Discussion on the Geological Characteristics and Metallogenic Mechanism of the Gold and Silver Deposits in the Linjiasandaogou-Xiaotongjiapuzi Ore-Concentrated Area, Eastern Liaoning

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The Linjiasandaogou-Xiaotongjiapuzi gold-silver ore-concentrated area, located in the Paleoproterozoic Eastern Liaoning rift belt, is of a large scale concealed ore field, including a dozen of medium-large-sized Au (-Ag) deposits, such as Xiaotongjiapuzi, Gaojiapuzi, Linjiasandaogou and Taoyuan, with a great prospect. The Linjiasandaogou and Xiaotongjiapuzi deposits are studied as typical cases to discuss the metallogenesis, ore-forming condition, ore fluid and isotopic geochemistry of the region, so that to determine the genesis of deposit and ore-forming mechanism and provide basis for the exploration of similar deposits in the Paleoproterozoic Liao-Ji rift belt.

1 Regional Geological Setting

The study area is situated in the west section of the southern Paleoproterozoic Liao-Ji rift belt, where a series of huge thick carbonate-clastic rock formations (Yangshugou Formation of Dashiqiao Sub-group and Tangjiagou Formation of Gaixian Sub-group, Liaohe Group) was accumulated and then reformed by multistaged intense deformation-metamorphism-magmatism. The rock series provided a material basis for the forming of gold and silver deposits. During Late Indosinian Period, the subduction of Pacific Plate to Eurasian Plate caused strong tectono-magmatism, making further activation and enrichment of the ore material.

2 Geology of the Orefield and Deposit

The ore-concentrated area lies on the northeast of the Qingchengzi lead-zinc orefield, running northwest. The gold (-silver) orebodies occur in the mica schist of Yangshugou rock formation and granulite and schist of Tangjiagou rock formation. Magmatic rocks, commonly Proterozoic plagiogranite and Late Indosinian granite porphyry and lamprophyre dikes, are developed in this area. The major structures are E-W-trending fold and NW- and NE-trending faults.

The Xiaotongjiapuzi gold deposit occurs in the interbedded ductile-brittle structural deformation zone in the mica schist, garnet mica schist, biotite granulite and dolomite marble of the 6th member of Yangshugou rock formation (Pt1Dy6). Gold and silver are hosted in the silicified crushed marble and silicified granulite. The orebodies are in stratiform and lens, consistent with the attitude of the strata. The Linjiasandaogou deposit is located 3 km northwest of the Xiaotongjiapuzi gold field. The ore belt occurs in the interbedded fracture zone in the biotite schist and biotite granulite of Tangjiagou rock formation (Pt1Gxt) in stratiform. The occurrence of the mineralized belt is roughly consistent with that of the strata, locally with undulation and gentle crossing angle. The orebodies are in stratiform and lens. The ore-bearing rocks are silicified crushed biotite granulite and biotite schist, with locally altered lamprophyre.

The metal minerals in the ore include mainly pyrite, arsenious pyrite, arsenopyrite and native silver, with minor galena, sphalerite, tennantite, pyrrhotite, chalcopyrite and electrum. Nonmetal minerals are dominated by micro-grained quartz, with minor sericite, dolomite and graphite.

The ores are mainly in euhedral-subhedral crystal texture, subhedral-anhedral crystal texture and poikilitic texture. The structures of ores involve mainly sparse disseminated structure and veinlet disseminated structure, with minor vein structure, massive structure and breccia structure.

The occurrences of gold include invisible and visible. The former accounts for about 80%. The grains of gold minerals are fine, dominated by micro-grained gold.

The wallrock alterations involve mainly silicification,
sericitization, pyritization, arsenopyritization and carbonatation, which are closely related to the gold (-silver) mineralization. The silicification is intensive and broadly distributed, in multiple stages. The sericite, commonly in micro-scale shape, is distributed along the beddings as band or mass. The carbonate minerals occur in veins, networks and spots, often accompanied by silicification, arsenopyritization and pyritization.

3 Geochemistry of Gold-Silver Deposits

3.1 Characteristics of ore-forming fluid

The quartz fluid inclusion type of the Au-Ag ore from the ore-concentration area is mainly gas-liquid two-phase, with medium-low homogenization temperature, low salinity of ore-forming fluid, medium-low pressure and shallow metallogenic depth.

The contents of cations of Na⁺, K⁺ and Ca²⁺ are high in the liquid composition of inclusion. The anion composition is mainly Cl⁻, followed by SO₄²⁻ and NO₃⁻, with minor F⁻. The gas-phase composition is dominated by H₂O, also rich in CO₂, followed by N₂ and CH₄. It is inferred that the ore-forming fluid in the ore-concentration area is from multi-sources, i.e. dominantly hot brine, mixed with a little magmatic water and meteoric water.

The hydrogen-oxygen isotope of quartz fluid inclusion of gold ore from the ore-concentration area shows that the ore-forming fluid is mainly derived from geothermal water and connate formation water, with a little from meteoric water. That fatherly confirms the multi-sources of the ore-forming fluid for the gold-silver deposits.

3.2 Characteristics of stable isotopes

The sulfur isotope result of pyrite in the gold-silver ore from the ore-concentration area indicates that the sulfur in the ore is derived mainly from the Paleooproterozoic strata and Indosinian intrusive rocks, with a disperse δ³⁴S range. It also shows the complicated sources of sulfur during the mineralization.

The lead isotope result of pyrite in the ore shows that the lead isotopic compositions are mainly plotted above the line of µ = 9.8, with exceptions between the lines of µ = 9.8 and µ = 7.8, belonging to high-µ type of transitional evolution from mantle to crust. It is suggested that the magmatism and metallogenesis of the area be characterized by mixed source of crust and mantle, showing the dual source of lead. Therefore it is inferred that the ore materials of gold-silver (lead-zinc) also have the dual source.

4 Analysis on the Ore-Forming Time

Quite a few researchers have studied the ore-forming time of the gold-silver deposits in the area. The results focus on 202 – 241 Ma, reflecting the control of Late Indosinian to Early Yanshanian tectono-magmatism to the gold-silver metallogenesis. In addition, Late Indosinian granite porphyry dikes and lamprophyre dikes are developed in the mineralized area. The orebodies are commonly associated and paralleled with the lamprophyre dikes, which themselves form the gold (-silver) orebodies as one of the major ore types of the area. Therefore, the metallogenic time of the gold-silver deposits in this area should be Late Indosinian.

5 Discussion on the Metallogenic Mechanism

The metallogenesis of the gold-silver deposits in the ore-concentration area is characterized by “both old and new”, with metallogenic attribute of “multi-stage and complex genesis”. The metallogenesis is the complicated “three-in-one” process of formation-structure-magmatism:

- The clastic rock formation + carbonate rock formation of upper Liaohe Group with high ore-forming element background play the ore-bearing formation, being the source and basis of metallogenesis. Kinds of structures in the complicated structural evolution, such as the interbedded detachment structure zones and shear zones in upper Liaohe Group, provide necessary ore-controlling and hosting conditions for the migration and deposition of ore material. The Mesozoic magmatism performs as the necessary ore-forming and controlling factor, forming the migrating channel and storage space for ore fluid, except for the theoretic heat and ore sources.

References

References