Multi-stage metasomatism and metamorphism of the Mesoarchean Ulamertoq ultramafic rocks in southern West Greenland

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Archean geological units are widely exposed in southern West Greenland. Ultramafic rocks occur as large, lens-shaped bodies within gneisses and/or granitic rocks. The largest ultramafic body - the Ulamertoq peridotite body (1 km x 1.5 km) - occurs in the Mesoarchean Akia Terrane of the region. The origin of these ultramafic rocks and their tectonic setting remain unclear: (i) residues after partial melting (Friend et al., 2002; Friend and Nutman, 2011), or (ii) ultramafic cumulates formed by mafic mineral accumulation or crystallization from komatiitic melts (Szilas et al., 2018). However, anthophyllite-bearing phlogopitite and amphibole-rich rock layers are observed along the boundary between the host orthogneiss and the ultramafic body. Orthopyroxenite veins/networks are also observed near the country rock contact. These petrological characteristics indicate that the Ulamertoq peridotites experienced metasomatic events involving the surrounding granitic rock/gneiss. Moreover, hydrous minerals such as phlogopite and amphibole, as well as orthopyroxene are not restricted to the boundary areas but are heterogeneously distributed throughout the body. In terms of their geochemistry, HFSEs (Ti and Zr) abundance of whole-rock and minerals of the amphibole-rich rock along the surrounding metamorphic rock are low. On the other hand, an Opx-nite vein near the boundary shows positive Sr, Zr anomalies and TiO_2 contents of amphibole are high. These features suggest that hydrous mineral-rich layers and orthopyroxenite veins/networks were formed by invading hydrous fluids rich in alkalis and by silica-rich melts, respectively. Orthopyroxene in the peridotite main body, far from the contact with the orthogneiss, occurs as fine grained and/or poikilitic aggregates, with low Cr_2O_3 and Al_2O_3 contents, consistent with metasomatic secondary/metamorphosed orthopyroxene (Arai,1974; Ishimaru et al., 2007). Hence, the whole rock chemical trend is likely consistent with metasomatic addition of amphibole and orthopyroxene to the dunitic rocks rather than partial melting trends. On the other hand, titanian clinohumite, ilmenite, magnetite-inclusions in olivine and high forsterite contents of olivines in a dunite indicate their deserpentinized origin. The dehydration process is supported by the similar trace elements abundance of orthopyroxene in titanian clinohumite-bearing dunite and harzburgite to deserpentinized peridotites observed in the Almirez massif (Marchesi et al., 2013). In conclusion, the Ulamertoq peridotites experienced multiple stages of metasomatic and metamorphic events: initial hydration followed by dehydration at 800-900˚ under <2GPa conditions (Nishio et al., 2019), the early stage metasomatism that formed amphibole and orthopyroxene in the main peridotite body, and finally followed by the latest stage of metasomatism related to granitic rock intrusion [600-650˚C and below 1 GPa conditions (Whyatt et al., 2020)]. It should be emphasized that the effect of geochemical and petrological modifications due to multi-stages of metasomatism and metamorphism are required to constrain the origin of the ultramafic body.

Keywords: Ultramafic rock, Metasomatism, Archean, Greenland, Deserpentinization

