

## Large and heterogeneous isotopic anomalies of Sm and Gd in the Norton County meteorite

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### Introduction

Cosmic rays in space penetrate a few meters into the surface of planetary materials, and produce cosmogenic nuclides in the materials. The exposure history of meteorites has been characterized by several cosmogenic nuclides. Sm and Gd isotopic shifts by neutron capture reactions also provide useful information for understanding the exposure records of meteorites, because <sup>149</sup>Sm and <sup>157</sup>Gd have very large thermal neutron capture cross sections and shift to <sup>150</sup>Sm and <sup>158</sup>Gd, respectively.

Enstatite achondrites (aubrites) are highly reduced achondrite meteorites, and must have formed in a very unique part of the solar nebular. The Norton County aubrite is known as one of the longest cosmic-ray exposure ages (111 Ma [1]), and its recovery of the main mass over 1000 kg is large enough to accumulate many kinds of cosmogenic nuclides. Therefore, Norton County is one of the best examples to study cosmic-ray irradiation effects [2-5]. We found very large and heterogeneous isotopic shifts of Sm and Gd in specific phases of Norton County, and would like to discuss the possible existence of preirradiation materials migrating into the meteorite body.

### Experiments

In this study, whole rock, handpicked material of the light-colored phase (consisting mainly of enstatite), and chemical separates obtained by a sequential acid-leaching method (acetic acid-ammonium acetate, 0.1 M HCl, 2 M HCl, aqua regia, and the residue) were prepared from the same single fragment of Norton County. Sm and Gd were separated from the individual samples by a conventional method using cation exchange methods [6]. A thermal ionization mass spectrometer was used for the isotopic measurements of Sm and Gd.

### Results and Conclusions

Large and heterogeneous isotopic variations of <sup>150</sup>Sm/<sup>149</sup>Sm and <sup>158</sup>Gd/<sup>157</sup>Gd due to neutron capture reactions caused by cosmic-ray irradiation were found in chemical and mineral separates from the Norton County meteorite. The light-colored separates have a very large neutron fluence of  $1.98 \times 10^{17}$  n cm<sup>-2</sup>, which is 10 times higher than that of the whole rock. Furthermore, four chemical separates showed a large variation in neutron fluences, ranging from  $1.82 \times 10^{16}$  to  $1.87 \times 10^{17}$  n cm<sup>-2</sup>. The variable amounts of neutron fluences from a small single fragment of the Norton County meteorite cannot be simply explained by single-stage cosmic-ray irradiation in space.

[1] Lorenzetti et al. (2003) *GCA* **67**, 557-571. [2] Eugster et al. (1970) *JGR* **75**, 2753-2768. [3] Hidaka, Ebihara & Yoneda (1999) *EPSL* **173**, 41-51. [4] Hidaka, Yoneda & Marti (2006) *GCA* **70**, 3449-3456. [5] Herzog et al. (2011) *MAPS* **46**, 284-310. [6] Hidaka & Yoneda (2007) *GCA* **71**, 1074-1086.

## Microscopic Structure of Interfaces of Minerals in Relation to Macroscopic Ion Adsorption Phenomena

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Mineral-water interfaces are important in regulating the free ion concentration of many minor elements in nature. In the interface, a bulk mineral meets the water network, forming a reactive structure for ion adsorption in which surface groups are a key for understanding reactivity. Surface groups and surface complexes can be characterized with modern spectroscopy (e.g. X-ray techniques, FTIR) and computational approaches (MO/DFT and MD simulations). Microscopic surface complexation is usually conditional, i.e. it will depend on pH, ionic strength, the concentration of the ion involved as well as the presence of cooperative and competitive ions. Surface complexation models (SCM) can be used to generalize experimental microscopic information and to rationalize macroscopic adsorption behavior as a function of environmental conditions. Microscopic data and tools are also highly valuable for parameterization and development of mechanistic adsorption frameworks, such as the CD and MUSIC model. Achievements and challenges will be discussed.

The variable surface speciation of a particular ion is largely regulated by the joint electrostatic interactions of all ions in the interface and there is a feedback from the water network. The structure of interfacial water and location of interfacial charge are essential. Interfacial structure and mechanisms of charging of minerals are very different. This will be illustrated, comparing metal oxides, silver halides, and ice, using experimental information as well as computational data.