International Symposium on Earth Science and Technology, CINEST 2012

Integrated Exploration Method to Determine Cu Prospect In Seweden District, Blitar, East Java

Andy Yahya Al HAKIM¹, Budi SULISTIJO²

¹Master Candidates, Department of Mining Engineering, Faculty of Mining and Petroleum Engineering, Institute Technology Bandung, Bandung, Indonesia
²Department of Mining Engineering, Faculty of Mining and Petroleum Engineering, Institute Technology Bandung, Bandung, Indonesia

Abstract

Seweden district is located in the mountain range of Southern Java shows the indication of polymetallic mineralization. The area of study is characterized by the crystalline limestone, claystone intercalation (Campurdarat Formation), and andesitic-basaltic-lava, porphyry lattice, rhyolite, dacite (Mandalika Formation). This area is chosen as the presence of copper mineralization, strong alteration, and magmatic activities that exposed because of the human activities.

Aerial photo shows that the lineaments structure dominated in the area of study. Petrography and mineragraphy analysis shows the alteration mineral e.g. quartz (SiO₂), dickite (Al₂Si₂O₅(OH)₄), pyrite (FeS₂), sericite KAl₂[Si₃AlO₁₀](OH,F), plagioclase (NaAlSi₃O₈) and cryptocrystalline mineral. Silicified quartz is clearly identified, where the fragment consist of quartz and sericite mineral.

Geochemical study in this area is taken by analyzing samples from stream sediment, Bulk Leach Extractable Gold (BLEG), panned concentrate and rock chip samples. Gold grades varies from 4 ppb (stream sediment sample), 110 ppb (rock chip sample), 56 ppb (panned concentrate sample), and 293 ppb (BLEG sample). Copper grades varies from 1760 ppm (rock chip sample), 66 ppm (panned concentrate sample). It is predicted that hydrothermal activities in Seweden district controls the mineralization.

1. INTRODUCTION

Java is an island arc that forming during the Early Cretaceous tectonic evolution. Mineralization in Java begins at the Tertiary until Holocene. The island of Java is relatively young and dominated by volcanic rocks. The southern mountain belt of East Java and the southern part of Cianjur as a part of the southern part of mountain belt of Java are thought to have potentially metallic mineral deposits. In general, these areas are underlain by various volcanic-sedimentary rocks that are of Tertiary to Quaternary in age and some igneous rocks that are locally attributed to the formation of hydrothermal alteration and mineralization. (Widodo et. al., 2002).

The area of study located in Seweden District, Wonotirto, Blitar, Southern part of East Java, Indonesia. The previous research was conducted by semi-detailed investigations during the cooperative exploration of DMRI-JICA in 2002. The results show the maximum grade of Au by chemical analysis is 0.314ppm Au with the average grade of Cu is 0.57% Cu (Widodo, 2003).

Data collected from the rock chip, soil sample, panned concentrate, bulk gold concentrate with the fraction of -40# and +80#, and stream sediment samples with the fraction of -80#. Wall rock alteration also collected to identify clay
minerals, with the supposition that there is adequate evidence of hydrothermal solutions and epigenetic processes in the area of study.

2. GEOLOGICAL CONDITION
Sumatra and Java is a system of Sunda Banda arc, as a result of the convergence between Indo-Australian arc and Eurasian arc in Cenozoic. Sunda Banda arc lies from Northern Sumatra (Aceh), Java, Nusa Tenggara, until Banda Island. (Katili, 1975; Hamilton, 1979; Carlille and Mitchel, 1994). Southern mountain of Java relatively uplifted and tilted to the South. Its Northern boundary is marked by the escarpment and has a complex structures. Between Pacitan and Popoh, found limestone that formed by the volcanic activity, e.g. granite, andesite, dacite (Bemmelen, 1949).

Pacitan, Ponorogo, Wonogiri, and Blitar, geologically located in the Old Volcanic Metallogenic, formed in Mandalika Formation, and sediment rock from Arjosari Formation (Samodra et.al., 1992). Mandalika Formation is the oldest formation (Oligo-Miocene) that appears in the location of study. These formations consist of volcanic rocks and volcanic clastic, as the presence of interlayering brecciated volcanic, lava, and basaltic tuff, andecite and dacite. Transition between Mandalika Formation and Arjosari Formation consist of epiclastic, sedimentary rock (e.g. conglomerate, sandstone with brecciated volcanic, lava and tuff) Arjosari Formation and Mandalika Formation is intruded by andesite, diorite, and metamorphic limestone. Campurdarat Formation formed in Early Miocene; Wuni Formation in Middle Miocene; Wonosari Formation in Late Miocene; meanwhile the volcanic rock and the intrusion (diorite, andesite, dacite and basalt) are found in Pacitan, Ponorogo and Wonogiri; forming during Quartenary Period (Widodo, 2002) (Figure 2).
3. GEOCHEMICAL PROSPECTING

Geochemical prospecting entails the systematic measurement of one or more trace elements in rocks, soil, stream sediments, vegetation, water or gases. The aim is to reveal geochemical anomalies, i.e. abnormal concentrations of certain elements which clearly contrast with their environment or ‘geochemical background.’ The formation of anomalies results from the mobility and dispersion of elements concentrated in mineralized zones (Chaussier and Morer, 1987).

The metals may be contained in grains of minerals, but they are more commonly held in soil particles or precipitated coatings on rock and mineral fragments. Stream sediments are a natural composite of all the material upstream from a sample site (Peters, 1978). About 50 grams of minus 80 mesh material are taken from near the middle of the stream, from the active or “live” stream bed, from pools, or from accumulations of fine material beneath boulders.

4. REMOTE SENSING FOR PROSPECTING

Remote sensing can be used as a tool of mineral prospecting and understanding the geological characterization (Kurniawan, 2010). Hydrothermally altered rocks are characterized by unusually colorful rocks. The various colorful rocks are the host rocks of those mineral deposits with the colors representing the results of chemical interaction with the surrounding hydrothermal fluids. The hydrothermal fluid processes altering the mineralogy and chemistry of the host rocks can produce distinctive mineral assemblages which vary according to the location, degree and duration of those alteration processes (Yetkin, 2003).

For the purpose of digital image processing, the information extraction is carried out using band rationing, multispectral classification, and principal component analysis. Rationing is prepared by dividing the gray level of a pixel in one band by that another band, to recognize alteration. Multispectral classification is particularly used for large area covered by dense vegetation, as differences in the vegetation reflect the underlying geology (Moon et. al., 2006). Principal component analysis is used to enhance or distinguish lithological differences because spectral differences between rock types may be more apparent in principal components images than in single bands (Moon et. al., 2006).

Digital imagery can be used to detect any alteration in an area by utilizing the wavelength range and sensor resolution. Wavelength range that can be used for the detection of the alteration is a short wave infrared (1.6 to 2.5 μm). These wavelengths can be utilized for the detection of mineral alteration zones due to the alteration zones have absorption in the wavelength range.

Alteration zone is wider than the zone of mineralization. Alteration is characterized by the present of clay mineral in the area that affected by the hydrothermal process. So that, the characterization of alteration can be used to localized the area of research.
Lineaments, is the name given by geologists to lines or edges, of presumed geologic origin, visible on remotely sensed images. These early uses, prior to availability of aerial images, applied to specific geologic or geomorphic features, such as topographic features (ridgelines, drainage systems, or coastlines), lithologic contacts, or zones of fracture (Campbell, 1987).

Lineaments, fault, shear is a product of earth movements, that becomes a media for the mineralization in the past. Mineralization occur through crack zone, fracture, and fill up on those area. Lineaments in aerial photo or satellite imagery occur as a product of difference brightnesses between one area and another. Not all of the features classifieds as a lineaments and geological structures. For example the lineaments betwen plantation in the farm, shadow zone, or backslope of hill.

5. SAMPLE AND ANALYSIS

The location of prospect area, is localized based on the secondary information from previous research, and also from the enhancement process. Alteration is characterized by clay bands, causes low reflectance at 2.2 μm (TM band 7), but altered rocks have a high reflectance at 1.6 μm (TM band 5). A ratio of band 5/7 will result in enhancement of altered rocks. Area of alteration can be detected well by accentuating those channels with channel ratio. The results are visible in the form of the alteration has a brighter hue than the surrounding area.

Samples used in this study are consisting to outcrop and float samples. Rock chip, soil sample, panned concentrate, bulk gold concentrate with the fraction of -40# and +80#, and stream sediments samples with the fraction of -80# are being collected during the study, to support for the geochemical analysis in the area of study. Samples were taken in Kali Puthih, Kali Kuning and Kali Centong, that predicted to be the source of mineralization.

Samples show tuff to andesitic, quartz calcite to brecciated textures, low to moderate altered and weathered. Samples from Kali Centhong shows silicification, altered and weathered. Samples is divided into four analysis methods, which are:
- Atomic Absorption Spectroscopy for the stream sediment and panned concentrate samples,
- X Ray Diffraction for the alteration clay and soil samples,
- Grain counting for the panned concentrate,
- Optical mineralogy and petrography for the rock chip and stream float.

Atomic Absorption Spectroscopy is done on nine samples of panned concentrate and stream sediment samples, X-Ray Diffraction is studied in two samples of clay and soil samples, and seven samples are studied for the purpose of mineral identification under microscope.

6. RESULT

Prospect area in Southern East Java and its surrounding areas, had been localized previously were chosen for semi-detailed investigation areas during the cooperative exploration of DMRI-JICA, and literature (Bemmelen, 1949; Widodo, 2002; Widodo, 2003 Setiawan, 2008), and overlay by the combination of band 5/7 from satellite imagery. Based on the satellite imagery processing, lineaments and altered zone shows in the Figure 3a and 3b.

Petrography analysis in sample SWD-0605 shows porphyritic texture with fine grained (less than 1.5 mm), anhedral-subhedral, consists of quartz phenocrysts, with feldspar relic. The microcrystalline consist of feldspar, quartz, sericite-illite, and opaque mineral. Phenocryst altered into secondary mineral. In sample SWD-0604, the rock strongly altered into secondary mineral, so that no primary texture found from the sample. Fine material with anhedral-euhedral texture, with the average size of 1.5 mm, consists of fine quartz, clay (illite-sericite), and opaque mineral. Vein of quartz and opaque mineral (sphalerite-pyrite) shown in figure 4a and 4b under parallel and crossed polar.

Geochemical study in this area is done by the analyzing samples from stream sediment (SS), panned concentrate (PC), Bulk Leached Extractable Gold (BLEG), rock chip (RC) and grab samples (GR). The result of the analysis is done by using Atomic Absorption Spectrometry. Grades analysis from the samples is shown in the Table 1. Generally, grades of ore vary as a result of size distribution.

Mineragraphy analysis shows the alteration mineral e.g. quartz (SiO₂), pyrite (FeS₂), plagioclase (NaAlSi₃O₈), and cryptocrystalline mineral. Silicified quartz is clearly identified, where the fragment consist of quartz and sericite mineral. Sulphide minerals is also identified, e.g. galena (PbS), sphalerite (Zn,Fe)S. Malachite (Cu₂CO₃(OH)₂) and azurite (Cu₂(CO₃)₂(OH)₃) is also identified, both from macroscopic and microscopic identification. Previous research (Widodo, 2003) found arsenopyrite (FeAsS) appear in the photomicrograph of samples taken from Seweden area.
7. DISCUSSION

Band ratio is one way to show the alteration area. For the 5 and 7 ratio, alteration mineral has a low reflectance in TM band 7, and high reflectance in TM band 5. Alteration zone has a brighter color than the surrounding area which is unaltered. Alteration zone correspond to magmatic activity, may also form in a ring structure zone, as a product of old volcanoes in the past. Mineralization in Sweden district also proved by ground check, and the analysis is taken out by geochemical study from panned concentrate, stream sediment, bulk leach extractable gold, rock chip and chip sample. Ore microscopy analysis show that existences of sulfides-silicate minerals. The analysis shows existences of pyrite, chalcopyrite, galena, sphalerite. Pyrite is general opaque mineral that found in samples. These are found as euhedral to subhedral mineral and coexist with chalcopyrite. Chalcopyrite is sulfides minerals that also common to identify in all samples. These are found as subhedral to anhedral minerals. Polymetallic mineralization found in samples that contain malachite and azurite veins, that formed together with clay minerals. Mineralized vein located in Sembon and Seweden district. Minerals assemblages are common to none.

The presence of dickite, as a phyllosilicate clay mineral, is an important alteration indicator in hydrothermal systems (Ksanda and Barth, 1934). It is commonly of hydrothermal origin along veins derived in part from the alteration of aluminosilicate minerals; also as an authigenic sedimentary mineral. Dickite also forms in a transitional setting between these two crustal levels and temperature ranges (Corbett and Leach, 1997). Acid alteration contains a suite of minerals formed in low pH conditions (e.g. kaolin-dickite, alunite, pyrophyllite, dickite) (Corbett, 2002). It is predicted that the area of study is related with the system of high sulphidation, but the advance study in this area must be done to convince the hydrothermal system.

Grades variation from samples, is dependent to size distribution of samples. The term of support in geostatistical approach, that refers to size and shape of sample is used to explain about the grade differences between rock chip and stream sediment sample. More detailed study in geostatistic is important to understand the correlation between the grades distribution in the area of study, alteration and correlation between major element and trace element.

8. CONCLUSION

Seweden prospect area within the Southern Mountain Belt of East Java had been localized using indirect exploration and direct exploration. Satellite imagery, geochemical study, petrography and mineragraphy study as a integration method to delineate the prospect study in Seweden area. The presence of sulphide mineral in location area and grade distribution in Seweden district is

ACKNOWLEDGMENT

Writers thanks to Adrian Kusumo for the sharing and discussion, and satellite image processing and analysis.

References

1. Bemmelen, R.W. van. *The Geology of Indonesia.* The Hague: Govt. Printing Office, 1949. 2 volumes (1949)
2. Campbell, J. B. *Introduction to Remote Sensing.* The Guilford Press. New York (1987)
3. Carlille, J.C. and A.H.G. Mitchel. *Magmatic Arcs and Associated Gold and Copper Mineralization in Indonesia.* Journal of Geochemical Exploration. (1994)
4. Chaussier, J B and Morer, J. *Mineral Prospecting Manual.* North Oxford Academic Publishers Ltd. London. (1987)
5. Corbett, G. Leach, T. *Southwest Pacific Rim Gold Copper Systems: Structure, Alteration and Mineralization.* Short Course Manual. 5/97 Edn. (1997)
6. Corbett. *Epithermal Gold For Explorationists.* AIG Journal – Applied Geoscientific Practice and Research In Australia. (2002)
7. Jébrak, M. *Hydrothermal Breccias in Vein-Type Ore Deposits: A Review of Mechanisms, Morphology and Size Distribution.* Ore Geology Reviews 12 (3):
8. 111-134. DOI:DOI:10.1016/S0169-1368(97)00009-7. (1997).
9. Hamilton, W., *Tectonics of the Indonesian Region: U.S. Geological Survey Prof. Paper 1078.* (1979)
10. Katili, J. A., 1975, Volcanism and Plate Tectonics In The Indonesia Island Arcs, Tectonophysics, 26, 165-188
11. Ksanda, C. J. and Barth, F.W., *Note on the structure of Dickite and Other Clay Minerals*. American Mineralogist, vol. 19, pp. 557-575, (1934)

12. Moon, C J, Whateley, M K G, Evans A M. *Mineral Exploration*. Blackwell Publishing. (2006)

13. Kurniawan, E.A. *Analisis Daerah Basahdan Daerah Potensi Air dengan Menggunakan Data Citra Landsat ETM+ di Kabupaten Tuban, Provinsi Jawa Timur*. Undergraduate Thesis. ITB. Unpublished. (2010)

14. Peters, W C. *Exploration and Mining Geology*. John Willey & Sons, Inc. Canada (1978)

15. Setiawan, I. *Mineralisasi Hidrotermal di Daerah Pacitan dan Sekitarnya*. Graduate Thesis. ITB. Unpublished (2008)

16. Samodra, H., Gafoer, S. and Tjokrosaporo, S. *Geologi Lembar Pacitan, Jawa*, Geological Center of Research and Development. Bandung. (1992)

17. Sulistijo, B. *Inventarisasi Wilayah Potensi Mineral Logam Dalam Rangka Penyusunan Penetapan Wilayah Pertambangan di Kabupaten Tulungagung dan Blitar*. Department of Energy and Mineral Resources, East Java Province. (2010)

18. Widodo, W., Simanjuntak, S., *Hasil Kegiatan Eksplorasi Mineral Logam Kerjasama Teknik Asing Daerah Pegunungan Selatan Jawa Timur (JICA/ MMAJ-Jepang) dan Cianjur (KIGAM-Korea)*. Kolokium Direktorat Inventarisasi Sumber Daya Mineral (DIM) TA. (2002)

19. Widodo, W., *Inventarisasi Bahan Galian Logam di Kab. Malang dan Kab. Lumajang Dan Eksplorasi Lanjutan Mineralisasi Logam Di Daerah Tempursari (Kab. Lumajang), Seweden (Kab. Blitar) Dan Suren Lor (Kab. Trenggalek), Prov. Jawa Timur*. Kolokium Direktorat Inventarisasi Sumber Daya Mineral (DIM) TA. (2003)

20. Yetkin, E. *Alteration Mapping By Remote Sensing: Application To Hasandağ – Melendiz Volcanic Complex*. Master Thesis. The Graduate School Of Natural And Applied Sciences Of The Middle East Technical University. (2003)