

Structural modifications in densified soda aluminosilicate glasses

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Summary:

The behaviour of soda aluminosilicate glasses and melts under pressure and temperature is of interest in both the materials and Earth Sciences, especially for understanding magmatic processes. Although these systems have been well studied at room pressure by several workers, their structural modifications at high pressure (HP) are less well known. Several studies have been carried out on glasses quenched from HP using both NMR and XANES. The latter have also been performed on glasses and melts at HP. All these studies revealed structural changes occurring in the glasses and/or melts with increasing pressure.

We synthesized glasses along the NS3/Albite glass join extended into the peraluminous domain. The glasses were permanently densified in a Belt press at the Lyon Plateform of High Pressure Experimentation (PLECE) (5GPa, 600°C) and in a Multi Anvil press at the University of Toronto (7GPa, 600°C). The densified samples were studied with various methods in order to follow the pressure induced structural modifications. Short range order (SRO) was investigated using ²³Na, ²⁷Al NMR and Si L-edge XANES. The intermediate range order (IRO) was studied by Raman spectroscopy and long range order (LRO) with Brillouin spectroscopy.

²⁷Al NMR spectra show, with increasing pressure, an increase in the Al coordination, with large amounts of ^VAl and ^{VI}Al appearing in glasses with low Al₂O₃ contents. Contrary to this, ^VAl and ^{VI}Al increase more slowly for albite and peraluminous glasses. ²³Na NMR spectra exhibit a decrease in the Na-O bond length with pressure.

For glasses between NS3 and albite composition, Raman experiments show an increase in Q² and Q⁴ species with pressure and a symmetrical decrease of the Q³ species. A strong shift of the vibrational band around 500 cm⁻¹ toward higher wavenumbers is observed for albite and peraluminous glass.

The pressure induced structural modifications noted in these glasses are dependent upon composition. For compositions characteristic of depolymerized glasses Al coordination increases and further depolymerization are primarily responsible of the densification process. For compositions indicative of fully polymerized glasses densification mainly occurs as a decrease in the intertetrahedral angle T-O-T. Al L-edge XANES and O, Na, Al, and Si K-edge XANES along with *in situ* (DAC) experiments will be performed soon to complete this preliminary study.

Heterogeneous hydrous mantle in arc settings: Constraints on the genesis of silica-undersaturated arc magmas

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Partial melting of a hydrous lherzolite mixed with variable amounts of amphibole-bearing clinopyroxenite (OCA2) [1] has been experimentally investigated at 1 GPa between 1150 and 1300°C (piston-cylinder, Au₈₀Pd₂₀ capsules) under oxidized condition (FMQ+2). Our new capsule configuration [2] allows efficient melt extraction, with melt layers more than 50 µm wide in the capsule traps.

Peridotite derived melts are hypersthene-normative while amphibole-clinopyroxenite melts are strongly Si-undersaturated (~7 % normative nepheline). Melts derived from lherzolite-clinopyroxenite mixtures containing less than 50% clinopyroxenite have identical major element compositions than melts derived from pure peridotite. Above 50% pyroxenite, the CaO content in melt increases and the SiO₂ content decreases with increasing fraction of pyroxenite in the starting mixture. The transition between Hy-normative and Ne-normative melts occurs for mixtures containing between 50 and 75 % clinopyroxenite, when orthopyroxene disappears from the residue. In contrast, minor elements (K₂O, Na₂O, TiO₂ and H₂O) show a more linear behaviour with continuous mixing trends between the two lithologies, thus highlighting the source heterogeneity. Thus the signature of mantle heterogeneities is preserved in the minor/trace elements composition of the magmas, whereas the major elements are buffered by the dominant peridotitic lithology. Forsterite content of olivines in equilibrium with the melts reaches 91.3 for peridotite and 91.8 for clinopyroxenite and/or mixed lithologies at 1300°C. High-Mg olivines can thus crystallize from non-peridotitic magmas under relatively oxidized conditions at high temperatures.

Most primitive magmas found in arc environments and preserved as melt inclusions in high-Mg olivine (Fo ≥ 88) show Si-undersaturated compositions. The involvement of a heterogeneous source containing amphibole-bearing clinopyroxenites in addition to peridotites is often mentioned to account for the Si-undersaturated character of these melt inclusions [1; 3-5]. Our experiments give further support for this hypothesis, but indicate that either the source is almost exclusively made of amphibole-bearing clinopyroxenites, or the Si-undersaturated melts issued from the clinopyroxenites do not reequilibrate with the peridotites.

[1] Médard *et al.* (2006) *J. Petrol.* **47**, 481-504. [2] Hoffer (2008) PhD thesis, Clermont-Ferrand [3] Métrich *et al.* (1999) *EPSL* **167**, 1-14. [4] Schiano *et al.* (2000) *G3* **1**, n°5, 1018. [5] Elburg *et al.* (2007) *Chem. Geol.* **240**, 260-279.