The Bainaimiao copper deposit in Inner Mongolia is located in the copper polymetallic belt of the Ondor Sum Caledonian accretion zone in the eastern part of the Central Asian Orogenic Belt. The deposit is comprised of the northern and the southern ore belts. The host rock of the southern ore belt is greenschist while the orebodies in the northern belt mainly occur in the Caledonian strongly deformed and metamorphosed granodiorite porphyry. The geological settings and ore genesis have been well documented in a number of studies. However, the mineralization process has received little attention, especially the associated gold minerals. The previous researches indicate that the deposit should belong to Paleozoic porphyry system that is engendered by island arc granodioritic porphyry under subduction environment. So, the study on mineralization process can not only point out prospecting orientation but also are important in understanding the diverse mineralization process in porphyry system.

1 Mineralization Characteristics of Bainaimiao Deposit

Bainaimiao is a large porphyry copper deposit along the Central Asian Orogenic Belt. According to recent prospecting reports of the First Create Group, reserves exceed 0.7 Mt copper, 8500 t Mo and 8 t Au. The deposit is comprised of the northern and the southern ore belts. Ore bodies in the southern ore belt with large tonnages are mainly occurred in EW-trending shear zones in greenschist. Small sheeted quartz–sulfide veins systems concordant with the foliations of the host greenschists are very common in ore bodies, which are the most important ore forming texture. The Cu and Au content of the ores decreases with depth while Mo concentration increases.

Ore bodies in the northern ore belt are mainly hosted by granodiorite porphyry and the contact zones between the porphyry and the greenschist. In addition, the Cu and Au content of the ores in contact zones are much higher than in granodiorite porphyry whereas Mo content is actually just the opposite. To sum up, Ores from the northern ore belt have higher Mo and lower Cu and Au content than those from the southern ore belt. The Cu and Au content of the ores decreasing as Mo concentration increasing with depth is a very common phenomenon both in the southern and the northern ore belts.

2 Mineralization Process of Bainaimiao Deposit

The Bainaimiao intrusion forms potassic alteration (including K-feldsparization and biotitization) in the deep (mainly occurring in northern ore belt) with relatively high salinity, containing little base metals liquid. Only a spot of pyrite and pyrrhotite are formed during above early stage. As magma solidification (middle stage), the entire system progressively cools and lithostatic gives way to hydrostatic pressure (Hedenquist et al., 1998; Heinrich et al., 2004; Sillitoe, 2010). Under lower temperature and pressure conditions, silicification, sericitization begin to form mainly from a deeply derived, aqueous liquid, which has been proved by stable H, O, and S isotope research (Nie, 1993; Meng, 1993). The principal ore minerals are pyrite, chalcopyrite, molybdenite and associated gold minerals. Though detailed optical microscopy work, we propose the genesis sequence of the ore minerals from early to late in this stage as follow: pyrite → molybdenite → chalcopyrite ± gold minerals (FIG. 1a, 1b, 1c). Native gold and electrum are commonly present in the southern ore belt as small inclusions (< 80μm and in irregular shapes) in chalcopyrite (FIG. 1b), the contact position between pyrite and chalcopyrite, and only a few in gangue minerals, whereas no gold minerals are found in the northern ore belt in our studies. In
addition, the contents of molybdenite and chalcopyrite also show regular changes between the southern and the northern ore belts as well as with depth (see section 1). To sum up, it is a remarkable fact in spatial distribution that Mo content of the ores is relatively high in granodioritic porphyry while the Cu and Au content is enriched in greenschist, especially in southern ore belt. The mineralization characteristics indicate that ore bearing liquid undergoes different degree changes in Cu, Au, and Mo solubility in fluid evolution process caused by either intense boiling in upflow conduits or admixture of the liquid derived from magma with ground water. Therefore, the fluid evolution and mineralization process of middle stage can be concluded as follow: the liquid mainly originated from magma containing Cu, Au, Mo, and S begin to precipitate molybdenite and chalcopyrite mainly in the porphyry intrusions as parental magma crystallize or/and pressure and temperature decrease. However, an appreciable amount of Cu, Au, and S still remain in solution because they are not appreciably concentrated in the sulfides. The upward-escaping liquid generates variable degrees of porphyry Cu ± Au mineralization in greenschist and contact zones between the porphyry and the greenschist. Under these conditions, potassic alteration (mostly in porphyry intrusions) and intense silicification and sericitization (FIG. 1d) (mainly in greenschist) develop. At the last stage, as the entire system progressively cools, the liquid of depleted metallogenic materials continues upward into the lithocap where chlorite–epidote–carbonate alterations are produced plus minor amounts of galena and sphalerite. In addition, the fluid evolution and mineralization process have been proved by our recent stable C, H, O, and S isotope research.

3 Conclusions

There appears a regular variation of Cu, Au, and Mo content of the ores that Mo tends to concentrate on granodiorite porphyry whereas Au is inclined to enrich in greenschist. The mineralization characteristics are consistent with the ore bearing liquid evolution process. Native gold and electrum are commonly present as small inclusions (< 80 μm and in irregular shapes) in chalcopyrite, the contact position between pyrite and chalcopyrite, and only a few in gangue minerals. Small amount of granodiorite porphyry apophyses closely associated with mineralization are found in deep southern ore belt in recent exploration work, which imply prospecting potential.

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