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Phase relations and melt compositions in hydrous pyrolite system

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Many studies suggest that there could be significant amount of water in the deep Earth, especially in the mantle transition zone (Inoue et al., 1995; Kohlstedt et al., 1996). Water plays an important role in understanding the geodynamics process in the mantle, such as the melting behavior (Inoue, 1994; Kawamoto and Holloway, 1997), phase transformation (Ohtani and Litasov, 2006), and so on. To clarify the effect of water for the mantle peridotite, a series experiments were carried out in pressure range from 12 to 21 GPa and temperatures from 1400 degree C to 1600 degree C in pyrolite+water system, by using a Kawai-type multianvil apparatus with 3mm TEL second stage WC anvils in Ehime University. Some different compositions (Mg/(Mg+Fe)) of olivine were used for pressure calibration under high temperature, and 2cpx-geothermometer was used to estimate the temperature gradient in the run charge. The starting samples were the mixtures of "pyrolite - MgO" glass, MgO and $Mg(OH)_2$, thus the water contents were adjusted by the $Mg(OH)_2$/MgO ratio. The samples were sealed by AuPd capsules to prevent the loss of water. The recovered samples were polished, and the phases were identified by micro-Raman spectroscopy and X-ray diffraction pattern, the textures were observed by BEI, and the chemical compositions were measured by SEM-EDS system. Under hydrous condition, the phase boundary of olivine/wadsleyite moved to lower pressure, while the appearance of ringwoodite moved to higher pressure, and both phase boundaries became much sharper, compared with dry condition. Liquidus phase changed from garnet to garnet and stishovite, and finally magnesium perovskite at 21GPa.

Compositions of partial melts at 12-21 GPa had high Ca/Al ratio (4-13), and magnesium-rich with (Mg+Fe)/Si ratio larger than 1.7, which is beyond komatiite composition, and quite different from that of the partial melt from dry system. The water contents of hydrous melt were determined by mass balance calculations. It shows that the water content of melt is more than 10wt.% at 410km depth, even along the hot geotherm, which is much larger than the critical value reported by Matsukage et al.(2005) and Sakamaki et al.(2006). That means the hydrous melt may not be stable atop the 410km depth, and should migrate upwards into the mantle. Density calculation also gave the same conclusion. Thus the low velocity zone atop the 410 km depth reported by Revenaugh and Sipkin (1994) may not come from the melting of the mantle minerals.

Keywords: pyrolite, partial melt, water content, low velocity zone