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Influence of iron content, iron redox state and atmosphere conditions on the crystallization of supercooled aluminosilicate melts

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Iron is an element of fundamental importance in igneous petrology whose influence on magma evolution must be understood. As part of this goal, we have studied the crystallization of a series of supercooled aluminosilicate melts as a function of iron content, iron redox state and oxygen fugacity. Our starting Fe-free composition is 41.7 SiO_2, 24.8 Al_2O_3, 17.9 CaO and 10 wt% Na_2O. To this base material iron has then been added in amounts reaching 10 wt% with differing $Fe^{2+}/\sum Fe_{tot}$ ratios.

For the homogeneous starting materials, the density and Young modulus have been measured at room-temperature by an Archimedean method and by ultrasonic experiments, respectively, the liquidus temperature by optical observations of samples quenched from various temperatures, the heat capacity by Differential Scanning Calorimetry, and the viscosity by creep experiments above the glass transition and by a Couette method at superliquidus temperatures.

Crystallization of 25 - 40 μm powdered samples has then been investigated by differential thermal analysis up to 1350˚C at a heating rate of 10K/min under either air or a reducing Ar-H atmosphere. Duplicate heat treatments have been performed on the same powders to determine the nature and composition of crystals from X-ray diffraction experiments. Without iron, nepheline precipitates first, followed by wollastonite. For iron-bearing samples, gehlenite for example precedes wollastonite when ferric iron predominates. These results will be presented and discussed in the light of the structural role of iron which can be either a network modifier or a network former.