

CAO Rui, SONG Xuebing and TAN Qian, 2014. Fe Isotope Fractionation Mechanisms and its Application in Geoscience Field. *Acta Geologica Sinica* (English Edition), 88(supp. 2): 1552-1553.

Fe Isotope Fractionation Mechanisms and its Application in Geoscience Field

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1 Introduction

The Fe isotope has been proved to be a effective means for researches of geoscience field with the breakthrough in analytical and testing techniques. This paper gives a brief introduction for fractionation mechanisms and application in geoscience field of Fe isotope.

2 Fe Isotopic Fractionation Mechanisms

The Fe isotope of hematite precipitate during $\text{Fe(III)}_{\text{aq}}$ hydrolysis at 98°C in 1–100 days had significant change. Fe isotopic fractionation coefficient ($\alpha_{\text{Fe(III)}_{\text{aq}}\text{-hematite}}$) between $\text{Fe(III)}_{\text{aq}}$ and hematite was -1.00132 (Skulan et al., 2002). Wiesli et al. (2004) studied the Fe isotopic fractionation during the process from $\text{Fe(II)}_{\text{aq}}$ to FeCO_3 precipitate at 20°C. There was no isotopic fractionation effect between $\text{Fe(II)}_{\text{aq}}$ and FeCO_3 in the experiment of quick precipitation. On the contrary, the isotope enrichment coefficient between FeCO_3 and $\text{Fe(II)}_{\text{aq}}$ was -0.48‰ in the experiment of slow precipitation.

Inorganic reaction, such as the change of oxidation-reductions conditions could result in variation of valence of element and the coordination number, and Fe isotope fractionation (Yu et al., 2001). Leaching experiments of ion exchange resins showed that the solution leached at early stage riched ^{56}Fe and lacked ^{56}Fe at late stage. This experiment indicated inorganic reaction could result in notable isotope fractionation without bacteria (Anbar, 2008).

Rouxel et al. (2004) found $\delta^{56}\text{Fe}$ of pyrite was -0.2‰ to -0.5‰ precipitated under the high temperature condition ($>300^\circ\text{C}$) and that was -1‰ to -2‰ under $100\text{--}300^\circ\text{C}$. The result indicated the $\delta^{56}\text{Fe}$ of precipitated pyrite gradually decreased with decreasing of temperature. ^{56}Fe

enrichment coefficient between $\text{Fe(II)}_{\text{aq}}$ and remnants was $0.5\text{‰}\text{--}1.3\text{‰}$ in the process of water-rock leaching reaction; altered mineral, such as smectite and chlorite had priority to getting heavy Fe isotope (Rouxel et al., 2003).

Fe widely distributed in nature, and may participate in biochemical reaction. Bio-organic process involves multiple reaction steps, such as bio-filtration membrane and enzyme catalysis, and therefore biological process can trigger remarkable Fe isotope fractionation (Yu et al., 2001). The $\delta^{56}\text{Fe}$ value of tint stratum was about 0.91‰ , that of dark stratum was about -0.34‰ in the research on iron sedimentary formation in the Proterozoic strata. Reduction reaction of bacteria was responsible for the difference of $\delta^{56}\text{Fe}$ value. However, the difference between red stratum and black stratum was quite small in the Archeozoic strata, that showed there wasn't bacteria reduction reaction during the iron sedimentary formation (Beard, 1999).

3 Fe Isotopic Application in Geoscience Field

Li et al. (2008) conducted the research of Fe isotope and REEs of BIF and found apparent positive correlation between Fe isotope composition and Eu abnormality in Anshan-Benxi area, revealing that iron sources were connected with marine volcanism.

Jiang (2003) introduced detailedly application of Fe isotope in meteorites and paleoceanography. He thought that Fe was one of the most volatile elements in the meteorites and the residual enriched heavy Fe isotope after Fe volatilization. Fe isotope composition of oceanic Fe-Mn incrustation was studied in the research of paleoceanography and was controlled by Fe isotope from hydrothermal fluid, river and pore water of continental shelf areas.

Polygon et al. (2000) inferred the mineral containing

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Fe³⁺ was more inclined to gathering heavy Fe isotope than that containing Fe²⁺ based on the Mossbauer spectroscopy data. Zhu et al. (2002) found symbiotic mineral assemblages Ol-Opx-Cpx-Amp (olivine- orthopyroxene-clinopyroxene-amphibole) in the xenolith of mantle peridotite in Tanzania and British Columbia, Canada exhibited Fe isotope fractionation. They were characterized by Ol<Opx $\approx$ Cpx<Amp for $\delta^{57}\text{Fe}$. In addition, amphibole formed by mantle metasomatism riched heavy Fe isotope compared with other minerals of mantle peridotite xenolith, showing that Fe isotope had significant potential for research of mantle metasomatism and mantle concentration (Zhu et al., 2002). On the other hand, Fe isotope composition of mantle olivine may be affected by deep mantle process, mantle metasomatism, partial melting, etc, therefore Fe isotope may be used as a new mantle geochemical tracer (Zhao et al., 2008).

Acknowledgements

We thank Professor GuanYin, Doctor Xuesong Tian for their detailed discuss and pertinent suggestion for manuscript.

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