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Analytical transmission electron microscopy study of a natural MORB sample assemblage transformed at high pressure and high temperature

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Abstract

Natural mid-ocean ridge basalt (MORB) samples recovered from diamond-anvil cell (DAC) experiments performed between 33 to 89 GPa and 1700 to 2600 K were studied with a transmission electron microscope (TEM). We used the focused ion beam (FIB) lift-out technique to prepare the recovered high-pressure, laser-heated samples for TEM study. Observations of TEM sections show the presence of five phases for samples transformed at pressures ranging from 33 to 45 GPa: Al-bearing Mg-perovskite, Ca-silicate perovskite, stishovite, and two Al-rich phases. The Al-rich phases were identified by selected area electron diffraction (SAED) patterns and chemical composition analysis, and include the new aluminous (NAL) phase with hexagonal structure and the calcium ferrite (CF) type phase. Chemical analyses obtained by analytical transmission electron microscopy (ATEM) show that Mg-silicate perovskite is the major host for Al, with significant amounts also distributed between the CF-type and NAL phases, and less than 1 wt% in stishovite. Beyond pressures of ~40 GPa (~1100 km depth), the Al content of Mg-perovskite and CF-type phase increases. Between 45 and 50 GPa, the NAL phase disappears. This mineralogical change may explain reported seismic anomalies in subduction zones at mid-mantle depths.

Keywords: High-pressure phases, ATEM, aluminous phases, high-pressure MORB samples, lower mantle, perovskite