Goldschmidt Medal Abstract

A model for volatile element condensation and accretion of rocky planetary bodies

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All materials formed in the inner solar system share similar, but not identical, element abundance patterns, i.e. constant and solar refractory element abundances, decreasing moderately volatile element concentrations that correlate with their respective condensation temperatures and variable absolute but close to chondritic relative abundances of highly volatile elements. The depletion of moderately volatile elements has been generally attributed to incomplete condensation and/or evaporative loss by heating during the early stages of planetesimal formation.

The stable isotope compositions of almost all moderately volatile elements show no evidence for a Rayleigh-type fractionation that could be attributed to partial condensation or evaporation. To explain this, models assume that the loss of volatile compounds during condensation and/or evaporation occurred under equilibrium conditions at high temperatures. However, such conditions do not necessarily apply during the formation of solids from the solar nebula. Any model for the formation of the precursor solids for the different meteorite parent bodies has to account for the lack of isotope fractionation and at the same time for the depletion of moderately to highly volatile elements. One scenario where this could occur is a solar nebula from which elements condensed following their respective condensation temperatures and at the same time the gas concentration with the remaining more volatile elements decreased due to the migration of the gas phase away from the site of already condensed material. In this scenario solids with different abundances of volatile elements are generated and this diversity is preserved particularly well in the suite of carbonaceous chondrites. Accretion of this condensed material prior to complete condensation of the nebular gas can account for the observation that planetesimals are depleted to different extents in the more volatile elements. The bulk Earth composition can be modelled by accretion of planetesimals with different degrees of volatile element depletion.