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AMORPHOUS MATERIALS: PROPERTIES, STRUCTURE, AND DURABILITY

Solubility and solution mechanisms of chlorine and fluorine in aluminosilicate melts at high pressure and high temperature†

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ABSTRACT

The solubility and solution behavior of F and Cl in peralkaline aluminosilicate compositions in the systems Na_2O-Al_2O_3-SiO_2 and K_2O-Al_2O_3-SiO_2 have been determined for glasses quenched from melts equilibrated at 1400 and 1600 °C in the 1.0–2.5 GPa pressure range. With Al/(Al+Si) increasing from 0 to 0.33 in sodium aluminosilicate melts, F solubility (saturation concentration) increases from 3.3 to 7.4 mol%, whereas Cl solubility decreases from 5.7 to 2.5 mol%. There is no difference in F solubility in sodium or potassium aluminosilicate melts. However, the Cl solubility in potassic aluminosilicate melts is 40–60% lower than in sodic melts with the same Al/(Al+Si) and Na or K mole fraction.

Fluorine depolymerizes the silicate melt structure and forms Si-F, Al-F, and Na-F complexes, the proportion of which depends on the melt Al/(Al+Si) ratio. Dissolution of Cl results in a small degree of depolymerization of Al-free silicate melt, whereas Cl has a polymerizing effect in aluminosilicate melts. In both cases, formation of Na-Cl complexes appears to be the driving solution mechanism.

The differences in F and Cl solution mechanisms result in contrasting depolymerizing effects that become more pronounced with increasing degree of magmatic differentiation. Through such modifications of melt structure, F and Cl have significant effects on magma properties such as viscosity, compressibility, and element partitioning.

Keywords: Fluorine, chlorine, solubility, solution mechanism, aluminosilicate melt, ionic complexes, magma degassing