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Geological and geochemical characteristics of the Huayangchuan U-Nb-Pb deposit, Shan'xi China

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INTRODUCTION

Huayangchuan U-Nb-Pb deposit is located in the west part of Xiao Qinling area at the southern margin of the North China Block. It is proved to be a super-larger U-Nb-Pb polymetallic deposit in China in recent years [1-9]. The Huayangchuan deposit is located at a junction between Huashan Granites (92-142 Ma) [10] on the north and Laoniushan Granites (146 and 228 Ma) [11] on the south. Archeozoic gneissic suite is the wall rock in the area. The NW trending (290°-310°) Huayangchuan fault runs through the area, controlling the distribution of the ore bodies and vein rocks. The fractures are well developed in the deposit with mainly NNW and NW trending. Various vein rocks filled in the fractures includes biotite amphibole, biotite granite porphyry, pegmatite, calcite veins, lamprophyre, fine-grained granite veins and so on. Calcite veins are the main ore-bearing vein rocks.

Based on the collection and analysis of regional geological data and the exploration and investigation work in recent years, we made clear about the ore-forming background, the characteristics of ore-bearing pegmatite and carbonate rock and the characteristics of U-Nb-Pb mineralization. The ore-controlling mechanism and genesis of ore deposit are preliminarily discussed under this paper.

DESCRIPTION

Characteristics of vein rocks

Various vein rocks outcroping in the Huayangchuan deposit includes biotite amphibole, biotite granite porphyry, pegmatite, calcite veins, lamprophyre, Fine-grained granite veins and so on. These vein rocks have been divided into three groups (Pre-mineralization group, Mineralization group and Post-mineralization group) based on their rock types, relationship with mineralization and cross-cutting relationship.

Biotite granite porphyry veins, located on the south of fault zone, are NNW trending, 4km in length and 10 to 200m in width. They were cut by the ore-bearing quartz-calcite veins. Hui (2014) suggested two episodes of intrusions of biotite granite porphyry veins (225.5±4.2Ma and 207±2.3Ma). Qiu (1993) obtained the K-Ar age of 204-206Ma in the ore-bearing carbonate veins, which is younger than the age of biotite granite porphyry confirmed that they are prior to the mineralization. Lamprophyre amazonite pegmatite and fine-grained granite veins cut the ore-forming quartz and calcite vein rocks, and they are not cut by other veins indicated that they are post to the mineralization.

The mineralization epoch is divided into two stages: Pegmatitic stage and Carbonate stage. Veins in the Pegmatitic stage includes Pegmatite veins and migmatic pegmatite veins. The Pegmatite has the porphyritic and graphic texture and lumpy structure. Migmatic pegmatite veins mainly consists of k-metasomatism pegmatite, biotitization- actinolitization pegmatite and the biotite-feldspar -quartz veins. Uneven U-Nb mineralization developed during this stage.

Veins in the Carbonate stage include quartz –calcite veins, feldspar- aegirine-augite veins, barite-quartz -calcite veins with aegirinite and sodium amphibolite veins, barite –quartz-calcite veins with biotite and a small number of aetolite and barite-quartz calcite veins with zeolite. (1) Quartz –calcite veins are the most widely distributed ore bearing veins in the region, consisting of quartz (> 50 %), calcite (30-40%,), barite and

a small amount of plagioclase. Quartz is mostly "breccia". The calcite is xenomorphic granular breccia. Pb mineralization was found in this type of veins. There is no obvious uranium mineralization. (2) Feldspar-aegirine-augite veins have strong Pb-U mineralization. The dark minerals in this type of veins are dominated by aegirinite and light-colored minerals are mainly microcline, followed by quartz, calcite and barite. Pb minerals are often disseminated in the aegirine-augite and are irregular clumps and become thin veins between feldspar and calcite granules. (3) Barite-quartz - calcite veins with aegirinite and sodium amphibolite have obvious banding phenomenon. The main mineral is calcite follow by aegiran, microcline, quartz, barite and so on. (4) The barite –quartz-calcite vein with biotite and a small number of aetolite veins are not large and are generally 0.5-1m wide, with the characteristics of collection of biotite. Calcite is mainly gray and white. The gelenite and blomstrandite are disseminated and star point distributed. The mineralization is weak. The mineral distribution in the veins is disorder. (5) Barite-quartz calcite veins with zeolite veins are not large and is generally 1-2mm in width and they are reticular and fine veins filled in the early-formed fractures. It is seen that the galena is granular living with barite, calcite and quartz. The mineralization is weak, we do not find the U mineralization, mainly Pb mineralization. These veins are the last phase of ore-bearing veins, and cut the early mineralized veins. The second and third type of veins are the most important U-Nb-Pb mineralized veins.

The ore bearing rocks are mainly pegmatite and carbonate veins. The single vein is not large (tens cm wide), but dense. Veins of different types and scales penetrated in different directions and different types of fractures. The veins of different stages are interlaced and interwoven, so we saw branches and meshes on the wall. The overall trending is NW, especially for those with mineralization.

Characteristics of mineralization

The Huayanchuan deposit is mainly a U-Nb-Pb deposit, with a combination of precious metals and rare earth elements. The U mineralization minerals are mainly blomstrandite and uraninite, followed by the uranium contained changbaiite and fergusonite. The Nb mineralization minerals are mainly blomstrandite followed by a small amount of fergusonite and niobium rutile. The Pb mineralization minerals are mainly galena and a small amount of oxidized cerussite. Precious metal Ag and scattered elements Bi, Cd, Se and Te are mainly dispersed in galena. Rare earth elements here are mainly about La, Ce and Y, and the minerals mainly include xenotime, allanite , monazite, bastnasite and fergusonite and so on.

The biotitization, actinolitization and potassic alteration are typical characteristic of the uranium mineralization during the pegmatite stage. In the pegmatite with biotitization, we found the uranium grade is normally over one-in-one-thousand. Blomstrandite was found in the area where biotitization and actinolitization developed

The mineral assemblages of biotite-aegirine-augite-sphene-zoisite-amphibole-apatite is closely related to U mineralization. The more these minerals develop the more obvious uranium mineralization found. Among these assemblages, the biotite-aegirine-augite- sphene is especially closely correlated with the U mineralization. The galena is mainly produced on the boundary, and in general where pyritization developed, where there is strong lead mineralization. Assemblage of aegirine-augite and pyrite is the main metallogenic character of galena.

DISCUSSION AND CONCLUSION

The wall rock of Huayangchuan deposit is Archeozoic gneissic suite. The boundary between ore-bearing veins and wall rocks is clear. And the wall rock alteration is not obvious. There are no specific wall rocks that are closely related to the mineralization. However, there are differences of the development degree of the fractures among different types of wall rocks. For example, it is easier to form more dense fracture and fissure system among the biotite-plagioclase gneiss than hornblende gneiss and granite gneiss. The development degree of fractures and fissures in the region directly affected the density and mineralization of ore-bearing veins.

We divide the metallogenic process into two stages: pegmatite stage and carbonate stage. Qiu (1993) date the feldspar within the carbonate using the K-Ar dating and got 204˜206Ma. Yu (1992) date the flogopite in carbonate using the K-Ar dating and got 181Ma. He et al. (2016) obtained the age (39Ar-40Ar) of 133.01±0.74Ma from biotite in the carbonatite, and the age (39Ar-40Ar) of 91.49±1.97Ma biotite in pegmatite. The ages, 204˜206Ma and 181Ma can be compared with that of the intrusion of Laoniushan granites (146 and 228 Ma) [11] and the ages, 91.49Ma and 133.01Ma were basically in line with the time of the intrusion of Huashan Granites (92-142Ma) [10]. There is a high degree of consistency and affinity in time and spatial distribution between the formation of pegmatite and carbonate veins and the Huashan and Laoniushan Granites. In different stages, symbols of hydrothermal metasomatism was found. We suggested that the Huayangchuan U-Nb-Pb deposit is the result of the co-action of the carbonate rocks and the Huashan, Laoniushan plutons. And the deposit is magmatic-hydrothermal genetic type.

In summary, we found that: (1) The Huayangchuan U-Nb-Pb deposit occurred in the Archean gneiss. The main ore-hosted rocks are pegmatite and various veins of carbonate rocks. (2) U-Nb mineralization occurred during the pegmatite stage within granitic pegmatites and migmatic pegmatite veins. U-Nb-Pb mineralization mainly developed in the carbonate rock stage within quartz- carbonatite veins. (3) Ore bodies extended NW

and are mainly controlled by the NW-trending Huayangchuan fault followed by NNW-trending secondary fractures. (4) The characteristic symbols for the uranium mineralization within the pegmatite stage are the biotite-actinolite assemblages, and that in the carbonate rock stage are the biotite-aegirine-kaolinite-kaolinite-amphibole-apatite assemblages. In contrast, characteristics of Pb mineralization are marked by breccia aegirineaugite -metal sulfide combinations. (5) We proposed that the Huayangchuan deposit is the magmatic-hydrothermal superposition type.

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