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He-Ar Isotopic Compositions of Ore-Forming Fluid from the Yushui Copper -polymetallic Deposit in Eastern Guangdong Province, South China

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The Yushui deposit located in Meizhou, Guangdong Province, is a middle-scale copper deposit associated with Ag, Pb, and Zn, and was discovered in the late 1980s. This deposit has got geologists' attention because of its high grade of copper in a small area, with contents averaging 3.25% and a maximum of 50-60%, and being associated with a medium-sized reserve of silver. Researchers had begun to study this deposit in the early 1990s (He, 1990; Chen et al., 1992; Cai et al., 1996; Liu, 1997; Wang et al., 1999; Gu et al., 2003), but its ore-forming fluids need further study. This paper is aimed to research He-Ar isotopic compositions of the fluid inclusions in sulfides from the Yushui deposit. We expect to use the He-Ar isotopic evidence to discuss the ore-forming fluids source for the Yushui Cu-polymetallic deposit, and to provide the evidence for further work.

1 Deposit Geology Characteristics

The Yushui Cu-polymetallic deposit is located in the middle part of the Yong (an)-Mei (xian) Late Paleozoic Hercynian depression. The stratigraphy of the regional outcrops include clastic rocks of the Middle Devonian-Lower Carboniferous, carbonatite of the Upper Carboniferous Hutian group, continental volcanic rocks of the Upper Jurassic Gaojiping Group, inland lake volcano - sedimentary clastic rocks of the Lower Cretaceous Guancaohu Group. Although there is no distinct folded deformation in the mine area, fault structures were well developed by the influence of two regional faults.

The ore body of the Yushui deposit is morphologically bedded, lenticular and veined. The ore body is located at the unconformable plane between the limestone of the Upper Carboniferous Hutian Group and the quartz sandstone of the Lower Carboniferous Zhongxin Formation with the thickness of 0 - 19m. The ores are mainly massive, dominated by chalcopyrite, bornite, chalcocite, pyrite, sphalerite and galena as the metallic minerals and calcite, dolomite, quartz, muscovite, sericite and fluorite as the gangue minerals. The whole alterations of main ore body are weak, but silification is slightly stronger, other alterations such as chloritization, sericitization, carbonatation, pyritization, etc, are secondary, locally the rare earth element mineralization is strongly.

2 He-Ar Isotopic Results and Discussion

The sulfides from the Yushui deposit were analyzed He-Ar isotopic compositions of their fluid inclusions. The results are as follow: (1) ^{4}He = (2.27～22.41×10^{-5} cm^3 ($STP·g^{-1}$), ^{3}He = (0.53～4.06)×10^{-12} cm^3($STP·g^{-1}$), ^{40}Ar = (0.63～3.78)×10^{-6} cm^3($STP·g^{-1}$), ^{36}Ar = (1.25～10.40)×10^{-9} cm^3($STP·g^{-1}$). (2) $^{3}He/^{4}He$ value of the fluid inclusions are 0.006-0.056 R_a (R_a is the $^{3}He/^{4}He$ value of atmosphere, conventionally is 1.39×10^{-6}), with the average of 0.026 R_a. (3) $^{40}Ar/^{36}Ar$ value of 333.76～501.68 with average of 398.71, is slight higher than the atmosphere (295.5).

On the $^{40}Ar/^{36}Ar$ vs. R/R_a diagram (not shown), the sulfides from the Yushui deposit plot in the field of crustal fluids. It indicates that there is no mantle helium in the ore-forming fluids and the ore-forming fluids come from the crust. The $^{3}He/^{4}He$ values and $^{40}Ar^*/^{4}He$ values of samples are 0.006 ～ 0.056R_a and 0.0011 ～ 0.0155 respectively while the lithospheric mantle fluids are 6～8R_a and 0.5 and the crustal fluid are <0.1R_a and 0.2 (Stuart et al., 1995). On the $^{40}Ar^*/^{4}He$ vs. R/R_a diagram (Fig.1), the samples fall in the field of crustal fluids. The

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$^{40}Ar^*/^4He$ values of two samples are far lower than the others. It can also be identified in the $^{40}Ar/^{36}Ar$ vs. R/R_a diagram that the two samples plot slightly under the field of crustal fluids. As a consequence, it is necessary to analyze the two samples.

By the analysis of trace element and rare earth elements, we find that the contents of U and REE in the two samples are much higher than the others, and the total rare earth elements contents are more than 1300ppm. Furthermore, more evidences are found that the REE minerals distribute spatially along veins and replacement the later stage vein of galena, based on the observations of microscope and scanning electron microscope. These evidences show that the primary He-Ar isotopic compositions of the two samples were changed by the influence of later stage hydrothermal alteration. However, the influences of hydrothermal alteration on the other four samples are week. He-Ar isotopic compositions of the four samples can represent the primary He-Ar isotopic compositions of ore-forming fluids. In a word, the ore-forming fluids of the Yushui deposit are crust-derived.

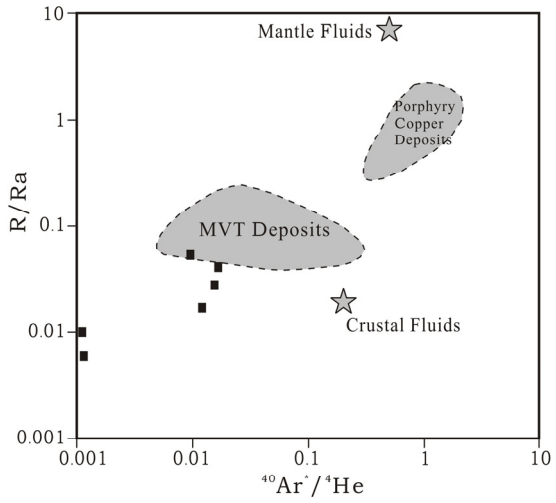

Fig. 1 $^{40}Ar^*/^4He$ vs. R/R_a diagram for inclusions in sulfides collected from the Yushui deposit in Eastern Guangdong Province, South China

3 Conclusion

(1) The $^3He/^4He$ values and $^{40}Ar/^{36}Ar$ values of the fluid inclusions in sulfides from the Yushui copper-polymetallic deposit are $0.006 \sim 0.056R_a$ and $333.76 \sim 501.68$, respectively, belong to the range of crustal fluids. It is indicated that the ore-forming fluids of the Yushui deposit may be the crustal fluids without mixing with mantle fluids.

(2) The $^3He/^4He$ values and $^{40}Ar^*/^4He$ values of some samples in the Yushui deposit are significantly lower than the characteristic value of crustal fluids. Combined with microscopic observation and analysis of trace element and rare earth element, indicated that part of the Yushui ore body are influenced by later stage hydrothermal alteration.

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