Mn-Cr chronology of five IIIAB iron meteorites
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Introduction: Well-defined trends of chemical compositions among IIIAB irons suggest that they were derived from a single magmatic unit (core). Since thermal conductivity of iron is much higher than that of silicates, if a group of iron meteorites was derived from a core of the parent body, they are expected to have the same age. However, previous Mn-Cr chronological studies [1,2] suggested that there are age differences of several Ma. among IIIAB irons, indicating that they were not derived from the core of the parent body. We reanalyzed the same iron meteorites that were studied by Hutcheon et al [1,2] in order to find out plausible reasons for the diverse Mn-Cr ages of the IIIAB irons.

Experimental: Mn-Cr systems of Mn-rich phosphate minerals in IIIAB iron meteorites (Bella Roca, Chupaderos, El Sampal, Grant and Sand Town) were studied. In addition, two IIIAB irons (Thunda and Tambo Quemado) that do not contain Mn-rich phosphate were analyzed for various calibration purposes. Analyses were performed with the CAMECA-6f using an 16 O primary beam. Mass resolving power was set to 4000-6000, depending on the height of [CrH] peak relative to the height of [Cr] peak. [Ti] and [V] were measured and used for correction of interferences to [Cr]. Instrumental mass fractionation was corrected using the [Cr]/[Cr] ratios. Corrections for spallogenic [Mn] were made either based on [Cr] measurements of Fe-rich and Mn-poor minerals or based on the literature data on the exposure ages.

Results: Almost all the Mn-rich phosphate minerals in the IIIAB irons contained radiogenic [Cr]. Sarcopside was found in four meteorites. In all sarcopside, [Cr] is well correlated with Mn/Cr. The initial [Mn]/[Mn] ratio inferred from the isochron is about 3.1x10^-6. Graftonite was found in two meteorites. Their ages are somewhat (a couple of Ma.) younger than those of sarcopside. Beusite was found in two meteorites. Their ages are much (up to many tens of Ma.) younger than those of sarcopside. In one beusite grain, [Cr] is constant in spite of fairly large variation in the Mn/Cr ratios. This suggests that Mn is added to beusite after the complete decay of [Mn]. Johnsomervilleite (including galileiite) was found in four meteorites. This mineral was mostly located in sarcopside (or graftonite) and seems to have exsolved from the host phosphate. However, their Mn-Cr data points are located above the isochron of the host phosphates. A plausible interpretation for the apparently old ages is that the johnsomervilleite has lost some Mn after the decay of [Mn].

Summary: It appears that various phosphates in IIIAB irons have different closure temperatures because of different diffusion rates and because of slow cooling of IIIAB irons. Sarcopside seems to have the highest closure temperature and graftonite has the next highest closure temperature. Both beusite and johnsomervilleite seem to have low closure temperatures, which depend on the concentrations of trace elements (Na, Ca, Mg etc.). In particular, Mn in these minerals seems to be able to move at low temperatures, allowing loss (or gain) of Mn after the complete decay of [Mn]. Since sarcopside in four IIIAB irons shows nearly identical ages, we define it as the Mn-Cr age of IIIAB irons. The nearly identical ages for all IIIAB irons in which sarcopside was located suggest that the IIIAB irons were derived from the core of the parent body. Base on the cooling rates, the diameter of the IIIAB parent body is estimated to be several tens of km [3].