Pressure-induced polymorphic phase transition in liquid germanate

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In situ x-ray absorption fine structure (XAFS) measurements of liquid germanate under pressures indicate that a sharp liquid-liquid transition accompanied by fourfold-sixfold coordination change occurs around 3 GPa at 1273 K. The fourfold-sixfold coordination change also occurs around 9 GPa for both pure GeO_2 glass (Itie et al. 1989) and Li_2O-$4GeO_2$ glass (Ohtaka et al. 2001, Ohtaka et al. 2002). The higher transition pressure for these glasses is due to the kinetic limitations on glass structure. GeO_6 octahedron in the high density liquid phase is more compressible than that in crystalline solid phases, suggesting the possibility of a density inversion between liquid and solid at higher pressure. These results give not only evidence for liquid polymorphism but also some far-reaching implications for the evolution and dynamics of Earth's interior, when the analogy of germanates to silicates is considered. 1. Proposed olivine flotation in partial melts of the Earth's upper mantle may be due to the polymorphic transition in liquid silicates. 2. At the early stage of Earth's history, magma ocean might be composed of three distinct liquid layers; low density silicate, thin transition zone, and high-density silicate. This process may have yielded extensive compositional differentiation between the liquid layers and might have resulted in the stratification of the present solid mantle. 3. There would be a density inversion between magma and solid mantle under lower mantle conditions. That is, melts originating in lower mantle would never rise to Earth's surface, but instead drain down to the core mantle boundary to form D" layer.

References

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Phase transformaion in wet oceanic crust and subduction dynamics of the slab

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Recent seismic tomography data imply existence of heterogeneities in the mantle. Distribution of basalt component of the slab is one of the most important factors to produce chemical heterogeneity in the mantle observed in the seismic tomography. We determined subsolidus phase relation in hydrous mid-ocean ridge basalt (MORB) by high pressure and temperature in situ X-ray diffraction study together with conventional quenching experiments. The phase boundary of the perovskite appearance in the wet MORB composition has a positive slope expressed as P(GPa) = 0.0056 (±0.0009)T(°C)+15.4(±1.1) based on the gold pressure scale [1]. The phase boundary of the wet MORB is 1 GPa lower than that determined under the dry condition at 1000°C. In the lower temperature range around 1000~1100°C at 18~25 GPa, we observed cubic perovskite by the in situ X-ray diffraction study when we used a glass starting material. However, quenching experiments with a long duration revealed that the cubic perovskite is metastable, and it eventually decomposes into two perovskites.

The chemical and mineralogical structure of the transition zone has been a matter of great debates; i.e. one model suggests the transition zone is peridotitic, whereas the other suggests it is majorite garnet enriched composition[2]. The present result implies that the phase boundary of perovskite appearance in wet MORB locates at a pressure lower than that of the decomposition of ringwoodite at temperatures below 1300°C[3], resulting in higher density of the basalt layer of the slab throughout the transition zone and the lower mantle compared to the peridotite portion of the slab. Thus, the hydrated slabs can penetrate effectively into the lower mantle without separation from the peridotite layer at the 660 km discontinuity. The former basaltic crust continuously sinks into the lower matle without separation from the underlying peridotite in the hydrous and relatively cold subducting slabs. It is buoyant and can be trapped at the depth of the 660 km discontinuity in relatively hot and dry subducting slabs.

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