Barium isotopes and incomplete mixing in the solar nebula

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The Early Solar System (ESS) may not have been as isotopically well mixed for heavy elements as as previously thought. The nucleosynthetic processes which formed all the heavy elements (r-,s-,p-processes, neutron burst) did not necessarily homogenize themselves so that various planetary bodies have the same isotopic composition of the heavy elements. This has been shown in isotopes of Mo, Zr, Os and Nd where bulk chondrites are enriched in the r-process or the neutron burst process compared to the s-process. The Nd data are more complicated because of the possibility that fractionation between Sm and Nd and subsequent decay of ^{146}Sm could have caused the variations in Nd isotopes. To further investigate the effects of incomplete mixing we have studied the Ba isotopic composition of both carbonaceous and ordinary chondrites. All samples studied show an excess of up to 50 ppm in the ^{138}Ba/^{136}Ba ratio compared to the Earth when normalized to ^{134}Ba/^{136}Ba, two s-only nuclides. This is consistent with an r-process excess (^{138}Ba is made by both the r- and the s-processes) or a neutron burst component excess. The only way that Ba isotope differences can exist between bulk planetary bodies is by incomplete mixing of nucleosyntheic components, not by fractionation within a planet. The Ba data predicts a deficit in ^{142}Nd (an s only nuclide) in chondrites suggesting that the ^{142}Nd/^{144}Nd differences between chondrites and the Earth are not due to Sm/Nd fractionation and ^{146}Sm decay in the early Earth, but rather that the ESS was not perfectly mixed with regard to the carrier grains of different nucleosynthetic processes.