The Sr, Ba, Nd, and Sm Isotopic Compositions of Non-Allende CAIs

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An integrated isotopic study of meteoritic materials

Studying the stable isotope compositions of calcium-aluminum-rich inclusions (CAIs), the first solids in the Solar System, provides insights into the formation and evolution of our Solar System. The majority of CAIs from the Allende meteorite appear to be isotopically uniform, yet distinct from terrestrial standards in a number of elements suggesting the CAI-forming region was isotopically homogeneous [1]. Below the isotopic compositions of CAIs from other meteorites are examined in order to assess the extent of homogeneity of the CAI-forming region.

Characterization of CAIs

Table 1. Characteristics of the CAIs in this study.

Meteorite	Type	CAI name	Textural Type	REE Patterns
Unnamed	CK3	Homer	Fine-grained	Group II
Unnamed	CK5	Bart	Unclassified	Non-group II
NWA 6619	CV3	Marge	Coarse-grained	Non-group II
NWA 6991	CV3	Lisa	Coarse-grained	Non-group II

The CAIs selected for this study from four non-Allende meteorites (Table 1). These CAIs, along with the previously studied Allende CAIs, have a variety of lithologies and REE patterns. Fig. 1 shows the REE patterns of the CAIs examined in this study along with two Allende CAIs for comparison. These CAIs have group II as well as non-group II REE patterns. Fig. 2 A/B shows back scatter electron images of Lisa (coarse-grained) and Homer (fine-grained) demonstrating a range of textural types.

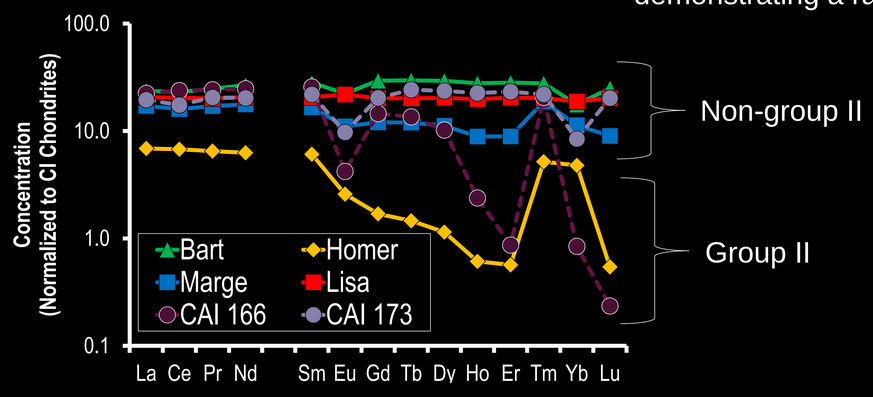

Fig. 1. The REE patterns of the CAIs examined in this study, along with two Allende CAIs (CAI 166 and CAI 173).

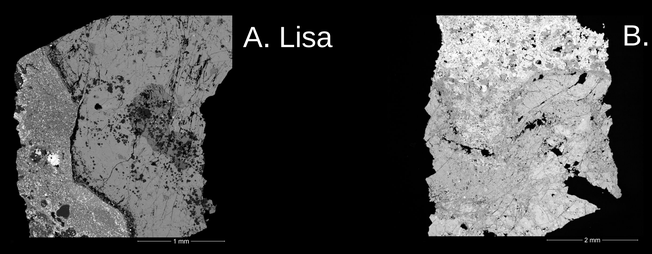

Fig. 2A/B. SEM back scatter electron images of Lisa and Homer from this study.

Results and Discussion

The Sr and Ba isotopic compositions of CAIs analyzed in this study are presented in Fig. 3A/B along with the average isotopic compositions for Sr and Ba from previously studied Allende CAIs [1] (white symbols). Note that some of the CAIs analyzed here are isotopically distinct from the Allende CAIs analyzed previously. These samples have the most radiogenic Sr isotopic compositions consistent with addition of Sr and Ba from terrestrial weathering. The CAIs with the least radiogenic Sr are isotopically similar to the Allende CAIs suggesting derivation from the same reservoir.

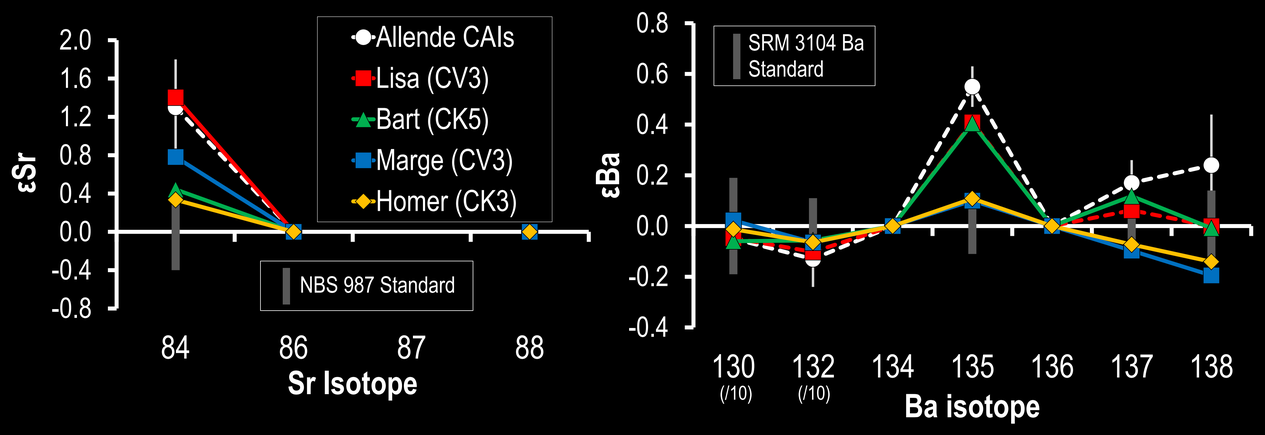

Fig. 3A/B. The Sr and Ba isotopic compositions of CAIs normalized to terrestrial standard values. Average Allende CAIs from [1] in white. Uncertainties reflect 2SD of eleven Allende CAIs analyzed by [1]. Labeling is consistent for all the following figures.

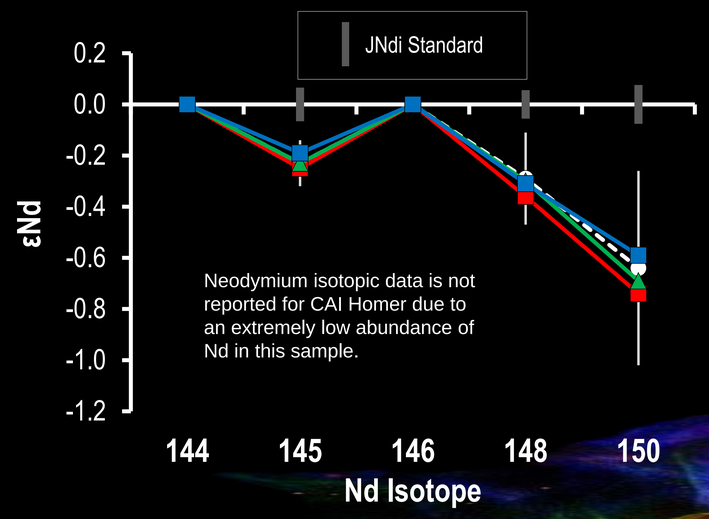

Fig. 4. Nd isotopic compositions of CAIs normalized to terrestrial standards values.

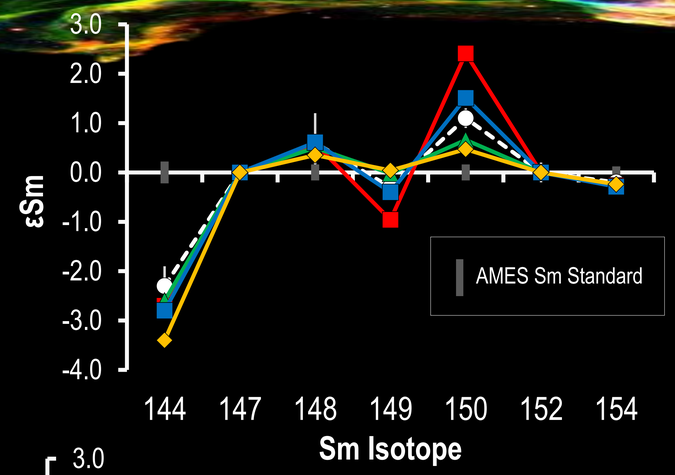

Fig. 5. Sm isotopic compositions of CAIs normalized to terrestrial standard values.

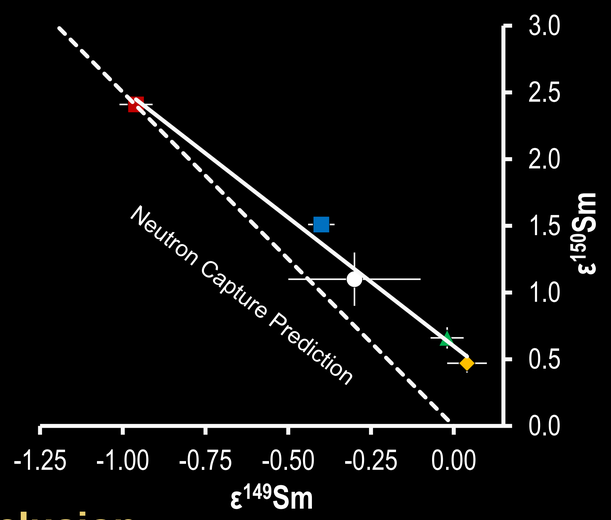

Fig. 6. Plot of ^{149}Sm versus ^{150}Sm of CAIs analyzed in this study and by [1] illustrating the effects of neutron capture. The dashed line represents the effects of neutron capture on a theoretical terrestrial sample. The solid line is a parallel line regressed through CAI data indicating CAIs are effected by neutron capture on ^{149}Sm.

Conclusion

The CAIs analyzed in this work appear to have very similar Sr, Ba, Nd, and Sm isotopic compositions to Allende CAIs analyzed by [1-5]. This suggests that the CAI-forming region was isotopically homogeneous for these elements. Isotopic differences between Sr and Ba in the four samples analyzed here are consistent with addition of terrestrial Sr and Ba associated with desert weathering. Contamination of mobile, water-soluble elements, such as Sr and Ba, is common to desert meteorites. The Nd and Sm isotopic compositions of non-Allende CAIs and Allende CAIs agree well within uncertainty when neutron capture processes are taken into account. Additionally, this work suggests variable neutron fluences/energies exist within different regions of the CV3 parent body. No clear neutron captures signatures are resolvable from samples from the CK parent body.

Works Cited
[1] Brennecka et al. (2013) *PNAS*, *110*, 17241. [2] Hans et al. (2013) *EPSL*, *374*, 204. [3] Moynier (2012) *ApJ*, 758:45.
[4] Bermingham et al. (2014) *GCA*, *133*, 463. [5] Harper et al. (1992) *Meteoritics*, *27*, 230.

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