GEOLOGICAL AND GEOCHEMICAL CHARACTERISTICS OF THE HUAYANGCHUAN U–Nb–Pb DEPOSIT, SHAN’XI, CHINA

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1. INTRODUCTION

The Huayangchuan U–Nb–Pb deposit is located in the western part of the Xiao Qinling area on the southern margin of the North China Block. This deposit has proved to be the largest U–Nb–Pb polymetallic deposit to have been discovered in China in recent years [1–9]. The Huayangchuan deposit is located at a junction between Huashan granites (142–92 Ma) [10] to the north and the Laoniushan granites (228–146 Ma) [11] to the south. An Archaean gneissic suite is the host rock in the area and includes biotite–plagioclase gneiss, hornblende–biotite–plagioclase gneiss, pyroxene–hornblende–plagioclase gneiss, hornblende gneiss, granite gneiss, etc. The NW trending (290–310°) Huayangchuan Fault controls the distribution of the orebodies and dykes in the area. The fractures are well developed in the deposit and trend mainly NNW and NW. Calcite veins are the main ore-bearing host.

On the basis of the collection and analysis of regional geological data and on the exploration and investigation work performed in recent years, the authors have clarified the ore genesis, the characteristics of ore-bearing pegmatite and carbonate rock, and the characteristics of U–Nb–Pb mineralization. The ore controlling mechanism and the genesis of the ore deposit are principally discussed in this paper.

2. DESCRIPTION

2.1. Characteristics of dykes and vein fillings

Various dykes and vein fillings crop out in the Huayangchuan deposit area, including biotite amphibole, biotite granite porphyry, pegmatite, calcite veins, lamprophyre, fine-grained granite, etc. These dykes and vein fillings have been divided into three groups (pre-mineralization, mineralization and post-mineralization groups) on the basis of their nature, relationship with the mineralization and their cross-cutting relationships.

Biotite granite porphyry dykes, located to the south of a fault zone, are NNW trending, 4 km long and 10–200 m wide. They are cut by the ore-bearing quartz–calcite veins. Guo et al. [10] suggests two episodes of intrusion of biotite granite porphyry veins (225.5 ± 4.2 Ma and 207 ± 2.3 Ma) using U–Pb dating on zircon. Qi et al. [11] dated the feldspar within the ore-bearing carbonate veins using the K–Ar dating to 204–206 Ma. Yu [12] dated the phlogopite in carbonate using the K–Ar dating to 181 Ma and He et al. [6] obtained the age of 133.01 ± 0.74 Ma from biotite in the carbonate, and a 39Ar–40Ar age of 91.49 ± 1.97 Ma for biotite in pegmatite. The age of ore-bearing carbonate veins is younger than the age of biotite granite porphyry, which confirms its emplacement prior to the mineralization. Lamprophyre, amazonite pegmatite and fine-grained granite dykes cross-cut the mineralized quartz and calcite vein rock, but are not cut by other veins indicating that they were emplaced after the mineralization episode.
The mineralization event is divided into two stages: pegmatite and carbonate. Veins in the pegmatitic stage includes granite pegmatite veins and anatectic pegmatite veins. The granite pegmatite has a porphyritic and graphic texture and a ‘lumpy’ structure. Anatectic pegmatite veins mainly consist of K-metasomatic pegmatite, biotite–actinolite pegmatite and biotite–feldspar–quartz veins [13]. Irregular U–Nb mineralization is developed during this stage in both types of pegmatite.

The carbonate stage includes quartz–calcite veins, feldspar–aegirine-augite veins, baryte–quartz–calcite veins with aegirine-augite and sodium amphibolite, baryte–quartz–calcite veins with biotite and a small number of aegirine-augite and baryte–quartz–calcite veins with zeolite. The mineralization suites are characterized as follows:

1) Quartz–calcite veins are the most widely distributed ore-bearing veins in the region, consisting of quartz (>50 %), calcite (30–40%), baryte and small amounts of plagioclase. The quartz is mostly ‘brecciated’. Calcite also occurs as xenomorphic brecciated grains. Galena was found in this type of vein. There is no obvious uranium mineralization;

2) Feldspar–aegirine-augite veins exhibit strong U–Pb mineralization. The dark minerals in this type of vein are dominated by aegirines and the light coloured minerals are mainly microcline, followed by quartz, calcite and baryte. Galena is often disseminated in the aegirine-augite and forms irregular clumps and thin veins between the feldspar and calcite grains;

3) Baryte–quartz–calcite veins with aegirine and sodium amphibolite present clear banding. The main mineral is calcite followed by aegirine, microcline, quartz and baryte;

4) Baryte–quartz–calcite veins with biotite and a small number of aegirine-augite veins are not large, generally 0.5–1 m wide, and characterized by the presence of biotite. Calcite is mainly grey and white. The galena and blomstrandite are finely disseminated. The niobium minerals (blomstrandite, fergusonite and niobium rutile) are poorly represented. The mineral distribution in the veins is irregular;

5) Baryte–quartz calcite veins with zeolite veins are generally 1–2 mm wide and they are reticular and form fine vein fillings in earlier formed fractures. The galena occurs as grains included within baryte, calcite and quartz. There is no U mineralization. These veins represent the last ore-bearing episode and they cut all earlier mineralized veins. The second and third type of veins are the most important U–Nb–Pb mineralized veins.

The single ore-bearing vein is not large (several tens of centimeters wide), although it is dense. Veins of different types and scales penetrated in different directions and occur different types of fracture. The veins of different stages are interlaced and interwoven with branches and meshes on the wall-rock. The overall trend is NW, especially that of the mineralized veins.

2.2. Characteristics of the mineralization

The Huayanchuan deposit is mainly a U–Nb–Pb deposit, associated with precious metals and rare earth elements. The uraniferous minerals are mainly blomstrandite and uraninite, followed by the uranium-bearing changbaite and fergusonite. The Nb mineralization minerals are mainly blomstrandite followed by minor amounts of fergusonite and niobium rutile. The Pb mineralization minerals are mainly galena and a small amount of oxidized cerussite. Other elements, notably Ag, Bi, Cd, Se and Te, are dispersed in the galena. Rare earth elements are mainly La, Ce and Y, mainly hosted in xenotime, allanite, monazite, bastnasite and fergusonite.

Biotitization, actinolitization and potassification are typical alterations associated with the uranium mineralization during the pegmatite stage. In pegmatite exhibiting biotitization, the uranium grade usually exceeds 0.1%. Blomstrandite has been found in the area where biotitization and actinolitization are developed.
The mineral assemblages of biotite–(aegirine-augite)–sphene–zoisite–amphibole–apatite are closely related to U mineralization and the greater their development, the more uranium mineralization is found. Among these assemblages, the biotite–(aegirine-augite)–titanite assemblage is especially closely correlated with the U mineralization. The galena mainly occurs at the boundary and in general where pyritization is developed, where strong Pb mineralization occurs. The assemblage of aegirine-augite and pyrite is the main metallogenic association with galena.

3. DISCUSSION AND CONCLUSION

The wall-rock of Huayangchuan deposit is Archaean gneiss. The boundary between ore-bearing veins and wall-rock is clear but wall-rock alteration is not obvious. There is no specific wall-rock that is specifically related to the mineralization. However, there are differences in the degree of fracturing among the different types of wall-rock. For example, a denser fracture and fissure system is developed in the biotite–plagioclase gneiss than in the hornblende gneiss and granite gneiss. The degree of development of fractures and fissures in the region directly affected the density of ore-bearing veins and the grade of the mineralization.

The metallogenic processes can be divided into two stages: the pegmatite stage and the carbonate stage. The ages, 204–206 Ma and 181 Ma obtained on the carbonate veins can be compared with those for the intrusion of Laonuishan granites (228 and 146 Ma) [11] and the ages, 91.49 Ma and 133.01 Ma obtained on the pegmatite and carbonatite [6] are nearly coeval with the intrusion of the Huashan granites (142–92 Ma) [10]. There is a high degree of temporal and spatial consistency and affinity between the formation of pegmatite and carbonate veins and the emplacement of the Huashan and Laonuishan granites. During the different stages, evidence of hydrothermal metasomatism was found. The authors propose that the Huayangchuan U–Nb–Pb deposit is the result of the simultaneous action of the carbonate veins and the emplacement of the Huashan and Laonuishan plutons. A magmatic–hydrothermal genetic type model is proposed for the deposit.

In summary, the authors conclude that:

1) The Huayangchuan U–Nb–Pb deposit occurs in the Archaean gneiss. The main ore-bearing rocks are pegmatite and various carbonate veins;
2) The U–Nb mineralization occurred during the pegmatite stage within granitic pegmatites and migmatite–pegmatite veins. The U–Nb–Pb mineralization mainly developed during the carbonate rock stage within quartz–carbonatite veins;
3) Orebodies trend NW and are mainly controlled by the NW trending Huayangchuan Fault, followed by NNW trending secondary fractures;
4) The characteristics for the uranium mineralization within the pegmatite stage are presence of biotite–actinolite assemblages and in the carbonate rock stage are the biotite–aegirine–kaolinite–amphibole–apatite assemblages. In contrast, the characteristics of Pb mineralization are marked by brecciated aegirine-augite and metal sulphide combinations;
5) The authors propose that the Huayangchuan deposit is the magmatic-hydrothermal superposition type.

REFERENCES


