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Stable Isotopic Geochemistry of the Bainaimiao Copper Deposit

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The Bainaimiao copper deposit is located in the Ondor Sum Caledonian accretion zone in the Central Asian Orogenic Belt. This area has undergone complex tectonic development, including ocean formation, subduction and closure. The geological settings and geochemistry of Bainaimiao copper deposit have been well documented in a number of previous studies. However, the evolution process of ore bearing liquid is still unclear especially for the identity and distinctiveness between the northern and the southern ore belts. In addition, the genesis is debatable because of its complicated process of mineralization. Therefore, the contrast study on liquid evolution can not only provide evidence on genesis but also bring us a deeper comprehension on ore forming system.

1 Ore Geology and Stable Isotope Geochemistry

The deposit consists of the northern and the southern ore belts. The host rock of the southern ore belt is greenschist while the orebodies mainly occur in the mineralized granodiorite porphyry intrusions contact zones with the Bainaimiao Group in the northern belt. The metallogenic process can be divided into early, middle, and late stages, which are characterized by quartz-pyrite (early stage) (Fig. 1. a), quartz-chalcopyrite, molybdenite (middle stage) (Fig. 1. b), and quartz, calcite, galena, sphalerite (late stage) (Fig. 1.c, d), respectively. So, the evolution process of ore bearing liquid can be represented by the geochemistry characteristics of gangue minerals and sulfides of these stages. Nine quartz samples were collected from early stage to late stage in the northern and the southern ore belts separately. The $\delta^{18}O_{H2O}$ and δD ratios of fluid inclusions in quartz range from -3.2 ‰ to 5.5 ‰, and -94.2 ‰ to -69 ‰, respectively. The δD value is relatively constant, whereas the $\delta^{18}O_{H2O}$ value decreases gradually from early to late stages.

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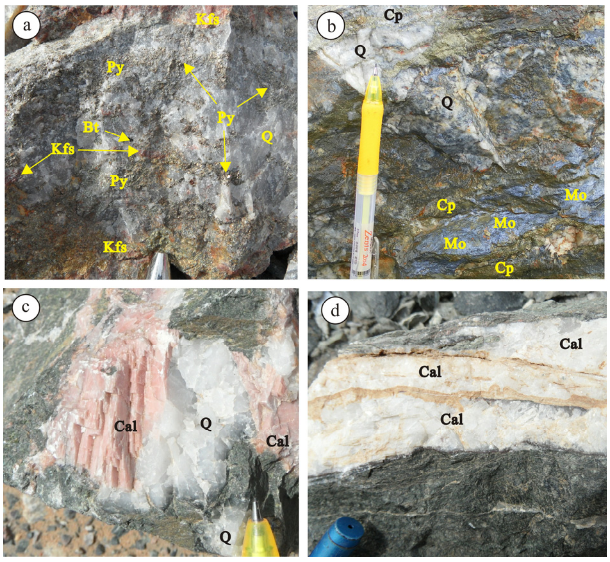

Fig. 1. Ore mineral assemblages and occurrence of the Bainaimiao copper deposit.
(a). Early stage quartz vein, the main ore mineral is pyrite and potassic alteration zone are on the both sides. (b). Mineralization period quartz vein, the main ore minerals are chalcopyrite and molybdenite. ©. Late stage quartz vein and calcite vein containing almost no mineralization. (d). The calcite of different stages. Abbreviations: Ccp—chalcopyrite, Py—pyrite; Mo—molybdenite, Kfs– potassium feldspar, Bt—biotite, Q—quartz, Cal–calcite

Similarly, the $\delta^{13}C_{PDB}$ and $\delta^{18}O_{SMOW}$ of twelve hydrothermal carbonate mineral samples of middle stage and last stage range from -5.4 to -2.4 ‰, and from -3.1 to 10.9 ‰, respectively. The $\delta^{13}C_{PDB}$ kept steady, and the $\delta^{18}O_{SMOW}$ gradually reduced during the process of mineralization.

The $\delta^{34}S$ values of the fourteen sulfide samples range from -0.6 to -6 ‰ and are typical of mantle sulfur. The C, H, O, and S isotopic compositions of the samples from the southern and the northern ore belt show that the fluids mainly come from magma and mantle system, and there is no obvious difference between them. However, the fluids in the southern ore belt have more close connection with meteoric water and crustal substances. On basis of spatial distribution of granodiorite porphyry intrusion, wall rock alternation, liquid evolution process and mineralization characteristics, we propose that granodiorite porphyry intrusions may be the key factor of mineralization.

2 Discussion

Previous studies mainly proposed three genesis models: (1) submarine exhalation accompanied with volcanism (Nie et al., 1993; Xiao et al., 2000); (2) porphyry copper system (Nie et al., 2004; Zhao et al., 2013; Li et al. 2012). (3) orogenic type ore systems (Li et al., 2008). Previous isotopic dating studies (Nie et al., 1994; Zhao et al., 2013; Li et al., 2012) show that metamorphism is later than mineralization, which imply that Bainaimiao copper deposit should not belong to orogenic type ore systems. The ore bearing liquid of model (1) mainly originates from sea water and a small amount of magmatic water (Liu et al., 1997), which is inconsistent with C, H, and O isotopic compositions in our research. Though our systematic comparative studies on stable isotopic compositions, we suggest Bainaimiao is related to porphyry system.

Besides the Bainaimiao, large scale porphyry copper deposits have been found in the Central Asian Orogenic Belt, such as Bozshakol porphyry Cu–Mo–Au deposit, Oyu Tolgoi porphyry Cu–Au–Mo deposit, Yandong-Tuwu porphyry copper deposit. These porphyry deposits are mostly formed in island-arc geological settings within the Paleo-Asian Ocean.

Combined with geological features of the deposit, it is concluded that the deposit was produced by granodioritic magma formed by anatexis under subduction environment, which arose along fissures upto the shallower crust. Therefore, the Bainaimiao porphyry copper deposit was formed.

3 Conclusion

The Bainaimiao copper deposit should belong to porphyry system. The ore bearing fluids of the southern and the northern ore belt mainly come from magma system. However, the fluids in the southern ore belt have closer connection with meteoric water and crustal substances and the difference depends on spatial distribution of granodiorite porphyry intrusion.

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