

Variation of the seawater Sr isotope on a geological time scale: implications for solid earth and environmental change.

KASHIWAGI, Hirohiko^{1*}, Yasumasa Ogawa², Naotatsu Shikazono³

¹Keio University, ²Tohoku University, ³Keio University

In order to reveal the petrogenesis of ore deposits, it is necessary to elucidate origin and age of oceanic crust forming the deposits and the earth environment at that period. In this respect, the seawater strontium isotope ratio ($87\text{Sr}/86\text{Sr}$) recorded in marine sediments is regulated by a balance between weathered materials originated from continents and mantle-derived materials by hydrothermal reaction, which could be a useful proxy for the ancient crustal production and environmental change. We point out the reasons for the variation of seawater $87\text{Sr}/86\text{Sr}$ and its related problems based on the recent geochemical knowledge.

With regard to continental weathering, young volcanic rock is important. It would contribute to the variation of the seawater $87\text{Sr}/86\text{Sr}$ because the strontium isotopic value of this type of rocks is low and they have high reactivity. Moreover, metamorphosed carbonate in the orogenic zone is significant. It has higher $87\text{Sr}/86\text{Sr}$ than marine carbonate since the metamorphosed carbonate is formed by reactions with surrounding silicate minerals. Concerning the hydrothermal reaction, recent studies indicate that the hydrothermal reactions take place at ridge flank and that the off-axis hydrothermal reaction as well as the ridge axial reaction on high temperature should be taken into account as a controlling factor on the seawater $87\text{Sr}/86\text{Sr}$ value.

On a geological time scale, temporal change of continental area and sealevel is often discussed which alter the seawater $87\text{Sr}/86\text{Sr}$ variation. In Achaean, a sudden increase of the seawater $87\text{Sr}/86\text{Sr}$ due to the formation of the juvenile continents is pointed out. Also, the correspondence to Wilson cycle and sealevel fluctuation from Paleozoic to Cretaceous in Mesozoic area is known. However, in Cenozoic, the seawater $87\text{Sr}/86\text{Sr}$ variation is not consistent with the sealevel change. Instead, the elevation and denudation in the Himalaya and Tibet, weathering of Columbia flood basalt, specific weathering accompanied with glaciations, and link to the atmospheric CO_2 variation are discussed.

Among these geochemical factors, seafloor spreading in the early Cenozoic is possibly a part of the factors controlling the seawater $87\text{Sr}/86\text{Sr}$ at that period. In respect of the uplift of Himalayan and Tibetan region, in general terms, there are two kinds of the explanations about the cause of the seawater $87\text{Sr}/86\text{Sr}$ in the late Cenozoic, that is, increase in the weathering amount, and/or the high $87\text{Sr}/86\text{Sr}$ value of weathered materials of those regions, although some numerical studies oppose the former case. In terms of the atmospheric CO_2 variation, its concentration in the late Cenozoic is roughly same as that at present and it does not match the trend of variation of the seawater $87\text{Sr}/86\text{Sr}$. Thus, the seawater $87\text{Sr}/86\text{Sr}$ could not be used as a proxy for the atmospheric CO_2 level during this period.

Finally, the seawater $87\text{Sr}/86\text{Sr}$ variation on a geological time scale cannot be explained by a simple factor, but combination of them. Accordingly, for example, it is useful to elucidate the reasons for the seawater $87\text{Sr}/86\text{Sr}$ variation by using the numerical models which parameterize the possible controlling factors on the seawater $87\text{Sr}/86\text{Sr}$ variation. Especially, because the relationship between the variation of the seawater $87\text{Sr}/86\text{Sr}$ and the change of atmospheric CO_2 and development of glaciation would indicate a close link between behavior of a specific element and environmental change, it should be further discussed in the future.

Keywords: strontium isotope, weathering, hydrothermal reaction, Cenozoic, Himalaya, glaciation