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Diffusion and partition coefficients of 36 elements in magnetite as a function of oxygen fugacity

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There is increasing interest in using the trace element geochemistry of magnetite as a petrogenetic indicator, particularly in ore deposit studies [1]. Insofar as trace element concentrations may be reset by diffusion after the growth of a magnetite crystal, it is desirable to know the rates of diffusion of trace elements in magnetite and their dependence on petrological variables including oxygen fugacity (fO_2).

Lattice diffusion coefficients and partition coefficients have been determined for Li, Mg, Al, Sc, Ti, Cr, V, Mn, Co, Ni, Cu, Zn, Ga, Ge, Y, Zr, Nb, Mo, In, Hf, Ta, U and all 14 REE in single crystals of natural magnetite as a function of oxygen fugacity (fO_2) (FMQ - 1 to FMQ + 4.89) at 1150°C and 1 bar, by equilibration with a synthetic silicate melt reservoir. Twelve-hour experiments generated diffusion profiles between 25 to >1000 µm in length, which could be analysed using scanning laser-ablation inductively-coupled-plasma mass spectrometry. Diffusion coefficients (D), the element concentration at the magnetite-melt interface, and the initial element concentration in magnetite, were calculated by fitting data from individual element diffusion profiles to the conventional diffusion equation. The equilibrium magnetite/melt partition coefficients are given by the ratio of the interface concentrations to those in the melt. Plots of log D as a function of log fO_2 produce V-shaped trends for all the investigated elements, representing two different mechanisms of diffusion that depend on $(fO_2)^{-2/3}$ and $(fO_2)^{2/3}$, similar to that previously observed for both divalent and trivalent cations [2].

Diffusion coefficients at a given fO_2 generally increase in the order Cu > Co > Sc > V > Cr. Thus, Cu contents of magnetites are most susceptible to diffusive reequilibration whereas the original content of Cr should be best preserved.

[1] Dare et al. (2014) Miner. Deposita **49,** 785-796. [2] Aggarwal & Dieckmann (2002) Phys. Chem. Minerals **29**, 707-718.