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Are cumulate granites characteristic of migmatitic gneiss domes? An example from the Fosdick Mountains of Marie Byrd Land, West Antarctica

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In the Fosdick migmatite–granite complex, Cretaceous granites yield U–Pb zircon crystallization ages of 117–102 Ma, corresponding to the timing of doming during a regional transition from transpression to transtension that facilitated exhumation of the complex. The results of P–T phase equilibria modeling and occurrence of leucosome-bearing normal-sense shear zones are consistent with suprasolidus conditions during the early stages of exhumation. Commonly, leucosomes in normal-sense shear zones and sub-horizontal sheeted granites within the complex have coarse blocky plagioclase or K-feldspar grains with interstitial quartz, suggesting a cumulate origin.

The Cretaceous granites have whole rock Sr and Nd and zircon Hf and O isotope compositions consistent with derivation from regionally-associated source materials comprising a Devonian–Carboniferous calc-alkaline granodiorite suite (dominant component) and a Cambrian metaturbidite sequence (minor component). However, the major and trace element chemistry of these granites is highly variable and inconsistent with melt compositions expected from simple anatexis of such source materials. Furthermore, major element compositions are inconsistent with those of cotectic granites and more variable than those reported from melt inclusions. The granites typically have large positive Eu anomalies and the overall geochemistry is consistent with the early accumulation of feldspar and quartz, and drainage of fractionated melt.

These granites are interpreted to record the collapse of sub-horizontal partially-crystallized layers of magma by filter pressing during vertical shortening associated with dome exhumation, leaving behind cumulate-rich residues. Consequently, the extracted melt is expected to be more evolved and variable than compositions of experimental melts and melt inclusions in peritectic minerals. A potential sink for melt complementary to the cumulate granites is represented by the Cretaceous Byrd Coast Granite suite, which was emplaced at higher structural levels outside the Fosdick complex. These granites yield U–Pb zircon crystallization ages of 105–102 Ma. They have elevated K2O contents relative to granites in the Fosdick complex and large negative Eu anomalies. Furthermore, their Sr and Nd whole-rock and Hf and O zircon isotope compositions are consistent with derivation from crystallizing granites within the Fosdick complex.

These results contribute to a growing number of studies that suggest granites in migmatite–granite complexes are accumulations of residual and newly crystallized feldspar and quartz after melt drainage rather than primary or minimum-melt compositions. There are two important implications of cumulate granites in migmatite complexes. First, it demonstrates that melt crystallization began during melt migration and emplacement. As a result, it is possible that cumulate minerals in melt transport conduits may restrict the flow of melt or could locally clog the anatectic plumbing system. This possibility may need to be considered as a rate-limiting step in studies that examine the timescales of melt extraction from the deep crust. Second, the drained melt will have evolved compositions with higher concentrations of the heat producing elements. This has important implications for the tectonic history of large hot mountain belts, cooling ultrahigh-temperature (UHT) metamorphic terrains, priming the crust for future UHT metamorphic events and the long-term stability of the continental crust.