Clusters of aligned, highly elongate, prismatic quartz (Qtz) rods occur in a few fayalite (Fa) crystals in an eulysite from a recently identified ~1.8 Gy UHP site in central West Greenland (Glassley et al. 2014). Additional detailed analyses of the crystallography and phase compositions of these olivines were conducted to evaluate the postulate that the Qtz rods formed during inversion of super-silicic ahrensite to Fa+Qtz during decompression. These new observations show the Qtz rods consistently occur in crystallographically coherent clusters with the Qtz grains aligned parallel to [100] of Fa. The contrasting compositions of coexisting primary UHP Fa and Fa postulated to have formed by inversion of ahrensite are consistent with the inversion scenario. We thus conclude that all available data are consistent with the postulate that ahrensite was part of the equilibrium phase assemblage formed during UHP metamorphism and that it inverted to Fa+Qtz upon decompression. If true, this would represent the first occurrence of terrestrial ahrensite formed through natural tectonic processes.

Keywords: Ahrensite, UHP, quartz exsolution, fayalite, Greenland

INTRODUCTION

In an earlier paper documenting evidence for a new UHP regime (ca. 6–8 GPa at ~1000 °C; ~1.8 Gy) in central West Greenland (Glassley et al. 2014), we reported the occasional occurrence of quartz “lamellae” (for reasons noted below, we will henceforth refer to these as rods) in fayalitic olivines (Fa) in sample 123220, an Fe-Mn-rich olivine-pyroxene-quartz-garnet metasediment (eulysite) that forms part of the collection at the Aarhus University. Because the rods are prismatic, clustered in parallel arrays, and have a uniform morphology reminiscent of exsolution features, we postulated they formed as a result of exsolution from the host Fa. Super-silicic Fa has not been reported in the literature, but excess silica has been reported for spinel-structured olivines (i.e., the wadsleyite-ringwoodite series) from experimental studies (Akaogi and Akimoto 1979; Irifune and Ringwood 1987; Hazen et al. 1993). Theoretically, therefore, spinel-structured, super-silicic olivine could exsolve silica upon decompression and inversion to olivine. On the basis of these experimental results we therefore postulated that the Qtz rods formed in response to inversion of high-pressure super-silicic ahrensite (Fe-rich ringwoodite) to Fa during decompression, the reaction being

\[
\text{Fe}_2\text{SiO}_4 + (\text{Fe}_2\text{SiO}_4 + \Box\text{SiFe}_2) \leftrightarrow \text{Fe}_2\text{SiO}_4 + 2\text{SiO}_2 \\
(\text{ahrensite}) \quad (\text{Fa}) \quad (\text{Qtz})
\]

where excess Si in the ahrensite is accommodated via a vacancy substitution mechanism in which \(\Box\text{SiFe}_2\) (Day and Mulcahy 2007) occurs. If correct, sample 123220 contains the first known occurrence in which ahrensite resulted from tectonic processes on Earth rather than shock-induced transformations related to meteorite impacts (Xie et al. 2002; Feng et al. 2011; Ma et al. 2014, 2016) or anthropogenic activity (Diaz-Martinez and Ormø 2003).

To further document the characteristics of this unusual phase relationship, we report here the results of additional optical and chemical analyses of this sample. This research involved a grain-by-grain examination of every olivine crystal in a thin section of sample 123220, and further comparison of the observed olivine compositions with published experimental data of olivine (α-phase) and Fe-ringwoodite (i.e., ahrensite; γ-phase).

ASSUMPTIONS

If the Qtz rods formed as a result of exsolution, a systematic relationship would be observed in thin section in which: (1) the crystallographic orientation of the host Fa and the elongation direction of the rods is consistent; (2) the crystallographic orientation of the Fa host and the enclosed Qtz rods is consistent (which also requires that all of the rods in a given host have the same crystallographic orientation); and (3) all of the rods occur along a low-energy interface such as a primary crystallographic axis. Assuming that the rods are aligned parallel to one of the principal Fa crystallographic axes, the maximum elongation of the Qtz rods would be observed when the crystallographic axis of interest lay in the plane of the thin section. When that same crystallographic axis is oriented perpendicular to the plane of the thin section, the rods would be seen in cross section and exhibit minimum dimensions. In any other orientation, the maximum rod length would be some intermediate value, the absolute magnitude of which would depend upon the angle between the axis of interest and the plane of the thin section. Hence, if the rods result from exsolution, a sufficiently large number of measurements would exhibit a correlation between measured rod lengths and the Fa crystallographic orientations. In addition, all Qtz rods