

Oxygen Isotopic Heterogeneity Among Eucrites

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We have measured precise abundances of ¹⁶O, ¹⁷O and ¹⁸O for a total of 35 howardites, diogenites, and eucrites using bulk rock powders, rock fragments and mineral separates. The $\delta^{18}\text{O}$ values range from 3.1 to 4.5 ‰ relative to SMOW. $\Delta^{17}\text{O}$ values of the eucrites span a range of -0.25 ‰ to -0.07 ‰ below the terrestrial fractionation line. Howardites and diogenites are restricted to between -0.23 and -0.26 ‰. The most extreme deviation from the diogenites and howardites is displayed by Ibitira with an $\Delta^{17}\text{O}$ of -0.07 ‰. However, Caldera, Pasamonte and Moama ($\Delta^{17}\text{O} = -0.19$ to -0.20 ‰) also are significantly different from the diogenites and howardites. Chervony Kut and Binda give slightly higher $\Delta^{17}\text{O}$ values than Kapoeta which may relate to proposed differences in initial strontium isotope ratios (Smoliar 1993). From these results it is clear that the eucrites are not derived from a single source. For example, on the basis of oxygen isotopes it seems unlikely that Stannern, Ibitira, ALHA76005, and Chervony Kut ("Stannern trend") formed by different degrees of melting of the same source as has been proposed from petrological arguments (Stolper 1977) unless this source was relatively poorly mixed. Classically speaking the oxygen isotopes of an achondrite are the "fingerprint" of its parent body (e.g. Clayton and Mayeda 1996). However, on this basis the O data would require that the studied eucrites must come from, at least, 4 different parent bodies. It is certainly hard to reconcile the data with derivation from a single parent body homogenised by a magma ocean or other forms of convective mixing. Asteroid number 4 Vesta is the assumed parent body of the eucrites (EPB). If all the eucrites come from Vesta it was never homogenised completely and the eucrites are derived from different reservoirs. The eucrites may have crystallised from different magma regions generated by large impacts on the same planetary body. The putative impactors may have contributed to this heterogeneity. For example, with the exception of Ibitira, the entire range of $\Delta^{17}\text{O}$ compositions could be produced by adding less than 5 % ordinary chondrite like material. Such a model would be consistent with the relatively young ages for Caldera and Moama. It would require, however, that the metal portion of the impactor separated efficiently from the silicate portion.

References

Smoliar (1993) *Meteoritics* 28, 105-113

Iron isotope variations in a complete natural soil catena with lateral iron mobilization and reprecipitation

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The Fe cycle in soils is driven by both abiotic and biotic reactions and mainly based upon redox transitions between Fe^{II} and Fe^{III}. Usually Fe redistribution is limited to vertical translocation within the soil profile. However, under certain topological and geochemical conditions a lateral flux of Fe between different soil profiles takes place. We have chosen such a system to perform the first complete characterization of Fe isotope variations within a soil landscape.

The sampling area (Black Forest, Germany) is a well-studied type location in soil science (Blume, 1988, Fig.21-15) that has developed during the last ~10-15 kys on hematitic sandstone. A substantial part of the area is subject to reducing conditions due to water saturation throughout the whole year. Hence large amounts of Fe are mobilized by reductive dissolution and transported downslope until its oxidation and reprecipitation in a better drained landscape position. We sampled the whole soil catena vertically and laterally and performed a separation of soil Fe into the following Fe pools: (1) "poorly-crystalline" Fe(III) and Fe(II) minerals (0.5M HCl extract); (2) "well-crystalline" Fe (total dissolution); (3) pore water solutions. Fe isotopes were measured by MC-ICP-MS (Nu Plasma) with an analytical precision of $\pm 0.15\%$ (2 σ) for $\delta^{56}\text{Fe}$ and expressed relative to IRM14 Fe standard.

While the unaltered bedrock is unfractionated relative to IRM14, $\delta^{56}\text{Fe}$ of soil samples ranges from +1.5‰ in the reduced, Fe-depleted soil, to -0.5‰ in the oxidized, Fe-enriched soil. Pore waters exhibit locally highly variable values. Solutions from the reduced soil show $\delta^{56}\text{Fe}$ of ~+1‰ heavier than the unaltered bedrock. This might appear unexpected, since light Fe isotopes are usually enriched in solution upon reduction of iron. However, results from both Fe solid pools suggest that light Fe removal has proceeded so intensely over the past kiloyears, that an enrichment in ⁵⁶Fe of up to 1.5‰ accumulated in the water-saturated soil. The removed light Fe is encountered in the lower soil, where re-oxidation has led to Fe reprecipitation.

Therefore an unexpected picture emerges: whereas Fe isotope theory and experiments predict light isotopes in reduced solutions and heavy isotopes in oxidized precipitates, time-integration of lateral Fe transport results in the reversal of this "instantaneous" picture. Perhaps we present a first attempt to reconstruct soil redox histories.

Blume, H.P. (1988). In *Iron in soils and clay minerals* (eds. Stucki, J.W., Goodman, B.A., and Schwertmann, U.), p.749-777. D.Reidel, Dordrecht