Experimental study of disequilibrium effects in metal-silicate interactions: possible consequences for core composition

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Although core formation, in differentiated meteorite parent bodies as well as in the Earth and planets, is probably associated to relatively short characteristic times, the role of kinetics in metal/silicate exchanges has not been much studied. In the experimental studies shown below, kinetics of metal/silicate interactions are measured for evaluating to which extent they could affect metal and silicate compositions during core formation.

In a first study (Libourel *et al.*, 1998), the rate constants of transfer reactions of Ni, Fe and Si between olivine and (Fe,Ni) alloy have been measured at $P = 1$ bar and $T = 1600°C$, under controlled oxygen fugacities (C-CO buffer). The exchange rates decrease from Ni to Fe to Si, and correlate with thermodynamic affinities. We will discuss the significance of such relations, and their importance for core formation models, as well as for the core-mantle boundary in the Earth.

In a second study (Lemelle *et al.*, 1998), composition profiles (Fe,Mg,Ni) in olivines, induced by exchanges with metal and fluid phases, have been characterized by electron microprobe and analytical transmission electron microscopy. The kinetics of atomic diffusion are systematically compared with reaction rates and orders of reaction. At relatively low temperatures (1100°C), surface and interface processes control the kinetics, rather than atomic diffusion.

In a third study (Leroux *et al.*, 1998), ultrafast exchanges between liquid metal alloys and molten silicates, associated to shock waves, are characterized. Large impacts in the accreting Earth have indeed been proposed as a main driving force for core formation. The compositions of quenched liquid metal alloys in contact with quenched molten silicates, resulting from the dynamic short timescale high pressures, have been analysed in the shocked veins of the Tenham chondrite. An hypothetical Earth's core produced by such rapid processes would contain significant amounts of non-siderophile elements, whereas silicates would retain non-negligible sulphide ions, and presumably some chalcophile elements.

The results of these three studies will be used to speculate about the pertinence of disequilibrium effects during core formation

References

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