

ScienceDirect.com - Geochimica et Cosmochimica Acta - Quadruple sulfur isotope analysis of ca. 3.5 Ga Dresser Formation: New evidence for microbial sulfate reduction in the early Archean

Abstract

1. Introduction
2. Geological outline of the North Pole area
2.1. The Dresser Formation

2.2. Hydrothermal silica-barite vein swarm

Quadruple sulfur isotope analysis of ca. 3.5 Ga Dresser Formation: New evidence for microbial sulfate reduction in the early Archean

Yuichiro Ueno^{a,*,}, Shuhei Ono^{a,†}, Douglas Rumble^a, Shigenori Maruyama^a

^a Global Edge Institute, Tokyo Institute of Technology, Post Number 0-21, Maguro, Tokyo 152-8551, Japan
^b Research Center for the Evolving Earth and Planet, Tokyo Institute of Technology, Meguro, Tokyo 226-8503, Japan
^c Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Meguro, Tokyo 226-8503, Japan
^d Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road, NW Washington, DC 20015, USA
^e Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Avenue, MA 02139, USA

<http://dx.doi.org/10.1016/j.gca.2008.08.026>, [How to Cite or Link Using DOI](#)
[Permissions & Reprints](#)

[View full text](#)

[Purchase \\$39.95](#)

Abstract

Multiple sulfur isotope system is a powerful new tracer for atmospheric, volcanic, and biological influences on sulfur cycles in the anoxic early Earth. Here, we report high-precision quadruple sulfur isotope analyses (³⁴S/³²S, ³⁶S/³²S) of barite, pyrite in barite, and sulfides in related hydrothermal and igneous rocks occurring in

ScienceDirect.com - Geochimica et Cosmochimica Acta - Quadruple sulfur isotope analysis of ca. 3.5 Ga Dresser Formation: New evidence for microbial sulfate reduction in the early Archean

Abstract

Multiple sulfur isotope system is a powerful new tracer for atmospheric, volcanic, and biological influences on sulfur cycles in the anoxic early Earth. Here, we report high-precision quadruple sulfur isotope analyses (³⁴S/³²S, ³⁶S/³²S) of barite, pyrite in barite, and sulfides in related hydrothermal and igneous rocks occurring in the ca. 3.5 Ga Dresser Formation, Western Australia. Our results indicate that observed isotopic variations are mainly controlled by mixing of mass-dependently (MD) and non-mass-dependently fractionated (non-MD) sulfur reservoirs. Based on the quadruple sulfur isotope systematics ($\delta^{34}\text{S}$ - $\Delta^{34}\text{S}$ - $\Delta^{36}\text{S}$) for these minerals, four end-member sulfur reservoirs have been recognized: (1) non-MD sulfate ($\delta^{34}\text{S} = -5 \pm 2\%$, $\Delta^{36}\text{S} = -3 \pm 1\%$); (2) MD sulfate ($\delta^{34}\text{S} = +10 \pm 3\%$); (3) non-MD sulfur ($\delta^{34}\text{S} > +6\%$, $\Delta^{36}\text{S} > +4\%$); and (4) igneous MD sulfur ($\delta^{34}\text{S} = \Delta^{36}\text{S} = 0\%$). The first and third components show a clear non-MD signature, thus probably represent sulfate and sulfur aerosol inputs. The MD sulfate component (2) is enriched in ³⁴S (+10 ± 3%) and may have originated from microbial and/or abiotic disproportionation of volcanic S or SO₂. Our results reconfirm that the Dresser barites contain small amounts of pyrite depleted in ³⁴S by 15–22% relative to the host barite. These barite–pyrite pairs exhibit a mass-dependent relationship of $\delta^{34}\text{S}$ / $\delta^{36}\text{S}$ with slope less than 0.512, which is consistent with that expected for microbial sulfate reduction and is significantly different from that of equilibrium fractionation (0.515). The barite–pyrite pairs also show up to 1‰ difference in $\Delta^{36}\text{S}$ values and steep $\Delta^{36}\text{S}/\Delta^{34}\text{S}$ slopes, which deviate from the main Archean array ($\Delta^{36}\text{S}/\Delta^{34}\text{S} = -0.9$) and are comparable to isotope effects exhibited by sulfate reducing microbes ($\Delta^{36}\text{S}/\Delta^{34}\text{S} = -5$ to -11). These new lines of evidence support the existence of sulfate reducers at ca. 3.5 Ga, whereas microbial sulfur disproportionation may have been more limited than recently suggested.

Figures and tables from this article:

ScienceDirect.com - Geochimica et Cosmochimica Acta - Quadruple sulfur isotope analysis of ca. 3.5 Ga Dresser Formation: New evidence for microbial sulfate reduction in the early Archean

Figures and tables from this article:

Fig. 1. Geological map of the Dresser Formation in the North Pole area modified from Kitajima et al. (2001). The samples mainly come from two areas enclosed by boxes (Dresser domain (Fig. 2) and Dolterite Creek domain (Fig. 3)). Stars indicate locations of the outcrops sketched in Fig. 4 and Fig. 5. Locality of pyrites from bedded chert analyzed by Hu et al. (2003, Table 5) is also shown.

Fig. 2. Sulfur isotopic distribution in the Dresser domain. Sulfide-bearing silica veins developed exclusively below the chert-barite unit of the Dresser Formation, indicating syngenetic nature of the veins. The $\delta^{34}\text{S}$ and $\Delta^{36}\text{S}$ values of sulfide are shown in parentheses (red: CRS extracted from bulk powder, blue: pyrite separates). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)