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Melt inclusions and origin of granite in migmatitic granulites from the Kerala Khondalite Belt, Southern India

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Both glassy and crystallized melt inclusions (MI) occur in garnet in metapelitic granulites from the Kerala Khondalite Belt. These rocks were metamorphosed and partially melted at UHT conditions during the Pan-African event, and MI represent droplets of the anatectic melt, originated by dehydration melting of biotite and trapped by garnet growth at supersolidus conditions. An extensive ESEM-BSE mapping study, along with EMPA analysis and re-heating experiments, has been carried out to characterize these anatectic MI. The inclusions range from 4 to 35 µm in diameter and occur as clusters in garnets. In spite of the long time it took for these rocks to cool below 350 °C (at least 60 m.y.), different degrees of crystallization were observed in the same cluster, ranging from totally crystallized to totally glassy.

The crystallized MI are referred to as "nanogranites" (Cesare et al., 2009) and always contain quartz, Mg-rich biotite (XFe=0.23) and two feldspars in a fine-grained polycrystalline aggregate. Based on microstructural evidence, biotite crystallized as first phase, preferentially on the walls of the MI, while quartz and feldspars crystallized later, often forming graphic intergrowths and/or melt pseudomorph-like structures ($\geq$ 50 nm) similar to coarser structures ($\approx$ tens of microns scale) observed in the host rocks. The glassy inclusions are rare (about 15% of the total) and smaller in size ($\leq$15 µm in diameter) compared to the crystallized nanogranite MI. Both MI types often show negative crystal-shape and contain trapped crystalline phases that are accessories in the host rock, including rutile, titanite, zircon, apatite and Zn-rich spinel. Partially crystallized MI have been also recognized, containing an amorphous phase identified as a residual melt Where Cl and Ca are preferentially partitioned.

Re-heating experiments in a HT hearing stage succeeded in re-homogenizing the nanogranite inclusions. EMP data on 40 re-homogenized MI show an average SiO2=73 wt%, K2O =6.7 wt%, Na2O =1 wt% and CaO <1 wt%. EMP analyses on the primary glassy inclusions in not re-heated samples provide similar compositions, while the differentiated melt in partially crystallized MI has higher CaO content and lower K2O content. The EMP characterization therefore confirms the work hypothesis that the different types of MI had the same original composition, except for the different trapped accessories, and that melt in partially crystallized MI is the result of a differentiation of the original trapped melt via crystal fractionation. The low Na content of melt in inclusions is consistent with the scarcity or absence of plagioclase in the melanosome of the studied samples, and with the UHT conditions at which the rocks melted. In fact, in the Q-Ab-An diagram melts plot far from the haplogranitic minima.

Our results show that MI studies represent a powerful novel approach in the petrology of crustal melting and S-type granite genesis, and highlight the potential pitfalls of assuming anatectic melt as having a minimum melt composition.

References

Cesare, B., Ferrero, S., Salvioli-Mariani, E., Pedron, D., Cavallo, A., 2009. Nanogranite and glassy inclusions: the anatectic melt in migmatites and granulites. Geology 37, 627-630.