AL-MG SYSTEMATICS OF HIBONITE-BEARING CA-AL-RICH INCLUSIONS FROM NINGQIANG

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Introduction: Hibonite-bearing CAIs in CMs and CHs possess petrographic and isotopic characteristics distinctive from other typical CAIs [1-3]. Most hibonite-bearing CAIs are essentially devoid of ^{26}Al but preserve large stable isotope (e.g., Ca and Ti) anomalies. On the other hand, spinel-hibonite spherules usually contain evidence of ^{26}Al but lack large Ca and Ti isotopic anomalies. We carry out a petrologic and Mg isotopic study of hibonite-bearing CAIs from Ningqiang and use these results to shed some new lights on the origin and distribution of ^{26}Al in the early solar system.

Results: Ningqiang is an ungrouped carbonaceous chondrite. It shares many similar chemical and petrologic characteristics with CVs and CKs [4]. About 7 % of CAIs in Ningqiang are hibonite-bearing. They range in size from ~20 to 400 μm and exhibit different petrographic textures: (1) aggregates of euhedral hibonite plates in matrix or mantled by multilayered rims, (2) euhedral hibonite crystals or fragments in matrix, (3) hibonite and aluminous pyroxene spherules, (4) hibonite and melilite+perovskite inclusions, (5) hibonite-spinel fragment.

Mg isotopes were analyzed in seven hibonite-bearing CAIs with the Cameca 7f-GEO ion microprobe at Caltech. Hibonite and melilite have relatively high but variable ^{27}Al/^{24}Mg ratios (up to 195 and 28 respectively). Within the analytical uncertainty, hibonite in two hibonite aggregates and two hibonite-pyroxene spherules show no ^{26}Mg excesses. The inferred ^{26}Al/^{27}Al ratios are $< 8\times10^{-6}$. Two hibonite-melilite spherules are chemically and mineralogically indistinguishable but show different Mg isotopes. Hibonite and melilite in one of them display positive ^{26}Mg excesses (up to 25 ‰), correlating with Al/Mg. The inferred ^{26}Al/^{27}Al is $(5.5\pm0.6)\times10^{-5}$. The other one contains normal Mg isotopes. The inferred ^{26}Al/^{27}Al is $< 3.4\times10^{-6}$. Hibonite in a hibonite-spinel fragment shows large ^{26}Mg excesses (up to 38 ‰) that correlate with Al/Mg, with an inferred ^{26}Al/^{27}Al ratio of $(4.5\pm0.8)\times10^{-5}$.

Discussions: It is evident that hibonite-bearing CAIs in Ningqiang also display a bimodal distribution of ^{26}Al in the early solar system. These observations can be interpreted as (1) prolonged formation duration of hibonite-bearing CAIs; (2) thermal alteration of Al-Mg systematics of hibonite-bearing CAIs; (3) local heterogeneity of ^{26}Al distribution in the early solar system; (4) formation of ^{26}Al-free/poor hibonite-bearing CAIs prior to the injection and homogenization of ^{26}Al in the protoplanetary disk. The first two models are inconsistent with the refractory nature and petrologic and isotopic observations of the inclusions [1-3]. The heterogeneous distribution of ^{26}Al is possible, but the high degree of homogeneity of Mg isotopes in the inner solar system makes such an interpretation less attractive [5]. Our results are most consistent with formation of ^{26}Al-free/poor hibonite-bearing CAIs prior to the injection of ^{26}Al into the nebula from a stellar source [2,6].

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