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Structure of basaltic glass at pressures up to 18 GPa

Tomonori Ohashi[1,*,§], Tatsuya Sakamaki[1,†], Ken-ichi Funakoshi[2], Takanori Hattori[3], Naoki Hisano[1], Jun Abe[2], and Akio Suzuki[1,‡]

[1]Department of Earth Science, Graduate School of Science, Tohoku University, Sendai, 980-8578, Japan
[2]Neutron Science and Technology Center, Comprehensive Research Organization for Science and Society (CROSS), Ibaraki, 319-1106, Japan
[3]J-PARC Center, Japan Atomic Energy Agency, Ibaraki, 319-1195, Japan

Abstract

The structures of cold-compressed basaltic glass were investigated at pressures up to 18 GPa using in situ X-ray and neutron diffraction techniques to understand the physicochemical properties of deep magmas. On compression, basaltic glass changes its compression behavior: the mean O-O coordination number (CN_{OO}) starts to rise while maintaining the mean O-O distance (r_{OO}) above about 2–4 GPa, and then CN_{OO} stops increasing, and r_{OO} begins to shrink along with the increase in the mean coordination number of Al (CN_{AlO}) above ~9 GPa. The change around 9 GPa is interpreted by the change in contraction mechanism from bending tetrahedral networks of glass to increasing oxygen packing ratio via the increase in CN_{AlO}. The analysis of the oxygen packing fraction (η_O) under high pressure reveals that η_O exceeds the value for dense random packing, suggesting that the oxygen-packing hypothesis recently proposed cannot account for pressure-induced structural transformations of silica and silicate glasses. The rise of the CN_{OO} at 2–4 GPa reflects the elastic softening of fourfold-coordinated silicate glass, which may be the origin of anomalies of elastic moduli in basaltic glass at ~2 GPa previously reported by Liu and Lin (2014).

The widths of both the first sharp diffraction peak and the principal peak show contrastive compression behaviors between modified silicate and silica glasses. This result suggests that modified silicate glasses represent different pressure evolutions in the intermediate- and extended-range order structures from those of silica glass, likely due to the presence of modifier cations and the resultant formations of smaller rings and cavity volume.

Keywords: Glass structure, permanent densification, high pressure, X-ray diffraction, neutron diffraction; Physics and Chemistry of Earth's Deep Mantle and Core