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Lithochemistry and Dynamic Mineralization in Shangzhuang Gold Deposit, Northwest Jiaodong, China

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1 Geology of the Ore-district mining area and the Deposit

Almost 1/4 gold reserves in China were distributed in northwest Jiaodong. Jiaojia fault zone which was one of the most important ore-bearing fault zones.

Shangzhuang gold deposit was located in the north of Jiaojia fault zone. The fault zone struck roughly NNE, dipped NW, which consisted of Dongzhuangzi, Houjia and Wangershan secondary faults in Shangzhuang mining area. The gold orebodies existed mainly in Wangershan fault and Dongzhuangzi fault. Wangershan fault occurred mainly in Guojialing granodiorite, Dongzhuangzi fault occurred mainly in Linglong granite. Wangershan fault was the boundary line between Guojialing granodiorite and Linglong granite in ground surface.

The gold orebodies deposited in the altered and broken fault zones. The direct ore-bearing rock was beresitization altered rock. Electrum and pyrite were the main metal minerals in the ore, while there were a small amount of chalcopyrite, sphalerite, galena and pyrrhotine.

Potassic alteration were well developed in Linglong granite and Guojialing granodiorite near ore-bearing faults. Carbonatization alteration could be often seen in orebodies and wallrocks. Dolomite often associated with sulfide and quartz in orebodies, calcite veins was often found in wallrocks. There were also clayization gouge of 5-30cm thick near the major fracture planes of the broken fault zones.

2 Principal Component Characteristics of the Rocks

Compared with the fresh Linglong granite, content of K_2O , SiO_2 increased a little, content of Fe_2O_3 , MgO , SrO and BaO decreased obviously, while content of Al_2O_3 , CaO and Na_2O decreased a little in the potassic alteration Linglong granite, which indicated element of K, Si were taken in and Fe, Mg, Sr, Ba, Al, Ca, Na were brought out in this progress. Compared with the fresh Guojialing granodiorite, content of K_2O , SiO_2 increased obviously, and content of Al_2O_3 , Fe_2O_3 , CaO , MgO , Na_2O , TiO_2 , P_2O_5 , SrO , BaO decreased in the the potassic alteration Guojialing granodiorite, which indicated that element of K, Si were taken in obviously, Al, Fe, Ca, Mg, Na, Ti, P, Sr, Ba were brought out. Output of Fe provided iron for pyritization, and output of Ca, Mg provided material source for the formation of carbonate minerals, such as dolomite and calcite.

Compared with the fresh Linglong granite and Guojialing granodiorite, content of SiO_2 , MgO , K_2O increased, and Al_2O_3 , CaO , Na_2O , MnO , SrO , BaO decreased in the beresite, which showed Si, Mg, K were taken in, and Ca, Na, Mn, Sr, Ba were brought out during forming of the beresite. Input of Mg related to the dolomitization alteration.

Content of K_2O , MgO , Fe_2O_3 , TiO_2 , Al_2O_3 of the clay fault gouge in Wangershan fault were higher obviously than in the Linglong granite and in the Guojialing granodiorite. While content of SiO_2 , CaO , Na_2O were relatively lower in the clay fault gouge. This phenomenon indicated that K, Mg, Fe, Ti, Al were obviously taken in, Si, Ca, Na element were brought out during forming of the clay alteration. The output of Si from the clay fault gouge provided silicon source for beresitization. And output of Na and input of Al, Ti in the clay fault gouge had correlation with migration of the corresponding elements in the process of potassic alteration and beresitization.

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3 Rare Earth Elements Characteristics

With the potassic alteration of fresh Linglong granite and Guojialing granodiorite, Σ REE and LREE/HREE ration decreased obviously, howere HREE increased, which indicated that LREE were brought out obviously and HREE were taken in.

Compared with the fresh Linglong granite and Guojialing granodiorite, Σ REE and LREE/HREE ration of the beresite, the clay fault gouge in Wangershan fault increased obviously. compared to fresh Guojialing granodiorite and Linglong granite, LREE were taken in and HREE were brought out during forming of the beresite. Both LREE and HREE were taken in markedly during forming of the clay fault gouge in Wangershan fault.

The REE distribution patterns of fresh Guojialing granodiorite and Linglong granite were gently inclined curve to the right and with no obvious Eu abnormality. In the La/Yb- Σ REE diagram, all samples of fresh Guojialing granodiorite, Linglong granite and lamprophyre veins dropped into basalt area, which showed close relation in material source and origin between Yanshanian magmatic rocks.

4 Dynamic Mineralization

Isotope age data showed that metallogenic epoch of gold deposits in northwest of Jiaodong mainly concentrated in the 120 ± 5 Ma (Miao Laicheng et al., 1997)^[1], the rock-forming age of Linglong granite occurred in 160~150 Ma, the rock-forming age of Guojialing granodiorite occurred in 130~126 Ma (Zhai Mingguo et al., 2004)^[2]. Visibly, metallogenic epoch was shortly after the rock-forming age of Guojialing granodiorite.

The sulfur isotopic composition of the gold deposits in northwest of Jiaodong was characterized by evidently rich in ^{34}S . According to the geologic background and ancient geographical environment in northwest of Jiaodong in Yanshanian, sulfur source of the ores in northwest Jiaodong was believed to be related to seawater sulfur.

The origin of gold deposits in northwest Jiaodong could be summarized as dynamic mineralization: The forming of Hedong gold deposit was related to hydrothermal convection in the shallow crust; The environment of hydrothermal convection and circulation in the shallow crust was dynamic with the change of temperature, pressure, pH value, Eh value, oxygen fugacity, sulfur fugacity, carbon dioxide fugacity and other physicochemical parameters; The occurrence and motion state of ore-forming metallic elements and mineralizer

elements such as sulfur, carbon were changed constantly in the dynamic physicochemical condition^[3]; The dynamic change of physicochemical condition was the key to control water-rock interreaction and activation-moving-accumulation of ore-forming elements; Water's ionization reaction and a series of related electrochemical reactions played important roles in the process of alteration and mineralization

It's important to note that hydrothermal mineralization occurred in shallow crust had evitable connection with the natural magnetotelluric field. When the hot brine transferred in the circumstance where there were electric potential difference, it could become the medium of current conduction. And gold ore bodies could also be the medium of current conduction because of good electrical conductivity, which would help aggregation and growth of conductive minerals such as gold minerals and metal sulfides, and would provide condition for ionization of water and for water-rock interactions.

Water-rock interactions near the gold orebodies often consumed H^+ , such as beresitization. The reaction of forming beresitization was $3\text{KAl}_3\text{Si}_3\text{O}_8 + 2\text{H}^+ \rightarrow \text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2 + 2\text{K}^+ + 6\text{SiO}_2$. Water's ionization reaction was the main channel to provide H^+ . OH^- formed by water's ionization reaction would move away from the negatively charged orebodies. Therefore, the aggregation of gold minerals and sulfides had connection with the critical conversion from SO_4^{2-} to S^{2-} . And the reaction could be expressed as $\text{Me}^{2+} + \text{SO}_4^{2-} + 8\text{H}^+ + 8\text{e}^- \rightarrow \text{MeS} + 8\text{H}_2\text{O}$. The water-rock interactions consuming OH^- such as potassic alteration and carbonate alteration generally occurred outside of the orebodies and indicated mild alkali condition.

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