High precision Mg isotopic analyses of achondrites: Is the ^{26}Al-^{26}Mg chronometer concordant with other high resolution chronometers?

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We are investigating ^{26}Al-^{26}Mg systematics in achondritic meteorites in which ^{53}Mn-^{53}Cr and/or Pb-Pb systematics have been previously determined. The goals are: (1) to constrain the timing and duration of igneous activity on planetesimals and (2) to determine whether the relative ages from the ^{26}Al-^{26}Mg chronometer are concordant with those obtained from other high resolution chronometers. Currently there are only a few instances where multiple high resolution chronometers have been applied to the same objects. In these cases, the relative ages provided by two or more such chronometers are not always in agreement (e.g., [1]). Constraining the causes of such discrepancies is important since this has implications for the sources and distributions of short-lived radionuclides, and consequently for obtaining high resolution age dates for events in the early solar system.

Our initial report on the high precision Mg isotopic composition of mineral separates from the Juvinas eucrite indicated an upper limit on the $^{26}Al/^{27}Al$ ratio of $<9 \times 10^{-8}$ [2], significantly lower than previously estimated [3]. Assuming the canonical $^{26}Al/^{27}Al$ ratio at 4567.2±0.6 Ma ago (i.e., time of CAI formation) [4], we estimated an ^{26}Al-^{26}Mg age of ≤~4561 Ma. This upper limit is similar to the ^{53}Mn-^{53}Cr age (4562.5±1.0 Ma; [5]), suggesting that it may reflect the true crystallization age of Juvinas. However, we have since analysed the Mg isotopic composition of additional Juvinas plagioclase separates with higher Al/Mg ratios which further constrains the upper limit on the $^{26}Al/^{27}Al$ ratio to $<5.6 \times 10^{-8}$. This implies that the ^{26}Al-^{26}Mg and ^{53}Mn-^{53}Cr chronometers in Juvinas are discordant either because the former was reset at a later time or ^{26}Al was heterogeneously distributed in the early solar system. The only condition under which ^{26}Al-^{26}Mg and ^{53}Mn-^{53}Cr systematics in Juvinas may still be concordant would be if the time of CAI formation (i.e., when the $^{26}Al/^{27}Al$ ratio was $\sim 5 \times 10^{-5}$) was older than ~4567 Ma by at least ~2 Ma. We are determining ^{26}Al-^{26}Mg systematics in additional achondrites since this will be required to distinguish between the above possibilities.

References

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Single mineral Rb-Sr isochron dating

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In the Rb-Sr chronology, conventional mineral isochron method, which necessitates several minerals, have the problem that the closure temperature of each mineral and the extent of weathering differs from one another. And thus, not all rock-forming minerals equally maintains the infomation of the time when the rock formed. As shown in the zonal structure of plagioclases, the chemical composition in a single mineral grain is not homogeneous. Therefore, if the variation of Rb / Sr ratio was sufficiently large, isochron age of single mineral grain is obtainable.

Single mineral Rb-Sr isochron was obtained from two type of rocks in Cretaceous. A welded tuff from the Nohi Rhyolite and a quartz porphyry which occures as a dyke intruded in the Toki Granite are examined. Phenocrysts of K-feldspar and chlorite (from quartz porphyry) were drilled with a striker in order to obtain several fractions from a single grain. Sr isotope ratio and Rb, Sr concentrations were analized for each fraction, which is 0.5-5 mg.

Single K-feldspar grain, extracted from the welded tuff, shows Rb-Sr age of 72±4Ma. It is clearly younger than the CHIME zircon age 85±5Ma (possibly the eruption age)[1]. The age is regarded as the date of contact metamorphism caused by the intrusion of the Toki Granite. Rb, Sr heterogeneity of the grain is likely to have caused by the perthite exsolution during the cooling process.

K-feldspar age obtained from the quartz porphyry was 70.1±7.4 Ma. It is indicating the intrusion age of the dyke. On the other hand, chlorites in the quartz porphyry shows a distinctly younger age of 56.9±5.6Ma (Fig.1). It dates the formation of the chlorites by the secondary hydrothermal alteration. The Single mineral isochron dating will provide us the details for geochemistry and petrology.

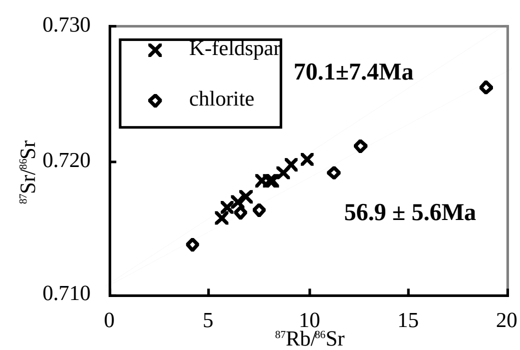

Figure 1 Isochron diagram showing isochrones of K-feldspar and chlorite from the same quartz porphyry.

Reference

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