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Epithermal Cu-Pb-Zn Mineralization in the Cidolog Area, Sukabumi Regency West Java Province, Indonesia

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Abstract. There is epithermal system of Cu-Pb-Zn deposit in Cidolog area, Sukabumi, West Java Province, Indonesia. The alterations in the research area were carefully classified into three types of alteration zones, they are argillic alteration, propylitic alteration and silicic alteration. The mineralization then was carefully classified as pyrite(FeS2), chalcopyrite (CuFeS2), Galena (PbS), Sphalerite (Zn,Fe)S, Hematite (Fe2O3), Magnetite (Fe3O4), Chalcocite (Cu2S), Malachite (CuCO3(OH)), Azurite (Cu3(CO3)2(OH)2). The analysis result of Cu, Pb and Zn elements in the area showed relatively higher than another elements (Au, Ag). In the research area, the mineralization process is controlled by geological structure such as faults and fractures. The appearances of the mineralization is abundant and can be found fulfilling the fracture zone mainly shear joints. This study will emphasize on the measurement and detailed analysis to know more about the Galena, Chalcopyrite and Sphalerite mineralization process and other minerals controlled by structures patterns. The controlling structure of this area generally are fractures and faults zone in NW-SE direction, the analysis of controlling structure can really be a good aid in locating the mineralized areas. In this research, presence of galena, chalcopyrite, sphalerite and bornite minerals were found at several fault zones and also brecciated quartz. It could be interpreted that several site locations are Epithermal Intermediate Sulfidation type deposit zones. However, the research area was generally classified as an Epithermal Low Sulfidation type deposit.

Keywords: Epithermal, alteration, mineralization, deposits, structure.
I. Introduction

Cidolog is an area in West Java that is potential of mineral ore deposit, such as gold, copper, plumbum (lead) and zinc. The rock was resulted from ancient volcanic activities such as volcanic sediment and intrusion, and other geological process had supported the ore mineral deposit formation. The study area which is located at 106˚50′55,8" - 106˚51′54,9" eastern longitude and 7˚18′13,9" - 7˚18′51,26" southern latitude features geological structure controlling ore mineral deposit in the area. The research area was an artisanal mining of gold, copper and galena that had been closed down. Former studies showed that the research area and its surrounding is an Epithermal Low Sulfdation type deposit which generally was identified in quartz veins. (Suparka, 1987, Sunarya, 1989. Soeria Atmadja, 2001). This research aims to understand the alteration and ore mineral zones in the research area, the lithology and its geological structure. The research method is surface geological mapping and laboratorium analysis of AAS (Atomic Absorbtion Spectometry), XRD (X-Ray Diffraction) and polished section (Mineragraphy) which was performed on specific vein samples to detect the potency of ore mineral deposit.

In this research, we found galena, chalcopyrite, sphalerit and bornite mineral at several fault zones and brecciated quartz indicating zone of Epithermal Intermediate Sulfdation type deposit, although the research area is in general an Epithermal Low Sulfdation type.

2. Regional Geology

The research area is part of Southern Mountain physiography of West Java (Van Bemmelen, 1949) in which the stratigraphy was comprised of Jampang Formation and Bentang Formation. The Early – Middle Miocene of Jampang formation consists of breccia lithology that was overlain by tuffaceous sandstone and andesite lava with different thickness at each site. On top of Jampang formation, the Late Miocene of Bentang Formation was unconformably deposited and was consisted of tuffaceous sandstone with little lava intercalation at the bottom. The lower part was composed of interbedded tuffaceous sandstone and lava, conglomerate with abundant of limestone fragments was deposited on top, then followed by well-layered tuffaceous sandstone, interbedded claystone and sandstone, and also clastic limestone and reef limestone. Two geological structures development were identified in West Java, dextral fault in northwest – southeast direction and sinistral in northeast – southwest direction. Typically in West Java, some of those faults were speculated to have rejuvenation since Pliocene (Asikin, 1986).

3. Discussion

3.1. Geological Condition of The Research Area

Based on classification of rock unit from surface geological mapping, the oldest unit of the research area is comprised of Diorit intrusion subjected to weak to strong alteration. This intrusion was reckoned as the oldest lithology in research area and the contact with overlying rock was exposed at the bottom of valley as riverbed. The diorite intrusion was unconformably overlain by andesite-basalt lava unit that has conformity contact with tuffaceous sandstone unit of which the contact is almost in horizontal position. The youngest unit in the area is andesite intrusion that was found to break through the tuffaceous sandstone (Figure 1).
The geological structure developed in the area is dextral strike-slip fault in southeast – northwest direction (Figure 1-a,b). Which is the main fault controlling mineralization in research area. Mineralization vein was found in shear joint having N300°E direction, which was a synthetic shear joint resulted from the existing dextral strike-slip fault. Based on the data obtained, the alteration in research area could be divided into three classification defined by its mineral. Silicic alteration which is indicated by silica mineral (SiO$_2$), was only could be found on quartz vein and few was developed outside. The argillic alteration was comprised of clay mineral of kaolinite and sericite, according to X-Ray Diffraction (Figure 2A). Propylitic alteration was indicated by albite and chlorite substituting some of pyroxene minerals in andesite-basalt lava in the area (Figure 2B). The alteration in research areas was generally following pattern of the existing geological structure, as alteration area was developed not distant from the fault zone.

Figure 1. (a) The feature of dextral strike-slip zone controlling alteration and mineralization in the research area. (b) Mineralization vein with the change of surrounding alteration zone in Andesitic lava.

Figure 2. Show the result of XRD analysis. (A) in site 02 show the argillic alteration with mineral association quartz, pyrite, kaolinite, and sericite. (B) in site 93 show the propillitic alteration with mineral association quartz, pyrite, chlorite, plagioclase, and smectite.
3.2. Mineralization in The Research Area

The mineralization in research area was relatively associated with quartz vein (vein or veinlets) with quartz breccia texture in southeast-northwest direction that was found in sandstone and andesite-basalt lava. The mineralization vein was resulted from hydrothermal fluid filling process along with shear joint formation. Ore minerals found in research area were native elements, they are copper (Cu), lead (Pb) and zinc (Zn) and other following metal element such as Pyrite (FeS₂), Chalcopyrite (CuFeS₂), Galena (Pbs), Bornite (Cu₅FeS₄), Magnetite (Fe₃O₄), Gold (Au).

The ore element that were presence, based on AAS analysis, contains: Cu (14 ppm – 5.81%), Pb (15 – 3060 ppm), Zn (59 ppm – 1.02 %), Ag (0.3 – 16.4 ppm), and Au (5 – 447 ppb). The following analysis result (Table 1) is obtained from sample analysis of the selected quartz veins in research area.

| No | Method Code | Cu ppm | Cu % | Pb ppm | Zn ppm | Zn % | Ag ppm | Au ppb |
|----|-------------|--------|------|--------|--------|------|--------|--------|
| 1  | AAS LP-1    | -      | 3.36 | 181    | 641    | -    | 9.9    | 447    |
| 2  | AAS LP-2    | 243    | -    | 18     | 95     | -    | 1.6    | 23     |
| 3  | AAS LP-7    | 1247   | -    | 3060   | -      | 1.02 | 1.7    | 50     |
| 4  | AAS LP-11   | -      | 5.81 | 26     | 91     | -    | 16.4   | 47     |
| 5  | AAS LP-12   | 5016   | -    | 88     | 178    | -    | 7.2    | 67     |
| 6  | AAS LP-16   | 888    | -    | 15     | 188    | -    | 0.3    | 15     |
| 7  | AAS LP-47   | 14     | -    | 15     | 59     | -    | 2.3    | 5      |

Note:  
1 % = 10.000 ppm  
1 ppm (gram/ton) = 1.000 ppb

The analysis result of mineragraphy and megascopic visibility of several ore mineral samples and features found in the field:

The analysis at site 02, field description and mineralography analysis result (site 02) shows Chalcopyrite, Galena and Sphalerite mineral that was reckoned to had developed together.

![Figure 3. Showing visibility of Cp = Chalcopyrite, Gn= Galena and Sp= Sphalerite that had developed together (site 02).](image-url)
At the site location 01, physical appearance in the field and visibility of mineralogy (site 01, No 1) shows Chalcocite mineral in the rim of Sphalerite and Chalcopyrite together with Bornite and other ore mineral, Pyrite and Covellite.

![Figure 4](image_url)  
Figure 4. (1) Cc=Chalcocite, Sp=sphalerite. (2) Bn=bornite, Py=pyrite, Cv=covellite, Cp=chalcopyrite (LP 01).

The analysis at site 07 with mineralogy sample of site 07 No.1 shows Pyrite mineral that had developed together with Galena. Galena was also found to had developed together with Chalcopyrite. Other presenced ore mineral were Covellite and Sphalerite.

![Figure 5](image_url)  
Figure 5. (1) Py=pyrite, Cp=chalcopyrite, Gn=galena, Sp=sphalerite. (2) Cv=covellite (site 07).

The analysis at site 12 according to mineralography sample showed ore minerals such as Pyrite, Chalcopyrite and Covellite and also Iron oxide encircling ore mineral that was reckoned to be resulted from weathering process of oxidation.
3.3. Interpretation of Type Deposite

The research area was artisanal gold mining that had been closed down and the presence of gold is related to the galena, chalcopyrite and sphalerite minerals and several secondary mineral such as malachite and covellite.

The area have been classified by the researcher as low sulfidation type deposit, though there is a presence of galena unevenly spread at alteration and mineralization sites. The presence of galena was considered as an indication of low sulfidation type deposit which is close to relatively higher temperature fault zone.

We also found an abundant amount of galena together with pyrite chalcopyrite, spharelite at fault zones, brecciated quartz and secondary mineral such as covellite nad malachite.

The presence of silicic, argillic and propylilitic alteration in research are usually indicating ore mineral carrying gold, silver, zinc and lead such as Chalcopyrite, Sphalerit Galena and Pyrite, based on classification made by Siltoe (2015). Therefore, the epithermal deposit in research area could be classified as Epithermal Intermediate Sulfdation type deposit for zones containing galena and sphalerite mineral especially for several location close to fault zones and brecciated quartz. On the other hand (Figure 7), the research area was generally classified as Epithermal Low Sulfdation type deposit.
Table 2. Classification table of epithermal type deposit at the research area [4]

| Epithermal type       | High-sulfidation (HS) | Intermediate-sulfidation (IS) | Low-sulfidation (LS) |
|-----------------------|-----------------------|-------------------------------|----------------------|
| Main mineralization styles | Steep and shallowly inclined replacement bodies, hydrothermal breccias | Veins, stockworks | Veins, stockworks, disseminated bodies |
| Main proximal alteration types | Silicification, vuggy residual quartz, quartz-alunite | Silicification, quartz-sericite/filitie | Silicification, quartz-adularia-filitie |
| Main gangue minerals | Quartz, alunite, barite | Quartz, calcite, manganese carbonates, rhodochrosite, adularia | Quartz, chalcedony, adularia |
| Sulfide abundance | High (10–80 vol.%) | Moderate (5–30 vol.%) | Low (1–5 vol.%) |
| Sulfidation-state indicators | Enargite/luzonite/famatinite | Tetrathedrite, chalcopyrite, low-Fe sphalerite | Pyrrhotite, arsenopyrite, high-Fe sphalerite |
| Typical metal signature | Cu-Ag-Cu ± Bi ± Te | Ag-Au-Zn-Pb-Mn ± Cu | Au ± Ag ± Se ± Mo |

Summarized from Einaudi et al. (2003), Silitoe and Hendenquist (2003)

4. Conclusion

Cidolog area is potential to ore mineral carrying Cu-Pb-Zn existed in quartz vein system. The presence of quartz vein resulted from hydrothermal activities was found in shear joint controlling dextral strike-slip fault as the main fault. The developed alteration was following fault zone of which gradate from the main zone having silicic lateration, argillic alteration, and propylitic alteration at the outer part. Based on the presence of ore mineral carrying Cu, Pb, and Zn found in Chalcopyrite, Sphalerite and Galena mineral, and also secondary mineral of Malachite and Covellite, the epithermal deposit in research area was classified as Epithermal Low Sulfdiation type and for some areas close to fault zone and quartz breccia in the area was Epithermal Intermediate type deposit.

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LEAD, COPPER AND GOLD DEPOSITES MODEL
CIDOLOG, SUKABUMI, WEST JAVA

(Generated by Wrenching Fault and Epithermal Low Sulphidation Type, Boreen to Base Metal and Precambrian Base Metal)