American Mineralogist, Volume 88, pages 308–315, 2003

Chemical transfer during redox exchanges between H_2 and Fe-bearing silicate melts

**FABRICE GAILLARD,[1,*] MICHEL PICHAVANT,[1] STEPHEN MACKWELL,[2] RÉMI CHAMPALLIER,[1]
BRUNO SCAILLET,[1] AND CATHERINE MCCAMMON[2]**

[1]CNRS, ISTO- 1 A rue de la Férollerie, Orléans cedex 02 45071, France
[2]Bayerisches Geoinstitut, Universität Bayreuth, D-95440 Bayreuth, Germany

ABSTRACT

Kinetics and reaction paths of Fe^{3+} reduction by H_2 in high-Fe and low-H_2O silicate melts have been investigated at 800 °C. Time-series experiments were performed in cold-seal pressure vessels at 50 bars of pure H_2 using rapid-heating and rapid-quench strategies. Within the first minutes of the experiments, a fast partitioning of Na occurred between the gas and the melt due to the reducing conditions. Kinetically decoupled from the Na partitioning, the progression of a front of Fe^{3+} reduction within the quenched melt was observed and was identified as a diffusion-limited process. The growth of the reduced layer is accompanied by an increase in concentration of OH-groups suggesting that reduction operates through proton incorporation within the melt. As this growth rate is slightly faster than predicted from the diffusion of molecular H_2O, a different and mobile water-derived species seems likely. One possible mechanism is the reduction of Fe^{3+} by the transport of molecular H_2. As this process is limited by the flux of H_2, it will depend on both diffusivity and solubility of H_2 in the melt. Alternatively, migration of protons (H^+) and electronic species within the melt could control the velocity of the reduction front. The increase in concentration of the reaction-derived OH groups produces a water over saturation followed by partial dehydration of the melt. This dehydration leads to a change in the redox conditions within the gas that influences the Na partitioning between gas and melt.