Ultrahigh-pressure polyamorphism in GeO_2 glass: implications for structure of magma at the core-mantle boundary

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Silicate magma at the core-mantle boundary is one of the most important components in understanding nature and evolution of the Earth’s deep interior. However, structure and properties of silicate magmas at the pressure condition of the core-mantle boundary remain poorly understood, because of experimental challenges. Pioneering works by Murakami and Bass (2010; 2011) showed a kink in the pressure dependence of shear-wave velocity in SiO_2 and $MgSiO_3$ glasses around 130-140 GPa, which was interpreted as evidence of ultrahigh pressure structural transition. However, no structural information is available under such high pressures. Here we show new experimental evidence of ultrahigh pressure structural transition in GeO_2 glass with Ge-O coordination number (CN) significantly greater than 6, investigated using a newly developed double-stage large volume cell combined with multi-angle energy dispersive X-ray diffraction technique for in situ amorphous structure measurement. The Ge-O coordination number (CN) is found to remain constant at ~6 between 22.6 and 37.9 GPa. At higher pressures, CN begins to increase rapidly to 6.4 at 49.4 GPa and reaches 7.4 at 91.7 GPa. The structural change to CN higher than 6 is closely associated with the change in oxygen packing fraction (OPF). This transformation begins when the OPF in GeO_2 glass is close to the maximal dense packing state (the Kepler conjecture=~0.74), which provides new insights into structural changes in network-forming glasses and liquids with CN higher than 6 at ultrahigh pressure conditions. For example, extrapolation of OPF-pressure trend in SiO_2 glass shows that OPF of SiO_2 glass reaches to 0.74 around 108 GPa, where structural change to CN higher than 6 is expected. The data imply that silicate magma at the core-mantle boundary may possess ultrahigh-pressure structure with CN higher than 6.

References

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