REE TRENDS IN RARE-ELEMENT GRANITIC PEGMATITES: ENRICHMENT VS. DEPLETION IN GRANITE-TO-PEGMATITE SEQUENCES

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Information on the REE concentrations in the bulk composition of rare-element pegmatites is very limited because the bulk composition of these pegmatites is very difficult to analyze, and the REE data are rarely collected. Bulk compositions of the wall zone are occasionally analyzed in the belief that they are representative of the bulk of zoned pegmatites, but the modes of rock-forming minerals and distribution of accessory phases across the zoning of these bodies invalidate this assumption. Nevertheless, the meagre data available permit to distinguish two principal trends in REE abundances from parent granites to their pegmatite progeny.

A prominent REE depletion is observed in the granite-pegmatite sequences of the LCT family, defined as peraluminous to hyperaluminous systems of S- or rarely I-derivation, mainly late- to post-tectonic, commonly B- and P-enriched, with strong tendency to accumulate substantial Li, Rb, Cs and Ta, Be, Sn into the most evolved pegmatite members. The parent granites routinely display moderately to slightly HREE-depleted patterns and low REE abundances (chondrite-normalized La ~60–5, Yb ~10–1). From primitive biotite-bearing granites toward the leucocratic pegmatitic facies the abundances decrease, the patterns flatten, and the prominent negative Eu anomalies may initially increase but shrink in late stages. A conspicuous break usually separates the REE patterns and abundances of even the most primitive pegmatites from those of the parent granites: the pegmatite patterns tend to be flat or somewhat MREE-enriched and generally very REE-depleted (chondrite-normalized La ~10–0.3, Yb ~10–0.005); the negative Eu anomaly is occasionally well expressed but in most cases absent. Partial melting of metamorphic protoliths leaving REE-rich accessory minerals in the residua, progressive REE-depletion of the differentiating melts by precipitation of monazite, xenotime, apatite, garnet, tourmaline, columbite-tantalite and microlite, and a change in oxidation state of Eu produce these features. Slight late accumulation of HREE-bearing minerals is found in some lepidolite-subtype pegmatites, but this seems to be rooted in the overall geochemistry of the granite-pegmatite system rather than in systematic accumulation by F-complexing, as most lepidolite-subtype pegmatites do not carry REE-rich minerals.

In contrast to the above, the granites generating pegmatites of the NYF-family are typically subaluminous to metaluminous, mainly A- to locally I-derived, predominantly post-tectonic to anorogenic; the granite-pegmatite suites are commonly B- and P-depleted, poor in Li, Cs, Ta and Sn, and their most evolved pegmatites belong to either the gadolinite subtype enriched in Y, HREE, Be, Nb, F, U, Th, Ti, Zr and Sc, or the allanite-monazite subtype with LREE, U, Th, Be, Nb and F. As shown by, e.g., W. B. Simmons and associates, the parent granites show HREE-depleted to near-flat patterns but high overall REE abundances (chondrite-normalized La ~500–80, Yb ~80–30) and prominent negative Eu anomalies. The patterns do not appreciably change, and the abundances may just slightly increase or decrease in differentiated granite suites. High-percentage melting of (previously LILE-depleted) protoliths and possible input from mantle-derived magmas, followed by limited ranges of differentiation, seem to be responsible for these features. The REE patterns of the most evolved granites are closely mimicked by the wall zones of derived pegmatites. Data are not available for complete bulk compositions of the pegmatites but the abundances can be expected higher than in the wall zones and parent granites: the wall zones are routinely devoid of Y, REE-bearing accessory minerals, which are accumulated in core-margins and late albitic units. This paragenetic position of the Y, REE-minerals and the prominent role of F in the NYF systems indicate that F-complexing is an important mechanism here, which preserves significant quantities of REEs, and particularly HREEs, well into late stages of pegmatite consolidation and causes an increase of their abundances with progress of granite-to-pegmatite fractionation.

The work performed to date just scratches the surface of the problem of REEs in the broad spectrum of rare-element pegmatite categories, as related to their parent igneous systems. Extensive studies are required to fully describe and interpret the processes which lead to spectacular depletion on one hand, and distinct enrichment on the other.