Zr-REE-Y-Rich Accessory Minerals from Peraluminous Granites of the Montes de Toledo Batholith (Iberian Hercynian Belt)

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INTRODUCTION.

The study of compositional and textural characteristics of accessory minerals in granitoid rocks may provide a broad register of the origin and compositional evolution of magmas. The discussion on petrogenesis of these minerals being either residual, or early- to late-magmatic phases, together with the lack of widespread re-equilibration processes, are the clues for reconstructions of magmatic evolution.

The Hercynian Montes de Toledo Batholith (MTB) is a discontinuous E-W outcrop made up by late- to post-tectonic granite plutons from Madridejos (Toledo) to Belvís de Monroy (Cáceres). This large batholith is characterized by a marked S-type affinity which contrasts with the more complex I- and S-type character of the granite plutons of the Spanish Central System (SCS). Compositional variations have been distinguished along the MTB suggesting a segmented batholith (Villaseca et al., 2008): the slightly lower CaO and higher P2O5 contents of the western-sector (Toledo) to Belvís de Monroy (Cáceres). Some granites from the Peraleda pluton show higher the peraluminosity character and the less evolved composition (SiO2 = 68.67 wt.%). This whole-rock compositional spectrum is reflected in the geochemistry of the Zr-REE-Y-rich accessory phases.

RESULTS.

About 95 quantitative electron-microprobe analyses of zircon and REE phosphates in 9 characteristic granite samples were conducted using a Jeol JXA-8900 M electron microprobe, in the “Centro de Microscopía Electrónica Luis Bru” (Complutense University of Madrid). The crystal size is usually too small to allow a representative number of core-rim analyses to assess variation on this scale.

Three main types of zircon can be defined in the studied MTB samples: (1) subhedral to euhedral crystals, unzoned or showing two-zoned irregular sectors, with sizes below 100 µm and aspect ratios between 2 and 5. They are hosted by biotite. Their composition is very poor in ESC (Ca, Fe, Al, Mn, Y, Ti, P), accompanied by deficient totals and the highest HO2 contents (1.8 to 7.1 wt.%). Similarly to other highly evolved granites (e.g. Nasdala et al., 2009), the deficient total increase displayed by Zr-poor zircon is associated with progressively higher AI, Ca, Fe, Mn and P contents, reaching high values (in wt.%) of P2O5 14.9, Al2O3 < 7.0, CaO < 2.2, FeO < 2.9 and MnO < 0.4. Composition of zircon type-3 is explained partially by the berline type substitution Prr+ + Al >+ ↔ 2Si4+. This type has been observed exclusively in the most fractionated unit of the Belvís pluton. The subtypes 2a and 2c (i.e. with more or less clear oscillatory zoning only occur in the microgranites, which outcrop in the Peraleda and Navalmorral plutons.

The zircon types 1 and 2 display a compositional range (including core-rim analyses) rather homogeneous (near to stequiometric zircon composition). On the contrary, zircon type 3, from the most fractionated granite of the Belvís pluton, shows significant contents of not ESC (Ca, Fe, Al, Mn and P contents, reaching high values (in wt.%) of P2O5 14.9, Al2O3 < 7.0, CaO < 2.2, FeO < 2.9 and MnO < 0.4. Composition of zircon type-3 is explained partially by the berline type substitution Prr+ + Al >+ ↔ 2Si4+. This type has been observed exclusively in the most fractionated unit of the Belvís pluton. The subtypes 2a and 2c (i.e. with more or less clear oscillatory zoning only occur in the microgranites, which outcrop in the Peraleda and Navalmorral plutons.

The Belvís de Monroy pluton consists of the most felsic leucogranites (SiO2 = 74.51 wt.%), with higher P2O5 contents (mainly concentrated in the albite plagioclase and K-feldspars by the berline substitution), and high F content in the magmatic muscovite and biotite (Villaseca et al., 2008). Some granites from the Peraleda pluton show the higher peraluminosity character and the less evolved composition (SiO2 = 68.67 wt.%). This whole-rock compositional spectrum is reflected in the geochemistry of the Zr-REE-Y-rich accessory phases.
Monazite-(Ce) tends to occur as small (< 30 µm) and equant subhedral crystals, showing diffuse zoning. Monazite is associated to apatite (in Navalmoral pluton) or less frequently to zircon. In the Belvís pluton, exceptionally large monazite crystals of circa 100 µm appear. Monazite-(Ce) in restite-rich granites occurs as large crystals, sometimes acicular, mainly unzoned and occasionally rich in inclusions.

Monazite compositional range is (in wt.%): ThO₂=1.41 to 14.3; UO₂ = 0.11 to 17.67; Y₂O₃ = 0.2 to 15.05; La₂O₃ = 30 to 167.4; Ce₂O₃ = 16.74 to 32.26. Cheralite compositions are restricted to the most fractionated plutons, displaying the highest U content (up to 17.67 wt.%) in the leucogranites of the Belvís pluton. The Ce contents of cheralite from the Belvís pluton are clearly lower than the other studied crystals. These variations are explained by monazite-cheralite substitution, as is shown by the similar atomic abundance of (Th + U) and (Si + Ca) (Fig. 2). Only those monazite crystals included in large crystals of apatite display a distinct excess of Ca, similarly to those ones described by Harlov et al. (2008), which are interpreted as magmatic in origin. The huttonite mole fraction in monazite is practically zero in the studied plutons.

CONCLUSIONS

1) Zircon composition is very similar in all granites excepting in the more perphosphorous granite of the Belvís pluton, where the zircon type-3 shows berlinite- and brabantite- substitutions, which would be explained as zircon being practically the only Y-REE-Zr accessory mineral in this unit. The typical oscillatory zoned crystals (type-2a and 2c), with short range of composition, are indicative of stable growth conditions in the microgranites units where they have been found. On the contrary, the type-2b and 3 suggest changing saturation levels of these elements during the zircon growing.

2) Monazite compositions reflect more clearly the magmatic evolution of magmas.

(3) The absence of magmatic xenotime is consistent with the poorness of Y-HREE in these peraluminous magmas (Y ≤ 23 ppm, HREE ≤ 16.2 ppm) (Villaseca et al., 2008). Even in the more evolved sectors, appropriate saturation levels of these elements are not reached, which determines that these elements are incorporated both in the structure of zircon and/or monazite.

REFERENCES


