

Phase relations in peridotite and eclogite systems with H₂O and CO₂ at 3-27 GPa Phase relations in peridotite and eclogite systems with H₂O and CO₂ at 3-27 GPa

Konstantin Litasov^{1*}, Anton Shatskiy¹, Eiji Ohtani¹

LITASOV, Konstantin^{1*}, SHATSKIY, Anton¹, OHTANI, Eiji¹

¹Dept. Earth Planet. Mater. Sci., Graduate School of Science, Tohoku University, Sendai

¹Dept. Earth Planet. Mater. Sci., Graduate School of Science, Tohoku University, Sendai

Oxidized fluid compounds, H₂O and CO₂, dominate in the upper mantle at depths to 100-200 km and have key importance to deep magmatism. The simplified and complex systems with CO₂ or H₂O alone are studied experimentally up to pressures of 20-32 GPa. The systems, containing both H₂O and CO₂, are studied only at low pressures to 3-5 GPa and in few cases to 10-12 GPa under specific conditions. Here we report the results of the experimental study of the systems peridotite-H₂O-CO₂ and eclogite-H₂O-CO₂ up to a pressure of 27 GPa. The starting compositions of peridotite and eclogite contained 3 wt% H₂O and CO₂ each. The experimental details can be found elsewhere.

The association of silicate minerals in the peridotite system includes olivine / wadsleyite / ringwoodite - orthopyroxene / clinoenstatite - garnet. Clinopyroxene occurs only at 3 and 6.5 GPa. Ringwoodite + garnet are stable at 21 GPa; at 1000-1100°C stishovite is added to them. The typical peridotite association of Mg-perovskite-Ca-perovskite-ferropericlasite is stable at 27 GPa. Magnesite is the only carbonate phase over the entire pressure range. The temperature of magnesite stability is 1300°C in the pressure range of 10-27 GPa and it decreases only at lower pressures. Water-bearing superhydrous phase B and phase D were identified only at 21 and 27 GPa and 1000-1100°C. Melts of low melting degrees (from 9 to 33 wt%) in the peridotite system are enriched in SiO₂ and alkalis, which is typical for the peridotite-H₂O systems, and differ from carbonatitic melts in the systems peridotite-CO₂. The temperature trends correspond to a decrease in the relative concentration of SiO₂ and alkalis and an increase in the (Mg + Fe)/Ca ratio.

The association of silicate minerals in the eclogite system includes garnet and clinopyroxene at 3-10 GPa, garnet and stishovite at 16-21 GPa, and a post-garnet assemblage of Mg-perovskite, Ca-perovskite, stishovite, and Al-phase CF at 27 GPa. Garnet is a liquidus phase melting after clinopyroxene and stishovite with increasing temperature. At 3-10 GPa rutile appears as an accessory phase and at 16-21 GPa Fe-Ti-oxides appear episodically. Dolomite is stable at 3 GPa, but at higher pressures magnesite is the only carbonate phase. The temperature of magnesite stability in the eclogite system is 1100°C in the pressure range of 10-27 GPa, which is lower by 200°C than in the peridotite system. Hydrous phases were not observed even in the lowest temperature experiments.

Low degree melts in the system eclogite-H₂O-CO₂ are enriched in SiO₂ and alkalis to a greater degree in comparison with the peridotite system, which is also typical for the system eclogite-H₂O, and strongly differ from carbonatitic melts in the eclogite-CO₂ system. Melts at 16-21 GPa are strongly enriched in Na₂O (up to 10-16 wt%) in comparison with melts at 3-10 GPa. This is explained by Na₂O incorporation into omphacite at low pressures and into CF-phase at 27 GPa, whereas garnets at 16-21 GPa contains only up to 1.9 wt% Na₂O.

Peridotite and eclogite solidi in the studied systems have a flat slope to the pressure axis in the range of 6-27 GPa. Consequently this will result in melting of H₂O-CO₂-bearing rocks at intersection of the solidi with PT-profiles of the subduction zones and hotter geotherms, which have a steeper slope to the pressure axis. Magnesite is the only carbonate phase in both systems at pressures above 6 GPa. The temperature of stability of hydrous phases in the peridotite system decreases by 100-200°C in comparison with the peridotite-H₂O system. Hydrous phases, such as phengite or lawsonite were not observed in the experiments at 6.5 GPa and 900°C in the eclogite system as well. This provides evidence for the fact that addition of carbon or carbonates results in mobilization of structurally bonded hydrogen in peridotitic and eclogitic minerals and decreases the temperatures of melting of hydrous systems.

キーワード: mantle, peridotite, eclogite, volatile, melting, carbon

Keywords: mantle, peridotite, eclogite, volatile, melting, carbon