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Fluid-fluxed melting and the origin of hornblendites in Archean TTG

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Most of the preserved Archean continental crust is composed of deformed and metamorphosed sodic granitoids of the tonalite-trondhjemite-granodiorite (TTG) suite that are associated with diverse mafic to ultramafic rocks. Most TTGs formed through partial melting of hydrated mafic crust, where hornblende or garnet are important residual phases, and/or by hornblende-controlled fractionation of hydrous basaltic magmas [1]. In this context, water plays a key role in transforming primitive mantle-derived magmas into buoyant and evolved continental crust [2]. In this study, we investigate the origin of hornblendites (>90 vol.% hornblende) preserved as pods or lenses in Archean TTGs from the mainland Lewisian Gneiss Complex in NW Scotland by combining bulk rock geochemistry and microprobe analyses with phase equilibrium modeling.

The three studied hornblendite samples are composed of hornblende (91%), quartz (7%), plagioclase (2%) and accessory minerals (zircon, and apatite). Mg- and Al–rich calcic amphiboles exhibit different textures: i) ~5mm large crystals with pargasitic cores, Mg-hornblende mantles and actinolitic coronae; ii) <500 μm small actinolite grains with minor Mg-hornblende cores form the groundmass around the large crystals; and iii) vermicular actinolite–quartz intergrowths. These different textures and chemical compositions indicate different generations of amphibole, possibly formed at different *P–T* conditions. To test whether the hornblenditic pods were in equilibrium with TTG melts, approaches considering fluid-saturated and fluid-undersaturated scenarios have been considered. The obtained mineralogy (hornblende, augite, quartz) and water content (~12%) of the hornblendites is consistent with them having been fully hydrated and equilibrated at conditions around the wet granite solidus. The nearly monomineralic composition of the hornblendites could be interpreted to indicate that these rocks represent mafic enclaves that were entrained in the TTG melt and exposed to extensive melt-induced metasomatism during migration and emplacement of TTG magmas. An alternative interpretation is that the hornblendites are residues of fluid-fluxed melting of mafic rocks, which is predicted to produce a hornblende-rich residue [3]. This interpretation is consistent with the compact nature of the hornblenditic pods, as entrainment typically softens the rocks and mechanically disaggregates them.

[1] Foley, 2002. *Nature*, *417*(6891)
[2] Hartnady, 2022. *EPSL*, *594*(117695)
[3] Pourteau, 2020. *EPSL*, *550*(116548)