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Mineralogical Characteristics and Significance of Wolframite from the Xihuashan Tungsten Deposit, Jiangxi Province, China

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1 Geological Setting

The Xihuashan tungsten deposit is located in the Chongyi-Dayu-Shangyou tungsten-polymetallic orefield, eastern Nanling region. Exposed strata are mostly represented by rocks of Middle to Upper Cambrian age with Quaternary cover. The composite Xihuashan granite is the main intrusion, forming a stock-like body intruding into Cambrian strata. The main rock types are medium-grain biotite granite and medium-grain porphyritic biotite granite. NE-NNE-striking faults are recognized as orecontrolling structures. The host rocks are also folded.

The orebodies occur as veins located at the inner contact zone of the southwestern granite body. The veins are thin, long and display a plate-like morphlogy and complex zoning. The main ore minerals are wolframite, molybdenite, scheelite, bismuthinite, cassiterite, pyrite, pyrrhotite and chalcopyrite. Gangue minerals are quartz, feldspar, mica, beryl, garnet and fluorite. Ore mineral assemblages indicate the following stages of mineralization: beryl-wolframite- quartz- (feldspar); wolframite-quartz (feldspar); sulfide-quartz; and fluorite-calcite-quartz (Huang Huilan et al., 2006).

2 The Occurrence of Wolframite

Wolframite in the Xihuanshan ore occurs as aggregates or associated with other minerals (scheelite, cassiterite, molybdenite, beryl and sulfides) within quartz veins of the inner contact zone of the granite body, and also dispersed within greisen, feldspathized rock, or other altered granite. Wolframite is bright black or brownish black in color, varying greatly in size and occurring as grains that are foliated columnar, lenticular, needle-like or columnar, or granular in morphology.



Fig. 1. Correlation diagrams of oxide components in wolframite from the Xihuashan tungsten deposit

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Fig. 2. Relationship between the chemical composition of wolframite from different levels of vein V29.

3 X-ray Powder Diffraction Analysis

Using X-ray powder diffraction, the following cell parameters are obtained for wolframite: $a_0=0.477$ nm; $b_0=0.573$ nm; $c_0=0.498$ nm; and $\beta=90^{\circ}21'$. These cell parameters suggest the wolframite belongs to manganese tungsten ore. The conclusion that the Xihuashan wolframite contains isomorphous substitution of Fe and Mn is borne out by comparison with the cell parameters of wolframite from south China given by Li Binglun and Liu Yimao (1965).

4 Compositional Characteristics

Electron probe microanalysis shows that the wolframite contains WO₃, FeO and MnO: 72.25-75.9% WO₃, 6.73-15.05% FeO, 8.23-11.13% MnO (Wu Yongle et al., 1987), belonging to manganese tungsten ore (Li Yiqun and Yan Xiaozhong, 1991). Wolframite also contains minor amounts of Nb₂O₅, Ta₂O₅ and Sc₂O₃.

There is a positive correlation between Nb_2O_5 and Ta_2O_5 content and a negative correlation between FeO and MnO (Fig. 1). In vein V29, the data show a slight increase in FeO content from deep to shallow, accompanied by a slight

reduction in MnO, Nb₂O₅ and Ta₂O₅ (Fig. 2). For the same vein, the wolframite content change regularly vertically. It can reflect the migration features of ore-forming material. Analysis of trace elements, including REE, in wolframite from vein V248 show the Nb content ranges from 3.8 to 77.9 ppm and Ta content ranges from 0.6 to 16.3 ppm, with an uneven distribution. It is generally thought that higher content of Nb and Ta in wolframite correlate with proximity to granite (Li Yiqun and Yan Xiaozhong, 1991), but our data show dynamic changes of content, which can reflect more complex migration features of ore fluid. Wolframite also contains Sc, Y, Sr, Zr, Ga, Cu, Zn and other elements.

REE are concentrated in wolframite. Σ REE contents are 397 to 1071 ppm, LREE are 12 to 18 ppm, HREE are 397 to 1053 ppm, giving LREE/HREE ratios of 0.02 to 0.04, δ Eu are 0.01 to 0.02, δ Ce are 0.68 to 1.02. Chondrite-standardized REE distribution patterns of wolframite have steep slopes in agreement with the strong relative enrichment in HREE.

Wolframite from different genetic types of tungsten deposit has characteristic REE fractionation trends. These have value as criteria to identify metal source and ore genesis (Zhang Yuxue et al., 1990). Compared with the



Fig. 3. $\Sigma REE-La_N/Yb_N$ diagram for wolframite



Fig. 4. w(Y)/w(Ho)-w(La)/w(Ho) diagram for wolframite

characteristics of REE in wolframite of tungsten deposits from Xihuashan, Pangushan, Taoxikeng and Dajishan (Yu Ping, 2012; Hei Huan, 2012; Zhang Siming, 2012), Fig. 3 shows that wolframite from the Xihuashan deposit, at the inner contact zone of the granite body, is characterized by relatively high SREE and obvious REE fractionation. Wolframite from the Dajishan deposit (inner and outer contact zone of granite) is characterized by relatively low ΣREE and a lack of REE fractionation. Wolframite of Taoxikeng and Pangushan (outer contact zone of granite) is characterized by great changes of ΣREE and REE fractionation. The ratio of w(Y)/w(Ho) is generally characterized by a horizontal distribution (Fig. 4), with the exception of the Dajishan deposit. It suggests that the behavior of REE in fluid may differ from that in traditional geological process and that the ore-forming fluids are multi -source (Ding Zhenju et al., 2000). The w(Y)/w(Ho) ratio of wolframite from the Pangushan and Taoxikeng deposits is characterized by near or horizontal distribution, and the La/Ho ratio displays a successive variation, implying that the wolframite is the product of distinct genetic stages. The w(Y)/w(Ho) ratio of wolframite from the Xihuashan deposit has a horizontal distribution indicating a homogeneous ore-forming fluid.

In conclusion, our studies on the spatial distribution and chemical composition of wolframite from the Xihuashan deposit, and comparison with published data for other tungsten deposits reveal the character of ore-forming processes. The results show the regularity of REE patterns for wolframite in the inner or outer contact zone of a granite body, which can be useful criteria to identify metal sources and ore genesis.

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