

MIS002-P01

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Melting phase relations in the peridotite and eclogite systems coexisting with reduced C-O-H fluid at 3-16 GPa Melting phase relations in the peridotite and eclogite systems coexisting with reduced C-O-H fluid at 3-16 GPa

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Melting phase relations of peridotite and eclogite systems coexisting with reduced C-O-H fluid has been studied at 3-16 GPa and 1200-1600°C. In order to perform these experiments the double-capsule technique with fO_2 control by outer Mo-MoO₂ or Fe-FeO buffer capsule was designed and developed for multianvil experiments at pressures above 3 GPa. This technique can be successfully used up to pressures of 20-21 GPa using conventional multianvil devices. The inner capsule contained silicate starting material with an addition of 8-10 wt% stearic acid, which served as a fluid source, whereas outer capsule contained talc, which served as a hydrogen transmitting medium to maximize fH_2 in the inner capsule.

Silicate phase assemblages resemble those in volatile-free lithologies, i.e. olivine/wadsleyite-orthopyroxene-clinopyroxene-garnet in peridotite and garnet-omphacite in eclogite. Melting was detected by appearance of quenched crystals of pyroxene, feldspar and glassy silica. Abundant voids indicate presence of fluid in all runs. The compositions of partial melt were estimated from mass-balance calculations. The partial melt from peridotite runs has CaO-poor (6-9 wt%) basaltic composition with 44-47 wt% SiO₂ and 1.1-1.6 wt% Na₂O (all oxides recalculated to 100% of dry residue). Eclogitic melts contain more SiO₂ (47-49 wt%) and are enriched in CaO (9-15 wt%), Na₂O (9-14 wt%), and K₂O (1.3-2.2 wt%). All runs contained graphite or diamond crystals along with porous carbon aggregate with microinclusions of silicate phases. Analyses of carbon aggregates by defocused electron microprobe beam reveal compositions similar with estimated partial melts.

The appearance of quench crystals was considered as an indication of melting and allows to estimate the solidus temperatures in the studied systems. The solidi have relatively steep slope in the pressure range between 3 and 16 GPa. Estimated solidus temperatures for peridotite + C-O-H fluid with fO_2 control by Fe-FeO buffer are 1200°C at 3 GPa and 1700°C at 16 GPa. The solidus of the system with fO_2 control by Mo-MoO₂ buffer was about 100°C lower. Estimated solidus temperatures for eclogite + C-O-H fluid with fO_2 control by Fe-FeO buffer are 1100°C at 3 GPa and 1600°C at 16 GPa. The solidus of the system with fO_2 control by Mo-MoO₂ buffer was 20-50°C lower. These solidus temperatures are much higher (300-500°C) than those for peridotite/eclogite systems with H₂O and CO₂. However, they are still 300-400°C lower than solidi of volatile-free peridotite and eclogite at studied pressures.

We did not measure fluid compositions in present experiments. The estimations of fluid compositions using known equations of state for real gases (e.g. Zhang and Duan, 2009) show that fluid is H₂O-rich (H₂O > CH₄) in case of Mo-MoO₂ buffer and CH₄-rich (CH₄ > H₂O) in case of Fe-FeO buffer. The role of H₂O in the fluid increases with pressure. The high melting temperature of silicate assemblages coexisting with essentially H₂O-bearing fluid can be explained by the effect of methane and hydrogen, which may inhibit dissolution of silicate components in reduced fluids even if their absolute amounts are subordinate.

The present results have important implication for modeling of mantle melting. The oxygen fugacity decreases with pressures from about Fayalite-Magnetite-Quartz buffer at shallow mantle of 20-50 km to about Iron-Wustite at 250-300 km according to fO_2 estimations from cratonic peridotite (Frost and McCammon, 2008). Subduction/upwelling processes would perturb mantle oxygen fugacity regimes and cause its local increase or decrease. We show significant increase of solidus temperatures in peridotite and eclogite coexisting with reduced CH₄-H₂O fluid relative to the systems with oxidized H₂O-CO₂ fluid. We argue that redox melting by change of oxidation state across a mantle section, a phase transition, or lithosphere-asthenosphere boundary can be dominant melting process in the deep Earth's interior.

キーワード: upper mantle, peridotite, eclogite, oxidation state, C-O-H fluid

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