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Ore-forming fluid characteristics and ore-forming materials source of the Tudimiaogou – Yindongshan lead-zinc polymetallic orefield, west Henan

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1 Introduction

The Tudimiaogou-Yindongshan lead-zinc polymetallic orefield is located in the Tudimiaogou-Weimoshi lead and zinc silver polymetallic metallogenic belt. The belt is an important part of southwestern Henan lead and zinc silver polymetallic metallogenic province, of which molybdenum, gold resources play an important role in China. Frequent magmatic activity and widespread structure in the area provide favourable metallogenic conditions(Fu, 2012; Zhang, et al, 2015). Based on the study on the geochemical characteristics of the orefield and the macroscopic geological survey, this paper discusses the characteristics of the ore-forming fluid and the ore-forming material source, and analyze the genesis of the orefield. This work is to make contributions to enriching the metallogenic theory of southwestern Henan.

2 Major characteristics of orefield

Archaeozoic, Neoproterozoic, Lower Paleozoic, Upper Triassic, Jurassic, Cretaceous and Quaternary strata outcrop extensively in this area,. the Neoproterozoic Luanchuan group are main ore-bearing strata.Large NW-trending faults develop in the area, including Luanchuan-Weimoshi fault, Waxuezhi-Qiaorui fault, Zhuyangguan-Xiaguan fault and Xiguanzhuang-Zhenping fault. Magmatic rocks are dominated by Yanshanian biotite diorite, plagioclase granite, monzonitic granite. Discontinuous NW-SE trending orebody, with the inclination of 40 ° - 65 °, occur in shape of vein, lens and stripes which suggest they are formed in the way of hydrothermal filling. The main metal minerals are galena, sphalerite, pyrite, chalcopyrite, and gangue minerals are quartz, silicified marble, dolomite, sericite, diopside, chlorite, calcite. The ore structures are dominated by vein structure and massive structure. The ore textures are mainly granular texture, metasomatic dissolution texture, filling texture, fragmentation texture, solid solution texture. The wall rock alteration are mainly silicification, pyrite mineralization, carbonation, diopside, chloritization, sericitization, sericite-quartz alteration, kaolinization. The mineralization stage can be divided into quartz-pyrite stage, quartz-polymetallic sulphide stage, and quartz-carbonate stage, according to cross-cutting relatingship and mineral paragenesis.

3 Characteristics of ore - forming fluid

According to the results of fluid inclusions microthermometry, the ore-forming fluid is a moderate-low temperature and low salinity H_2O-NaCl system.

Pyrite is one of the main associated minerals in ore mineral deposits. The results of EPMA analysis show that the *w(Fe) / w(S)* values are greater than 0.88 indicating the formation of pyrite is related to magmatic hydrothermal mineralization. The *w(Fe) / w(S+As)* values range from 0.86 to 1.16, which indicates that the pyrise is formed in the depth for the shallow into the environment. The data points of *w(Co) / w(Ni)* values fall into hydrothermal fluids area indicating the ore-forming fluids are mainly derived from magmatic hydrothermal fluids. The results of EPMA analysis on sphalerite indicate that the sphalerite is

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formed in the condition of moderate temperature. They are consistent with the results of fluid inclusions microthermometry that the homogenization temperatures of fluid inclusions at the main mineralization stage range from 149℃ to 230 ℃, with an average value of 187 ℃.

According to H-O isotopic analysis data of the same geological condition deposits in the metallogenic zone from previous studies(Liu, et al,1997; Qi, et al, 2007;Duan, et al, 2010; Xiang, et al, 2012; Zhang, et al, 2014), It is considered that ore-forming fluid derives from magmatic fluid with higher salinity at the initial mineralization stage, and has meteoric water mixed into at the late stage.

4 Mineral source

Meiyaogou Formation of Luanchuan Group is the main ore-hosting strata of lead-zinc mineralization. Compared with the geochemical characteristics of REE and trace elements in ores, magmatic rock and three types of wall rocks(marble, greenschist, amphibolite), it is considered that both magmatic rock and wall rock provide ore-forming materials, for they display similar geochemical characteristics with ores.

The S-Pb isotopic analysis was performed on pyrite, galena and sphalerite of the main mineralization stage. The $\delta^{34}S$ values range from -2.9 ‰ to 5 ‰, with an average of 1.21 ‰, and the trend of $\delta^{34}S_{sphalerite} > \delta^{34}S_{Galena} > \delta^{34}S_{pyrite}$ was found. Sulfur isotopic system is not an equilibrium system, but all the data points fall into the zone of granite δ34S, indicating that it is mainly derived from magma. Meanwhile, the $\delta^{34}S$ values of pyrite is close to those of the Meiyaogou Formation strata, which indicates that the sulfur may also originate from strata.

The $^{206}Pb / ^{204}Pb$ ratios of the sulfide in orefield range from 17.258 to 18.453, with an average of 17.756; the $^{207}Pb / ^{204}Pb$ ratios range from 15.495 to 15.598, with an average of 15.536; the $^{208}Pb / ^{204}Pb$ ratios range from 37.843 to 39.572, with an average of 38.664. Pyrite, galena and sphalerite have similar lead isotopic compositions, indicating that they have consistent lead origin. In the lead isotope Carnon triangle diagram and the $^{207}Pb / ^{204}Pb$-$^{206}Pb / ^{204}Pb$ and $^{208}Pb / ^{204}Pb$-$^{206}Pb / ^{204}Pb$ diagrams, the variation of lead isotopic compositions is relatively small, and most of them are normal lead. The data points fall into the intersection area between the Th lead and J lead, which indicates that the main ore-forming materials have a multi-source origin. In the tectonic pattern and the tectonic setting classification diagrams, the data points are mainly distributed in the area of the orogenic belt, outlined by the orogenic line and the lower crust line, which results from the mixing of the crustal lead and the mantle lead. This evidence proves that the lead in the ore has a crust-mantle mixed origin.

Comprehensive study suggests that the source of ore-forming materials is mainly from the magmatic rock, but the ore-hosting wall rock also provide some ore-forming materials.

5 Conclusions

(1) The ore-forming fluid of orefield derives from magmatic fluid with higher salinity at the initial mineralization stage, and has meteoric water mixed into at the late stage;

(2) The source of ore-forming materials is mainly from the magmatic rock, but the ore-hosting wall rock also provide some ore-forming materials;

(3) The Tudimiaogou - Yindongshan lead-zinc polymetallic deposit is a moderate temperature hydrothermal lead-zinc deposit related to magmatic hydrothermal mineralizaiotn.

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