Mn-Cr Chronology of IIIAB Iron Meteorites

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The time scale from the differentiation of asteroids to solidification of the core is discussed. In IIIAB iron meteorites there are some Mn-rich phosphates and Mn-Cr systematics (half-life=3.76[Myr]) can be applied. From Cr isotopic ratio measured with an ion microprobe, the Mn-Cr system closed about 1-7[Myr] after the mantle-crust differentiation of the HED meteorite parent body. Closure temperature is estimated to be about 880[K] and cooling rate was about 50[K/Myr], 10 times faster than the value proposed earlier (about 1-10[K/Myr]) at this temperature. The Mn-Cr ages of IIIAB range over 6[Myr] and there are two possible interpretations; (1) the differences in diffusion coefficients in various phosphates, (2) the differences in meteorite parent bodies.

Several events in the early solar system occurred in a time scale of several Myrs. Short-lived radioactive nuclide systematics can be used to measure the time scale from the differentiation of asteroids to solidification of the core (iron meteorites). In IIIAB iron meteorites (El Sampal[IIIA], Bella Roca[IIIB], Grant[IIIB]) there are some Mn-rich phosphates (sarcopsides/graftonites, beusites and johnsomervilleites) and Mn-Cr systematics (half-life=3.76[Myr]) can be applied.

From Cr isotopic ratio measured with an ion microprobe, the Mn-Cr system closed about 1-7[Myr] after the mantle-crust differentiation of the HED meteorite parent body. The contribution of cosmic ray irradiation to Cr isotope anomaly is insignificant. There was an argument that sarcopsides/graftonites were formed first and johnsomervilleites were formed later (Olsen et al.(1999)), but the difference in ages among these phosphates was found to be small. In contrast beusite seems to have become a closed system after these phosphates because of fast diffusions in this mineral.

Next, the meaning of Mn-Cr chronology is discussed. We assume that the Mn-Cr system closed when the diffusion of Mn in phosphates stopped. Closure temperature (Dodson(1973, 1976)) is estimated to be about 880[K] using a cooling rate, distance of diffusion and a diffusion coefficient (diffusion profile) of Mn in phosphates. Core-mantle-crust of the meteorite parent body differentiated at about 1500[K]. Phosphides formed at about 1240[K] when the core solidified. Phosphates formed by oxidization of phosphides at about 1000[K] and became a closed system at about 880[K]. The Mn-Cr chronology suggests that cooling rate was about 50[K/Myr] at this temperature. This is 10 times faster than the value proposed earlier (about 1-10[K/Myr]), but is consistent with a recent argument (Hopfe and Goldstein(2001)).

The Mn-Cr ages of IIIAB range over about 6[Myr]. There are two possible interpretations of this range. (1) It may be due to differences in diffusion coefficients in various phosphates. (2) If this range can not be attributable to diffusion coefficients, the difference in ages may suggest that IIIAB were not derived from a single core, because each part of core is expected to have the same age.