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Magmatic degassing and fluid metasomatism promote compositional variation from I-type to peralkaline A-type granite in the late Cretaceous Fuzhou felsic complex, SE China

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Abstract

A-type granites generally have much lower water, higher temperature, and incompatible element concentrations than I-type granitoids. Yet it remains unclear why I-A-type granitic complexes occur in convergent plate margins. Here we conduct geochemical analyses on apatite and mafic minerals from the late Cretaceous I-A-type granitic complex in Fuzhou area, SE China, aiming to decipher differentiation, fluid metasomatism, and degassing that primarily control the compositional diversity of felsic magmas. Apatites in both rock types are F-rich and show large H_2O and δD variations, i.e., 341–3892 ppm H_2O and –325 to +336‰ δD in I-type granitoids; 67–1366 ppm H_2O and –251 to +1439‰ δD in A-type granites. H_2O in apatite is negatively correlated with La/Sm and Sr/Y in the I-type granitoids, whereas it is positively correlated with Ce and total rare earth element (REE) concentrations in the A-type granites. Once H_2O increases up to hundreds of ppm, both rock types show a rapid decrease of H_2O/Ce, an increase of F/Cl, and extensive H isotope fractionation.

Arfvedsonite occurs as a late crystallizing mineral in the A-type granite and has much higher contents of Na_2O, K_2O, F, and high field strength elements (HFSE) than hornblende in the I-type granitoids, indicating the addition of F-HFSE-rich alkaline fluids during its magmatic evolution. The consumption of arfvedsonite and formation of aegirine further indicate the role of fluid metasomatism and H_2 degassing via a reaction of $3Na_3Fe_5Si_8O_{22}(OH)_2 + 2H_2O = 9NaFeSi_2O_6 + 2Fe_3O_4 + 6SiO_2 + 5H_2$.

The combined geochemical data demonstrate that the systematic differences in mineral assemblage, whole-rock composition, magma temperature, H_2O content, and δD of apatite between the I- and A-type granites are likely attributed to varying degrees of differentiation, fluid metasomatism and magmatic degassing. The I-type granitoids experienced hornblende, biotite, plagioclase, K-feldspar, and apatite fractionation and close-system degassing. The A-type granite was likely formed from the I-type monzogranitic magma that was metasomatized by the mantle-derived F-HFSE-rich alkaline fluids to produce the peralkaline magma, which further experienced K-feldspar + plagioclase + biotite + apatite fractionation and open-system degassing. Further numerical estimation indicates that the primary magma of Fuzhou granitic complex contained ~3.0 wt% H_2O, and the lower water content of A-type granite was likely attributed to strong degassing during its emplacement. Our results indicate that some peralkaline A-type granites can be generated from relatively water-poor I-type granitic magmas by fluid metasomatism and degassing.

Keywords: Magmatic degassing, fluid metasomatism, water content and H isotopes, apatite, Fuzhou I-A-type granitic complex, SE China