American Mineralogist, Volume 87, pages 1699–1709, 2002

Hydrothermal alteration of olivine in a flow-through autoclave: Nucleation and growth of serpentine phases

CHARLES NORMAND,* ANTHONY E. WILLIAMS-JONES, ROBERT F. MARTIN, AND HOJATOLLAH VALI

Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal (Que), Canada, H3A 2A7

ABSTRACT

A single-pass flow-through experiment was conducted to induce serpentinization, and to relate serpentine mineralogy to reaction progress during open-system alteration of San Carlos olivine by air-saturated water. The fluid flowed at 300 °C and 300 bars for 1368 hours through crushed olivine contained in a tubular titanium reaction cell. Chemical analysis of the fluids indicated a steady-state composition with respect to Mg and pH after 550 hours, which was interpreted to reflect saturation with brucite and one or more serpentine-group minerals. The alteration products were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and high-resolution transmission electron microscopy (HRTEM). Nucleation and growth characteristics of serpentine phases on the fracture surfaces of olivine were studied by TEM using platinum/carbon replica techniques. After reaction, olivine fragments displayed clear signs of dissolution, and growth of neoformed phases. Brucite and magnetite were distributed uniformly through the reaction cell, although magnetite was more abundant. There is, however, a distinct zonal distribution of the serpentine phases from the inlet to the outlet of the reaction cell. Lizardite is the dominant serpentine phase at the inlet, whereas fibrous serpentines are predominant near the outlet. Lizardite crystals are more numerous (but smaller) in the middle of the cell, and are topotactically aligned along a single preferential crystallographic orientation of the olivine. Cylindrical chrysotile formed predominantly on the surfaces of lizardite, conical or polygonal serpentine. The morphology and sorting of the serpentine phases through the reaction cell suggest that crystallization of lizardite was controlled by heterogeneous nucleation on olivine under supersaturated conditions, and crystallization of chrysotile by nucleation on lizardite at higher levels of supersaturation.