Fluid-enhanced crystallization to generate high-S apatite of silicic magmas: Evidence from Pinatubo and other calc-alkaline systems

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We consider high-S apatites to be apatites with ≥0.7 wt.% SO_3. High-S apatites of magmas with rhyolitic melt are of particular interest because experimental data suggest that such apatites are 'over enriched' in S relative to equilibrium crystal-melt partitioning processes. In Pinatubo dacite, 29% of all investigated apatites (N=69) include high-S concentrations. Conversely, the dominant apatite populations of silicic oxidized magmas are medium- (0.3-0.6 wt.% SO_3) and low-S (<0.3 wt.% SO_3) apatites (also at Pinatubo), which are consistent with crystallization from melt at or below S saturation at various temperatures.

Explanations for high-S apatites range from inheritance (from mafic magmas or country rock) to S exchange between apatite and anhydrite as a consequence of close petrographic association of both phases in systems containing anhydrite (e.g. at Pinatubo). The compositional fingerprint (e.g. REE, Sr) ties high-S apatites to the same melt environment as the dominant populations, and thus makes inheritance unlikely. Finding low-S apatite inclusions in anhydrite in conjunction with the lack of consistent rimward enrichment of S of anhydrite-hosted apatites, argues against S exchange between these two phases.

To generate high-S apatite, we envision a process that we call 'fluid-enhanced crystallization,' whereby the high-S signal is controlled by the presence of a S-rich fluid adjacent to a growing apatite while other compositional characteristics are mostly controlled by the silicate melt. This process would be consistent with observed reverse S zonation towards the rim, small scale and strong changes in S content within single grains, occurrence of low- to high-S apatites as inclusions together in single host minerals, and compositional similarity among low- to high-S apatites. At Pinatubo the existence of such S-rich fluid is corroborated by S isotopes of anhydrite as well as growth features of anhydrite. A suitable source for S-rich fluids would be fluids derived from degassing underplated mafic magmas.

Post-collisional magmatism during Variscan orogeny: The Furcatura pluton (Danubian domain, Romanian Southern Carpathians)

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Exploratory geochronological data indicate that the Furcătura pluton (312 ±2.8 Ma) was emplaced during the Hercynian orogeny. This late stage magmatism is essentially granitic/granodioritic, lacking associated basic rocks. Furcatura pluton (FP) is remarkably heterogeneous, showing wide ranges for most of the petrographical and geochemical parameters. The metaluminous to slightly peraluminous (average A/CNK of 1.04) granitoids are high-K (K_2O/Na_2O of 0.51-1.63) calc-alkaline, while some samples have shoshonitic affinity (maximum K_2O of 5.61). They lack significant Eu anomalies (average Eu/Eu* of 0.94) and have subparallel REE patterns, with ΣREE ranging from 51.11 to 203.7. The heterogeneous character of the FP is further reflected in the $\delta^{18}O$ values of the quartz separates, ranging from 7.37 to 11.59‰, with the highest values measured in the late magmatic aplitic veins. In conventional discrimination diagrams, as well as reflected by their trace elemental compositions, FP granitoids show both I- and S-type granite features. Geochemical evidence suggests the pluton was derived from a heterogeneous, primarily (lower?) crustal source, with subordinate additions of mantle-derived melts (e.g. low Nb/U and Ce/Pb). However, based on available data, contributions from a previously subduction-enriched mantle component can not be completely ruled out. Therefore, the FP granitoids may provide clues for deciphering the processes involved in the production of post-collisional magmas.