

Phase Relations in MORB-H₂O System and Water Solubility in Perovskite and NAL-phase

Konstantin Litasov[1], Eiji Ohtani[2], Hisayoshi Yurimoto[3], Tomoaki Kubo[4], Tadashi Kondo[5]

[1] CNEAS, Tohoku Univ, [2] Institute of Mineralogy, Petrology, and Economic Geology, Tohoku University, [3] Earth & Planet. Sci., TiTech, [4] Tohoku Univ, [5] Sci., Tohoku Univ.

Subduction of oceanic lithosphere into the deep Earth interior is responsible for chemical heterogeneity in the lower mantle. The anhydrous Mid-Ocean ridge basalt (MORB) has different melting temperature and density changes with depth relative to peridotite. Therefore, parts of subduction slab, peridotite, basalt, and sediment, have different phase relations and water storage capacity with increasing pressure. Meanwhile water-bearing systems of the subducting slab components are still poorly studied. We present the results of high-pressure experiments on water-bearing peridotite and MORB, which is very important for water distribution in the mantle, changes in phase transitions, and seismic anomalies.

We provided high-pressure experiments in the system of multi-component MORB with 2wt% of H₂O. Phase relations were determined at 18-25 GPa and temperature range between 1000 and 2400°C. There were no dense hydrous phases, which are stable in the MORB at 18-25 GPa. We observed the expansion of stability field of Al-rich perovskite and NAL-phase (Miura et al., 2000; Mijajima et al., 2001) to the lower pressures. Al-rich perovskite was observed below 1400°C at 25 GPa, whereas in anhydrous experiments it is stable above 27 GPa at 1400°C. NAL-phase occasionally stable at 20-25 GPa and temperature below 1200°C. At the higher temperature at 20 GPa, NAL-phase is replacing by CAS-phase. We have supposed influence of water on stability field of the perovskite and NAL and provided additional experiments on water solubility in perovskite and NAL in the Fe-bearing and Fe-free systems. FTIR and SIMS data suggest that NAL phase contain no water (less than 30 ppm at 20-25 GPa).

Water solubility in the silicate perovskite is a matter of great debates. Meade et al. (1994) reported results of in situ FTIR measurement of water solubility in Mg-perovskite and documented two pleochroic hydroxyl absorbance peaks at 3483 and 3423 cm⁻¹, corresponding to 60-70 ppm H₂O. However, Bolfan-Casanova et al. (2000) showed absence of water (1 ppm H₂O) in Mg-perovskite. Preliminary data on water solubility in peridotite Mg-Al-Fe-perovskite (Al₂O₃=7 wt%, FeO_{total}=6 wt%) measured by SIMS and FTIR reveal about 0.1-0.2 wt% H₂O (Murakami et al., 2002). Our data suggest that water content in Mg-perovskite by FTIR is 80-110 ppm (peaks at 3423, 3448, and 3482 cm⁻¹); water content in Al-perovskite (3-6 wt% Al₂O₃) is 0.1-0.2 wt% by SIMS and less than 100 ppm by FTIR (with small peaks at 3397 and 3423 cm⁻¹), water content in Fe-Al-perovskite (FeO_{total}=22-26 wt%; Al₂O₃=14-17 wt%) is 120-140 ppm by FTIR (peaks at 3397 and 3423 cm⁻¹) and less than 0.05 wt% by SIMS. Therefore, we suggest that water incorporation into pure MgSiO₃-perovskite, Al-rich perovskite (Al₂O₃, up to 7 wt%) and MORB-related Fe-rich perovskite are restricted, but not entirely absent.

Study of hydrous pyrolite (Litasov and Ohtani, in prep.) and hydrous MORB show that DHMS could exist only in pyrolitic composition and under the conditions of subducting slabs descending into the lower mantle. At the normal mantle and hot plume conditions wadsleyite or ringwoodite are the major H₂O-bearing phases. Thus, transition zone, where these phases are stable in pyrolite, can be a major water reservoir in the Earth mantle, whereas distribution of water to the upper mantle and lower mantle is restricted along the normal mantle geotherm. In the MORB composition, lawsonite and phengite are stable up to 12-13 GPa under slab conditions (Schmidt and Poli, 1998). At the higher pressure, distribution of water to the MORB components is very restricted. Trace amount of water can be stored in garnet, stishovite, and Al-Fe-perovskite. Therefore, MORB cannot be considered as important water carrier to the lower mantle. We imply that water in the MORB can evaluate local variations in the density anomalies at the top of the lower mantle due to expansion of the stability field of Al-Fe-perovskite to the lower pressures.