Megascale isotopic anomaly in Cr?

K. KITTS, R. H. NICHOLS JR. AND F. A. PODOSEK

Dept. Earth & Planetary Sciences and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, USA (kitts@levee.wustl.edu)

Undifferentiated meteorites provide many examples of microscale (spatial scale cm and smaller) isotopic anomalies, i.e. isotopic variations indicating incomplete mixing of stellar nucleosynthetic components, reflecting preservation of presolar solids [1]. Megascale anomalies, i.e. isotopic variations among different planetary bodies (e.g. in O [2] and arguably in Cr [3,4]), are fewer and smaller, and provide different constraints on solar nebula models.

Pursuant to better understanding of possible megascale anomalies in Cr, we have recently reported isotopic data for surface-correlated (putatively solar wind) Cr in lunar soil [5], finding excess ^{54}Cr of at least 8 epsilon-units, and also excess ^{53}Cr half that big. These results are well outside the envelope anticipated beforehand.

Perhaps these data do not represent presolar anomaly, but rather nuclear reactions within the solar system. The moon itself is a possible venue for such reactions; an interesting alternative is the atmosphere of the sun [6]. These two possibilities seem at the edge of plausibility [7]: They cannot be eliminated unambiguously but neither can they be supported in quantitative detail. In this work, therefore, we pursue ramifications of the interpretation that surface-correlated lunar Cr really is isotopically anomalous.

The direct interpretation is that the sun, or at least the source region of the solar wind, has a different isotopic composition than the terrestrial planets, reflecting different admixture or presolar nucleosynthetic components. This seems outlandish, but the difference need be only of order one permil. This situation could arise if the solar system's antecedent interstellar cloud were itself spatially heterogeneous.

Alternatively, instead of solar wind Cr we may have measured meteoritic Cr. There is enough inferred meteoritic material in lunar soils to permit this interpretation, but its distribution is not known well enough for definitive evaluation. An immediate objection to this hypothesis is that known meteoritic (whole rock) Cr is not so anomalous, so a very unusual source of meteoritic material would have to be postulated. Thus, this interpretation would permit the tenet that the sun and terrestrial planets were made from the same material but at the expense of requiring that most meteoritic infall to the moon is not like known meteoritic material, e.g. is possibly from isotopically exotic comets.

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Mercury in Carbonaceous Chondrites

B. KLAUE[1], D. S. LAURETTA[2], AND J. D. BLUM[1]

[1]University of Michigan, Dept. of Geological Sciences, Ann Arbor, MI 48109, <bklaue@umich.edu>

[2]University of Arizona, Lunar and Planetary Laboratory, Tucson, AZ 85721, < lauretta@lpl.arizona.edu>

Introduction: There are many reports of isotopic anomalies in meteoritic Hg [1, 2]. Every such report is based on neutron activation analysis, which can only detect two of the seven stable Hg isotopes. As a result only anomalies in the ^{196}Hg/^{202}Hg ratio have been reported.

We have developed a technique to measure low concentrations (pg/g levels) and isotopic abundances of Hg with a precision of ±0.005 – 0.02% using single- and multi-collector inductively coupled plasma mass spectrometry (ICPMS) coupled with continuous-flow cold-vapor generation. We first applied this technique to Murchison (CM) and Allende (CV), two meteorites which reportedly contain isotopically anomalous Hg. Our measurements suggest that the relative bulk abundances of all seven stable Hg isotopes in both meteorites are identical to terrestrial values within 0.7 ‰ [3]. Thermal analysis coupled with ICP-MS revealed distinct Hg release patterns for Allende and Murchison.

We have continued our study of mercury in primitive meteorites and expanded the suite of meteorites to include other members of the CM and CV chondrite group as well as CI and CO chondrites.

Methods: Clean, interior samples of the CI chondrite Orgueil, the CM chondrites Murray, Nogoya, and Cold Bokkeveld, the CO chondrites Kainsaz, Ornans, and Isna, and the CV chondrites Vigarano, Mokoia, and Grosnaja were gently crushed under ethanol to obtain uniformly-sized powders. The samples were digested in a mixture of $HF/HNO_3/HCl$ at 210°C/50 bar. Bulk abundance and isotopic composition measurements were performed using an ELEMENT2 (ThermoFinnigan) single-collector magnetic-sector ICP-MS. The continuous-flow, cold-vapor-generation apparatus is described in [3]. Thermal analysis was performed with a controllable oven coupled to the ICP-MS.

Results: The isotopic compositions of the meteorites show no significant isotopic anomalies greater than a few permil. These measurements will be repeated by MC-ICP-MS to determine if any fractionation is present below this level. Bulk abundances range from the sub-ppb level up to several ppm. Details of the thermal analyses are given in [4].

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