

The dehydroxylation of serpentine group minerals

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ABSTRACT

The thermal transformation, stability field, and reaction kinetics of serpentine minerals (antigorite, chrysotile, and lizardite) have been studied to draw a comprehensive model for their dehydroxylation and recrystallization reactions. In situ X-ray powder diffraction (XRPD) and kinetic studies were combined with transmission electron microscopy (TEM) observations to describe the mechanisms of dehydroxylation and later high-temperature crystallization. During dehydroxylation, a metastable transition phase with a characteristic peak around 9 Å was observed in antigorite and, to a minor extent, in lizardite. Rietveld refinements confirmed that the 9 Å phase actually possesses a talc-like structure. The appearance of this phase is controlled by structure and kinetic factors.

The kinetic parameters and reaction mechanism for lizardite and antigorite dehydroxylation in air at ambient pressure were calculated using the Avrami models and compared to those of chrysotile. For both lizardite and antigorite, the kinetics of dehydroxylation is controlled by diffusion. Apparent activation energy of the reaction in the temperature range 612–708 °C was 221 and 255 kJ/mol for lizardite and antigorite, respectively. The reaction sequences of chrysotile, lizardite, and antigorite leading to the formation of stable high-temperature products (i.e., forsterite and enstatite) are described taking into account previous topotactic and dissolution-recrystallization models.

Keywords: Main serpentine minerals, dehydroxylation, reaction kinetics, Avrami, metastable phases