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Revisiting the genesis of the adakite-like granitoids in collisional zones: Water-fluxed melting of intermediate to felsic rocks with dilution by low Sr/Y phases

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Abstract

High-Sr/Y granitoids in continental settings are sometimes erroneously regarded as the products derived from partial melting of thickened/delaminated mafic lower curst under relatively higher pressures (>1.5 GPa) in a collisional orogenic setting. In fact, multiple magmatic processes in the *trans*-crustal magma system, such as recycling of antecrysts, crustal assimilation, and fractional crystallization, can create or modify the primary "adakitic" signature. As a result, the generation of adakitic magmas in continental settings remains controversial from a bulk-rock perspective. Here, we address the origin of adakitic plutonic rocks through geochemical and textural characterization of rock-forming minerals in the pyroxene-bearing Zhuyuan granodiorite, West Qinling, China. The Zhuyuan granodiorite formed in a post-collisional setting and primarily consists of resorbed orthopyroxene, three types of clinopyroxene, amphibole, two types of plagioclases, K-feldspar, biotite, and quartz. Type-1 Cpx has high X_{Mg} (70.0–81.7). Type-2 Cpx displays normal zoning and decreasing X_{Mg} (80.9 to 71.5) from the core to rim. Type-3 Cpx is reversely zoned, where the rims have higher X_{Mg} (75.5–86.9), Ni, Cr, suggesting a recharge event. Orthopyroxene has high-Ni and -Cr contents, as well as high X_{Mg} (80.9–82.8), indicative of antecrysts that grew in mafic magma reservoirs. The injection of magmas from different sources is supported by sieve-textured plagioclase and crystal size distributions of non-poikilitic amphibole. Finally, non-sieve textured plagioclase, biotite, K-feldspar, and quartz are late-crystallized phases, indicative of an orthocrystic origin. The melts in equilibrium with these orthocrysts display significantly higher Sr/Y values than the magma batches that crystallized other mafic phases (i.e., amphibole, clinopyroxene, and orthopyroxene). Thus, we propose that the system involved an initial high-Sr/Y melts in equilibrium with the orthocryst assemblage was generated by water-fluxed melting of intermediate to felsic sources. The addition of low Sr/Y non-orthocrysts (e.g., amphibole and pyroxene) and associated melt diluted the original "adakitic signal" in the magma reservoir and drove the bulk composition to more mafic values. Consequently, the Zhuyuan pyroxene-bearing granodiorite represents a mixture of crystals with diverse origins and distinct magma batches of various compositions (from felsic to mafic compositions). Our study emphasizes that the origin of adakitic granitoids cannot be clearly deciphered without geochemical analysis of the constituent minerals. We also suggest that Sr/Y values in plutons should be cautiously used in paleo-crustal thickness estimates in collisional settings because of possible open system scenarios as described here.

Keywords: Adakitic rock, antecryst, dilution, pyroxene-bearing granodiorite, water-fluxed melting