Nucleosynthetic Nd isotope anomalies in primitive enstatite chondrites

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Introduction

The first high precision measurements of ^{142}Nd/^{144}Nd ratios in chondrites have revealed that different groups of chondrites are characterized by different ratios [1, 2]. In order to interpret properly the deviation of ^{142}Nd/^{144}Nd ratio measured between terrestrial samples and chondrite material, it is crucial to understand the cause of the ^{142}Nd deviation in the different groups of chondrites. Enstatite chondrites (EC) present similar isotope compositions to terrestrial samples for a large number of elements (O, N, Mo, Cr, Ti) and have also the smallest ^{142}Nd offset (-10±12 ppm, [3]). We have selected primitive EC belonging to the EH subgroup for further Sm-Nd isotope investigations using a step-wise acid disolution method. The goal of this study is to better characterize the carrier phase of Nd nucleosynthetic anomalies and define their isotope composition.

Methods and Results

Sample powders were subjected to the following sequential leaching procedure: (1) H_2O then acetic acid, (2) EDTA, (3) 6M HCl, (4) Aqua regia and concentrated HF-HNO_3 mixture.. The major and trace element compositions of each fraction have been measured by ICP-AES and ICP-MS, respectively. Sm and Nd were separated using a 3 steps chemistry procedure and isotopes were measured on the Thermo-Fischer thermal ionization mass spectrometer at Laboratoire Magmas et Volcan, Clermont-Ferrand.

Most of the REE (50 to 80%) are contained in the first two leachate fractions mostly derived from the dissolution of oldhamite and ninigerite as deduced from the major element compositions. The last fraction have small REE contents (5-20%) which is mostly derived from the dissolution of enstatite and djerfisherite. Nd isotopes anomalies (ratios normalized to ^{146}Nd/^{144}Nd=0.7219) are always positive for ^{145}Nd, ^{148}Nd and ^{150}Nd and negative in ^{142}Nd in fraction (1) to (3). The largest isotope anomalies are always measured in the last fraction (residu) with ^{142}Nd excess ranging from +200 to +600 ppm. The largest effects are measured in ALH77295, which is the most primitive EC analysed in this study.

Discussion

The residues obtained after leaching treatment are strongly enriched in s-process nuclides. The different Nd isotopes plot along the same correlation lines defined for leachates and residues of carbonaceous and odinary chondrites [4] suggesting that all residues contain s-process rich presolar grains. The amount of Sm in each fraction was too small to allow precise measurement of the ^{144}Sm/^{152}Sm ratios, however the p-process variability seems to be relatively small.

[1] Boyet and Carlson M. (2005) Science 309, 576-581. [2] Carlson et al. (2007) Science 316, 1175-1178. [3] Gannoun et al. (2011) PNAS 108, 7693-7697. [4] Qin et al. (2011) GCA 75, 7806-7828.

Aerosol release of Fe into the ocean: the extreme cases

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By now it is well-known that partial dissolution of Fe from atmospheric aerosols is a major source of iron for oceanic phytoplankton and nitrogen fixers. But many of the details of the process are only partially understood: (1) What regulates the degree of Fe dissolution? (mineralogy of the source and chemical processing within the atmosphere are believed to be important, with anthropogenic aerosols releasing more Fe either because of the source or processing from anthropogenic acidity and photochemical processing), (2) What determines the form that iron takes upon release into seawater? (it appears that most of the aerosol-released Fe is converted into organic or inorganic colloidal form in high-dust regions, although there is an expectation that soluble organic complexes should also be important), (3) How does the dust flux influence the biota? (both phytoplankton and nitrogen fixers).

In order to learn more about these issues, we will discuss the contrasting oceanic iron distributions under a high-dust region (tropical North Atlantic) and a low-dust region (southeast Pacific between Chile and Easter Island). Under the high-dust region, most of the surface water Fe is colloidal and is removed to low concentrations near the chlorophyll maximum. Phosphorus is depleted to extremely low concentrations, as any excess over Redfield N:P ratios is compensated by nitrogen fixation. Below that, iron increases in step with increasing AOU, and the C:Fe ratio is low (~100,000). Under the low-dust environment, Fe is relatively low (0.10-0.15 nM) and uniform in the upper few hundred meters (despite increasing AOU below the chlorophyll maximum) and then increases to much higher C:Fe ratios (~500,000). Dissolved inorganic phosphorus remains at fairly high concentrations (~0.20 uM) because insufficient Fe prevents nitrogen fixers from compensating for the low N:P ratio in the upwelling deep waters.