

Aluminium-26-Magnesium-26 dating of chondrule in ordinary chondrite NWA7936(L3.15) by NanoSIMS

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[1] Introduction

Meteorites are important samples for understanding the history of early solar system. Their structure and age would give us valuable information about early solar system. The undifferentiated meteorites, whose parent bodies haven't experienced differentiation processes, may have the oldest information before planetesimal formation.

In our study, we studied ordinary chondrites which are undifferentiated meteorites and found on the earth. They, however, generally show some degree of thermal metamorphism. For chondrites with petrologic type (i.e., the degree of thermal metamorphism, increase from 3 to 6) >4.0 , only information after thermal metamorphism would be obtained. We can study the formation ages of chondrules or chondrites with petrologic type 3. Even this group, however, is affected by thermal metamorphism to some extent, and further important to know the relationship between the reliable Al-Mg age and the degree of thermal metamorphism. In this study, we conducted Al-Mg dating of chondrules in an ordinary chondrite (L3.15) NWA7936, which haven't been well studied, trying to examine reliability of the chronometer.

[2] Method

We chose ^{26}Al - ^{26}Mg dating method. Half life period of ^{26}Al is 0.7 My. We plotted $\delta^{26}\text{Mg}$ against $^{27}\text{Al}/^{24}\text{Mg}$, where the slope of the correlation line gives the $^{26}\text{Al}/^{27}\text{Al}$ initial ratio. We compare the obtained $^{26}\text{Al}/^{27}\text{Al}$ initial ratios of chondrules with that of CAIs (5.0×10^{-5} , whose absolute age is known to be 4567.3 My). Then we compare the present results with those of previous works.

Before the SIMS analysis, we analyzed the chondrules using SEM-EDS at the department of Earth and Planetary Science, the University of Tokyo and selected the areas with high Al/Mg ratios >30 , suitable for an isochron plot. The analyzed chondrules consist mostly of olivine phenocrysts with mesostasis including small anorthite grains, and minor amount of metals. We applied the ^{26}Al - ^{26}Mg dating method for three chondrules using NanoSIMS at Atmosphere and Ocean Research Institute, the University of Tokyo. We analyzed four points in each chondrules. Primary ion beam is $^{16}\text{O}^+$, $2 \mu\text{m}$ in diameter, with an intensity of 200 pA. Secondary ions of $^{27}\text{Al}^{++}$, $^{26}\text{Mg}^+$, $^{25}\text{Mg}^+$, and $^{24}\text{Mg}^+$ were measured simultaneously with EMs. We measured 100 cycles for each point. The time of 1 cycle was 25s.

[3] Result

The three chondrules show clear excesses in ^{26}Mg and we can draw 'isochrons' passing through the origin. The obtained $^{26}\text{Al}/^{27}\text{Al}$ initial ratios are 1.33 ± 0.41 , 1.67 ± 0.94 , and $1.10 \pm 0.71 (\times 10^{-5})$, respectively. Relative ages are $1.34 (+0.38, -0.27)$, $1.11 (+0.83, -0.45)$, and $1.52 (+1.04, -0.50)$ (Ma), respectively. The three ages are identical within errors. If we assume a single formation ages for chondrules in this meteorite, we may obtain weighted average of $1.34 (+0.30, -0.23)$ Ma after formation.

[4] Discussion

We compared the present results with those of previous work. The initial $^{26}\text{Al}/^{27}\text{Al}$ ratios of chondrules are consistently in the range of $(0.5 \text{ to } 2.0) \times 10^{-5}$ for chondrites with petrographic types of 3.0 to 3.3, and this range most likely corresponds to the time when chondrules formed. On the other hand, meteorites

with petrographic types of >3.4 tend to show much lower values of initial $^{26}\text{Al}/^{27}\text{Al}$ ratio, suggesting that the values probably show the timing of thermal metamorphism.

The present results show identical formation ages for three chondrules in NWA7936 within uncertainties. The previous data for Semarkona(LL3.0), however, suggests that formation ages of chondrules in the same chondrules in the same chondrite may have true variation (1 to 2 My). Hence, the present results may be fortuitous, and we may find variations in chondrules ages for NWA7936 if we increase the number of analyses. If 1-2My difference exists in the chondrule formation ages in a single chondrite, it may require a long-lasting (for a few Mys) mechanism for the formation of chondrules. Further studies about the formation mechanisms of chondrules are required for better understanding of the evolutionary history of the protoplanetary disk.

[5]References

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