Kinetics of condensastion and cosmochemical fractionation of the planet forming materials in the early solar nebula

H. NAGAHARA* AND K. OZAWA

Dept. Earth Planet. Sci., The Univ. Tokyo, Hongo, Tokyo 113-0033, Japan
(*correspondence: hiroko@eps.s.u-tokyo.ac.jp)

Chemical Fractionation

Condensation is the first step of planet formation. The isotopic homogeneity except for oxygen of the planetary and meteoritic materials indicates that the early solar nebula was once totally evaporated and the precursor materials of the planets were subsequently condensed. Homogeneity of heterogeneity of the precursor materials of the planets is controlled by the competition between cooling time scale of the nebula, time scale of condensation, and time scale of transportation of the condensed phases.

Kinetic Condensation Experiments

We have carried out condensation experiments for Mg-silicates and metallic iron, which are the two most important solids for terrestrial planets, and obtained condensation coefficients (probability of condensation against number of collided molecules). The experimental results also showed unexpectedly wetted relationship between silicates and metallic iron, which further indicates heterogeneous condensation of planet forming materials.

Model and Results

We have developed kinetic condensation model and calculated the development of condensed phases as a function of gas cooling time scale, which includes physical separation of the dusts. The model contains two free parameters, the critical size for gas/dust separation and gas cooling time scale. The results show the relationship between the gas cooling time scale and the critical size for dust separation in order to generate chemical (Mg/Si/Fe) condensation. If the dust separation size was 1micron, the cooling time scale of the gas was 1-10^2 years, whereas the separation size was 1mm, the gas cooling time scale was 10^3-10^6 years. Thus, the precursor of the planets could have been fractionated depending on the viscosity of the disc, which predicts planets with diverse compositions in exoplanetary systems.

Molybdenum isotope fractionation in pelagic euxinia: Evidence from the modern Black and Baltic Seas

T.F. NÄGLER[1]*, N. NEUBERT[2], M.E. BÖTTCHER[3], O. DELLWIG[3] AND B. SCHNETGER[4]

[1]Institute für Geologie, Universität Bern, Switzerland
(*correspondence: naegler@geo.unibe.ch)
[2]Institut für Mineralogie, Leibniz Universität Hannover, Germany
[3]Marine Geology Section, Leibniz Institute for Baltic Sea Research, Warnemünde, Germany
[4]Institute for Chemistry and Biology of the Marine Environment, University of Oldenburg, Germany

We present a model to explain isotope data of vertical profiles of dissolved molybdenum (Mo) of the Black Sea and the Baltic Sea. The entire water column of the Black Sea, as well as the anoxic waters of the euxinic deeps of the Baltic Sea show δ^{98}Mo values (up to 2.9 ‰) significantly above the homogeneous, open ocean waters (2.3 ‰). Further all water samples are enriched in the heavy isotope compared to published data of sedimentary Mo from the same range of water depths. The observed isotope fractionation between sediments and the anoxic water column of the Black Sea can be reconciled by a model involving published ab initio calculations of Mo isotope fractionation and thermodynamic thiomolybdate distributions parameters in dependence of H_2S_{aq}. The observed pattern can readily be explained as decreasing importance of mono-, di-, or tri- thiomolybdate scavenging with increasing H_2S_{aq}. The model results further imply that Mo isotopic composition of the water column is in equilibrium with that of the sediments. The effective equilibrium fractionation factor at any given depth depends on the relative abundances of the different thiomolybdates, and thus H_2S_{aq} abundance. An extrapolation to a theoretical pure MoS_4^{2-} solution indicates a fractionation constant between MoS_4^{2-} and authigenic solid Mo of 0.5 ± 0.3‰. Results from the Baltic Sea are in principle agreement with themodel, but are slightly offset. The latter is probably related to the occasional large scale inflow events which lead to temporary disequilibrium distribution of thiomolybdate species, due to the slow reaction kinetics of the $MoOS_3^{2-}$ to MoS_4^{2-} transition. δ^{98}Mo values of the upper oxic waters of both basins are higher than predicted by mixing models based on salinity. The results can be explained by non-conservative behaviour of Mo under suboxic to anoxic conditions in the shallow bottom parts of the basin, most pronounced on the NW shelf of the Black Sea.