RARE EARTH AND TRACE ELEMENT ABUNDANCES IN INDIVIDUAL IDPs:

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Secondary ion mass spectrometry (SIMS) was used to determine Rare Earth (REE) and trace element abundances in individual stratospheric dust particles (SDPs). The H, C, and N isotopic compositions of all particles has been reported previously (1, 2); additional new Li, O, and Mg measurements were also made. Thus it is, for the first time, possible to compare isotopic and trace element abundance data of the same interplanetary dust particles (IDPs). The results of the O isotopic measurements and of the abundance measurements are reported here.

The O isotopic composition was determined in 35 fragments of 34 SDPs. The measurements were performed according to previously established routines (3) and all results are normalized to SMOW. Some of the results are shown in an 3-isotope-plot in Fig. 1 with 1σ error ellipses. In all but one of the measured particles the O isotopic compositions plot on (or close to) the terrestrial fractionation line. The variations along this line are large, with $\delta^{18}O$ values ranging from -18 ‰ to +50 ‰. Only in particle DIDIUS both measured fragments exhibit ^{16}O enrichments and fall close to the Allende mixing line. Similar O isotopic anomalies have previously been observed in refractory IDPs (4). The EDX spectrum of DIDIUS shows larger contributions of the refractory elements Ca and Al than a "chondritic" spectrum.

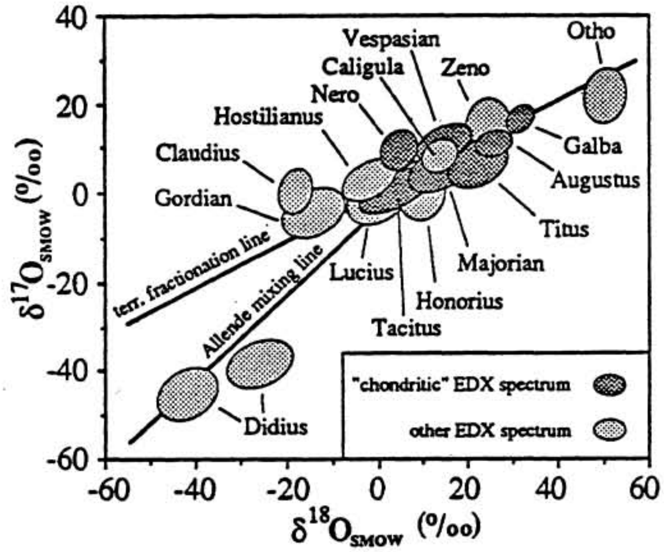
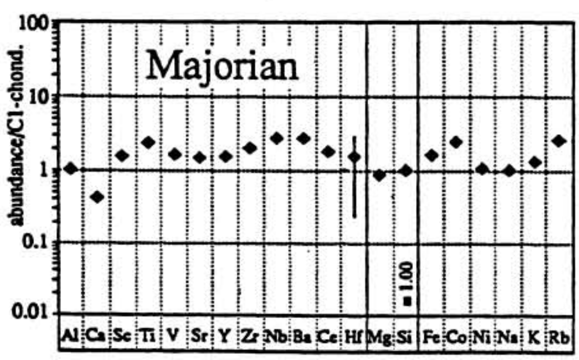


Figure 1: Oxygen isotopic composition of stratospheric dust particles.



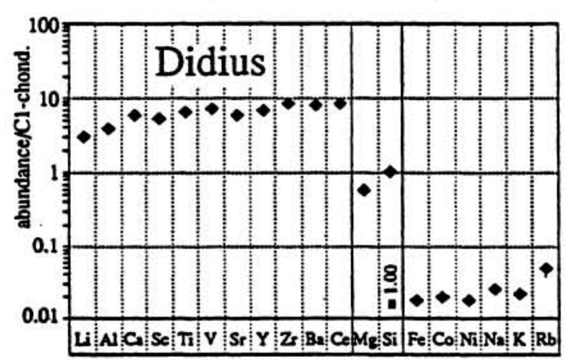


Figure 2: Trace element abundances in two interplanetary dust particles. In most cases the 1σ errors from counting statistics are smaller than the symbols.

Trace element abundances have been measured in 19 fragments of 16 SDPs. In addition, 5 of these particles were large enough to enable the determination of REE abundances. These SIMS analyses were made with an O^- primary beam, positive secondary ions, and energy filtering to remove interferences by complex molecular ions (5). Uncertainties of the determined elemental abundances, as a result of molecular interferences and "matrix effects", are expected to be smaller than 50 %. All results are normalized to Si and C1 abundances (*i.e.* Si ≡ 1). Seven particles exhibit C1 abundances — within a factor of three — for all measured trace elements (with the possible exception of Ca; see below). The trace element pattern of these particles are essentially "flat" (see MAJORIAN in Fig. 2) and there is no indication of any fractionation between refractory and volatile elements. There seems to be no significant loss of volatiles due to atmospheric entry heating. Ca depletions (up to a factor of 30 below C1 abundances) are found in 4 particles. Similar Ca anomalies have been observed before (e.g. 6, 7). The IR class was determined for 3 of the particles with Ca depletions: Two belong to the "anhydrous" and one to the "hydrous" class. This fact makes aqueous alteration as origin of the Ca anomaly (7) unlikely.

Particle DIDIUS is clearly identified as a refractory IDP by its trace elemental composition (Fig. 2). All refractory elements are enriched by up to a factor of 10 (relative to Si), while siderophile and volatile elements are depleted by up to a factor of 50. The trace element abundances and the O isotopic anomaly in DIDIUS are similar to those observed in Ca-Al-rich inclusions from chondrites (8).

Most of the other analyzed particles show seemingly unsystematic variations of the trace element abundances. In particular, no other particle with uniform enrichments or depletions of the volatile relative to the refractory elements has been found.

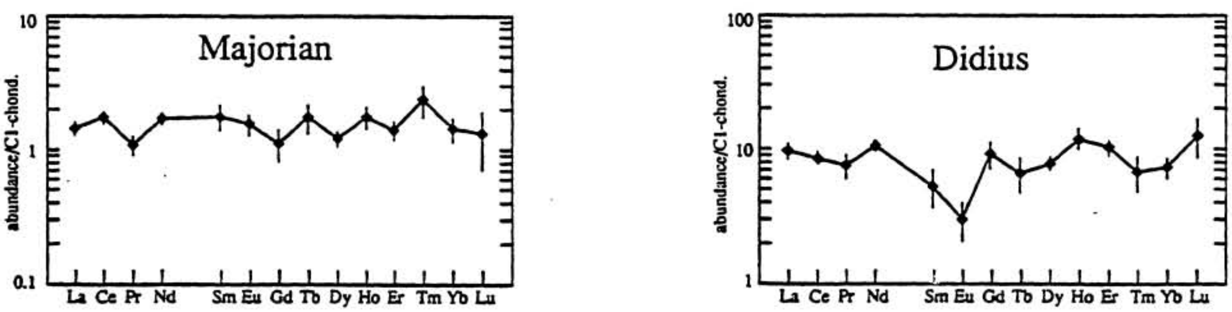


Figure 3: REE abundances in two IDPs. Errors are 1 σ from counting statistics.

In 4 particles the REE (Fig. 3) have C1 abundances (within 2 σ of the error based on counting statistics). Only in DIDIUS the REE are enriched by an average factor of 10 (relative to Si) and Eu is depleted relative to the other REE.

Of most of the analyzed IDPs there is still enough material left to make additional measurements possible. TEM measurements are currently being prepared for some of them (9). Future trace element analyses with SIMS can be extended to other elements as soon as suitable standards become available.

References: (1) Stadermann et al. 1989, Meteoritics 24, 327 (2) Stadermann et al. 1990, LPSC XXI (3) McKeegan 1987, Ph.D. thesis, Washington Univ. (4) McKeegan 1987, Science 237, 1468 (5) Zinner and Crozaz 1986, Int. J. Mass Spect. and Ion Proc. 69, 17 (6) Wallenwein et al. 1987, Proc. Europ. Regional Meeting IAU, Prague, 10, 245 (7) Schramm et al. 1989, Meteoritics 24, 99 (8) MacPherson et al. 1988, In: Meteorites and the early solar system (Kerridge and Matthews eds.) Univ. of Arizona Press, Tucson (9) T. Bernatowicz 1990, pers. comm.