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Generation of highly silicic magmas at ultra-high temperature conditions : evidence from melt inclusions in peritectic garnet

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Metamorphism at ultra-high temperature (UHT) conditions (i.e., $T > 900^\circ\text{C}$ and pressures from 7 to 13 kbar) is now recognized as a fundamental process of Earth's crust, and although progress has been achieved on its understanding, constraining melt generation and fluid regime at such extreme conditions is still poorly explored.

In this study we use former melt inclusions found in peritectic garnet to investigate anatexis and fluid regime of metapelitic granulites in samples from the Rundvågshetta area, the thermal axis of the Lützow-Holm Complex (East Antarctica). Peak P-T estimates are $925\text{-}1039^\circ\text{C}$ at 11.5-15 kbar. The studied rock is a coarse-grained heterogeneous metapelitic granulite with a predominant mafic residual domain and a relatively more felsic, melt-rich domain. The mineral association in the mafic domain typically contains orthopyroxene (Al_2O_3 6-8.1 wt.%) + sillimanite + quartz + garnet ($\text{Prp}_{42-55}\text{Alm}_{40-52}\text{Grs}_{3-4}\text{Sps}_{0.2-1}$; $X_{\text{Mg}} 0.5$) + K-feldspar (Kfs) + cordierite ($X_{\text{Mg}} 0.86$) + rutile \pm sapphirine \pm biotite ($X_{\text{Mg}} 0.75$; TiO_2 3.7-5.8 wt.%) \pm plagioclase (An_{35-46}). Interstitial Kfs and quartz with low dihedral angles are often present, in particular as thin films between sillimanite and quartz; these features are interpreted as evidence for the presence of former melt along the grain boundaries. In contrast, the more felsic, melt-rich domain is composed of mesoperthite + quartz + garnet + sillimanite + brown biotite ($X_{\text{Mg}} 0.7$; TiO_2 3.7-5.4 wt.%) + rutile, but is free of orthopyroxene. Cores of garnet porphyroblasts (0.2-0.8 cm, $\text{Prp}_{54-57}\text{Alm}_{39-42}\text{Grs}_{3-4}\text{Sps}_{0.2-0.6}$, $X_{\text{Mg}} 0.57$) in the melt-rich domains contain clusters of primary glassy inclusions (GI) and crystallized melt inclusions (nanogranitoids; NI) together with multiphase fluid inclusions (MFI) and accessory phases (mainly rutile and apatite).

The GI (5-20 μm) have negative crystal shapes and contain shrinkage bubbles with or without CO_2 and N_2 . In some cases, GI may have trapped apatite and rutile. Micro-Raman investigation suggest that the H_2O contents of these glasses range from 0 to 3.4 wt.%. Glasses are weakly peraluminous ($\text{ASI}=1\text{-}1.1$), have high SiO_2 (76-78 wt.%), very high K_2O (6.5-10 wt.%) and extremely low CaO and FeO+MgO contents.

The NI have variable sizes (10-150 μm) and often contains intergrowth of plagioclase + quartz, K-feldspar (Kfs) and biotite (Bt). Less frequently NI may have euhedral to subhedral grains of Kfs and Bt. Trapped phases are apatite and rutile, except for one inclusion that contains the sapphirine + quartz pair indicating that melt inclusions were trapped at UHT conditions.

The MFI are composed of CO_2 (with densities from 0.23 to 0.93 g/cm^3) and step-daughter magnesite, pyrophyllite. Methane, N_2 or H_2O were not detected.

Our results show that anatexis of metapelites at extremely hot conditions occurred in the presence of COH fluids and generated highly silicic, weakly peraluminous, mildly to strongly potassic magmas with low H_2O contents. Additional trace element data will be acquired to shed light on further geochemical fingerprints of these peculiar magmas.