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Carbon recycling during Neoarchean anatexis: evidence from multiphase inclusions in migmatites (Athabasca granulite terrane, Canada)

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Fluids and melts present or formed during high-temperature metamorphism and crustal anatexis play a fundamental role in mass and heat transfer with important consequences for the intracrustal reworking. The study of fluid and melt inclusions in partially melted rocks has become a key tool to investigate crustal melting processes and to decipher the evolution of granitoid magmas. Here we report a multi-technique, microstructural and microchemical investigation of multiphase inclusions trapped within peritectic garnet of a Neoarchean felsic granulite from the Upper Deck domain of the Athabasca granulite terrane (Canada). Inclusions have been characterized by SEM-EDS, FIB-SEM serial sectioning and Raman microspectroscopy. Two different typologies of inclusions have been recognized. Type I multiphase inclusions are small ($\leq$ 15 μm), primary in origin, and do not show evidence of decrepitation. Their multiphase assemblage consists of ferroan magnesite, quartz and graphite in association with minor amounts of corundum, pyrophyllite and Zn-spinel. Calcite, dolomite and zinc-bearing sulphide may also be present. The coexistence of quartz and corundum in these inclusions is interpreted as the product of metastable growth within pores of extremely small size. Type I inclusions always contain a CO_2-rich (96.5 mol. %) fluid phase with traces of N2 (3.3 mol. %) and CH4 (0.2 mol.%). These carbon-rich Type I inclusions coexist in the same cluster with large (up to 50 μm) primary melt inclusions (nanogranitoids; Type II). These are composed of K-feldspar, quartz and plagioclase with minor amounts of graphite, biotite and aluminosilicate. Preliminary remelting experiments by piston cylinder confirm the occurrence of a granitic melt within Type II inclusions. The coexistence of Type I multiphase inclusions with nanogranitoids proves the presence of a carbon-rich fluid during the Neoarchean anatexis of this portion of continental crust, in a likely situation of melt/fluid immiscibility. Correlation between phase equilibria modelling and the estimated entrapment conditions for Type I inclusions (800-950°C, 0.6-1.4 GPa), allows us to interpret the uncommon multiphase assemblage as the result of a post-entrapment carbonation reaction between an original CO_2-bearing fluid and the garnet host during rock cooling from UHT conditions.