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Helium and Argon Isotopic Compositions of Hydrothermal Sulfides from Southwest Indian Ridge and Their Geological Inferences

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Submarine hydrothermal sulfides deposits are famous as a type of mineral resources, distributed in a variety of tectonic settings on the ocean floor. These hydrothermal fields are rich in metallic elements, such as Cu, Zn, Fe, Au and Ag and almost similar to VMS deposits on land (Herzig and Hannington, 1995). Among them, hydrothermal fields in the Southwest Indian Ridge (SWIR) are characterized by ultraslow-spreading speed background, while little attention has been paid to their source of metallogenic material and fluid. For these issues, we can apply isotope systems to provide more metallogenic information. Thereinto, He-Ar isotope can remain unchanged in water-rock reaction, and at the same time isotopic compositions vary in different sources of fluid. So we can trace the origin of ore-forming fluid and evolutionary process by He-Ar isotope.

1 Geological Setting

Southwest Indian Ridge (SWIR) extends 7700 km from the Bouvet triple junction (BTJ) to the Rodrigues triple junction (RTJ). SWIR spreads at a much lower rate of 13~18mm/a, belonging to a typical ultraslow spreading ridge. Our study is based on a collection of 3 sulfide samples gained from eastern section of SWIR at 49~50°E, where the investigation of hydrothermal activity is most advanced in SWIR at present. Since 8-10Ma, this segment of ridge had undergone a suddenly increased melt-supplying process. And interaction between the Crozet hotspots and SWIR may be the reason of ridge abnormal accretion.

2 Results and Discussion

In this study, the average ^{3}He concentration is 2.61×10^{-13} $cm^3STP \cdot g^{-1}$, while ^{4}He is $2.00\times10^{-8}cm^3STP \cdot g^{-1}$. The ^{40}Ar average concentration is $2.55\times10^{-6}cm^3STP \cdot g^{-1}$, while ^{36}Ar is $8.61\times10^{-9}cm^3STP \cdot g^{-1}$. After calculation, the average $^{3}He/^{4}He$ value is $9.29R_a$ (R_a stands for the ratio of $^{3}He/^{4}He$ in the air, generally equals to 1.40×10^{-6}), and $^{40}Ar/^{36}Ar$ is 296.48.

Published analyses of He/Ar isotopic compositions show that there are three sources of rare gas in the fluid. (1) Air-saturated water (ASW; $^{3}He/^{4}He=1R_a$, $^{40}Ar/^{36}Ar$ = 295.5). (2) Mantle volatiles and mantle-derived rocks ($^{3}He/^{4}He$: 7~9 R_a, $^{40}Ar/^{36}Ar$>40000; Patterson et al., 1994). (3) He and Ar produced in the crust ($^{40}Ar/^{36}Ar$ ratios≥45000 and $^{3}He/^{4}He$ ratios≤0.1 R_a; Andrews, 1985). However, as accreted crust from mid-oceanic ridge, the oceanic crust are contain extremely low radiogenic elements, such as U, so $^{3}He/^{4}He$ ratios of oceanic crust approach to upper mantle (6-9R_a). As a result, varying mixture of He-Ar isotopic reservoirs lead to characteristic compositions of He-Ar isotope in hydrothermal fields.

Similar to the other hydrothermal fields, the average value of $^{3}He/^{4}He$ ratios (9.29 R_a) in SWIR hydrothermal fields fall in the range of mantle-derived He (Fig.1-A), suggesting that main He in the samples is derived from mantle. However, it is worth noting that this $^{3}He/^{4}He$ ratio is not only higher than Indian oceanic ridge MORB（8.49 R_a; Graham, 2002), but also than upper mantle fluid slightly （6~9R_a; Burnard et al., 1999). The author infers that a small account of lower mantle-derived He contribute to hydrothermal fluid in SWIR hydrothermal system, maybe related to Marion and Crozet hotspots activities.

On the other side, the average value of $^{40}Ar/^{36}Ar$ is 296.48, which approach to the value of air (295.5), but

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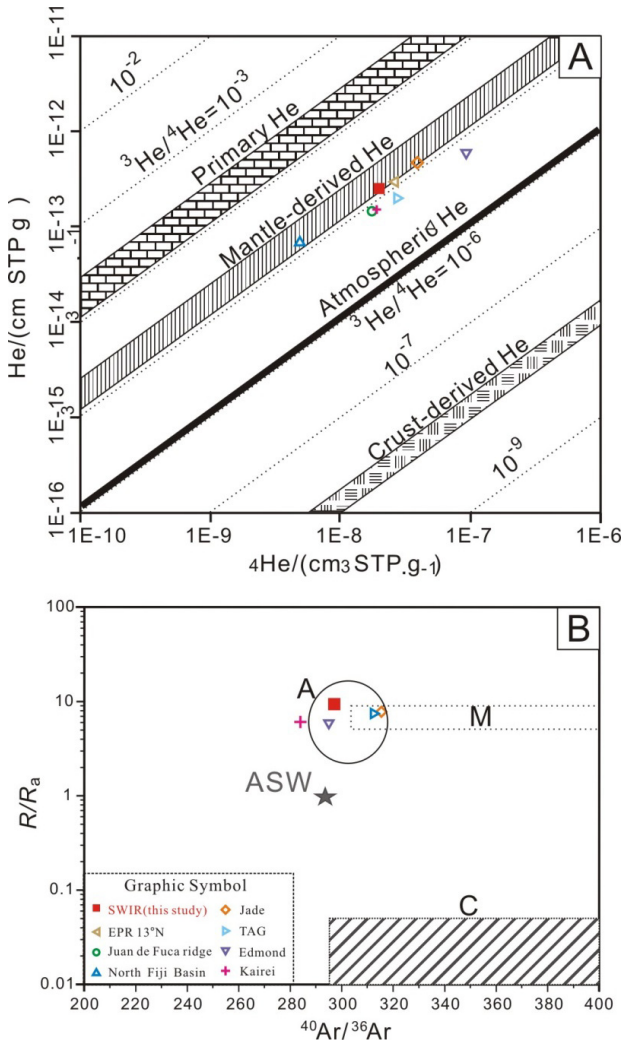

Fig. 1. ^4He -^3He (A) and R/R_a-$^{40}Ar/^{36}Ar$ diagram (B) compositions of the sulfides in SWIR hydrothermal fields.

are far below the value of upper and lower mantle. These results suggest that major of Ar in samples is derived from seawater, but the contribution from mantle-derived Ar cannot be ignored. Such as it is, little change occurs in the Ar isotopic composition mixed with mantle-derived fluid, because of Ar high solubility in the seawater. As a result, hydrothermal sulfides show the distinctive characteristics that are He derived from mantle but Ar isotopic compositions similar to air. Analogous to the other hydrothermal areas, He-Ar isotopic compositions in this study fall in typical submarine hydrothermal range (Fig.1-B).

3 Conclusion

The average value of $^3He/^4He$ and $^{40}Ar/^{36}Ar$ in sulfides samples from SWIR hydrothermal fields is 9.29 R_a and 296.48 respectively. He isotopic compositions suggest He is derived from mantle, and a part of He may come from lower mantle through Marion and Crozet hotspots activities. Ar isotopic analysis indicates that major of Ar in samples is derived from seawater.

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