - case of Bohemian granulites. - Acta Universitatis Carolinae, Geologica, 41, 113-125.

[17] KOTKOVA, J. & HARLEY, S. L. (1999): Formation and evolution of high-pressure leucogranulites: experimental constraints and unresolved issues. - Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy, 24, 299-304.