

Aluminosilicate melts and glasses at 1 to 3 GPa: Temperature and pressure effects on recovered structural and density changes

S. BISTA^{1*}, J. F. STEBBINS², W. B. HANKINS³
AND T. W. SISSON⁴

¹Department of Geological and Environmental Sciences,
Stanford University (*correspondence:
sbista@stanford.edu)

²Department of Geological and Environmental Sciences,
Stanford University (stebbins@stanford.edu)

³Volcano Science Center, USGS, Menlo Park

⁴Volcano Science Center, USGS, Menlo Park

Aluminosilicate glasses quenched from melts at pressures of 6-10 GPa show significant increase in AlO5 and AlO6. In this study we look at compositions in excess of non bridging oxygen- CAS(Ca₃Al₂Si₆O₁₈), NS3 (Na₂Si₃O₇ with 0.5% Al₂O₃) as well as Jadeite composition (1:1 Na:Al) glasses in pressures ranging 1-3 GPa.

We observed, even at shallower mantle pressures of 1-3 GPa, compositions with excess modifier cation contain up to 10's of percent of AlO5 and AlO6. ²⁷Al MAS NMR of the jadeite composition glass (Na:Al 1:1) at 2GPa quenched from 740°C (near to T_g) did not show any distinguishable AlO5 or AlO6 species.

NS3 and CAS glasses were compressed and held at temperatures ranging from near to their ambient glass transitions (T_g) up to temperatures above the liquidus. Samples that were quenched from above the melting point showed substantially lower recovered density and lower Al coordination number compared to the samples that were held near to T_g. For example, sodium aluminosilicate glass quenched from 510°C (near to T_g) had 70% more AlO5 than samples from 1200°C. Based on the measurement of actual cooling rates, fictive temperature differences for the glasses from these two extreme temperatures are not large enough to account for this apparent loss in density and Al-coordination during quench. Glasses held at near to T_g were held at target temperature and pressure for different durations and spectra were compared to confirm they were fully relaxed. The most likely cause for these differences is therefore probably the pressure drop during cooling from temperatures above liquidus as liquid contracts upon cooling. Results from previous high T and P quenching studies thus give only minimum estimates of pressure effects on melt structure.