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Garnet as a major carrier of the Y and REE in the granitic rocks: An example from the layered anorogenic granite in the Brno Batholith, Czech Republic

Sven Hönig[1,*], Renata Čopjaková[1], Radek Škoda[1], Milan Novák[1], David Dolejš[2], Jaromír Leichmann[1] and Michaela Vašinová Galiová[3,4]

[1]Department of Geological Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic
[2]Institute of Petrology and Structural Geology, Charles University, Albertov 6, 128 43 Praha 2, Czech Republic
[3]Department of Chemistry, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic
[4]Central European Institute of Technology (CEITEC), Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic

Abstract

Garnet and other rock-forming minerals from A-type granite dikes in the Pre-Variscan Brno Batholith were analyzed to determine relative contributions of individual minerals to whole-rock Y and REE budget and to assess incorporation mechanisms of these elements in garnet. Minor to accessory garnet (<2 vol%) is the essential reservoir for Y+REE in the Hlína granite accounting ~84% Y and 61% REE of the total whole-rock budget. Zircon is another important carrier of REE with ~13% Y and ~11% REE. At least ~21% REE and 1% Y were probably hosted by Th- and U-rich monazite that has been completely altered to a mixture of secondary REE-bearing phases. The contribution of major rock-forming minerals (quartz and feldspars) is low (~1% Y; 10% LREE; ~1% HREE) excluding Eu, which is hosted predominantly by feldspars (~90%). Minor to accessory muscovite and magnetite incorporate ~1% Y and ~2% REE of the whole-rock budget. Magmatic garnet $Sps_{41–46}Alm_{28–44}And_{0–13}Grs_{6–12}Prp_{0–1}$ is Y- and HREE-rich (up 1.54 wt% Y; up ~1 wt% ΣREE), and the Y+REE enter the garnet structure via the menzerite-(Y) substitution. The Y and REE show complex zoning patterns and represent sensitive indicator of garnet evolution, in contrast to a homogeneous distribution of major divalent cations. General outward decrease of Y+REE is a common feature due to the strong partitioning of Y+HREE in the garnet relative to the other phases. REE underwent significant fractionation during growth of early garnet I; the Yb_N/Nd_N ratio generally decreases from the core to rim of garnet I. Higher Mn and Al, lower Ca, and Y+REE contents, as well as higher Yb_N/Nd_N ratio and more negative Eu anomaly in garnet II overgrowths indicate its crystallization from a more evolved melt. Application of zircon saturation geothermometry provides upper temperature limit of 734 ± 14 °C for the closed-system crystallization. Mineral equilibria reveal that crystallization started at QFM + 1.2, and preferential sequestration of Fe^{3+} into garnet and magnetite was responsible for progressively reducing conditions. Equilibrium between magnetite, garnet, quartz, and plagioclase, representing the final crystallization stage of the granitic magma, occurred at 658–663 °C and QFM 0 to + 0.8, hence at undercooling of ~75 °C.

Keywords: Garnet, EMP, LA-ICP-MS, Y+REE mass-balance calculations, A-type granite, Brno Batholith