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Phase relations and thermoelastic properties of Ca3Al2Si3O12 grossular garnet up to 26 GPa and 2000 K.

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Silicate garnet is in term of abundance, the most important mineral in basaltic composition and the second mineral in a pyrolitic mantle. Garnets are believed to play a significant role in the nature and dynamics of shallower mantle parts in the Earth, and therefore the determination of their P-V-T properties is of importance to infer the appropriate mineralogical and compositional model in this region. It is also suggested that garnet-rich subducted crust can be gravitationally trapped in the lowermost part of the Mantle Transition Zone (MTZ) [1,2]. Recent seismological observations showed occurrence of multiple discontinuity in that region, which might be the result of post-garnet transformations [3,4]. Thus, the study of post-garnet phases at high-P,T is of great interest to constrain the mineralogy and structure of the MTZ. Instead of Mg- and Fe-rich garnets, the high-P,T behaviors of Ca-rich garnets are still poorly constrained.
In order to clarify this situation, we examinated $Ca_3Al_2Si_3O_{12}$grossular garnet at high-P,T using Kawai-type multi-anvil apparatus coupled with in situ X-ray diffraction techniques. Recovered samples were analyzed by a combination of micro-focused x-ray diffraction and transmission electron microscopy. First we report a set of new thermoelastic parameters for the grossular garnet up to 20 GPa and 1650 K.
Then we report the high-P,T phase relations of $Ca_3Al_2Si_3O_{12}$in the range of 19-26 GPa and 700-2000 K. Our results showed that grossular garnet transforms into an Al-rich $CaSiO_3$perovskite with a grossular-like composition as observed by Yusa et al. [5]. This phase has an orthorhombic structure and is shown to be stable at 23-26 GPa and 1000-1400 K. We also report a new phase assemblages in the high-temperature domain of the phase diagram of $Ca_3Al_2Si_3O_{12}$. At temperatures above 1500 K, CAS phase (with the composition $CaAl_4Si_2O_{11}$) appears beside two distinct populations of Al-bearing $CaSiO_3$perovskites with Al content of 1.7 at% and 4.5 at% respectively
Al-content and structural features of the $CaSiO_3$perovskites are discussed in regards with mechanisms of incorporation of Al in the perovskites. Those new insights in the properties of Ca, Al-rich garnets and related post-garnet transformations are discussed as possible alternatives to understand regional structures in the lowermost part of the MTZ.

[1] Irifune and Ringwood (1993), EPSL 117(1-2)
[2] Karato et al. (1995), EPSL 130(1-4)
[3] Deuss et al. (2006), Science 311
[4] Saikia et al. (2008), Science 319
[5] Yusa et al. (1995), PEPI 92(1-2)

Keywords: Grossular garnet, High-P,T Phase relations, P-V-T, Crust subduction, Lowermost transition zone