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Synthesis and characterization of amphiboles along the tremolite–glaucophane join

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ABSTRACT

Actinolite and glaucophane are the principal amphiboles in greenschist- and blueschist-facies metamafic rocks, respectively, and constitute an important mineral pair for deducing the conditions of medium- and high-pressure metamorphism. Here we present the crystal-chemical properties of amphiboles synthesized along the tremolite–glaucophane join as an important starting point for the more chemically complex samples occurring in nature. Amphiboles were synthesized in 10 mol% increments at conditions ranging from 840 °C and 0.6 GPa for tremolite-rich to 750 °C and 2.5 GPa for glaucophane-rich amphiboles. The amphibole yields were generally high (~95 wt%), though minor quartz, pyroxene, and amorphous material (either glass or quenched solute) were often present. Electron microprobe analysis of the amphibole showed that deviations from the nominal or intended compositions occurred, with the observed compositions showing solid solution primarily toward the katophorite component and reaching a maximum near the middle of the join. Unit-cell dimensions showed a pronounced positive deviation from ideality, even after (linear) correction for the non-join components, suggesting a strong tendency toward exsolution. Single-crystal refinements of a couple of selected amphiboles confirmed the deviation from nominal composition and confirmed the presence of ${}^{A}Na$, ${}^{T}Al$, and ${}^{C}Al$, the latter disordered between the *M*(2) and *M*(3) sites. Infrared spectra in the OH-stretching region were measured on samples that were heated to 250–350 °C to remove absorbed moisture. The spectra consist of a main band centered in the 3675–3660 cm^{-1} region and two minor absorptions on both sides of the dominant central peak, which are centered at 3720 and 3640 cm^{-1} and can be attributed to OH next to ${}^{A}Na$ and ${}^{C}Al$, respectively. The main band is evidently composed of several overlapping components due to local arrangements of B cations typical of tremolite, CaCa, glaucophane, NaNa, and cummingtonite, MgMg. Examination of several intermediate amphiboles by both single-crystal XRD and by high-resolution TEM analysis could not identify evidence of reflections or ordered domains that would violate the *C*2/*m* symmetry of the end-member amphiboles. Comparing the compositions of the synthetic amphiboles from this study with winchite-rich amphiboles in nature shows that deviations from the tremolite–glaucophane join are common. The inability to make pure winchite or even winchite-rich amphiboles on the tremolite–glaucophane join suggests that this structure is unstable.

Keywords: Glaucophane, tremolite, winchite, katophorite, high-pressure metamorphism, unit-cell dimensions, short-range order, HRTEM, FTIR