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# Fe Isotope Characteristics of Polymetallic Crusts and Nodules from South China Sea and its Geological Implications

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## 1 Introduction

As the third largest marginal sea in the world, South China Sea is rich in marine mineral resources, including the polymetallic crusts and nodules which are rich in Co, Ni, Cu, REE and PGE. As one of the main direct ore-forming elements, the study which focus on the Fe isotope compositions of the marginal sea-type polymetallic crusts and nodules from South China Sea is still not reported. Furthermore, polymetallic crusts and nodules record the information of paleoceanographic environment and climate change during their growth history. Therefore, the research that we directly study on the Fe isotope compositions of polymetallic crusts and nodules from South China Sea will contribute to the study of the material sources and ore-forming process, and play an important indicator of the South China Sea pale-environmental change research.

## 2 Samples and Fe Isotope Geochemical Characteristics

The polymetallic crusts and nodules studied here were dredged respectively from the regional surveys by "Haiyangsihao" in the South China Sea, sampling depths are range from 800– 2300 m.

The variability of Fe isotope compositions ($\delta^{56}Fe_{IRMM-014}$) we presented in the polymetallic crusts and nodules from South China Sea is between −0.81 to −0.25‰ (average −0.40‰, n = 7), compared with IRMM-014, all samples are enrichment of Fe light isotope. There are obviously differences for Fe isotopes in the different sea areas of South China Sea, samples where near the northern margin have lower $\delta^{56}$Fe values. In the modern ocean Fe has extremely low concentration, range with ＜1nM in the open ocean (Wu et al., 2001), and the residence time of Fe in seawater is very short (Bruland et al., 1994), it results that in the significant local scope and inter-basin differences in Fe isotope compositions. Compared between polymetallic crusts and nodules from South China Sea and ferromanganese crusts and nodules from the global ocean (Fig. 1), the result shows that Fe isotope compositions of all crusts and nodules are enrichment of Fe light isotope, and Fe isotope compositions of the samples we study are similar to the other oceans, slightly higher than oceanic nodules.

## 3 Fe Isotope Geological Implication

The polymetallic crusts and nodules from South China Sea were not affected by the phosphatization in the process of their growth, so their Fe isotope compositions are mainly controlled by material source, seawater REDOX environment and the metallogenic process, and the degree of precipitation and crystallization. Ferromanganese crusts and nodules growled directly in seawater, therefore Fe of seawater is the direct material source of ferromanganese crusts and nodules. The sources of Fe in seawater mainly include terrigenous material, riverine input, the pore water of continental shelf and sediments (remobilization of Fe from the bottom sediments), submarine hydrothermal fluids, submarine weathering and etc. (eg. Sharma et al., 2001; Beard et al., 2003a, 2003b; Rouxel et al., 2003; Fantle and DePaolo, 2004; Severmann et al., 2004, 2006; Bergquist and Boyle, 2006). Such multiple sources can provide the negative $\delta^{56}$Fe fluxes into seawater, and are consistent with the Fe isotope compositions of ferromanganese crusts and nodules. In contrast to the global oceanic ferromanganese

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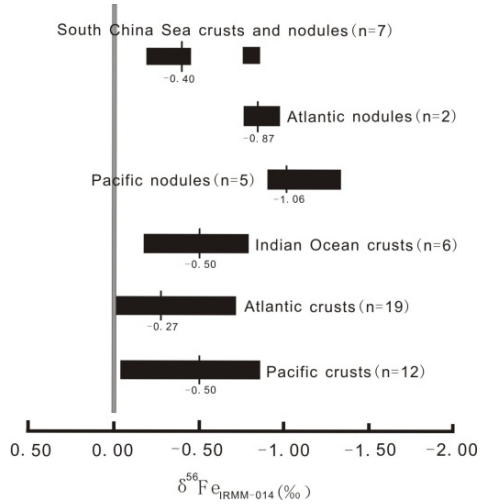


Fig. 1. Fe isotope compositions of worldwide ferromanganese crusts and nodules (The oceanic data from Levasseur et al., 2004; Chu et al., 2006; Beard and Johnson, 1999).

crusts and nodules (Fig. 1), the marginal sea-type polymetallic crusts and nodules from South China Sea show a relatively higher $\delta^{56}$Fe values. Because of the short residence time for Fe in seawater, Fe isotopes can't completely homogenize in ocean. It suggests that the polymetallic crusts and nodules from South China Sea may be mainly affected by the fluxes of terrigenous material and riverine input. In addition, compared to the research samples and oceanic ferromanganese crusts (Fig. 1), the nodules from Pacific and Atlantic have lower $\delta^{56}$Fe values, they may be mainly influenced by the remobilization of Fe from the pore water of sediments.

Ferromanganese crusts and nodules grew in a relative oxidation condition, and affected by seawater REDOX environment meantime. The formation of iron phase minerals of ferromanganese crusts and nodules contains two key metallogenic processes: the first step is $Fe(II)_{aq}$ oxidized to $Fe(III)_{aq}$ in seawater, and the second is the $Fe(III)_{aq}$ transform into ferric oxides/hydroxides precipitate (Beard et al., 2003a; Dauphas et al., 2004). Therefore, the research of the causes of variability of Fe isotope compositions of crusts and nodules requires a clear understanding on the two key steps in the degree of Fe isotope fractionation. Previous studies (eg. Johnson et al., 2002; Balci et al., 2006) show that the two steps mentioned in both biological oxidation and oxidation environment, and all can cause Fe isotope fractionation. In contrast to the less Fe isotope fractionation of formation

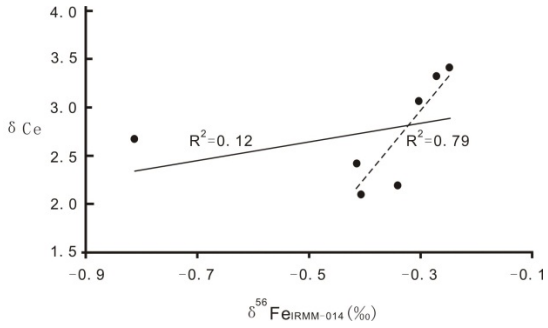


Fig. 2. Correlation diagram of Fe isotope compositions and $\delta$Ce.

process of Fe(III) precipitate, the fractionation of the process of $Fe(II)_{aq}$ oxidized to $Fe(III)_{aq}$ in seawater is greater and enrichment of Fe heavy isotopes in the $Fe(III)_{aq}$. The samples from South China Sea grew in a more oxidized seawater condition compared with the other oceans, the Figure 2 shows, the higher the degree of oxidation of seawater are, the more enriched Fe heavy isotopes in the samples. Therefore, the oxidation environment could be one of the reasons why more Fe heavy isotopes in the polymetallic crusts and nodules from South China Sea than other oceans.

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