Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT040-07 Room:104 Time:May 23 15:45-16:00

Study of melting phenomena under the deep mantle conditions

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It is known that the subducting plate carry the Earths surface materials (such as the basaltic crust) to the Earths deep interior. As a result of this process, the mantle is highly heterogeneous in chemical composition. At the core-mantle boundary, there is a possibility that Mid Ocean Ridge Basalt (MORB) exists and it causes the seismic anomalies. Seismological studies indicate the presence of Ultra-Low Velocity Zone (ULVZ) above the core-mantle boundary (Williams and Garnero, 1996). This region exhibits reduction of seismic velocities at least 10% and the thickness of this region is about 5 - 40 km. The most probable cause of the seismic velocity reduction is partial melting of the lowermost mantle.

In this study, We carried out melting experiments of MORB using a laser heated diamond anvil cell to investigate the melting phase relations of MORB. The phase relations in MORB were investigated from 31 to 156 GPa and 1500 to 4400 K by in situ X-ray diffraction experiments and chemical analysis of the quenched samples using field emission-scanning electron microscope (FE-SEM) and transmission electron microscopy (TEM). In-situ X-ray diffraction experiments were performed at SPring-8 to determine the subsolidus phase assemblage. The MORB composition consists of MgSiO3-perovskite, CaSiO3-perovskite, stishovite, and Al-rich phase (likely CaFe2O4-type Al-phase) in the upper part of the lower mantle. Stishovite transforms to CaCl2-type SiO2 phase above 60 GPa and 2000 K and further to alpha-PbO2-type phase above 110 GPa. Phase transition of CaSiO3-perovskite from tetragonal to cubic was also observed with increasing temperature. At 37 GPa, the first consuming phase is likely to be stishovite and the melting temperature is 2700 K. At 118 GPa, the first consuming phase is also alpha-PbO2-type SiO2 phase and the temperature is 3700 K.

Keywords: MORB, lower mantle, melting