Ba ISOTOPE ABUNDANCES IN EQUILIBRATED METEORITES AND CAIs. K. R. Bermingham[1] and K. Mezger[1,2], [1]Institut für Mineralogie, Universität Münster, WWU (katherine.bermingham@uni-muenster.de), [2]Institut für Geologie, Universität Bern (klaus.mezger@geo.unibe.ch)

Introduction: The extent of isotopic heterogeneity in the Solar System on the bulk sample scale is a key parameter constraining its early environment and dynamic evolution. It also indicates if regional isochrons need to be developed due to isotopic heterogeneity on the bulk scale throughout the Solar System.

Nucleosynthetic isotopic anomalies have been reported at both the grain scale and bulk sample scale. Anomalous isotopic systems on the bulk sample scale have been found for Ba [1,2,3], Ti [4], Sm [1, 5], Nd [1, 5], and Ni [6]. Barium has seven stable isotopes (^{130,132,134,135,136,137,138}Ba) which sample three key nucleosynthetic processes that may have contributed to the Solar System's composition. These nucleosynthetic processes are the s-process (^{134,135,136,137,138}Ba), the r-process (^{135,137,138}Ba), and the p-process (^{130,132}Ba). Additionally, direct evidence for live ^{135}Cs can be observed in the Ba isotope system as the decay of ^{135}Cs to ^{135}Ba ($t_{1/2}$ ~ 2.3 Myr [7]) contributed to the ^{135}Ba abundance. These features make the Ba isotope system particularly useful when investigating the question of isotopic heterogeneity in the Solar System.

Large Ba isotopic anomalies have been observed in presolar grains [8]. Anomalies in ^{135,137,138}Ba have also been identified in Fractionated Unknown Nuclear (FUN) inclusions and bulk equilibrated and unequilibrated meteorite samples [e.g. 10, 1, 2, 3 and 9]. However, reported anomalies in bulk meteorite samples have been questioned. Authors state that the anomaly pattern determined in unequilibrated primitive meteorites could be due to incomplete dissolution of the presolar SiC grains [1]. ^{138}Ba anomalies in enstatite, carbonaceous and ordinary chondrites have also been queried [9, 3].

We undertook a study eleven bulk samples to determine if the phases bearing large isotopic anomalies were homogeneously distributed in the early Solar System. Here we report Ba isotope data for common Allende CAIs, equilibrated ordinary chondrites, eucrites, and a diogenite. Equilibrated samples were selected to avoid as much as possible the potential problem of not dissolving refractory presolar grains with potentially large anomalies.

Experimental: We studied four equilibrated ordinary chondrites (Oesede H5, Pultusk H5, Butsura H6, Tugalin-Bulen H6), two non-cumulate Eucrites (Juvinas and Stannern), one diogenite (Johnstown), and four CAIs from CV3 chondrite Allende (CAI 1, CAI 2, CAI 4, CAI 5). Samples were dissolved in concentrated HF-HNO_3 in non-pressurized Teflon® vessels, dried, re-dissolved in HF-HNO_3, dried, treated with concentrated $HClO_4$, dried, and then dissolved in 2M HNO_3. Oesede and Butsura left a black fine-grained residue presumed to be refractory mineral grains (e.g. corundum). Barium was separated using a two stage cation exchange chromatography with a combination of HNO_3 and HCl.

^{132,134,135,136,137,138}Ba isotopes were measured with Ta-Re double filaments (sample size 200 - 400 ng) using a static measuring mode on the TIMS at the Zentrallabor für Geochronologie, Universität Münster. Interferences from ^{139}La and ^{140}Ce were monitored but were found to be negligible in all analyses. Two ratios were used to corrected for mass bias (1) r-,s-process isotopes ($^{134/138}$Ba = 0.033715 [2]) which produced a lower external reproducibility than (2), and (2) s-only process isotopes ($^{134/136}$Ba = 0.307776 [2]) to avoid nucleosynthetic bias which may be incorporated into the mass bias correction by using ratio (1). All measurements are reported with 2σ uncertainties.

Results: The mass fractionation corrected Ba isotope data from bulk meteorite samples are shown in Figure 1. These data indicate that all bulk meteorite samples are isotopically indistinguishable from terrestrial standards. The mass fractionation corrected Ba isotope data from bulk Allende CAIs are presented in Figure 2. Three of the measured CAIs possess an excess in ^{135}Ba of ~ ½ ε unit, however, no anomalies are resolvable for the other stable Ba isotopes.

Discussion: All meteorite samples analysed in this study have Ba isotope abundances that are the same as terrestrial standards. Three Allende CAIs have a positive ^{135}Ba anomaly, however, it is not coupled with other Ba isotope anomalies. A positive ^{135}Ba anomaly alone suggests that this excess is due to decay of short-lived radioisotope ^{135}Cs, thus signifying radiogenic-growth of ^{135}Ba as the source of the isotopic anomaly. This is in contrast to a heterogeneous distribution of anomaly bearing phases. Except for the in-growth of ^{135}Ba from the decay of ^{135}Cs, all Allende CAIs studied have identical Ba isotopic composition as terrestrial standards.

The mineralogy and major element bulk geochemistry of the CAIs do not correlate with the presence of a positive ^{135}Ba anomaly. This may suggest that the development of the ^{135}Ba anomaly occurred before condensation of common CAIs.

The terrestrial isotope composition of the samples indicate that the anomaly bearing phases were homogeneously distributed throughout the feeding zones of

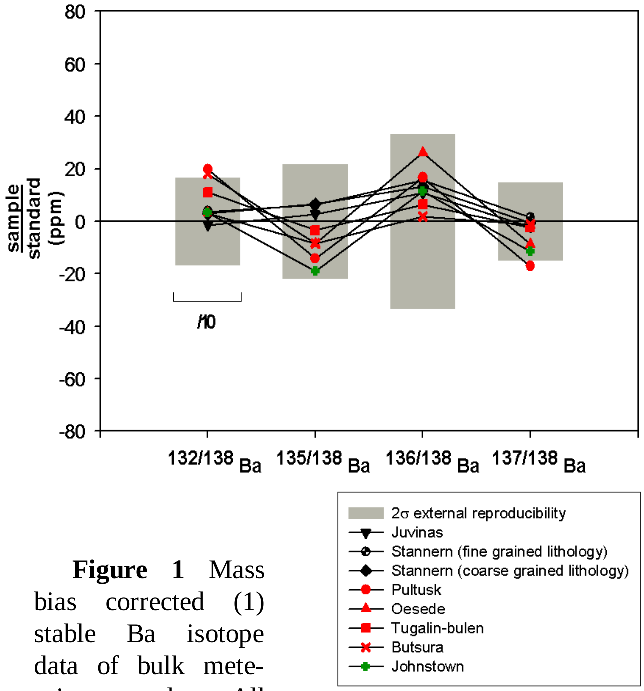

Figure 1 Mass bias corrected (1) stable Ba isotope data of bulk meteorite samples. All samples fall within external reproducibility fields indicating that the meteorites are isotopically identical to terrestrial standards.

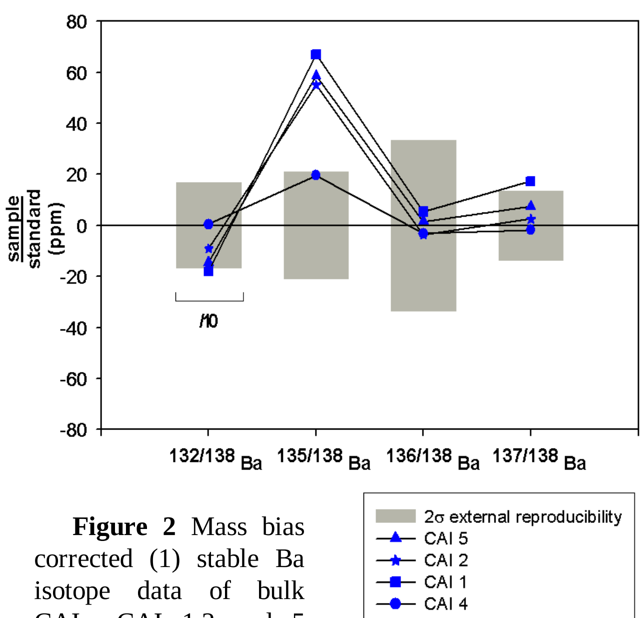

Figure 2 Mass bias corrected (1) stable Ba isotope data of bulk CAIs. CAI 1,2 and 5 display an excess in ^{135}Ba of ~ ½ ε unit. The remaining Ba isotopes are similar to terrestrial standards.

common CAIs, Earth, the HED parent body and the parent bodies of the equilibrated ordinary chondrites.

This conclusion could potentially be extended to include the parent bodies of enstatite and primitive carbonaceous chondrites. As mentioned above, the anomalies observed in primitive unequilibrated chondrites may reflect incomplete dissolution of presolar grains with large anomalies (e.g. SiC). The certainty of the ^{138}Ba isotope anomalies found in Pillistfer were also questioned [9].

Conclusion: Based on the presented Ba isotope dataset it appears that feeder zones for common CAIs, Earth, the HED parent body and the parent bodies of the equilibrated ordinary chondrites were isotopically homogeneous on the bulk sample scale. This signifies thorough mixing of the solar nebula prior to onset of condensation. It also implies a homogeneous distribution of short-lived isotopes (e.g. ^{26}Al). As a consequence, the short-lived isotopes used for constraining the chronology of key processes in the early Solar System or for heating of planetesimals, are universally applicable to date processes in the early Solar System.

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