

Hydrates in Synthetic Peridotites and Mechanisms of Hydrogen Transport at High Pressure

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The stability of hydrates (e.g. amphibole, chlorite and denser hydrous silicates) in ultramafic compositions is of primary concern to define physical properties of the mantle and of the subducted lithosphere. Although hydrous peridotites have been modeled in the simple MgO-SiO₂-H₂O (MSH) and MgO-Al₂O₃-SiO₂-H₂O (MASH) systems, more complex compositions are almost unexplored. This study focuses on the stability of chlorite structures and on their relations to other hydrates such as amphibole and 10Å phase in the model peridotite system Na₂O-CaO-FeO-MASH.

Piston cylinder and multianvil experiments were performed on three synthetic bulk compositions analogues of natural peridotites: a harzburgite, a Tinaquillo lherzolite and a particularly Al-enriched peridotite. Gels seeded with clinocllore, diopside, forsterite and pyrope were used as starting materials and run at 2.0-6.0GPa and 650°C-800°C. Runs lasted up to 430 hours. All experiments were performed at fluid saturated conditions and buffered with graphite. Run products were characterized by X-ray powder diffraction, backscattered and secondary electron images, and microprobe analyses.

In the Al-enriched peridotite, the amphibole + chlorite bearing assemblage was found at 2.2GPa, 700°C. At 2.0GPa, 800°C the assemblage amphibole + garnet + orthopyroxene + olivine is stable. With increasing pressure chlorite was found with clinopyroxene + olivine + garnet at 4.2GPa, 680°C. The anhydrous assemblage olivine + garnet + orthopyroxene + clinopyroxene was found at 4.6GPa, 750°C and at 3.0GPa, 800°C. Both total Na content and aluminium content in amphiboles increase with temperature (Na from 0.48 to 0.53 and Al

from 0.90 to 2.00 at 2.2GPa, 700°C and 2GPa, 800°C respectively, on the basis of 23 oxygens). As expected by the occurrence of chlorite, aluminium content of amphibole in the lower temperature runs is low leading to Na-Al poor hornblende rather than to pargasite. Chlorite at pressures up to 4.2GPa, 680°C is close to clinocllore in composition although the aluminium content slightly decreases with increasing pressure. As a result of the preferential Fe-partitioning in garnet, the reaction chlorite + enstatite = forsterite + pyrope + H₂O, at pressures lower than ca. 4 GPa, is shifted towards lower temperature if compared to data obtained in the model system MASH.

A Dense Hydrous Magnesium Silicate, the 10Å phase, appears with clinopyroxene + olivine + garnet at 4.8 and 5.3GPa (680°C). Assuming chlorite and 10Å phase as individual mineral species, experimental data suggest the H₂O-conserving reaction enstatite + chlorite = forsterite + pyrope + 10Å phase. However analyses of homogeneous "10Å phase" domains which contain more than 0.5 atoms per formula unit of aluminium, reveal the occurrence of a mixed layered chlorite-10Å phase structure. Such hypothesis is corroborated by expandable behaviour and by Raman investigation we performed on pure MSH 10Å phase structure. If such mixed layered structures develop with pressure, chlorite breakdown is a continuous process involving complex structural rearrangements which include different hydrogen speciation (OH groups, H₂O molecules and hydronium ions) and Mg chemical environments. The occurrence of a "mixed-layered 10Å phase" at pressures above chlorite stability promotes H₂O transfer to phase A and therefore hydrogen transport to the deep mantle (> 200km depth).