I128-012 **Room: 201A** **Time: May 28 15:00-15:15**

Post-perovskite transformation in the Kawai-cell of sintered diamond cubes

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The post-perovskite transformation in $MgSiO_3$ is has been considered as a key factor to characterize seismological complexity observed in the lowermost part of the mantle, so-called D-double layer. Especially the location and the Clapeyron slope of the phase boundary between perovskite (Pv) and post-perovskite (PPv) are of special importance to clarify the structure and dynamics of D-double layer, which, however, have not been determined in required accuracy by experiments using the laser heated diamond cell (LHDAC). We examined the post-perovskite transformation in $MgGeO_3$, a typical analogous compound of $MgSiO_3$, by squeezing the Kawai-cell of sintered diamond (SD) cubes in the DIA-type press at SPring-8. SD cubes with 14.0 mm edge length and 1.5 or 1.0 mm corner truncation were employed with a 5.0 or 4.56 mm octahedral pressure medium of MgO + 5%Cr_2O_3. A fine mixture of 10$MgGeO_3$ (ilmenite-type, Il) + 1Au (pressure marker) (in weight ratio) was put in a cylindrical TiB_2 heater set in the octahedron together with a thin W/Re thermocouple. Identification of phases and volume measurement of Au were performed by in situ energy dispersive X-ray diffraction methods using polychromatic synchrotron radiation. Pressure determination was based on Anderson's scale. In the first run, the Pv formed at 61.4 GPa and 1170 K, and almost complete transformation to the post-perovskite (orthorhombic $CaIrO_3$-type, PPv) was confirmed at 63.3 GPa and 1323 K on heating. Then the press load was gradually decreased keeping temperature constant. The reversed transformation to Pv was not observed until pressure went down to 60.5 GPa. In the second run, Pv formed at 40 GPa and 1300 K persisted through repeated heating up to ca. 74 GPa and 1800 K, which, however, transformed to PPv at ca. 1900 K within 10 min. Attempts to see the reverse ended up with blow-out at ca. 68 GPa an 2200 K without noticing Pv phase. The observation demonstrates that reaction kinetics for both the reactions is very slow and determination of the phase boundary by traversing it is quite difficult. Therefore in the next two runs we tried to observe the phases converted from the Il or immature or even metastable Pv. Along the line, we observed growth of PPv at 63.5 GPa and 1500 K and at 64,2 GPa an 1700 K from Pv with broad diffraction peaks. We further confirmed the transformation to Pv from Il at ca. 63.3 GPa and 1600 K. The P-T points obtained as the stabilities for Pv and PPv phases constrain the phase boundary to be close to $P(GPa) = 0.005xT(K) + 56$ which locates at slightly higher pressures with a shallower slope than the boundary suggested by Hirose et al. [2005]. The slope of 0.005 GPa/K obtained in the present study is close to the lowest estimate for $MgSiO_3$. Therefore the PPv layer in D-double layer would be more limited even for a cold geotherm model if the Clapeyron slope is almost identical between $MgSiO_3$ and $MgGeO_3$.