The ‘not so noble’ behaviour of nitrogen in silicate melts at high pressure and temperature

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The behaviour of nitrogen in silicate melts remains poorly characterized compared to other volatiles. It is however essential to understand its behaviour because, together with noble gases, nitrogen elemental and isotopic budgets are used to model the evolution of geochemical reservoirs.

The speciation and solubility of nitrogen in silicate melts have been investigated at between 1400 and 1700ºC and at pressures ranging from 10 to 30 kbar for 6 different alkali and alkaline-earth silicate and a Ca- Mg- aluminosilicate liquids. Hydrous melts have also been studied.

Characterization of quenched melts by Raman spectroscopy and ^{15}N solid state MAS NMR indicate that nitrogen is not only physically dissolved within the melt structure like noble gases. A fraction of nitrogen interacts with the silicate network. The most likely nitrogen-bearing species is a nitrosyl group. As water is added to the system, the content of this species decreases and ammonium complexes are formed.

The nitrogen content of the melts may be as high as 0.7 wt% depending on the melt composition, P and T. Our solubility data are in good agreement with ambient-pressure studies when the nitrosyl content is low. On the other hand, a significant departure from an apparent Henry’s law behaviour is observed for depolymerized melts, which contain more nitrosyl than the others.

The behaviour of nitrogen is generally assumed to resemble that of noble gases except under very reducing conditions. Our study demonstrates that such conditions are not required to observe a complex speciation of nitrogen in silicate melts. These results may then have significant implications for elemental and isotopic fractionation of nitrogen during mantle partial melting, magma crystallization and degassing.