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Sulfur Isotope Geochemistry of the Xincheng Gold Deposit, Jiaodong: Constraints on the Material Source and Ore-forming Environment

ZHANG Chao, DENG Jun*, YANG Liqiang, WANG Zhongliang, GUO Linnan, LIU Yu, ZHANG Liang, LIU Yue and LIU Xiangdong

State Key laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing 100083

1 Geological Setting and Mineralization

The Xincheng gold deposit, located at the Jiaodong peninsula currently the China's most important gold producer in Southeast of the North China Craton (Deng et al., 2008, 2011; Yang et al., 2009, 2014), is hosted in the Early Cretaceous Guojialing granodiorite which was generated by partial melting of the metamorphosed basement rocks of the Jiaodong group (Wang et al., 2014a). Besides the Guojialing granodiorite, the granulite, which is one kind of metamorphic rocks of Jiaodong group, and felsic dikes were also developed in the deposit. Although the gold deposit is one of the typical altered-type gold deposits, not only disseminated-stockwork but also quartz vein styles of mineralization was developed. The disseminated-stockwork orebodies, constituted the bulk of gold of the deposit, are controlled by the Jiaojia fault, while the quartz vein orebodies, which are less common ore type, are controlled by the subsidiary faults of the Jiaojia fault. Based on the crosscutting relationships and mineral paragenesis, four mineralization stages in Xincheng gold deposit were identified, which contained pyrite-quartz-sericite stage (stage I), quartz-pyrite stage (stage II), quartz-polysulfide stage (stage III) and quartz-carbonate stage (stage IV) (Wang et al., 2014b).

2 Pyrite Morphology and Sulfur Isotope Analysis

By using the binocular and microscope, the crystal morphology and size of pyrites from the four mineralization stages of two ore types are examined in detail. The result will be described in the part of Discussion and Conclusions below.

Thirty-three sulfide minerals samples from I, II and III mineralization stages of two ore types and fifteen samples from the fresh magmatic rocks are collected for sulfur isotope analysis ($\delta^{34}\text{S}_{\text{CDT}}$, $\delta^{34}\text{S}$ for short; Test Accuracy $\pm 0.3\%$), which were made on the MAT 251 Isotopic Mass Spectrometer by using the method of Giesemann et al. (1994) at Beijing Geological Research Institute of Nuclear Industry.

The sulfur isotope compositions of sulfide minerals of different mineralization stages and magmatic rocks from the deposit are listed below. The average sulfur isotopic compositions of sulfide from the stages I, II and III are 9.7‰, 8.7‰, and 7.1‰, respectively. And the mean sulfur isotopic composition of all thirty-three sulfide minerals samples is 8.3‰. The mean sulfur isotopic compositions of granulite, Guojialing granodiorite and felsic dikes are 8.0‰, 8.6‰, and 6.7‰, respectively.

3 Discussions and Conclusions

The mean $\delta^{34}\text{S}$ value of sulfide minerals is 8.3‰, which is consistent with that from other typical altered-type gold deposits in Jiaodong gold metallogenic province (Wang et al., 2002). That indicates the ore sulfur may come from the Guojialing granodiorite, the granulite and the felsic dike, while eventually derive from the metamorphosed basement rocks of Jiaodong group (Yang et al., 2007). However, the source of ore sulfur is distinguished in different mineralization stages. The average $\delta^{34}\text{S}$ value of stage I pyrites is higher, 9.7‰, indicating that sulfur came from both the Guojialing granodiorite and the granulite with a higher $\delta^{34}\text{S}$ value. The mean $\delta^{34}\text{S}$ value of pyrites from the stage II is 8.7‰, which suggests the felsic dikes with a lower $\delta^{34}\text{S}$ values may also provided partial sulfur, besides the Guojialing granodiorite and the granulite. The

* Corresponding author. E-mail: djun@cugb.edu.cn

mean $\delta^{34}\text{S}$ value of sulfide minerals in the stage III is 7.1‰, indicating that sulfur came from the Guojialing granodiorite, the granulite, and the felsic dikes.

Pyrites from stage I are usually small (5–600 μm) and cubic, which indicates a steady metallogenic environment with a relatively higher temperatures (300–350°C), low degree supersaturation of ore-forming fluid, fast cooling, low oxygen fugacity and sulfur fugacity, and insufficient supply of material; while pyrites from stages II and III have a spectrum of 3 μm to 2.5 mm, and the main crystal habit is pyritohedron, which represents an ore-forming environment of medium-low temperature (200–300°C), high degree of supersaturation of ore-forming fluid, slow cooling, high oxygen fugacity and sulfur fugacity, and sufficient supply of material; the stage IV pyrites are smallest (1–5 μm) and integral cubic, which means a steady metallogenic environment of lower temperature (<200°C), lower degree of supersaturation of ore-forming fluids, lower oxygen fugacity and sulfur fugacity, and insufficient supply of material (Chen et al., 1987; Cai and Zhou, 1993; Li et al., 2012).

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