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Partial melting of ultramafic granulites from Dronning Maud Land, Antarctica: Constraints from melt inclusions and thermodynamic modeling

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Abstract

In the Pan-African belt of the Dronning Maud Land, Antarctica, crystallized melt inclusions (nanogranitoids) occur in garnet from ultramafic granulites. The granulites contain the peak assemblage pargasite+garnet+clinopyroxene with rare relict orthopyroxene and biotite, and retrograde symplectites at contacts between garnet and amphibole. Garnet contains two generations of melt inclusions. Type 1 inclusions, interpreted as primary, are isolated, <10 μm in size, and generally have negative crystal shapes. They contain kokchetavite, kumdykolite, and phlogopite, with quartz and zoisite as minor phases, and undevitrified glass was identified in one inclusion. Type 2 inclusions are <30 μm in size, secondary, and contain amphibole, feldspars, and zoisite. Type 2 inclusions appear to be the crystallization products of a melt that coexisted with an immiscible CO_2-rich fluid.

The nanogranitoids were re-homogenized after heating in a piston-cylinder in a series of four experiments to investigate their composition. The conditions ranged between 900 and 950 °C at 1.5–2.4 GPa. Type 1 inclusions are trachytic and ultrapotassic, whereas type 2 melts are dacitic to rhyolitic. Thermodynamic modeling of the ultramafic composition in the MnNCKFMASHTO system shows that anatexis occurred at the end of the prograde *P-T* path, between the solidus (at ca. 860 °C–1.4 GPa) and the peak conditions (at ca. 960 °C–1.7 GPa). The model melt composition is felsic and similar to that of type 1 inclusions, particularly when the melting degree is low (<1 mol%), close to the solidus. However the modeling fails to reproduce the highly potassic signature of the melt and its low H_2O content. The combination of petrology, melt inclusion study, and thermodynamic modeling supports the interpretation that melt was produced by anatexis of the ultramafic boudins near peak *P-T* conditions, and that type 1 inclusions contain the anatectic melt that was present during garnet growth. The felsic, ultrapotassic composition of the primary anatectic melts is compatible with low melting degrees in the presence of biotite and amphibole as reactants.

Keywords: Nanogranitoids, partial melting, thermodynamic modeling, Antarctica, ultramafic granulites, kumdykolite, kokchetavite; High-Grade Metamorphism, Anatexis, and Granite Magmatism