

Al-Mg dating of a chondrule in Efremovka CV3 chondrite

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is classified as CV3 carbonaceous chondrite and its CAI showed one of the oldest Pb-Pb age (4567.2±0.7 Myr) in our solar system [1], while the formation age of the chondrule is not well documented. Recently Al-Mg ages of the chondrule have been reported by using a SIMS [2]. However these data were calculated by only one or two spot analysis of Plagioclase and the apparent precision is not sufficient. Here we report ²⁶Ar-²⁶Mg dating of a single anorthite grain located in Efremovka chondrule by using a NanoSIMS installed at Ocean Research Institute, The University of Tokyo.

A thin section of Efremovka was set in a sample holder together with standard anorthite (Miyakejima) and olivine (San Carlos) and carbon coated to dissipate charge during the SIMS analysis. The samples were evacuated in the air-lock system of NanoSIMS to reduce water absorbed on the mount. Using a critical illumination mode, a ~500 pA mass filtered O⁻ primary beam was used in the case of anorthite grains to sputter about 5 micron meter diameter crater and secondary positive beams were extracted for mass analysis using a Mattauch-Herzog geometry. We detected ²⁷Al⁺⁺ (a secondary electron multiplier detector called EM#1) at mass 13.5, ²⁴Mg⁺ (EM#2) at 24, ²⁵Mg⁺ (EM#3) at 25 and ²⁶Mg⁺ (EM#4) at 26 at the same time under a static magnetic field. A mass resolution of 7000 (Cameca definition) was attained for separating ²⁴Mg⁺ from ⁴⁸Ca⁺⁺ with adequate flat topped peaks. The Mg sensitivity of 100 cps/1 nA/ppm was obtained by an intensity of ²⁴Mg ion beam and abundance of Mg in the standard anorthite. In order to obtain accurate Mg isotopic ratios, we have also measured Mg isotopes (²⁴Mg, ²⁵Mg, ²⁶Mg) using a EM#3 detector by a magnet scanning mode.

Apparent excess ²⁶Mg was observed in a relatively small anorthite grain (#1) of the Efremovka chondrule. There is a positive correlation between the Al/Mg ratio and the excess ²⁶Mg, leading to a typical ²⁶Al-²⁶Mg isochron with the initial ²⁶Al/²⁷Al ratio of (3.4±1.1)×10⁻⁶. When we assume the initial ratio of (4.63±0.44)×10⁻⁶ in the Efremovka CAI [1], the formation interval is calculated as 2.64±0.55-0.36×10⁶ year. On the other hand, excess ²⁶Mg in the larger anorthite grains (#2 and #3) are smaller and there is not a correlation between the Al/Mg ratio and excess ²⁶Mg. The initial ²⁶Al/²⁷Al ratio of (0.0±1.5)×10⁻⁶ is consistent with the zero rate.

It has been well established that any anorthite in a single chondrule show the same origin. It is the basis that one may draw the ²⁶Al-²⁶Mg isochron based on the spot analysis of different grains in the same chondrule by using SIMS. However we show that there is a substantial difference between the initial ²⁶Al/²⁷Al ratios of grain by grain. Therefore a careful treatment is required to calculate the formation interval based on the different grains in a single chondrule.

Reference [1] Amelin et al. (2002) Science 297, 1678. [2] Hutcheon et al. (2009) GCA 73, 5080.

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