SEG 2017 Conference

Texture and chemical compositions of pyrites at the Zhuangzi Au deposit in the Jiaodong district and their metallogenic implications

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The Jiaodong gold district, with a total reserves of >3000 ton gold (Goldfarb and Santosh, 2014), is the largest gold producer in China. It has received much attention onmineralization timing, source of ore fluids, and process of hydrothermal activities. To know such informationis important butnot enough for understanding the genesis of these golddeposits and developingenhanced exploration strategies (e.g. Yang et al., 2016; Ma et al., 2017;). Chemical and textural analysis of the ore-bearing phases (mainly pyrite) which host vital information including composition of ore-forming fluids and ore-forming processes is generally lack in previous researches. Additionally, the Au occurrence andthe relationship between Au and As, and uncloaking "invisible gold", which was hampered by analytical techniques in previous studies, are deserved to study. Here we applied submicron-scale secondary ionizing mass spectrometry (NanoSIMS) mapping and sulfur isotopic (SIMS) analyses to pyrites to determine the above issues.

The Zhuangzi gold deposit is a lode gold system located in the Penglai-Qixia Metallogenic Belt in Jiaodong. The deposit is mainly hosted in Paleoproterozoic metamorphic rocks and structurally controlled by NNE-trending faults. Three stages of mineralization were identified, including gold-quartz-pyrite (stage 1), dolomite-pyrite-quartz-gold (stage 2), and pyrrhotite-calcite (stage 3).

Based on optical, scanning electron microscope observation and electron probe microanalysis, three types of pyrites have been identified. Pyrite I occurs as porphyroblasts associated with phyllic alteration, containinglow concentration of As and numerous randomly-distributed silicate inclusions. Pyite II, which overgrew pyrite I and formed in stage1, has characteristic oscillatory zoning and contains up to 3.9 wt.% As. Pyrite III, with low concentration of As, either overgrew pyrite II or occurred as elongated grains aligned along the shear foliation. Grains of pyrite III formed in stage2 and were contemporaneous with shearing deformation. Noting that numerous gold grains are concomitant with pyrite III, gold deposition may be related to the shearing deformation. The NanoSIMS maps reveal that the dominant form of Au in pyrite II is solid solution with a few fine particles existing in the highest arsenic zones, and the cyclic and elevated gold concentrations mimic the variation of As and Cu. The NanoSIMS maps also show significant trace elemental cyclicity of pyrite II with sharp textural and compositional boundaries between zones, which is reflective of repeated and sudden variations in fluid pressure and transient fluid flow regimes (Peterson and Mavrogenes, 2014). In situ SIMS sulfur analysis reveals slight variation from cores to rims of single grains, and a similar range of $\delta^{34}S$ (+6.3 to +9.4‰) among pyrite I to pyrite III, which reflects the stable sulfur fugacity and same source of fluid from stage1 to stage2. But the occurrence of pyrrhotites indicates that the sulfur fugacity decrease from stage2 to stage3.