

Infrared and TEM characterization of amphiboles synthesized near the tremolite-pargasite join in the ternary system tremolite-pargasite-cummingtonite

DAVID M. JENKINS,^{1,*} KRASSIMIR N. BOZHILOV,² AND KIYOTAKA ISHIDA³

¹Department of Geological Sciences and Environmental Studies, Binghamton University, Binghamton, New York 13902-6000, U.S.A.

²Central Facility for Advanced Microscopy and Microanalysis, Institute of Geophysics and Planetary Physics, University of California, Riverside, California 92521, U.S.A.

³Department of Evolution of the Earth and the Environment, Graduate School of Social and Cultural Studies, Kyushu University, 4-2-1 Ropponmatsu, Chuo-ku, Fukuoka 810-8560, Japan

ABSTRACT

High-resolution transmission-electron microscopy (HRTEM) and infrared spectroscopy (FTIR) analyses have been done on amphiboles near the join tremolite [$\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2 = \text{TR}$]-pargasite [$\text{NaCa}_2\text{Mg}_4\text{Al}_3\text{Si}_6\text{O}_{22}(\text{OH})_2 = \text{PG}$] in the ternary system tremolite-pargasite-cummingtonite [$\text{Mg}_7\text{Si}_8\text{O}_{22}(\text{OH})_2 = \text{MC}$] that were synthesized previously by Sharma and Jenkins (1999). Representative samples across the join were examined in detail by HRTEM to document the presence and concentration of chain multiplicity defects (CMFs). There was relatively little change in the defect density with composition, with the tremolitic sample (TREM 23-13) having the highest defect concentration (6%) and the more PG-rich samples having slightly lower CMF concentrations (4–5%). CMFs with multiplicities of 1, 3, 4, 5, and 6 were observed, usually as isolated chains, with the most common being triple-chain slabs. Correction of the bulk composition of the tremolitic amphibole for the presence of these Mg-rich, wide-chain defects reduces the MC content from an apparent value of 8.5 to 4–7.5 mol% MC, depending on which composition is used for the triple-chain defect. The entire amphibole join was examined by FTIR spectroscopy in the OH-stretching region (3000–3800 cm^{-1}) for the purpose of determining the presence of short-range order. A total of 10 component bands were fitted to the spectra across the join. These bands were assigned to specific cation configurations on the basis of earlier studies of the FTIR spectra of chemically simplified amphibole joins pertinent to this study. The extent of short-range order was qualitatively determined by comparing the observed intensities for groups of related bands, corrected for differences in their molar absorptivities, to their calculated intensities based on random-mixing probabilities. From this exercise, it is observed that the intensities of sodic amphibole configurations are consistently high, tremolite is lowest near the middle of the join, and aluminous amphibole configurations cross over from being higher (at low Al contents) to being lower (at high Al contents) than expected near the middle of the join. These differences between observed and predicted band intensities may reflect the presence of deviations in the thermodynamic activities of amphibole components from those predicted on the basis of random-mixing models.