Stability of dense hydrous phases in pyrolite-H2O system up to 25 GPa

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Series of experiments on hydrous mantle compositions were provided to evaluate the influence of water on stability field of the dense hydrous phases under high pressure. Phase relations in CMAS-pyrolite with 2 wt.percent of water were determined at 19-25 GPa and 1000-2400oC. Superhydrous B is stable in pyrolite at T below 1100oC and P=19 GPa and below 1300oC at 25 GPa. Al-rich hydrous phase was found at 1000oC and 19-25 GPa. Under the higher-T conditions, between 1000-1200oC and solidus, fluid/vapor-bearing segregations were observed. Superhydrous B could exist in pyrolitic composition only under the conditions of subducting slabs. Any exotic hydrous phases can not exist along the normal mantle geotherm.

Series of melting experiments on hydrous primitive mantle compositions were provided to evaluate the possible influence of water on stability field of the dense hydrous phases under high pressure. Phase relations and melt compositions in pyrolite with 2 wt.percent of water have been determined at 19-25 GPa and wide temperature range between 1000 and 2400oC. Anhydrous primitive mantle composition after Jagoutz et al. (1979) was simplified to system CaO-MgO-Al2O3-SiO2. Hydrous composition was prepared by addition of Mg(OH)2 adjusting the proportion of MgO. A Kawai 3000 tons and 1000 tons multianvil apparatuses were used for the present experiments. Platinum capsules were used as a sample container. Pressure was calibrated by blanketing the alpha-beta and beta-gamma phase boundaries of Mg2SiO4. Pressure uncertainty

We have found that Superhydrous phase B is stable in pyrolite at temperature below 1100oC and 19 GPa pressure and below 1300oC at 25 GPa. Beside, Al-rich hydrous phase (Al2O3=65-70 wt.percent, H2O=12-14 wt.percent) was found as inclusions in the central part of garnet grains (probably indicating metastable origin) at 19 GPa and 1000oC. The phase assembly was Superhydrous B + Ringwoodite + Gt + Al-rich hydrous phase +/- Cpx in this conditions. Al-rich hydrous phase was also found at 25 GPa and 1000oC and the phase assembly was MgPv + CaPv + Ringwoodite + MgO + Superhydrous B + Al-rich hydrous phase. Superhydrous phase B was also detected at 25 GPa and 1200oC, where total phase assembly was MgPv + CaPv + Superhydrous B + Gt + another Al-rich phase (similar with those reported by Irifune and Ringwood (1993) for MORB-mantle composition at 27 GPa).

Instead, under the higher temperature conditions between stability field of hydrous phases and solidus line, fluid/vapor-bearing segregations were observed in all samples. Fine-grained majoritic garnet is a major phase of these segregations, another were small unidentified phases or possible fluid phase. At the subsolidus condition water has been strongly partitioned to the melt phase. This is confirmed by lower total of the EPMA analyses of around 5-8 wt.percent the quenched melt formed by low degree of partial melting (<10 percent).

Our data suggest that Superhydrous phase B and probably phase G (in the water-saturated system) could exist in pyrolitic composition only under the conditions of subducting slabs descending into the lower mantle. Small amount of Al-rich hydrous phase was also identified for lowest-T experiments. Any exotic dense hydrous phases can not exist along the normal mantle geotherm. At the normal mantle and hot plume conditions modified spinel (wadsleyite, beta) or spinel (ringwoodite, gamma) phases are major water reservoirs.