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Melt viscosities in the system Na-Fe-Si-O-F-Cl: Contrasting effects of F and Cl in alkaline melts

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ABSTRACT

The shear viscosities of melts in the system Na-Fe-Si-O-F-Cl were determined over a wide range of temperatures (400–1200 °C) at 1 atm pressure in air. The compositions are based on the addition of Fe_2O_3, $FeCl_3$, and FeF_3 to a base melt composition corresponding to sodium disilicate ($Na_2Si_2O_5$). Viscosities were determined using concentric cylinder and micropenetration methods and measurements span the range of $10^{0.5}$ to 10^{11} Pa·s. The chemical compositions of these melts were analyzed after the viscometry determinations. The iron is fully oxidized under the conditions of the viscometry. Although F and especially Cl are volatile elements in silicate melts, levels of Cl and F up to over 3 and 4 wt%, respectively, were stabilized in these melts, assisted presumably by the presence of Fe^{3+}. Although some volatilization occurred during the original synthesis of these samples, none occurred during viscometry. The anionic substitutions Cl_2O_{-1} and F_2O_{-1} have very different influences on the viscosity. The F_2O_{-1} substitution causes a drastic decrease in viscosity over the entire investigated range whereas the Cl_2O_{-1} substitution causes a much smaller decrease in viscosity in the high viscosity range and a slight increase in viscosity in the low viscosity range. As a consequence, minor to major element abundance of Cl in strongly peralkaline undersaturated volcanic rocks are not likely to significantly influence melt viscosity.