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Thermal history of planetsimals in the early solar system, taking aluminum-26 heating into account

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We made calculations of the thermal history of planetesimals in the early solar system. We assume that if all the material in the solar nebula has the same abundance ratio of aluminum 26 to 27 as CAIs. The result shows that inner parts of planetesimals were heated above 2000K if their radii were larger than 10 km. The following possibilities are considered. (1) planetesimals were not formed in that period of time; (2) planetesimals were formed, but were smaller than several km; (3) the mean abundance ratio of aluminum 26 to 27 were smaller than that of CAIs.

Calculations of the thermal history of the parent bodies of ordinary chondrites have normally been done by assuming the heating of aluminum 26 decay (the so-called "the onion shell model"). In this model, an initial abundance ratio of aluminum 26 to 27 is usually taken to be an order of magnitude less than those of CAIs (Miyamoto et al., 1981). Kita et al. (1998) analyzed initial abundance ratios of aluminum 26 to 27 of chondrules in the ordinary chondrites, and revealed that they are from a fifth to a tenth of those of CAIs. If aluminum isotopes in the solar nebula were distributed homogeneously, the difference of the abundance ratio between CAIs and chondrules is interpreted as the difference of formation times, i.e. the parent bodies of the ordinary chondrites were formed more than 2 Ma after the formation of CAIs.

What kind of thermal histories had been experiences by the planetesimals formed before the formation of the parent bodies of ordinary chondrites? How the material in planetesimals had evolved? In order to elucidate these problems, we made numerical calculations of the thermal history of planetesimals. We took only aluminum 26 decay energy into account as the internal heat source.

The surface boundary condition is taken that the heating by the solar radiation is balanced the thermal diffusion from inner parts of planetesials and the radiative cooling from the surface of planetesimals. The specific heat capacity, thermal diffusivity and thermal conductivity which depend on temperature are used in our program; we used the specific heat capacity of H chondrite (Ghosh and McSween, 1999), the thermal diffusivity of H4 chondrite Monroe (Yomogida and Matsui, 1983), and the thermal conductivity calculated from the value of the specific heat capacity, the thermal diffusivity assuming a constant value of the density. Though the values of thermal diffusivity in Yomogida and Matsui (1983) are restricted from 100K to 500K, we calculated values for temperature above 500K by using the empirical equation in that paper.

Our calculation were made by assuming that all the material in the solar nebula had the same abundance ratio of aluminum 26 to 27 as CAIs, and the first generation of planetesimals were formed at that time. The result shows that inner parts of planetesimals were heated above 2000K if their radii were larger than 10 km. It is difficult to consider that parent bodies of chondrirtes were formed by accretion of planetesimals which experienced such thermal histories.

The following three possibilities are considered: (1) planetesimals were not formed in that period of time; (2) planetesimals were formed, but were smaller than several km; (3) the mean abundance ratio of aluminum 26 to 27 were smaller than those of CAIs.