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Solubility of niobium in peralkaline silica-undersaturated melts at 750–850 °C, 100–200 MPa

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Solubility and complexation data are necessary for understanding conditions for the formation of magmatic and hydrothermal ore deposits. The magmatic HFSE deposits imply high solubility of these elements in alkaline silicate melts, with the most important parameters being alkalinity, halogen and water contents, temperature of the magma, and silica activity. We have conducted a series of experiments on the solubility of Nb in alkaline silica-undersaturated melts. Experiments were carried out with using two synthetic silicate glasses with different Na/Al values: NAS4 (Na_2O 26.0 %(m/m), Al_2O_3 12.5 %(m/m), SiO_2 61.5 %(m/m)) with molar Na/Al = 3.36, and NAS2 (Na_2O 20.9 %(m/m), Al_2O_3 17.8 % (m/m), SiO_2 61.3 %(m/m)) with Na/Al = 1.93. The glasses were prepared from finely ground mixtures of quartz, aluminium oxide, and sodium carbonate. The mixtures were heated in a Pt crucible at 900 °C and subsequently at 1100 °C, and then crushed and remelted three times. Various amounts of Nb_2O_5 + glass (NAS4/NAS2) were placed in 1 cm long and 3mm wide Pt capsules and arc-welded shut. Then the capsules were placed in a cold-seal autoclave and run at 200 MPa and 750 °C for about 2 weeks. Rapid quench pressure vessels were used for experiments at 850 °C, 100 MPa, and run durations of 48 – 72 hours. In some runs, distilled water and/or CaF_2, NaCl were added to the reactant mixtures. Experimental products were analyzed by EMPA.

Liquids in all experiments quenched to transparent glass with small (5-10 μm) euhedral crystals of $NaNbO_3$ composition. These $NaNbO_3$ crystals are the only solid phase at the liquidus. In low-temperature experiments (750 °C) using the highly peralkaline glass NAS4, the Nb solubility increases substantially with addition of water from 2.54 %(m/m) Nb_2O_5 at dry conditions up to 2.91 %(m/m) Nb_2O_5 at 5 %(m/m) H_2O. The Nb solubility at dry conditions at 850 °C is higher in NAS4 in comparison with less alkaline NAS2 melt (3.72 %(m/m) Nb_2O_5 and 2.04 %(m/m) Nb_2O_5, respectively). Our data at 850 °C show that the solubility of Nb in the liquid increases significantly with the addition of water and NaCl for NAS4 (4.16 %(m/m) Nb_2O_5 and 4.35 %(m/m) Nb_2O_5, respectively) and for NAS2 (2.77 %(m/m) Nb_2O_5 and 2.17 %(m/m) Nb_2O_5). The effect of CaF_2 addition on the Nb solubility was insignificant.

In conclusion, the Nb solubility in silica-undersaturated melts is already high at 750 °C, and increases substantially with temperature. It also increases strongly with Na/Al ratio in the melt, with the addition of water and NaCl, but not in the presence of CaF_2. This suggests that chlorine,

unlike fluorine, is a ligand strongly enhancing Nb solubility in alkaline silicate melts.

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