6.1.25

Kinetic condensation of gas for the diversity of ferromagnesian chondrule compositions

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Diversity of chondrule compositions has been attributed to heterongeneity of the precursors, compositional change during chondrule formation due to evaporation/condensation, or both. Recent peroglogic studies have shown that chondrules retain various heterogeneity indicative of rapid condensation. It has been also pointed out that the variation of chondrule compositions are not reproduced by condensation of the solar nebula. Thus, the gas responsible for chondrule formation is not the solar nebula gas. The most plausible possibility for the nature of the gas is that formed by precursor of chondrules that was partialy to totally evaporated and that was cooled raidly to form melt droplet.

We have developed a kinetic model to describe the condensation under kinetic conditions. The model bases the Herz-Knudsen equation, and describes the degree of supersaturation of silicate melt as a function of ambient pressure. The system consists of O-Na-Ma-Al-Si-K-Ca-Fe, and the parameters include evaporation rates and fractionation factors that were optimised for pervious experimental results and condensation coefficients and supersaturation degree that are free parameters.

The results show that the kinetic condensation path is not so largely different from the equilibrium condensation path, but the degree of non-linearity of composition change is more emphasized, particularly, Mg- or Fe-enrichment is significant. This effect is correlated with the degree of supersaturation, and we have succeeded in finding a plausible degree of supersaturation to cover the compositional range of ferromagnesian chondrules, although the numbers are non-dimensionalized. Most important result is that kinetic condensation can reproduce the large Mg/Si fractionation with almost constant Al_2O_3 + CaO abundance in chondrules in unequilibrated ordinary chondrites. Equilibrium condensation and kinetic evaporation cause Al_2O_3 + CaO enrichment with progress of evaporation or a decrease of degree of condensation. In order to explain the whole range of chondrule compositional variation, depletion of the refractory component by 30% and FeO by 20 to 50%, which suggests the earlier fractionation of the refractory component as CAIs and Fe as metallic iron from the precursor of chondrules.

6.1.26

Dependence of metal/silicate partition coefficients of P, Ga, and W on pressure, temperature, and silicate melt composition

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Core formation in the Earth is best investigated through use of metal/silicate partition coefficients to interpret siderophile element patterns in the mantle. Partition coefficients depend on T, P, the major element compositions of the silicate and metal phases, and oxygen fugacity. Experiments investigating silicate melt dependence were performed in a one half inch non-end-loaded piston-cylinder press. Run products were analyzed by a CAMECA SX-50 electron microprobe.

The silicate melt compositional dependences for Ga and W are in broad agreement with previous work. We confirm that partition coefficients are a stronger function of nbo/t for higher valence cations (P, W) than lower (Ga). Our metal/silicate partition coefficients for Ga and W in LogD versus nbo/t space can plausibly be fit by trends of the same slope as those of one bar experiments. One explanation is that the higher pressure and temperature of the present work have offsetting effects.

We find a small increase of $LogD_{Ga}$ and $LogD_{W}$ with temperature at constant P and nbo/t. The effect of pressure at constant T abd nbo/t is too small to distinguish, and the observation that $LogD_{Ga}$ and $LogD_{W}$ values presented here are generally higher than in 1 bar experiments for a given nbo/t is attributed to the temperature difference. We conclude, therefore, that temperature and silicate composition have a greater influence on partitioning than pressure, at least over the pressure range of this study.