Element Depletion and the Accretion of Rocky Planetary Bodies

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A common characteristic of all inner solar system materials is their near chondritic relative abundance of refractory elements and depletion in volatile elements. The degree of volatile element depletion correlates with their respective condensation temperature (T_C). This phenomenon is therefore generally attributed to incomplete condensation and/or evaporative loss by heating prior to or during the early stages of planetesimal formation.

The different classes of meteorites are representatives of individual planetesimals and planets in the solar system. Their element abundances show that the absolute depletion of the more volatile elements is quite variable among them. For primitive and least disturbed carbonaceous chondrites the element depletion pattern is a smooth function of T_C. The accessible silicate Earth also shows this general depletion pattern, but in detail it is highly complex and requires differentiation processes that are not solely controlled by T_C of the different elements. Processes to consider are core formation and possible element fractionations during accretion. However, if only elements are considered that are unaffected by core formation, the depletion pattern of the silicate Earth reveals a step function that shows that moderately volatile lithophile elements have abundances that are ca. 0.1 times the chondritic value, irrespective of their T_C. A gradual depletion with T_C is only indicated for the highly volatile elements.

This element distribution can be approximated using a two-stage model, first by mixing of a highly depleted and reduced component with a more volatile element rich and oxidized component. Secondly, following final assembly of the Earth its silicate portion was further depleted by core formation involving the segregation of a metal as well as sulfide melt. Combining this accretion scenario with the evolution of the U-Pb and Rb-Sr isotope systematics indicates that Earth was essentially completed ca. 70 Myr after CAI formation.