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In situ observation of the pyroxene-majorite transition in $Na_2MgSi_5O_{12}$ using synchrotron radiation and Raman spectroscopy of Na-majorite†

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Abstract

In situ X-ray diffraction study of the pyroxene to majorite transition in $Na_2MgSi_5O_{12}$ was carried out in Kawai-type high-pressure apparatus coupled with synchrotron radiation. The phase boundary between Na-pyroxene and Na-majorite was determined over the temperature interval of 1073–1973 K and was described by a linear equation P (GPa) = 12.39 + 0.0018×T (K). The Clapeyron slope (dP/dT) determined in this study is similar to the one predicted by computer simulations (Vinograd et al. 2011) but smoother than the one obtained by quenched experiments (Dymshits et al. 2010). The presence of sodium in the system lowers the pressure of pyroxene-to-majorite transformation. For the first time Na-majorite was characterized using Raman spectroscopy. Raman peaks of Na-majorite are broader than pyrope due to the substitution of Mg^{2+} for Na^+ at the X site. Both Si-O symmetric stretching (A_{1g}-ν_1) and O-Si-O symmetric bending (A_{1g}-ν_2) modes of Na-majorite are significantly shifted to higher frequencies relative to corresponding bands of pyrope. In contrast the A_{1g}-R (SiO_4) mode of Na-majorite (342 cm^{-1}) displays a lower frequency than that of pyrope (365 cm^{-1}). Our results enable further understanding of the mechanisms responsible for phase transformations in the Earth's transition zone and lower mantle.

Keywords: Na-pyroxene, Na-majorite, phase transition, in situ experiment, diamond, mantle