Many Roads Lead to Granite: A Field Study of a High-K LLD

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Significant evidence exists that arc-related granitoids are the complex products of magmatic mixing between melts of different compositions. However, as magma mixing is limited to magmas with similar viscosities [1,2], composite granites must form through the mixing of compositionally distinct felsic melts with comparable viscosities. The production of 'calc-alkaline' silicic melts (dominated by tonalities, granodiorites, & granites) in arcs through fractional crystallization of silica-poor minerals (e.g., amphibole) from hydrous basalts is well documented [3,4]. The question then arises, however, whether there are other liquid lines of descent (LLDs) characterized by different parental melt compositions and crystallizing mineralogy that give rise to granitoids that are geochemically & texturally distinct from the common calc-alkaline sequence. Here we present results from a newly discovered arc section in the Dariv Range of the Mongolian Altaids in support of this idea. In Dariv, a complete hydrous alkaline fractionation sequence ranging from biotite-bearing ultramafic & mafic cumulates through liquid-like quartz-monzonites is exposed, which so far has been documented only in fragmentary phlogopite-bearing ultramafic xenoliths. We consider the rocks to represent an alkali-rich hydrous fractionation sequence defined by the appearance olivine + clinopyroxene ± Fe-Ti oxides → biotite + apatite → k-feldspar + plagioclase → amphibole + quartz. To quantify the LLD of an alkaline arc-related basalt, we present a fractionation model, which incorporates a stepwise subtraction of cumulates of a fixed composition from a primitive melt. The primitive melt composition was constrained from analyses of late-stage mafic dykes related to the alkaline sequence. The primitive melt is characterized by high Na_2O, K_2O, LILEs, and LREEs contents and depletions in HFSEs typical for arc magmas. The modeled LLD reproduces the compositions of 'liquid'-like plutonic rocks and follows the experimentally determined water-undersaturated Ab-Or cotectic (at 0.2-0.5 GPa). Many primitive arc melts have the appropriate composition to follow a similar LLD, suggesting that clinopyroxene- & biotite-dominated fractional crystallization may be a common mechanism for producing upper crustal LILE- and LREE-enriched granitoids in arcs. These alkali-enriched silicic melts could mix with calc-alkaline-like granitic melts to produce hybrid granitoids exposed in the upper crustal sections of paleo-arcs.

[1] Sparks & Marshall (1986), *JVGR*, 99-124 [2] Scaillet *et al* (2000), GSA *Special Papers* **350**, 61-72 [3] Sisson & Grove (1993), *CMP* **113**, 143-166 [4] Jagoutz (2010), *CMP* **160**, 359-381