Proto-polymorphs of jimthompsonite and chesterite in contact-metamorphosed serpentinites from Japan

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ABSTRACT

Proto-polymorphs of jimthompsonite and chesterite occur in metamorphosed serpentinites from two Japanese ultramafic complexes. The lattice constants of the proto triple-chain silicate, measured by X-ray diffraction, are $a = 0.93605(208)$, $b = 2.72560(588)$, and $c = 0.53160(89)$ nm, whereas those of the mixed double- and triple-chain silicate are $a = 0.94202(78)$, $b = 4.54402(392)$, $c = 0.53440(45)$ nm, and $\beta = 90.026(18)^\circ$. The lattice constants and systematic extinctions revealed by selected-area diffraction patterns are consistent with proto-triple-chain silicate ($P_{bcn}$) and mixed double- and triple-chain silicate ($A_2/m, A_{2m}$), but not with the ortho- and clino-polymorphs. High-resolution transmission electron microscopy [016] images of the triple-chain silicate and [0 1 15] images of the mixed-chain silicate indicate they have a (X) configuration. Proto forms of wide-chain pyriboles might be geologically widespread.

Keywords: Protopyribole, jimthompsonite, chesterite, protoanthophyllite, biopyriboles, serpentinite, HRTEM, Hayachine

INTRODUCTION

The biopyribole minerals provide excellent examples of polysomatism, a concept that not only explains structural and chemical similarities in the mica, pyroxene, and amphibole groups, but also can be used to predict new structures by combining layer modules (Thompson 1970, 1978). For example, combinations of pyroxene [P; Mg$_4$Si$_4$O$_{12}$ or Ca$_2$Mg$_2$Si$_4$O$_{12}$] and mica [M; Mg$_3$Si$_4$O$_{10}$(OH)$_2$] modules parallel to (010) can be used to describe the range of biopyribole structures such as double- (MP), triple- (MMP), and mixed double- and triple-chain (MMPMP) silicates (Thompson 1978). The recent discovery of mixed single- and double-chain silicate (MPP) at high temperature and pressure suggests that further exploration of composition-temperature-pressure space may yield new biopyribole species (Grobety 1996; Yang et al. 2001).

Biopyribole structures can also be viewed as consisting of SiO$_4$ tetrahedral and MO$_6$ octahedral layer modules parallel to the $b$-$c$ plane (Thompson 1981). The octahedral layers can have either of two orientations, with one related to the other by a half-rotation around the $c$ axis. Different octahedral orientations between adjacent tetrahedral layers cause different stacking sequences. The arrangements of these layer modules can be used to predict the structures of polymorphs of each biopyribole family member. Each structure may have a specific stability field, and their fine textures may record kinetic processes during igneous or metamorphic events. Thus, the various polymorphs and the fine textures they produce are potentially important for interpreting the geological histories of the rocks that contain them.

Triple-chain and mixed triple- and double-chain silicates were first reported from Chester, Vermont, and were named jimthompsonite [Mg$_{10}$Si$_{12}$O$_{32}$(OH)$_4$; $P_{bcn}$] and chesterite [Mg$_{17}$Si$_{20}$O$_{54}$(OH)$_6$; $A_2/m, A_{2m}$] (Veblen and Burnham 1978a, 1978b; Veblen et al. 1977). Their monoclinic polymorphs are, respectively, clinojimthompsonite ($C_{2}/c$) and an unnamed mineral ($A_2/m$) (e.g., Droop 1994; Konishi et al. 1993; Veblen and Burnham 1978a, 1978b; Veblen et al. 1977). Thompson (1981) and Veblen (1981) suggested the possibility that the proto varieties of jimthompsonite and chesterite may exist based on the analogy of the relation of protoenstatite and protoamphibole to their polymorphs (Gibbs 1969; Gibbs et al. 1960; Smith 1959). The recent discoveries of protoamphiboles from pegmatites and a metamorphosed Mn deposit (Sueno et al. 1998) increased the likelihood that proto varieties of jimthompsonite and chesterite occur naturally.

In this paper, we report the first occurrences of the proto...