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Trace Element Concentrations in Sulfides from the Chalukou Mo-Zn-Pb Deposit, Northern Great Xing'an Range, China: Implications for Ore Genesis and Exploration

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Using ICP-MS methods, trace element concentrations of pyrite (n=22) and sphalerite (n=7) have been determined in different occurrence and ore stages in the Chalukou Giant Mo-Zn-Pb deposit. We focus on the distribution characteristics of trace elements, and attempt to understand the relationship between trace element abundances of sulfides and genetic information in the Chalukou deposit. And we first propose that high Mo concentrations of sulfides in shallow level can provide useful clues for further exploration of deep porphyry Mo deposit.

1 Ore Deposit Geology

The giant Chalukou porphyry Mo deposit is located in northern Great Xing'an Range, NE China. With proven Mo metal reserves of 246Mt@0.078%, it is the largest porphyry Mo system so far discovered in China. Vein-type Zn-Pb mineralization occurs immediately above the porphyry system. The strata at Chalukou district consist of the Precambrian Dawangzi Group (mainly quartz chlorite schist; 685±85 Ma), Early Ordovician intermediate - felsic volcanic - sedimentary rocks (mainly rhyolite; 475-471 Ma), and Late Jurassic-Early Cretaceous Baiyingaolao Group (mainly dacite). The intrusions comprise of the Middle Jurassic pre-ore monzonitic granite, Late Jurassic ore-forming intrusions (aplite porphyry, granite porphyry and quartz porphyry, 148-147 Ma; Li et al., 2014), and Early Cretaceous post-ore intrusions (diorite porphyry, feldspar porphyry and quartz monzonite porphyry; 142-128 Ma).

The Chalukou deposit shows a consistent, broad-scale alteration zoning pattern composed of potassic, silicic-phyllic, argillic and propylitic alteration zones from the ore forming porphyries upward and outward. Two main mineralization style are identified at Chalukou: porphyry Mo and vein - type Zn-Pb mineralization. The porphyry Mo mineralization is hosted by Ordovician intermediate - felsic volcanic rocks, Middle Jurassic monzonitic granite and ore-forming porphyries at depth. Mineralization occurs as molybdenite veinlets, stockworks and veins, with minor dissemination in the matrix of breccias. Potassic and silicic alteration are intimately related to high-grade Mo, while phyllic alteration is related to local Mo mineralization. Zn-Pb hydrothermal veins are mainly hosted in Ordovician intermediate - felsic volcanic rocks at shallow level. The Zn-Pb ores are composed of sphalerite, pyrite, galena, with minor chalcopyrite, together with quartz and carbonate gangue and particularly abundant fluorite. Silicic, phyllic and argillic alteration are closely associated with Zn-Pb mineralization.

2 Sulfide Trace Element Chemistry and Its Implications

Previous studies have shown that sphalerite formed at moderate-low temperature is characterized by high Co, In, Cd, Ga and low Fe concentrations (Cook et al., 2009; Shimizu et al., 2012), with Zn/Cd ratios of 100-500 (Liu et al., 1984) and moderate In/Ga value. Seven samples of sphalerite from the Chalukou deposit is enriched in Mo (5.37-268 ppm), Cd (113-2413 ppm), In (63.3-324 ppm), Co (0.59-64.6 ppm) and Ga (1.08-85.9 ppm). It is relatively depleted in Fe (0.15-2 wt %), As (1.1-14.5 ppm) and Sb (1.25-26.7 ppm), Zn/Cd ratios range from 265 to 314. These data suggest that sphalerite formed at moderate-low temperature, in consistent with the fluid inclusions microthermometric data for sphalerite (180-250° C,

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The distribution patterns of trace elements in sulfide minerals can provide information on the source of ore-forming fluids, since trace element concentrations in sulfides can be used as a proxy for fluid composition (Deditius et al., 2009; Large et al., 2009). REE distribution patterns in pyrite show LREE enrichment, HREE depletion and a significant negative Eu anomaly. These patterns are similar to those of the ore-forming intrusions and Ordovician wallrocks. Furthermore, the Y/Ho values in pyrite (23.9-39) resemble that of ore-forming intrusions (27.4-38.7) and wallrocks (25.7-27.8). Thus, REE patterns and Y/Ho values may imply that both the magmatic source and interaction with wallrock have contributed to mineralization. This interpretation is confirmed by Sr isotopes of sphalerite [$(^{87}Sr/^{86}Sr)_i$ = 0.705221-0.710417, unpublished], ore-forming rocks [$(^{87}Sr/^{86}Sr)_i$ = 0.705413-0.707099,] and wallrocks [$(^{87}Sr/^{86}Sr)_i$ = 0.709945-0.711444].

Trace element concentrations in sulfides are also an important indicator for the presence of underlying ore bodies. The average Mo content of sphalerite and pyrite (75.6 ppm, n=6; 126.5 ppm, n=10) in shallow vein-type Zn -Pb mineralization at Chalukou deposit is higher than that in other vein-type Pb-Zn (-Ag) deposits (1.6 ppm, n=97; 5 ppm, n=42, collected data), so does the higher average Mo content of pyrite in porphyry Mo mineralization at Chalukou deposit (204.5 ppm, n=10) compared to other porphyry deposits (9.2 ppm, n=48). Besides, the Mo/Zn, Mo/Pb, Mo/Ni, Mo/Co, Zn/Ni, and Zn/Co ratios of pyrite in vein-type Zn-Pb mineralization at Chalukou deposit also show the relatively higher values than that in other vein type Pb-Zn (-Ag) deposits, and the so does the elevated Mo/In value of sphalerite. As the Mo content in wallrocks is not so high (27.3 ppm), the significant enrichment of Mo content and high element ratios in shallow vein-type Zn-Pb mineralization at Chalukou deposit could be attributed to the underlying Mo mineralizing system. And it provides useful clues for further exploration for deep porphyry Mo mineralization beneath shallow Zn-Pb mineralization.

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