

HE Jiale, XIAO Yuanfu, GUO Xianzhong, LI Xueren, ZHAO YaNan, WANG Liangguo and ZHANG Jie, 2013. Ore-forming Fluid Characteristics in Ga'erqiong Cu-Au Deposit of Bangong Lake-Nujiang River Metallogenic Belt, Tibet, China. *Acta Geologica Sinica* (English Edition), 87(supp.): 689-691.

Ore-forming Fluid Characteristics in Ga'erqiong Cu-Au Deposit of Bangong Lake-Nujiang River Metallogenic Belt, Tibet, China

HE Jiale^{1,2}, XIAO Yuanfu¹, GUO Xianzhong¹, LI Xueren¹, ZHAO YaNan¹, WANG Liangguo¹ and ZHANG Jie¹

¹ Academy of Earth Sciences, Chengdu University of Technology, Chengdu 610059, Sichuan, China;

² Chengdu Institute of Geology and Mineral Resources, China Geological Survey, Chengdu, Sichuan 610081, China

Bangong Lake - Nujiang suture zone is another important metallogenic belt in Tibet which is after of the Gangdese metallogenic belt. The geotectonic position of Tibetan Ga'erqiong copper-gold deposit is located junction belt of Bangong Lake - Nujiang suture zone and northern margin of Gangdese, which is one of the representative of the deposit in metallogenic belt. Predecessors have been doing for the diagenetic and metallogenic age, rock geochemistry, and ore characteristics. But forming fluids is still blank. System identification and testing of metal mineral symbiotic fluid inclusions are done for the first time, intends to explore the genesis of deposit following aspect such as the nature of the ore-forming fluids, metallogenic physicochemical conditions, the results provide a theoretical basis for the genesis of deposit.

1 Geological Background

Ga'erqiong is located the western part of Gangdese-nianqing-tangula plate and southern Qiangtang-Sanjiang composite plate suture zone, Regional structures was NWW-SEE trending. Mine strata of outcrop are mainly Cretaceous Duoai Formation (K_1d), rock is limestone, marble, volcanic breccia, tuff, angular rock and so on, marble due to magma intrusion on impact, and more widely distributed in the contact zone and near the rock mass, is closely related to the mineralization. Occurrence of stratum overall strike approximately EW, dip NNW, and dip angle is approximately $15^\circ \sim 85^\circ$. Mine developed in F_1 and F_2 two large fault structure, showed a NE-SW trending, which is the major ore-transmitting and ore-controlling structure.

The region widely distributed intrusive rocks, the

formation of the era of the late Yanshan, was batholith, rock strains, apophyses, dikes and other forms of output, according to the different types of rocks can be divided into granite porphyry, diorite porphyry, quartz diorite more in acidic intrusions. Including granite porphyry is the main ore-controlling rock mass, showing the strain of Little Rock, apophyses and dykes form output, and close to the ore body. The ore body is mainly produced in the granite porphyry and marble inside and outside the contact zone. Ore zircon U-Pb age granitic porphyry 83.2 ± 0.7 Ma, quartz diorite porphyry 87.1 ± 0.4 Ma, and molybdenite Re-Os model age of $86.87 \sim 87.29$ Ma.

2 Deposit characteristics

Main orebodies in the granite porphyry and carbonate rocks inside and outside the contact zone and the nearby surrounding rock, in which the ore body No. 1 is slightly higher degree of geological work, it is the largest, most representative contact metasomatic orebody in mine, the main ore-wall rock of garnet wollastonite skarn and altered hornfels. Form predominantly is stratiform and lenticular. Ore body No. 2 overall is lens-shaped ore body. The rock alteration main skarn, silicification, carbonation, propylitization, mudding and so on, the skarn and silicification are closely related to mineralization.

Ore structures are mainly massive, disseminated, mottled and star point / point of dust-like structure. The ore structure form by crystallization, metasomatism, solid solution separation, biological sedimentation and weathering formation, crystallization and metasomatism of various kinds of structure-based, followed by separation structure of the solid solution.

The ore composition can be divided into metallic minerals and non-metallic minerals. Metal minerals are pyrite, chalcopyrite, bornite, molybdenite, chalcocite,

* Corresponding author. E-mail:

native copper, sphalerite, galena, native bismuth, bismuth, sulfur, copper bismuth, tellurium, bismuth, sulfur-containing bismuth telluride and native gold, silver gold, tellurium, silver, copper and gold, zinc and copper intermetallic compounds, natural iron, magnetite, hematite, magnetite Mu, square iron ore, goethite, lepidocrocite, blue chalcocite, covellite. Non-metallic minerals are mainly skarn minerals, carbonate minerals.

3 Mineralization Periods, Mineralization Stages

According to the the ore field geology output characteristics and ore types, structures, mineral assemblages, combined with electronic microprobe analysis results, the mineralization process is divided into two mineralization period of magmatic hydrothermal and supergene weathering mineralization period, magmatic hydrothermal mineralization period as the main ore-forming mineralization period, further divided into three stages of mineralization: skarn-oxide phase, quartz-sulfide stage and carbonate-lead and zinc sulfide stage.

3.1 Magmatic Hydrothermal Mineralization Period

① Skarn-oxide stage: This stage is mainly the formation of a variety of silicate minerals and a small amount of quartz, magmatic gas-water hydrothermal along the wall rock contact with filling metasomatism, the formation of skarn minerals such as garnet, diopsideetc, late the formation of quartz. The metallic minerals are mainly magnetite, hematite, magnetite Mu, followed also found a variety of intermetallic compounds copper and gold, zinc and copper. Late the formation of a small amount of high-temperature sulfide molybdenite, bismuth, ore type disseminated ores.

② Quartz - sulfide stage: Magmatic hydrothermal along the filling and replacement of the secondary structure early formation of a large number of quartz and metal sulfide, and mineralization is closely related to the silification, formation of a large number of quartz. Ore types densely

disseminated and massive ore mainly; metallic minerals are native gold, silver gold, chalcopyrite, pyrite, and a variety of sulfur salt minerals.

③ Carbonate-lead and zinc sulfide stage: To late mineralization accompanied by temperature decreases, the formation of a large number of calcite, formed metal mineral galena, sphalerite, gold and silver telluride.

3.2 Supergene Weathering Period

It is the process that Surface and shallow sulfide ore is subjected to weathering and leaching, then form limonitization and malachitization. It is mainly displayed by copper, iron sulfide of oxidation zone leaching and dilution, and gold enriched in the oxidation zone.

4 Fluid Inclusions And Ore-forming Fluid Characteristics

The inclusions of garnet, diopside are rare, the majority of inclusions in quartz are so small (less than 5 μm) that bring some degree of difficulty to research, and more inclusions in calcite that fit into test requirements. To ensure the reliability of the test data, the test object is mainly greater than 6 μm gas-liquid two-phase inclusions in quartz and calcite. For the six samples of fluid inclusions were collected from No.1and No.3 orebody which belong to contact area of quartz diorite and wall rock.

According to the phase classification criteria of fluid inclusions at room temperature by Lu Huanzhang (2004), the primary fluid inclusions in the sample can be divided into three types: pure liquid inclusions, gas-liquid two-phase inclusions and including daughter minerals inclusions. The total characteristic are mass, the uneven area of distribution, and intensive parts of the formation of inclusions group, only one or two isolated inclusions in the sparse parts.

The research method of temperature measurement is homogenization and freezing. The testing of temperature accomplished at the Key Laboratory of mineral rock

Table 1 Characteristics of fluid inclusions in the G'erqiong Copper-Gold deposit

Mineralization stages	The main mineral	Type	Particle size / μm	Gas-liquid volume ratio	Homogenization temperature / $^{\circ}\text{C}$		Freezing temperatures / $^{\circ}\text{C}$		Salinity content (CaCl_2) /wt%	
					Range	average value	Range	average value	Range	average value
Skarn stage	Quartz	gas-liquid inclusion	5 ~ 12	10 ~ 20	469 ~ 480(3)	474	-	-	-	-
Quartz - sulfide stage	Quartz	gas-liquid inclusion	5 ~ 10	10 ~ 15	301 ~ 455(11)	386	-	-	-	-
	Calcite	gas-liquid inclusion	8 ~ 25	7 ~ 25	222.9 ~ 283.3(11)	245.5	-1 ~ -24.1	-13.93	3.5 ~ 11.8(3)	8.37
Carbonate - Sulfide stage	Calcite	gas-liquid inclusion	4 ~ 22	5 ~ 20	138 ~ 369(10)	214.11	-12.7 ~ -24.9	-18.04	8.1 ~ 11.9(7)	9.97
	Calcite	gas-liquid inclusion	7 ~ 25	8 ~ 25	169.8 ~ 324.2(21)	252.97	-15.5 ~ -19.3	-17.83	9.4 ~ 10.7(7)	10.07
	Calcite	gas-liquid inclusion	5 ~ 30	5 ~ 15	122.1 ~ 250.2(12)	193.37	-1.1 ~ -19.7	-9.6	3 ~ 10.8(5)	6.94

Note: “-” for unmeasured matters, (n) data measured by the number of inclusions.

deposits in Chengdu University of Technology, Sichuan Province, the equipment of testing are the UK the Linkam THNSG600 hot and cold station and Jilin Hunjiang Optical Instrument Factory TRL-02-type hot stage. The homogenization temperature error of reproducing is less than 2 °C, freezing temperatures error of reproducing is less than 0.3 °C, which are in line with the error standard.

4.1 Homogenization Temperature

Been tested and received a total of 68 homogenization temperature data, which show the lowest temperature is 122.1 °C and a maximum temperature is 480 °C. Combined with mineral assemblages and results of microscopic identification, the temperature is divided into three intervals: 469 °C~480 °C, 301 °C~455 °C, 122.1 °C~369 °C, which are corresponding to three mineralization stages in hydrothermal mineralization period of Ga'erqiong deposit (Table 1). Learned about later two stages are as the main mineralization stages. Mineral of testing is quartz in quartz-sulfide stage, a temperature of 301 °C~455 °C, the average temperature of 386 °C; Mineral of testing is calcite in carbonate-sulfide stage, a temperature of 122.1 °C~369 °C, the average temperature of 193.37 °C~252.97 °C.

The results of testing show that Ga'erqiong copper-gold deposit mineralization process is an evolution process from high temperature to the medium temperature, which are consistent with mineral assemblage in the ore. Quartz-sulfide stage formed mainly in the high-temperature phase, in this phase, mineral assemblage is native bismuth-bismuthinite-molybdenite-chalcopyrite. Carbonate-sulfide phase formed in the medium temperature stage, mineral assemblage is pyrite-chalcopyrite-native gold-galena-gold and silver telluride material.

4.2 The Salinity

In the most samples of quartz, less inclusions and the individuals of primary inclusions are generally relatively small (particle size of 4 to 6μm) and phase boundary blur, the freezing point and salinity can not be tested. So we selected four samples of calcite, in which primary inclusions relative development, by using freezing to test temperature. Eventually won 22 accurate freezing temperatures data, which are as low as -24.9 °C up to -1 °C, accounting to five data are higher than -21.9 °C, so we can see that its not entirely belong to the NaCl-H₂O system. We analyze by combining with incipient melting temperature (-49 °C to -50 °C) and the Ga'erqiong copper-gold deposit types, fluid inclusions are mostly from calcareous skarn, which have high elemental calcium, so it is inferred that its in part belong to CaCl₂-

H₂O system.

To calculate the salinity of this paper, in order to maintain consistency, inclusions salinity measured in the sample using the CaCl₂-H₂O system phase diagram projections obtained, the measured freezing point temperature into steam saturation T-X phase diagram of CaCl₂-H₂O system, obtained salinity 6.94 wt% to 10.07 wt % is a low salinity (table 1), which is why are including daughter minerals multiphase inclusions rare in deposit.

4.3 Density

Based on the CaCl₂-H₂O density formula:

$$\rho = g_1 + g_2 T + g_3 T^2 + g_4 T^3 + g_5 m + g_6 m^2 + g_7 m^3$$

$$+ g_8 Tm + g_9 Tm^2 + g_{10} T^2 m;$$

$$m = 1000 \times \omega / (111 \times (100 - \omega))$$

$$\rho \text{ Brine density (g} \cdot \text{cm}^{-3}\text{)}$$

$$T \text{ Homogenization temperature (°C)}$$

$$M \text{ CaCl}_2 \text{ molality}$$

$$\Omega \text{ Salinity (\%)}$$

$$g_i \text{ Constant (i subscript)}$$

Putting data in Table 1 into this formula, can be calculated as ρ 0.918 g cm⁻³ highest, and a minimum of 0.5137 g cm⁻³

Fluid inclusions in quartz-sulfide stage is too small, unable to carry out the determination of salinity, so these results represent only the Ga'erqiong copper-gold deposit carbonate-sulfide stage the density of the fluid inclusions as 0.918 to 0.5137 g cm⁻³, a medium-density ore-forming fluids.

5 Discussions

Homogenization temperature measurement results show that the main mineralization stage: skarn-oxide stage homogenization temperature of fluid inclusions 469 °C to 480 °C, mean value 474 °C; homogenization temperatures of fluid inclusions in quartz-sulfide stage 301 °C to 455 °C, the average for the 386 °C; carbonate-sulfide stage homogenization temperature of 122.1 °C to 369 °C, an average of 193.37 °C to 252.97 °C, showing the formation temperature of the deposit is high-medium temperature. This is consistent with the paragenetic association of high-temperature mineral in this paper. The salinity is 6.94% to 10.07%, indicating that the ore-forming fluid has the characteristics of low salinity and belong to low salinity Na-CaCl₂-H₂O system. And with the conduct of the mineralization, salinity trend from high to low. Ore-forming fluid density is 0.918 ~ 0.5137 g cm⁻³, and it is medium density. The deposit is a skarn-type deposit formed by magmatic hydrothermal contact metamorphism.