High-resolution TEM study of jimthompsonite, chesterite, and chain-width disorder in Archean ultramafic rocks from Isua, West Greenland

HIROMI KONISHI,1 HUIFANG XU,1,* AND ROBERT F. DYMÉK2

1Department of Geoscience, University of Wisconsin, Madison, Wisconsin 53706, U.S.A.
2Department of Earth and Planetary Sciences, Washington University in St. Louis, Saint Louis, Missouri 63130, U.S.A.

ABSTRACT

Jimthompsonite and chesterite occur as intergrowths within anthophyllite up to a few millimeters across in talc-magnesite schist from the ~3800 Ma Isua Supracrustal Belt, West Greenland. Pyribole lamellae span the entire intergrowth width and have their own crystal faces. The schist is strongly foliated and pyribole intergrowths are aligned with this foliation indicating broad synchronicity among metamorphic deformation, recrystallization, and pyribole formation.

Chain-width errors, polytypic disorder, zipper terminations, displacive planar faults, replacement products by sheet silicates, polygon-shaped cavities, cavity-filling materials, and low-angle grain boundaries were revealed by HRTEM. Based on cross-cutting relationships, the order of the formation of these defects was determined. Pyribole intergrowths formed prior to displacive planar faults and cavity-filling materials. Fine sheet silicates replaced pyroboles or filled cracks after the pyribole intergrowth formation. No obvious reaction or replacement products by talc or chlorite were confirmed at the interface between pyroboles and optically recognizable large sheet silicates, suggesting that fine sheet silicates replacing pyroboles formed later than talc and chlorite. Polysomatic and polytypic lamellae may have grown simultaneously because the lamellae cross cut each other and one does not affect the formation of the other.

The possible reaction fronts that separate jimthompsonite or chesterite from anthophyllite were not found in [001] HRTEM images of our samples. Instead, narrow jimthompsonite and chesterite lamellae that break termination rules were commonly found. These textural features can be better understood as a simultaneous growth of jimthompsonite, chesterite, and anthophyllite and not as a retrograde reaction product of anthophyllite.

Keywords: Jimthompsonite, chesterite, anthophyllite, pyribole, chain-width disorder, high-resolution TEM, Isua, West Greenland

INTRODUCTION

The structures of pyribole minerals can be understood as various combinations of (010) pyroxene layer (P) and mica layer (M) modules (Thompson 1970, 1978). For example, amphibole (MP: double-chain silicate) has a structure with a regular alternation of M and P modules, whereas triple-chain silicates have an arrangement of MMP. Pyriboles provide excellent examples of polysomatism in which intermediate compositions and structures occur and in which others can readily be hypothesized.

Natural triple-chain silicate jimthompsonite (MMP) [(Mg,Fe2+)2Si6O16(OH)2], mixed double- and triple-chain silicate chesterite (MMPMP) [(Mg,Fe2+)4Si10O34(OH)6], and their monoclinic polymorphs were first described from the black wall zone of a metamorphosed ultramafic body in Chester, Vermont (Veblen et al. 1977; Veblen and Burnham 1978a, 1978b). Veblen et al. (1978b) interpreted that Chester jimthompsonite, chesterite, and their monoclinic polymorphs are formed from hydration of anthophyllite or cummingtonite by solid-state reactions. Synthetic Na triple-chain silicates were reported (Drits et al. 1975; Tateyama et al. 1978), but jimthompsonite, chesterite, and their polymorphs have not been successfully synthesized.

The other occurrences of optically recognizable coarse jimthompsonite, clinjimthompsonite, or chesterite include an anthophyllite-cordierite rock from Orijarvi, Finland, Lewisian amphibolite-facies ultramafic rocks near Achmelvie, N.W. Scotland, cummingtonite-biotite schist at Norseman, Western Australia, and talc-chlorite schist in Western Australia (Schumacher and Czank 1987; Akai et al. 1997; Droop 1994). Proto-polymorphs of jimthompsonite and chesterite were found in contact metamorphosed ultramafic rocks from Hayachine, Japan (Konishi et al. 2008). In addition to these occurrences, several other occurrences of sub-micrometer pyroboles were described using high-resolution transmission electron microscopy (HR-TEM) (Jefferson et al. 1978; Veblen and Buseck 1981; Whittaker et al. 1981; Akai 1982; Cressey et al. 1982; Yau et al. 1986;