MINERALOGICAL STUDY OF QSP (QUARTZ-SERICITE-PRYITE) ALTERATION ZONE OF ERDENETIIN-OVOO PORPHYRY Cu-Mo DEPOSIT IN NORTHERN MONGOLIA

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Abstract

The Erdenentiin Ovoo Cu-Mo porphyry deposit is located in Northern Mongolia near the Erdenet city of the central part of Orkhon province which is 330km away to northwest from Ulaanbaatar. A great part of rock samples collected for this study in Erdenetiin-Ovoo Cu-Mo porphyry deposit are altered granodiorite and diorite, containing ore-bearing quartz veins. QSP (Quartz-Sericite-Pyrite) alteration is well developed in almost all the whole rock samples and the major observed minerals consist of sericite, quartz and pyrite. Main ore minerals are pyrite, chalcopyrite, molybdenite, chalcocite, covellite and sphalerite (Fig. 4). The first three ore minerals are dominant in the deposit. Chalcocite fills the space between pyrite grains or includes other sulfide mineral grains such as pyrite, sphalerite and chalcopyrite, suggesting that chalcocite was precipitated after other sulfide minerals had already formed. Sphalerite grains show relatively high copper contents ranging from 0.95 wt% to 2.9 wt%, whereas copper ore minerals have low or no zinc contents. And chalcocite grain shows 16 ppm gold concentration with low concentration of other elements such as Zn, Fe, As and Mo.

1. Introduction

Porphyry ore deposits are derived from magmatic-hydrothermal activity in the crustal levels. The most important metals in the deposits are Cu, Mo and Au. Minor amounts of other metals such as Ag, Pd, Te, Se, Bi, Zn and Pb also occur in these deposits. Porphyry Cu or Cu-Au-Mo deposits presently supply 75% of Cu, half of Mo, 20% of gold and all of Re. Porphyry deposits were generated world-wide since the Archean, even though Mesozoic and Cenozoic deposits are most abundantly preserved (Singer et al., 2008; Sillitoe, 2010).

The Erdenetiin-Ovoo Cu-Mo porphyry deposit is located in Northern Mongolia near the Erdenet city of the central part of Orkhon province which is 330 km away to northwest from Ulaanbaatar. The Erdenetiin-Ovoo magmatic center lies in the Orkhon-Selenge trough, which is the largest volcanogenic structures of the rift zone of the Permo-Triassic North Mongolian magmatic area (Berzina et al., 2007). According to the Erdenet Mining Corporation (2002), estimated metal reserves were 7.6 Mt Cu and 0.2 Mt Mo within 1490 Mt of ore with average grade of 0.509% Cu and 0.015% Mo.

The purpose of this study is to identify and understand petrologic and mineralogical characteristics of sulfide ore and alteration minerals with the micro-scope observation and EMPA analysis.

2. Geology

The Erdenetiin-Ovoo Cu-Mo deposit is hosted mainly by Late Permian to Early Triassic intrusive rocks, consisting of gabbro, diorite and granodiorite (Gerel, 1998; Gerel and Munkhtsengel, 2005). According to previous studies (Sotnikov et al., 1995; Dejidmaa and Naito, 1998; Gerel, 1998; Watanabe and Stein, 2000; Gerel and Munkhtsengel, 2005; Munkhtsengel et al., 2006), geology of Erdenettin-Ovoo deposit area is divided into five stages as following: (1) Precambrian and Early Paleozoic basement rocks, (2) Late Paleozoic to

Mesozoic calc-alkaline volcanism, (3) Late Permian Selenge complex, (4) Late Permian to Early Triassic Erdenet porphyry complex, (5) Post-mineralization syenite porphyry dikes and trachyandesite. Among these, Copper and molybdenum mineralization processes was associated with the Erdenet porphyry complex, consisting of diorite porphyry, granodiorite porphyry and granodiorite with breccia. Potassic silicate alteration is pervasive in the host porphyry and the main mineralization is related to subsequent sericite alteration (Watanabe and Stein, 2000).

Several authors also reported age dating results of the Erdenet deposit. Watanabe and Stein (2000) analyzed Re-Os age data of molybdenite, yielding 240.7±0.8 Ma. Sotnikov et al. (1995) showed age dates of biotite from 251±18 and 253±28 Ma by K-Ar method and 253±18 Ma by Rb-Sr method at the first-stage magmatism to 234±40 and 229±12 Ma by K-Ar method and 221±14 Ma by Rb-Sr method at second stage. Wantanabe and Stein (2000) suggested that porphyry copper molybdenum mineralization was related to Erdenet porphyry complex intrusion and occurred during the final stage of magmatic activity of the Selenege complex.

3. Samples and analyses

Rock and ore samples for this study were collected at nine positions in the open pit mine of the Erdenet deposit. The sampling positions range from 49°01'11.0'' to 49°01'42.3'' in latitude, from 104°06'40.9'' to 104°08'17.2'' in longitude, from 1275 to 1352 m in altitude, respectively (Fig. 1). For the identification of composition of mineral grains, EPAM (Electron Probe Micro Analyzer) analyses were carried out in NCIRF

(National Center for Inter-University Research Facilities), Seoul Nation University.

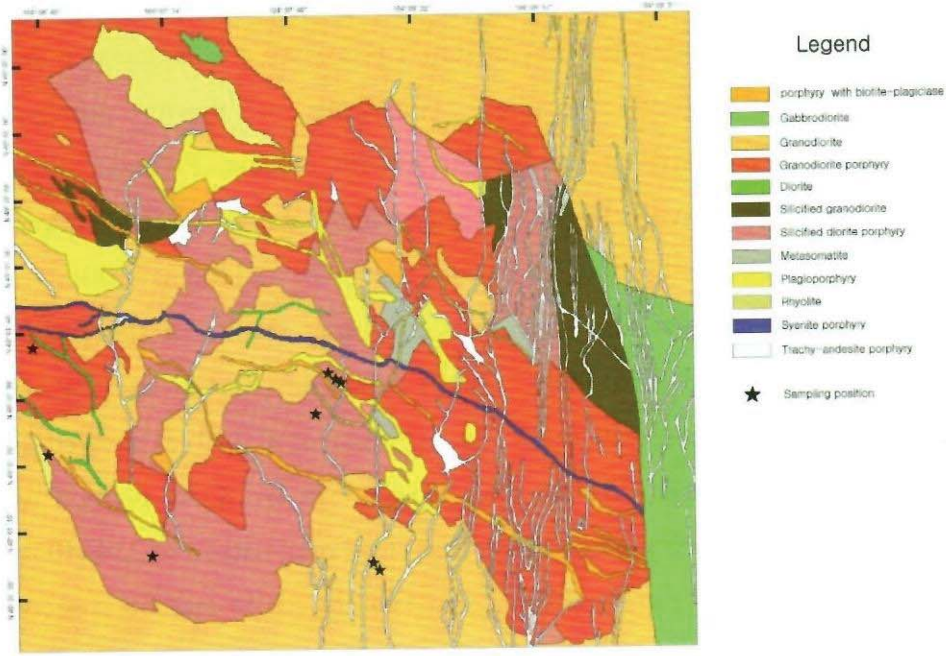

Figure 1. Geological map of Erdenetiin-Ovoo porphyry Cu-Mo deposit in Northern Mongolia, modified from Erdenet Mining Corporation (2002).

4. Results and discussions

4.1 Mineralogical and petrographic observation of samples

A great part of rock samples collected for this study in Erdenetiin-Ovoo Cu-Mo porphyry deposit are altered granodiorite and diorite, containing ore-bearing quartz veins (Fig. 2). QSP (Quartz-Sericite-Pyrite) alteration is well developed in almost the whole rock samples and the major observed minerals are sericite, quartz and pyrite (Fig. 2 and Fig. 3). Also, residual feldspar, primarily albite, are partly altered to sericite (Fig. 3-a).

Figure 2. Photos of rock samples.

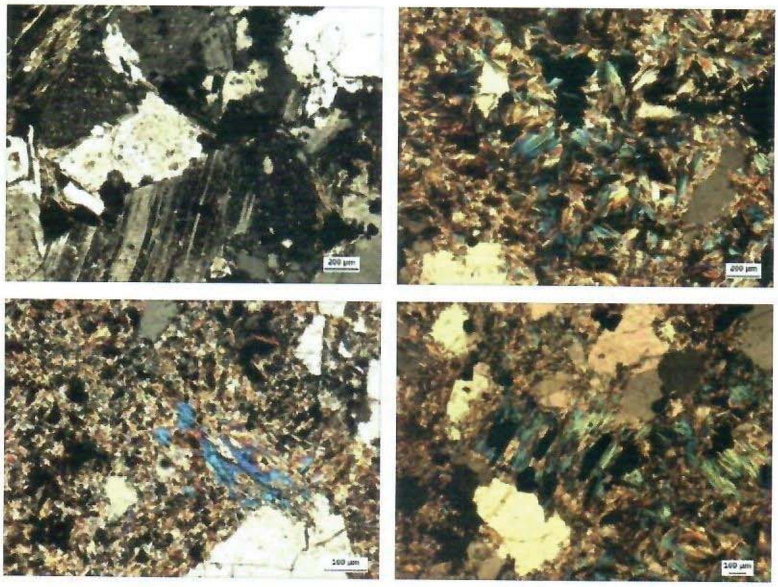

Figure 3. Microscopic photos of samples.

K-feldspar is not observed because K-feldspar is usually replaced by sericite during QSP alteration as following equation:

$$3KAlSi_3O_8 + 2H^+ \rightarrow KAl_3Si_3O_{10}(OH)_2 + 6SiO_2 + 2K^+$$

Observed ore minerals are pyrite, chalcopyrite, molybdenite, chalcocite, covellite and sphalerite (Fig. 4). The first three ore minerals are dominant in the deposit. Pyrite and chalcopyrite are disseminated within host rocks or occur in quartz veins, whereas most of molybdenite is precipitated in quartz veins. Under microscopic observation, it is shown that chalcocite fills the space between pyrite grains or includes other sulfide mineral grains such as pyrite, sphalerite and chlacoyrite (Fig. 4-e and f).

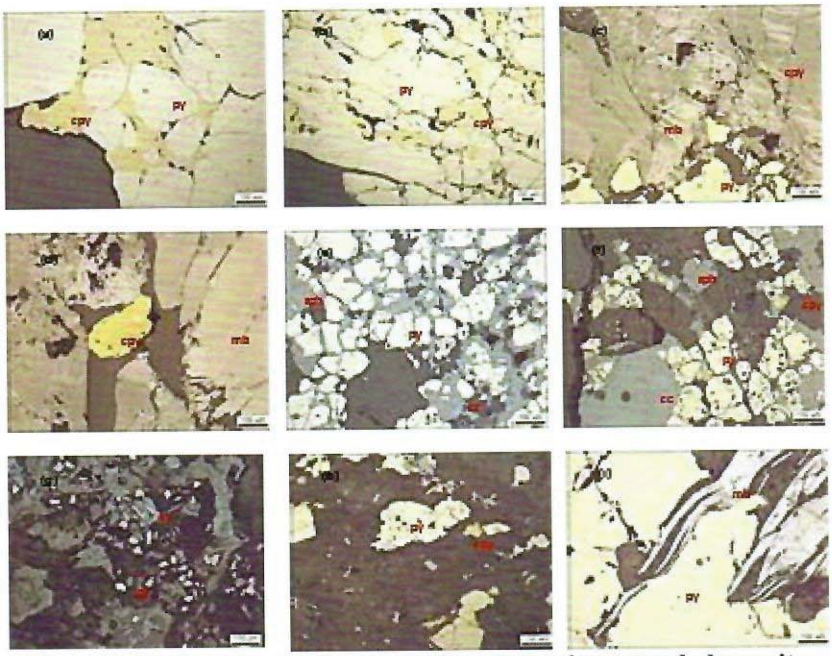

Figure 4. Photomicrographs of samples. py: pyrite; cpy: chalcopyrite; mb: molybdenite; sph: sphalerite; cc: chalcocite; cv: covellite.

This suggests that chalcocite was precipitated after other sulfide minerals had already formed. In addition to chalcocite, the presence of chrysocolla in some samples indicates that these minerals were precipitated as secondary minerals in relatively shallow levels of hydrothermal system of the Erdenet deposit.

4.2 EPMA analyses of ore minerals

Ore minerals are analyzed by EPMA. There are some noticeable results. First, sphalerite grains show relatively high copper contents ranging from 0.95 wt% to 2.9 wt%, whereas copper ore minerals such as chalcopyrite and covellite have low or no zinc contents. Chalcocite, which is secondary mineral, shows exceptional high gold concentration of approximately 3.6 wt%. Second, all analyzed sulfide ore minerals, except molybdenite which is unique economic molybdenum ore minerals, show very low molybdenum concentration near about 1 wt%. Third, chalcocite grain shows 16 ppm gold concentration with low concentration of other elements such as Zn, Fe, As and Mo.

5. Conclusions

1. Rock and ore samples for this study were collected at nine positions in the open pit mine of the Erdenetiin-Ovoo porphyry Cu-Mo deposit in Northern Mongolia.

2. QSP (Quartz-Sericite-Pyrite) alteration is well developed in almost the whole rock samples and the major observed minerals are sericite, quartz and pyrite.

3. Observed ore minerals are pyrite, chalcopyrite, molybdenite, chalcocite, covellite and sphalerite. The first three ore minerals are dominant in the deposit. Chalcocite fills the space between pyrite grains or includes other sulfide mineral grains such as pyrite, sphalerite and chlacoyrite, suggesting that chalcocite was precipitated after other sulfide minerals had already formed.

4. Sphalerite grains show relatively high copper contents ranging from 0.95 wt% to 2.9 wt%, whereas copper ore minerals have low or no zinc contents. And chalcocite grain shows 16 ppm gold concentration with low concentration of other elements such as Zn, Fe, As and Mo.

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