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Processes and timescales of melt metasomatism in the continental lower crust of West Greenland

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The lower continental crust is infiltrated by mantle-derived melts that are at extreme chemical disequilibrium with this reservoir. The chemical effect, and the degree and extent of melt infiltration within the lower crust are important parameters to investigating the role of this process in modifying local and regional crustal composition. However, in spite of ground-breaking contributions in this field, the processes of melt metasomatism within the lower crust are not entirely clear. Challenges lie in obtaining primary petrological, geochemical and chronological information from deep crustal rocks that are difficult to sample and are often repeatedly recrystallized and chemically modified.

In this study, we investigated mafic granulite xenoliths from the crustal root of the Archean North Atlantic Craton (Sarfartôq location) and the adjoining Paleoproterozoic Nagssugtôqidian Orogen (Sisimiut location), West Greenland. These rocks were chosen because: 1) they are xenolith and hence are unaffected by tectonic overprinting, 2) they show a rich petrological record of melt infiltration formed in the run up to their scavenging by the host aillikite magmas, 3) they represent two locations with similar crustal composition and architecture, but different underlying lithospheric mantle enabling teasing-out of the role of melt-mantle interaction.

We used various imaging techniques and in-situ chemical analysis by electron-probe micro-analyzer to characterize the different melt pockets within the samples, their textural relationships, as well as their composition. In addition, we performed thermometry and multi-method speedometry (Fe-in-rutile, majors-in-garnet) to assess the conditions and duration of melt infiltration for melts of different texture and composition.

The primary granular assemblage of the xenoliths has been infiltrated by three different types of melts, each of which is found in grain boundaries, melt-corroded cracks, and voids formed by melt-mediated dissolution and re-precipitation. These melts are either lamprophyric, felsic or carbonatitic, with the latter two occurring only at Sisimiut. Speedometry shows that melts have been present in the Sarfartôq samples since c. 700 Myr before eruption. For the more strongly metasomatized Sisimiut samples, these time scales typically exceed millennia, in particular for carbonatitic and associated felsic melt pockets. These differences are attributed to a fundamental difference in granulite grain size and texture, as well as to the degree of depletion of the underlying mantle, which to a large extent controls the duration of pre-eruptive crustal fluxing and the compositional evolution the metasomatic agents.