Fluid inclusions in gold-rich ores in the Wulashan Gold Deposit, Inner Mongolia, China

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Located 50km west to Baotou city, the Wulashan gold deposit (239 – 276 Ma, Meng et al., 2002) is the largest one in Inner Mongolia, China. The gold-bearing vein systems are hosted by the Archean Wulashan group, which is composed of hypersthene granulite in the bottom, biotite-hornblende plagioclase-gneiss sandwiching magnetite quartzite and amphibolite in the middle, and quartzite and marble sandwiching in the top. There is a biotite granite intrusion in the west of the mine area, but it is not related to gold mineralization because of earlier SHRIMP zircon U-Pb age (353 Ma, Miao et al., 2001). Gold mineralization includes altered rock type and quartz vein type. Felsic pegmatite veins occur widely in the mine area, which are intersected by gold-bearing quartz veins.

There are four mineralizing stages at the Wulashan gold deposit: (K-feldspar)-white quartz stage (I); pyrite-grey quartz stage (II); polymetallic sulphides (chalcopyrite, pyrite, galena) –grey white quartz stage (III); and calcite-quartz stage (IV). Stages II and III are main gold mineralizing stages. Gold-rich veins are substantially polymetallic sulphides-quartz tiny veins filling in fractures of early white quartz veins (Fig. 1). Gold occurs as native gold or electrum along the margins of tiny chalcopyrite veins (Fig. 1A, D and E). Native gold, electrum or sylvanite can also be found in fissures of quartz (Fig. 1B). Some gold occurs in galena-chalcopyrite veins (Fig. 1F). Grey white quartz surrounding gold-bearing sulphides had been recrystallized and shows less deformed; whereas white quartz away from the sulphides had been fractured and deformed, and appears wavy extinction. It is clear that this white quartz had been formed in early stage and had been affected by tectonic stresses during gold mineralization.

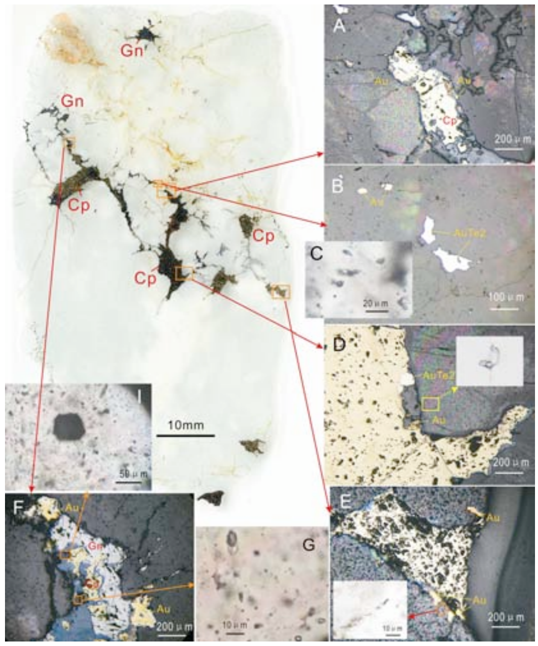

Fig.1. Gold-sulphides in tiny fissures and fluid inclusions in gold-rich quartz vein, the Wulashan gold deposit

Fluid inclusions can be frequently seen in both grey white quartz and early white quartz. Three types of fluid inclusions in quartz can be identified, and they are described as followings.

(1) CO_2-H_2O inclusions, composed of one aqueous phase and one CO_2 phase under room temperatures (Fig. 1C, G, I), dominate in gold-rich quartz vein that was examined. They have CO_2/H_2O volume ratios from 20 to 40%, with sizes of 5 to 30 µm. Sometimes three phases including liquid and gas CO_2 can be seen under room temperatures (Fig. 1D, I). They occur as isolated or random in quartz near gold-bearing sulphides, so they are of primary origin.

(2) CO_2 inclusions or carbonic (CO_2-CH_4-N_2) inclusions are composed of only one phase of CO_2 and are water-free inclusions. They occur occasionally with CO_2-H_2O inclusions in sulphide-

grey quartz veins (Fig. 1G), whereas they seem to be ruptured in early white quartz (Fig. 2). It is supposed that the fluid inclusions in early quartz had been broken during late gold mineralizing stages, because the pressure difference (internal minus external) can result in partial or complete decrepitating (Roedder, 1984).

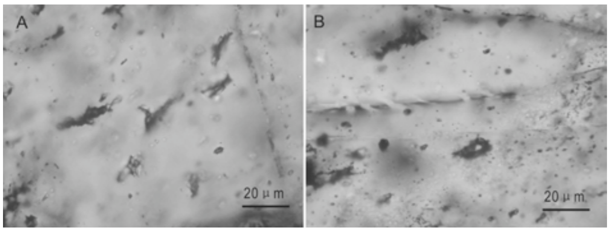

Fig.2.Broken CO_2-H_2O and CO_2 inclusions in early white quartz, the Wulashan gold deposit

(3) Aqueous inclusions, composed of a liquid water phase and a small bubble, occur in quartz outside of sulphide veins.

It is indicated from above petrographic evidence that gold has been introduced later than the bulk of the white quartz. Only those inclusions in recrystallized quartz near the sulphides are the actual gold-depositing fluid.

A microthermometry study shows that primary CO_2-H_2O inclusions in grey quartz near a galena-gold vein have similar melting temperatures of clathrate T_h(cla), i.e., from 5.3 to 7.3 °C (Fig. 3). The salinities are from 8.5 to 5.1 eq mass% NaCl according to Collins (1979). The total homogenization temperatures T_h(tot) are from 230.0 to 239.3 °C in the area of Fig. 3, but many inclusions decrepitated above temperatures of 215 to 273 °C. The partial homogenization temperatures of CO_2 phases in a few inclusions were observed to be between 27 - 31 °C, reflecting lower CO_2 densities of 0.66 - 0.47 g/cm^3. It can be estimated that mole fractions of CO_2 are 7.5 - 10.0% based on phase diagram of Diamond (2001). Hence, the trapping pressures would be at least 80 - 120MPa based on Takenouchi and Kennedy (1964). If we consider an average salinity of 6 eq mass% NaCl, the trapping pressures will be up to 250 MPa according to Brown and Lamb (1989). It is reasonable to speculate that many of inclusions decrepitate during heating because of high internal pressures.

We conclude that fluid inclusions occur in grey white quartz near gold and sulphides represent gold-depositing fluids. The precipitated T-P conditions for the gold-rich ores in the Wulashan gold deposit have been estimated to be at least 230 to 273 ˚C and 80 to 120 MPa.

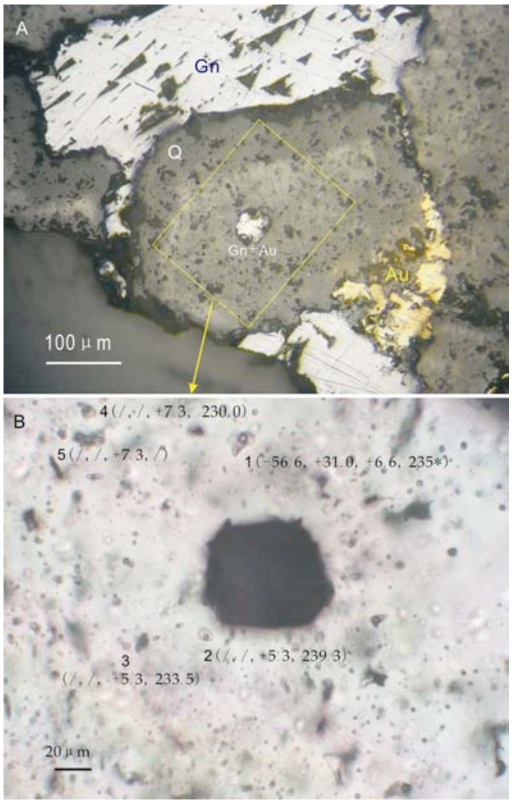

Fig.3.Thermometry of CO_2-H_2O inclusions in grey white quartz near gold-bearing sulphide vein, the Wulashan gold deposit. A: Au-gold; Gn-Galena; Q-Quartz; B: Number of inclusion ($T_m(CO_2)$, $T_h(CO_2)$, T_h(cla),T_h(tot))

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