Chemical evolution of the protosolar disk and chondrite compositions

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The diversity of bulk chemical composition of chondrites and specifically the volatile-poor composition of all the chondrite chemical groups along with terrestrial planets, which are cotnrolled by the volatility of elements in the system of the solar system elemental abundances suggest condensation and material transport within the disk should be solved simultaneoulsy. In order to clarify the temporal and spatial relationship between the protosolar disk and meteorites, we have carried out quantitative evaluation of chemical evolution of the disk by modifying the particle-tracking-model by Ciesla [1,2] and chemical equilibirum calculation.

The model describes the drift and dispersion of particles by turbulence, where the disk is a standard alpha disk. We divide the disk from 0.5to 50 AU into 18 bins, put 10,000 particles in the individual cell, trace the trajectory of all the particles, and evaluated how the particles moving outward and those inward mix with time. The particles are assumed to keep their initial chemical compositions defined by the distance from the proto-sun that were obtained with the chemical equilibrium calculation. The change of the chemical composition of the disk was obtained by summing the number of particles that keep their initial compositions.

We found that (1) initally high temperature of the disk over the asteroid belt is crucial for the chondrites with refractory element-rich compositions in carbonaceous chondrites, otherwise all the protoplanets should have CI-like comopositon, that is, we will not have protoplanets with non-solar composition, and (2) even if the disk was heated to a temperature high enough to evaporate, planetesimals need to be formed at the early stage of the disk evolution, approximately in 10^5 years, but not 10^6 years. This is because the disk is basicallly accreting to the proto-sun, and the materials initially located at the outer regions retain a composition with the solar abundance. The early formation of planetesimals is consistent with the iron core formation in some differentiated meteorites accreted in relatively inner region, because ^{26}A abundance was rich at the early stage.

[1] Ciesla, F. (2010) *Icarus* **208**, 455. [2] Ciesla, F. (2011) *ApJ* **740**, 1.