INTRODUCTION

The possible stability of Ca$_{0.5}$Mg$_{0.5}$SiO$_3$ perovskite (CM-perovskite) at high pressure is important for understanding the mineralogy of the lower mantle. This phase was first reported by Liu (1987) as a high-pressure polymorph of diopside with the cubic perovskite structure. However, the result was not consistent with other studies in which diopside breaks down into a cubic Ca$_2$SiO$_3$ perovskite phase and an orthorhombic Mg$_2$SiO$_3$ perovskite phase at pressures above 21 GPa (e.g., Mao et al. 1978; Tamai and Yagi 1989; Irifune et al. 1989). Kim et al. (1994) verified that a (Ca, Mg)Si$_2$O$_6$-glass transforms to Ca$_{0.5}$Mg$_{0.5}$SiO$_3$ cubic CM-perovskite at 13 GPa, whereas a diopside-crystal decomposes to CaSiO$_3$ cubic perovskite, Mg$_2$SiO$_4$ spinel and stishovite at 1800 °C when using a glass starting material. In another experiment using a crystalline pyroxene starting material, two cubic perovskites; Ca-perovskite and CM-perovskite, and orthorhombic Mg-perovskite formed simultaneously during the initial stage of the transformation. However, the cubic CM-perovskite subsequently decomposed into Mg- and Ca-perovskites and stishovite at 1200 °C. These results indicate that the assembly of cubic Ca-perovskite, orthorhombic Mg-perovskite and stishovite is stable and cubic CM-perovskite is a metastable phase at around 32 GPa and temperatures over 1000 °C in this system. Chemical analyses of product phases showed that Mg, Fe, and Al were preferentially partitioned into Mg-perovskite and the compositions of Ca-perovskite were close to pure CaSiO$_3$. The present study shows that CM-perovskite nucleates during the initial stage of Ca(Mg, Fe, Al)Si$_2$O$_6$ pyroxene transformation. Therefore, cold subducting slabs and impacted meteorites are the possible places in which CM-perovskite could exist. The Ca-rich glassy phase in a shocked chondrite (Tomioka and Kimura 2003) might have formed by vitrification of a metastable CM-perovskite-like phase.

ABSTRACT

We have carried out in-situ X-ray diffraction experiments on high-pressure transformations of a Ca- and Fe- rich pyroxene (Ca$_{1.03}$Mg$_{0.61}$Fe$_{0.23}$Al$_{0.14}$Si$_2$O$_6$) to investigate the stability of Ca$_{0.5}$(Mg, Fe, Al)$_{0.5}$SiO$_3$ perovskite (CM-perovskite) in a multi component system at about 32 GPa and up to 1900 °C. We observed that cubic CM-perovskite was formed at about 1300 °C and decomposed into cubic Ca-perovskites and orthorhombic Mg-perovskites and stishovite at 1800 °C when using a glass starting material. In another experiment using a crystalline pyroxene starting material, two cubic perovskites; Ca-perovskite and CM-perovskite, and orthorhombic Mg-perovskite formed simultaneously during the initial stage of the transformation. However, the cubic CM-perovskite subsequently decomposed into Mg- and Ca-perovskites and stishovite at 1200 °C. These results indicate that the assembly of cubic Ca-perovskite, orthorhombic Mg-perovskite and stishovite is stable and cubic CM-perovskite is a metastable phase at around 32 GPa and temperatures over 1000 °C in this system. Chemical analyses of product phases showed that Mg, Fe, and Al were preferentially partitioned into Mg-perovskite and the compositions of Ca-perovskite were close to pure CaSiO$_3$. The present study shows that CM-perovskite nucleates during the initial stage of Ca(Mg, Fe, Al)Si$_2$O$_6$ pyroxene transformation. Therefore, cold subducting slabs and impacted meteorites are the possible places in which CM-perovskite could exist. The Ca-rich glassy phase in a shocked chondrite (Tomioka and Kimura 2003) might have formed by vitrification of a metastable CM-perovskite-like phase.