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Estimating Sr/Y of granitic melts from minerals: are apatite plus coeval minerals up to the task?

VALDECIR DE ASSIS JANASI, ADRIANA ALVES, SILVIO R F VLACH AND LUCELENE MARTINS

Instituto de Geociências, Universidade de São Paulo

Sr/Y ratios of granitic rocks have been widely used to infer depths of magma generation and/or equilibration in continental crust, yet plutonic rocks are prone to crystal accumulation which may modify them, leading to erroneous conclusions. Trace-element composition of melts can be inferred from inversion of their constituent minerals composition given appropriate distribution coefficients. Common early-forming minerals that host Sr and Y in granitic melts are hornblende and apatite; plagioclase accommodates very low Y while titanite and zircon may be late-crystallizing and have low and no Sr, respectively. Apatite would then stand out as the mineral of choice given its widespread occurrence in granites and saturation at low SiO_2 (≤65wt%). Identifying early apatite crystals requires careful petrography; such approach is unfeasible for mineral concentrates, more so because, unlike zircon, it usually lacks reliable chemical tracers of melt differentiation. Our attempts to estimate the Sr/Y ratios of granitic magmas based on apatite composition alone met with important shortcomings. In most of our case studies, apatite Sr, although correlated with whole rock contents, is remarkably invariable (typical RSD <10% in any given sample) and systematically lower than the expected ~2-3 value for Kd(Ap-melt) experimentally determined and observed in silicic volcanic rocks. Such homogeneity may in some cases stem from late-magmatic diffusion, as the relatively high diffusivity of Sr in apatite could erase any higher contents originally present in small early crystals kept at high temperature for long time. We thus sought additional information on the behavior of other trace elements in apatite, and on textural and chemical relationships with coeval minerals. This allowed us to follow the magma evolutionary paths, documenting the influence of feldspar crystallization on Sr and Eu of apatite, as well as the REE drop with parallel decrease of the negative Eu anomaly following the (often late) entry of titanite (±allanite) in metaluminous granites. We conclude that reliable estimates of the initial Sr/Y ratio of granitic magmas benefit from the combined study of the chemistry of apatite and coeval Sr (and Y)-bearing minerals, especially plagioclase and, when present, hornblende, which are larger and thus less susceptible to diffusive re-equilibration.