PROCEEDING, SEMINAR NASONAL KEBUMIAN KE-8

Academia-Industry Linkage

15-16 OKTOBER 2015; GRHA SABHA PRAMANA

Jurusan Teknik Geologi
Fakultas Teknik UGM

seminar nasional kebumian ke-8

academia-industry linkage

15-16 OKTOBER 2015 GRHA SABHA PRAMANA

Diselenggarakan oleh :

PROCEEDING, SEMINAR NASIONAL KEBUMIAN KE-8
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HYDROTHERMAL BRECCIAS OF THE RANDU KUNING PORPHYRY Cu-Au AND EPITHERMAL Au DEPOSITS AT SELOGIRI AREA, CENTRAL JAVA INDONESIA

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ABSTRACT

The Randu Kuning prospect is situated at Selogiri area, Wonogiri, Central Java, about 40 km to the south-east from Solo city or approximately 70 km east of Yogyakarta city.

Many Tertiary hydrothermal altered dioritic rocks were found at the Randu Kuning area and its vicinity, including hornblende microdiorite, hornblende-pyroxene diorite and quartz diorite. Mineralisation type of the Randu Kuning prospect was interpreted as porphyry Cu-Au and a number epithermal Au-base metals deposits in its surrounding. The closed existing of porphyry Cu-Au and epithermal Au-base metals type deposits at the Randu Kuning area produduced a very complex of quartz-sulphides veins and hydrothermal breccias crosscutting relationship.

There are genetically at least two type of hydrothermal breccias have recognized in the research area, i.e. magmatic-hydrothermal breccia and phreatomagmatic breccia. Magmatic hydrothermal breccias are mostly occured in contact between hornblende microdiorite or quartz diorite and hornblende-pyroxene diorite, characterized by angular-subrounded of various altered diorites fragments/clasts supported or infilled by silicas, carbonates, magnetites and sulphides (chalcopyrites and pyrites) matrix derived from hydrothermal fluids precipitation. Whereas the phreatomagmatic breccias are characterized by abundant of the juvenil clasts, indicated contact between hot magma with fluid or water as well as many wall rock fragments such altered diorites, volcaniclastic, sedimentary and metamorphic rocks clasts set in sand-granule sized clastical matrix and lack of hydrothermal mineral as open space infilling. The juvenil clasts usually compossed by volcanic glasses and aphanitic rocks in rounded-irregular shape.

Brecciation also have an important role in gold and copper mineralisation of the Randu Kuning Porphyry Cu-Au and epithermal Au-base metals deposits, mostly related to the presence of quartz veins/veinlets. Mineralisation mostly were found as both of open space infilling and dessimetaned textures, particularly with quartz-sulphides veins overprinting.

I. INTRODUCTION

1.1 Background

The Randu Kuning area and its vicinity is a part of the East Java Southern Mountain Zone, mostly occupied by both plutonic and volcanic igneous rocks, volcanic clastic rocks, silisic clastic rocks as well as carbonate rocks. Magmatism and volcanism in this area is represented by the Mandalika Formation consisting mostly volcanic igneous rocks such as andesite-dacitic lavas, volcaniclastic rocks namely dacitic tuffs, and volcanic breccias. The rock unit was intruded by dioritic intrusive rocks. Volcaniclastic rocks of the Semilir Formation , as a product of the huge eruption, are exposed and scattered at the south of Selogiri area such as tuffs, lapilli tuffs, dacitic pumice breccias, tuffaceous sandstones and tuffaceous shales.

Many dioritic composition intrusive rocks were found at the Randu Kuning area, consist of pre- syn and post-mineralisation intrusive rock. However, it is difficult to distinguish this kind of dioritic intrusive in the area, due to the similar composition and texture with varying relationship to alteration-mineralisation. Imai *et al*. (2007) have identified three different type of intrusive rocks, namely hornblende andesite porphyry, hornblende diorite porphyry and hornblende diorite. Muthi *et al*.,(2012) recognized that there are at least four type of diorite at the Randu Kuning area i.e. coarse grain diorite, medium diorite, microdiorite and porphyrytic plagioclase diorite.

Mineralisation type of Randu Kuning prospect was interpreted as a porphyry Cu-Au ore deposit and a number gold-base metals epithermal deposits in its surrounding (Imai *et al*., 2007; Suasta and Sinugroho, 2011; Corbett, 2011, 2012 and Muthi *et al*., 2012). The intensive erosion process has uncovered the upper parts of the porphyry deposit, whereas several gold-base metal epithermal are preserved along adjacent ridge (Suasta and Sinugroho, 2011). Many epithermal veins were also found and crosscut into deeply porphyry veins and related potassic alteration (Suasta and Sinugroho, 2011; Corbett, 2012).

Many reseacher have recognized the mineralisation in the Selogiri area (Suprapto, 1998; Isnawan et al., 2002; Prihatmoko et al., 2002; Imai et al., 2007; Suasta and Sinugroho, 2011 and Muthi et al., 2012), but detailed scientific study on the deposit is still limited, particularly to develope the genetic model of hydrothermal deposit in the Selogiri area. The existing porphyry Cu-Au and low sulphidation epithermal Au-base metals type deposits at the Randu Kuning area provide an exellent opportunity to study the evolution of the hydrothermal fluids from the deep porphyry system to the sallow low sulphidation epithermal setting, by intergrating petrographic-ore microscopic, rock and mineral chemistry as well as fluid inclusion data. Although researchs on hydrothermal evolution of porphyry to epithermal mineralisation at several locations in the world have reported (e.g.: Hedenquist et al., 1998; Muntean and Einaudi, 2001; Kouzmanov et.al., 2009), but in Indonesia this theme has never been studied in detail by the intergrating data approach mentioned above.

Many breccias type including hydrothermal breccias type have rcognized at the research area, but detailed study about it have not been done. Corbett (2011, 2012) has gave comment on the Randu Kuning porphyry Cu-Au project that there are many type of breccia at the Randu Kuning area as well as polyphasal brecciation have taken place both in porphyry and epithermal environment.

1.2 Location and Accessibility

The Randu Kuning porphyry Cu-Au prospect area, situated in Selogiri, Wonogiri, Central Java, Indonesia. This location is reachable with four or two wheel vehicle, about 40 km to the south-east from Solo city, or approximately 70 km east of Yogyakarta city (Figure 1).

1.3 Eksploration History

Explorations of copper and gold deposits in Wonogiri area have done since the Dutch era (1929-1935), and by reference of this exploration, then were followed by the Japanese during the occupation of Indonesia (1942-1954) (Isnawan *et al*., 2002). The production recorded from this mine is in small amounts and could be exported to Japan (Van Bemmelen, 1949).The remaining mine tunnel of Japanese, now can still be seen in the village Ngrejo, Tirtomoyo, Wonogiri (Prihatmoko *et al*., 2005).

After independence, in 1958, hiring the mine employs experts from Japan, the Indonesian government evaluated the existing hydrothermal ore deposits in Tirtomoyo, which stated that there were three abundant outcrops of quartz veins containing chalcopyrite (Isnawan *et al*., 2002).

In 1969, PT. Kennecot started exploration through the COW Generation II, which covers an area of 7,000 km^2 in Wonogiri, Pacitan, Ponorogo, and Trenggalek to seek the porphyry Cu deposits (Burton, 1971 in Prihatmoko *et al*., 2005).

Since 1995, the Selogiri prospect area attracted the attention of university students when illegal gold mining activity started in the area (Suasta and Sinugroho, 2011).

May 2009, PT. Alexis Perdana Mineral (the owner of IUP in Selogiri) and PT. Oxindo Exploration subsidiary of the Minerals and Metals Group (MMG) signed a definitive Joint Venture Agreement to explore and develope the Selogiri porspect, and commenced the exploration activities (Suasta and Sinugroho, 2011). In 2011, Augur Resources then has 90% register interest in PT. Alexisi Perdana Mineral and the remaining 10% interest is held on behalf of PT. Oxindo.

1.4 Method

This paper is a preliminary study on the hydrothermal breccia and part of the dissertation research progress. The data used in the paper are limited based on the field outcrops and drilling core observation.

II. REGIONAL GEOLOGY

2.1 Eastern Sunda arc

Indonesia achipelagos are controled by many magmatic arcs, vary in age from Late Mesozoic through the Cenozoic. Most mineralisation are derived from five major Tertiary arcs include the Sunda-Banda, Central Kalimantan, Sulawesi-East Mindanau, Halmahera and Medial Irian Jaya (Carlile and Mitchell, 1994) (Figure 2.1).

Sunda-Banda arc is one of the most important six major Tertiary arcs in Indonesia extending from Sumatra through Java to east of Damar island, known has many ore deposits (van Leeuwen, 1994; Charlile and Mitchell, 1994). The arc is the longest arc in Indonesia, developed by northwards subduction of the Indian-Australian oceanic plate beneath the southeastern margin of Eurasian continental plate, named the Sundaland (Hamilton, 1979; Katili, 1989). Setijadji and Maryono (2012) divided this long arc in three segments i.e. the Western Sunda arc (Sumatra island), the Eastern Sunda arc (Java, Bali, Lombok and Sumbawa or Flores islands), and the Banda arc for the islands east of Flores. The Eastern Sunda Arch is one of the most complex arc magmatism settings in the world (Setijadji and Maryono, 2012).

2.2 Geology of the Selogiri and its vicinity

Magmatism-volcanism products at Selogiri area indicated by the abundant of igneous rocks and volcanic clastic rocks of Mandalika and Semilir Formation as part of the Late Eocene-Early Miocene magmatism. A K/Ar age of the diorite porphyry within Mandalika Formation in the south flank of a wall of the drepression is 21.7 Ma (JICA-JOGMEG, 2004 in Imai *et al*. 2007). The eruption and deposition of the Semilir Formation is believed as the final stage of volcanic activity in the the Southern Mountains Arcs, which distributed as over a wide area and may be comparible to the Pleistocene eruption of Toba in Sumatra (Smyth *et al*., 2008). After the Semilir eruption, there was a lull in volcanic activity during the Midle Miocene (Smyth *et al*., 2008), and then followed by the movement in Late Miocene-Pliocene arch activity to the north of the Late Eocene-Early Miocene Southern Mountain Arc.

The Southern Mountain stratigraphy is divided into two parts, ie. the eastern part and the western part. Stratigraphy of the eastern part, particularly Pacitan area and surrounding has been investigated by many geologists, include Sartono (1964), Nahrowi (1978), and Hanang Samudera (1992), consists of the Besole Formation that became known as Mandalika Formation and Arjosari Formation, Jaten Formation, Wuni Formation, Nampol Formation and Punung Formation.

While the western part has also been widely studied by van Bemmellen (1949), Surono et al. (1992) and Suyoto (1992), consists of Gamping-Wungkal Formation, Kebo-Butak Formation, Semilir Formation, Nglanggran Formation, Sambibitu Formation, Oyo Formation and Wonosari Formation. The complex uncomformably overlain on the basement rocks of the Pre-Tertiary Complex consist of metamorphic rocks such as slates, schists, gneisses, serpentinites and marbles. The Middle Eocene Gamping-Wungkal Formation is characterized by calcarenites, sandstones and mudstones intercalated by tuffaceous sandstones.

Surono, *et al*. (1992) interpreted that the Selogiri area is on the border between the westernpart and the eastern of the Southern Mountains, so there is a contact between the Semilir Formation and Mandalika Formation. Some rock units of the Southern Mountains Range both the western and eastern parts, were found at the Selogiri area and its vicinity will be described below, based on the 1: 100.000 Geological map of the Surakarta-Giritontro Quadrangle (Surono, et al.,1992) .

Based on the regional geologcal map of Surakarta and Giritontro quadrangle (Surono, et al., 1992), trend direction of the major structures in the area are dominated by the NW-SE trending and NE-SW trending. The Gajahmungkur-Kukusan mountain, Selogiri area was controlled by the NW-SE trending fault and it than contrubuted in the ascending of the hydrothermal fluids and the occurence of the porphyry Cu-Au and low sulphidation Au-base metals ore deposits at the Selogiri area and its vicinity.

III. GEOLOGY OF THE RANDU KUNING AREA

3.1 Intrusive rocks

Hornblende-pyroxene diorite: generally it shows gray colour in fresh condition (lighter than hornblende microdiorite), porphyritic texture (moderate-strong), having medium crystal size (1-2 mm) with pyroxene and hornblende phenocrys size varies up to 2 cm. Contain high proporsion of plagioclase or at about 35-50 percent with lesser amount of hornblende and pyroxene (3-8 percent). At the contact with the microdiorite, most of the primary minerals generally altered to the secondary minerals formed potassic zones and gradually became into prophyllitic zone outward. The SiO_2 content of the rocks (N= 2) varies from 55.19 to55.71 wt.%, Fe_2O_3* have range from 6.58 to 8.34 wt.%, the aluminium and titanium slightly higher than other intrusion, they are 15.42-15.69 wt.% and 0.61-0.69 wt.% respectively. MnO and CaO also relatif high (0.20-0.28 wt.% and 7.68-7.70 wt.%). The SiO_2-(Na_2O+K_2O) rock classification diagram (Midlemost,1975) indicates the sample are plotted in the andesite field and have calc-alkaline magma afinity within Zr-Sr/2-Ti/100 affinity discrimination diagram (Cann, 1973) (sample WDD 2-128.15 and WDD 19-44.90).

Hornblende microdiorite: Characterized by fine grained phenocrysts size (<1 mm), many of samples microscopically classified as andesite (porphyritic texture), commonly consist of about 30-45 percent of plagioclase and 5-14 percent of hornblende. The hornblende microdiorite is believed to be responsible for the extensive alteration and Cu-Au porphyry ore deposit in the study area. Physically, it seen darker in colour and finer in crystals size than pyroxene diorite. It is caused not only the amount of mafic minerals but also the abundant of the secondary magnetite. Most of the body was altered to potassic zone and lack of prophyllitic and phyllic alteration types. The SiO_2 content of the rocks (N= 3) varies from 57.20 to 58.26 wt.%., Fe_2O_3* have range from 7.38 to 7.79 wt.%, the aluminium has a wide range they are 14.56-16.26 wt.% and titanium slightly lower than hornblende-pyroxene diorite i.e. 0.47-0.60 wt.%. MnO relatifly low (0.13-0.15 wt.%) and CaO varies from 6.10-8.10 wt.%. The SiO_2-(Na_2O+K_2O) rock classification diagram (Midlemost,1975) also indicates the sample are plotted in the andesite field and have calc-alkaline magma afinity within Zr-Sr/2-Ti/100 affinity discrimination diagram (Cann, 1973).

Quartz diorite: This intrusive rock has the brightest colors and the coarsest crystals sizes (>2 mm), equigranular to weak porphyritic texture, characterized by the abundant of plagioclases (40-55 percent) and small quantities of quartzs (4-7 percent) and alkali feldspars (2-5 percent). Due to have coarse grained crystal size, Muthi et al. (2012) recognized and discribed the intrusive as coarse diorite. It was generally altered to phyllic-argillic and prophyllitic alteration type, associated with Au-base metals epithermal type mineralization. Dimensions and distribution of this intrusion relatively narrower and smaller than those of hornblende-pyroxene diorite and hornblende microdiorite intrusion. The SiO2 content of the quartz diorite is higher than other intrusions (63.66 wt.%), but the other major oxides mostly lower or relatively same (5.07 wt.% Fe_2O_3*, 32 wt.% TiO_2, 14.5 wt.% Al_2O_3, 0.13 wt.% MnO, 1.40 wt.% MgO, 4.76 wt.% CaO, 3.32 wt.% Na_2O, 0.28 wt.% K_2O and 0.15 wt.% P_2O_5). The SiO2-(Na_2O+K_2O) rock classification diagram (Midlemost, 1975) indicates the sample are plotted in the dacite field and also has calc-alkaline magma afinity within Zr-Sr/2-Ti/100 affinity discrimination diagram (Cann, 1973).

3.2 Veins type

Many various types of veins in porphyry-type ore deposit summarized from several experts (Gustafson and Hunt, 1975; Corbett, 2008; Sillitoe, 2010; Corbett, 2012) include EB type or EDM type, M type, A type, B type, AB type, C type and D type. A lot of vein type were observed at the Randu Kuning area, both porphyry vein type and epithermal vein type. Some of them are difficult to be grouped according to the classification of previous researchers above.

At least seven porphyry veins type have been observed, respectively from the earliest are Magnetite-chalcopyrite±quartz-biotite, Quartz±magnetite (A type) , Banded/Laminated quartz-magnetite (M type), Quartz±K feldspar (B type), Quartz with thin centre line sulphide (AB type), Pyrite±chalcopyrite (C type) and Pyrite-quartz+chalcopyrire+carbonate (D type). Most of the porphyry vein style cross cut by epithermal vein types. At least six epithermal environment veins clasifying into two group that are sulphide±quatz±calcite±magnetite veins and quartz+calcite±gypsum±sulphide veins.

3.3 Structural Geology

Major structures at the Selogiri area, dominated by relatively the NW-SE, NE-SW, and rare N-S trendings, cross cut all of the rocks in the area, but minor E-W trending fault also was found (Suasta and Sinogrogo, 2011). The earlist and most dominant structures in the research area are the NW-SE dextral (right) lateral-slip faults, and commontly have a longer dimension rather than other trends. These structural trends then were cross cut by NE-SW and N-S sinistral (left) lateral-slip faults. The NE-SW and N-S trend mostly concentrated in the central area.

Drill core and surface outcrop data suggest the the earlier porphyry vein types were may be controlled by dextral (right) lateral-slip faults, whereas the later porphyry vein and epithermal vein types controlled by sinistral (left) lateral-slip faults.

3.4 Alteration and Mineralisation

At least four types of hydrothermal alteration at the Randu Kuning area and its vicinity had identified, i.e. potassic, prophyllitic, argillic and phyllic types. Potassic alteration zone scattered on microdiorite intrusive rocks body and small part of pyroxene diorite intrusive rocks especially in contact to the microdiorite intrusion of Randu Kuning hill. This zone is characterized by secondary minerals assemblage i.e. one or both of secondary biotite and/or K-feldspar associated with magnetite (Suasta and Sinugroho, 2011; Corbett, 2011, 2012 and Muthi *et al*., 2012). Prophyllitic alteration is less commonly recognised typically as actinolite or chlorite-epidote-magnetite alteration at the margin of the hydrothermal system (Corbett, 2012). Prophyllitic zone mostly is widespread in hornblende-pyroxene diorite and quartz diorite rocks, both visible at the surface outcrop and in drill core samples.

Phyllic alteration is commonly appear in the fault structure zones, locally overprint to the potassic alteration and prophyllitic zone, on hornblende-pyroxene diorite rocks, microdiorite hornblende as well as quartz diorite (Suasta and Sinugroho, 2011; Corbett, 2011, 2012 and Muthi *et al*., 2012). This zone is characterized by retrograde silica-sericite-chlorite-pyrite assemblages, which is mostly limited to fault zones or selvages to late stage quartz-pyrite veins likened to D veins (Corbett, 2012). Argillic zone appears mainly adjacent to breccia and fault zone, especially in the epithermal prospect area, which is characterized by the present of clay minerals. Illite and monmorillonite are the main minerals identified in the vein samples suggesting structural controlled argillic alteration (Muthi *et al*., 2012).

IV. HYDROTHERMAL BRECCIA

Many experts have tried to classified breccia both on the basis of genetic and descriptive, such as Sillitoe (1985), Baker, *et al.* (1986), Lawless and White (1990). Sillitoe (1985) classified ore-related hydrothermal breccia into magmatic hydrothermal breccia, hydromagmatic breccia (phreatic and phreatomagmatic), magmatic breccia, intrusive breccia and tectonic breccia.

The hydrothermal breccia in the Randu Kuning and its vicinity has not previously been reported in detail. Corbett (2011) stated that the upper portion of breccia pipe of Jangglengan (WDD23) is intersects milled matrix breccia typical of other Pacific rim phreatomagmatic breccia pipes where are intruded by brecciaa term milled clast intrusion matrix breccias of an interpretated magmatic hydrothemal origin

In the basis of Sillitoe (1985) classification, genetically many type of breccias have recognized in the researched area, such as hydrothermal breccias, volcanic breccias, fault breccia and intrusive breccia. In this paper we focus to discuss about hydrothermal breccia only. There are at least two type of hydrothermal breccia have recognized in the research, i.e. magmatic-hydrothermal breccias and phreatomagmatic breccias, which were found at the Randu Kuning hill area. Magmatic-hydrothermal breccias are products of the release of hydrothermal fluids from magma chamber (Sillitoe, 1985). As an intrusive body cools, the residual melt become increasingly concentrated in volatile components including water and it therefore has a considerable potential for hydroulic fracturing of overlying rocks forming breccia and related mineral deposits (Lawless and White, 1986). Phreatomagmatic breccia occured when upwelling magma encounter water, may be groundwater, connate water or a body or surface water (Lawless and White, 1986).

4.1 Magmatic Hydrothermal Breccia

Magmatic-hydrothermal breccias in research area are characterized by various irregular body, showing subvertical to vertical in contact to the wall rocks, fragments mostly monomic, i.e. various altered diorite, angular-subrounded and larger in grain size (0.5-8.4 cm), matrix mostly consist of hydrothermal minerals (magnetite, chalcopyrite and pyrite) as open spce infilling, fragmment/matrix ratio is high (60-90 vol %) or predominantly fragment supported, texture/structures usually crackel, jig-saw and rotated fragments, no fluidization. The breccias are associated with potassic, phullic and prophyllitic alteration type and open space infilling mineralisation as well as veins/veinlets overprinting (Table 1, Figure 3). This breccias have a different characteristics to those of phreatomagmatic breccias, particularly in fragment and matrix as well as mineralisation style.

Magnetite-K feldspar-biotite (potassic) altered diorite clasts and also later magnetite flooding in the matrix indicated that the breccias developed during the process of intrusion empacement and hydrothetmal alteration (Corbett, 2012).

4.2 Phreatomagmatic Breccia

Phreatomagmatic breccias exhibite, irregular dyke and pipe body, subvetical-vertical, fragments/clasts consist of polimic components including juvenil (mostly rounded) and various wall rock such as altered diorites, veins/veinlets, sandstone, quartzite, conglomerate and schist (mostly subangular), 0.2-4.5 cm in size, low fragment/matrix ratio (10-65 vol %). These breccia commontly show fluidization, associated with potassic, prophyllitic and argillic alteration type, mineralisation occured in both dessimination and open space infilling (Table 1).

There are at least two phreatomagmatic breccia stages at the area, firstly is related with porphyry environment and the second one associated to the epithermal processes. The characteristics between such two phreatomagmatic breccias type in the researched area is realtively similar, particularly in the composition, size and roundness of fragments, fragment matrix ratio, and mineralisation styles, but different in the geometry of breccia body, matrix composition, texture and alteration type (Table 1, Figure 4,5). Geometry of breccia body of porphyry level phreatomagmatic breccia, mostly as irregular dyke, while in the epithermal level probably as pipe body. Magnetite, chlorite and chalcopyrite are common hydrothermal minerals which present as open space infilling matrix, otherwise in the epithermal level, pore space commontly were infilled by sphalerite, pyrite, epidote and carbonate. Breccia textures of epithermal enviroment more vary than those of porphyry level, consist of bedded, graded bedding, rebrecciated clasts and cut by many vein/veinlets. Corbett (2011) stated that the upper portion of phreatomagmatic breccia pipe of Jangglengan (WDD23) is intersects milled matrix breccia typical of other Pacific rim phreatomagmatic breccia pipes interpreted to have breached the surface, characterized by the bedded, locally gradded bedding and possiblity of accresinary lapilli components.

V. CONCLUSIONS

1. There are at least two type of hydrothermal breccia have recognized in the research area, i.e. magmatic-hydrothermal breccias and phreatomagmatic breccias, which were found at the Randu Kuning hill area, have taken place both in porphyry and epithermal environment.
2. Based on the texture/structure features, epithermal enviromnent phreatomagmatic breccia interpreted as eruption which have breached the surface.

VI. ACKNOWLEDGEMENTS

My sincere thanks go to the management of PT. Alexis Perdana Mineral, which has given us permission to do this research in the Selogiri prospect area and its vicinity.

REFERENCES

Baker, E.M., Kirwin, D.J., and Taylor, R.G., 1986, Hydrothermal Breccia Pipes, Contributions of the Economic Geology Research Unit, Geology Department James Cook University of North Queensland, 45 p.

Bemmellen, van, R.W, 1949, The Geology of Indonesia, and Adjacent Archipelagoes, Vol. IA, Gov. Print. Office, Martinus Nijhoff, the Hague.

Carlile, J.C. dan Mitchell, A.H.G., 1994, Magmatic Arcs and Associated Gold and Copper Mineralisation in Indonesia, Journal of Geochemical Exploration, Elsevier Science, Amsterdam, 50: 92-142.

Corbett, G., 2011, Comments on The Exploration Potential of The Wonogiri Porphyry Cu-Au Project, Central Java, Indonesia, *Corbett Geological Services Pty. Ltd*., *Unpublished*, 27 p.

Corbett, G., 2012, Further Comments on The Wonogiri Porphyry Cu-Au Project Central Java, Indonesia, *Corbett Geological Services Pty. Ltd*., *Unpublished,* 37 p.

Gustafson, L.B. dan Hunt, J.P. 1975, The Porphyry Copper Deposit at El Salvador, Chile, *Economic Geology*, v 70:pp. 857-912.

Hamilton,W.B.1979, Tectonics of the Indonesian Region. Professional Paper 1078,U.S. Geolology Survey, Washington, DC.,345 p.

Hartono, G., 2010, The Role of Paleovolcanism in The Tertiary Volcanic Rock Product Setting at Gajahmungkur Mt., Wonogiri, Central Java, *Dissertatio in UNPAD, Unpublished*, 190 p.

Hedenquist, J.W.,Arribas, A.J., and Reynolds, T.J., 1998. Evolution of Intrusion-Centered Hydrothermal System: Far Southeast-Lepanto Porphyry and Epithermal Cu-Au deposits, Philipines, Economic Geology, v.93, pp. 373-404.

Imai, A., Shinomiya, J., Soe, M.T., Setijadji, L.D., Watanabe, K., and Warmada, I.W., 2007, Porphyry-Type Mineralization at Selogiri Area, Wonogiri Regency, Central Java, Indonesia, *Resources Geology*, vol.57, no. 2:230-240.

Isnawan, D., Sukandarrumidi and Sudarno, I., 2002, Kontrol Struktur Geologi Terhadap Jebakan Tembaga Sebagai Arahan Eksploitasi di Daerah Ngerjo dan Sekitarnya Kecamatan Tirtomoyo, Kabupaten Wonogiri Propinsi Jawa Tengah, *Gama Sains IV* (2) Juli 2002, p.149-157.

Katili, J. A., 1989. Evolution of the Southeast Asian arc complex, Geol. Indon. Jakarta, 12: 113-143.

Kouzmanov, K., Moritz, R., von Quadt, A., Chiaradia, M., Peytcheva, I., Fontignie, D., Ramboz, C., and Bogdanov, K., 2009. Late Cretaceous Porphyry Cu and Epithermal Cu-Au Association in the Southern Panagyurishte District, Bulgaria: the Paired Vlaykov Vruh and Elshitsa Deposits, Mineralium Deposita (2009) 44:611-646.

Lawless, J.V. and White, P.J., 1990, Ore-Related Breccia: A Revised Genetic Classification, with Particular Reference to Epithermal Deposits, 12th New Zealand Geothermal Workshop 1990.

Maryono, A., Setijadji, L.D., Arif, J., Harrison, R., Soeriaatmadja, E., 2012, Gold, Silver and Copper Metallogeny of the Eastern Sunda Magmatic Arc Indonesia, *Proceeding of Banda and Eastern Sunda Arcs 2012 MGEI Annual Convention*, 26-27 November 2012, Malang, East Java, Indonesia, p.23-38.

Muntean, J.L. and Einaudi, M.T., 2001. Porphyry-Epithermal Transition: Maricunga Belt, Northern Chile, Economic Geology, Vol. 96, 2001, pp. 743-772.

Muthi, A., Basten, I.G., Suasta, I.G.M., and Litaay, N.E.W., 2012, Characteristic of Alteration and Mineralization at Randu Kuning-Wonogiri Project, *Proceeding of Banda and Eastern Sunda Arcs 2012 MGEI Annual Convention*, 26-27 November 2012, Malang, East Java, Indonesia, p. 117-132.

Nahrowi, T.Y., Suratman, Namida, S. and Hidayat, S., 1979. Geologi Pegunungan Selatan Jawa Timur, Bagian Eksplorasi Pusat Pengembangan Teknologi Minyak dan Gas Bumi, Cepu, 31 p.

Pirajno, F., 2009, *Hydrothermal Processes and Mineral Systems*, Springer-Geological Survey of Western Australia, 1250 p.

Setijadji, L.D., Kajino, S., Imai, A., and Watanabe, K., 2006, Cenozoic Island Arc Magmatism in Java Island (Sunda Arc, Indonesia): Clues on Relationships between Geodynamics of Volcanic Centers and Ore Mineralization, *Resources Geology*, vol.56, no.3,267-292.

Sillitoe, R.H., 1985, Ore-Related Breccias in Volcanoplutonic Arcs, *Economic Geology* Vol. 80, pp.1467-1514.

Sillitoe, R.H., 2010, Porphyry Copper System, *Economic Geology* v.105, pp.3-41, 2010.

Smyth, H.L., Hall, R. and Nichols, G., 2008, Cenozoic Volcanic Arch History of East Java Indonesia: The Stratigraphic Record of Eruption on An Active Continental Margin, The Geological Society of America Special Paper No. 436, p. 199-221.

Suasta, I.G.M and Sinugroho, I.A., 2011, Occurrence of Zoned Epithermal to Porphyry Type Cu-Au Mineralization at Wonogiri, Central Java, *Proceeding of The 36th HAGI and 40th IAGI Annual Convention*.

Samudera, H., 1990. Tatanan Stratigrafi dan Tektonik Pegunungan Selatan Jawa Timur, antara Pacitan dan Ponorogo, Bidang Pemetaan Geologi, Pusat Penelitian dan Pengembangan Geologi, 39 p.

Sartono, S., 1964. Stratigraphy and Sedimentation of the Eastern Most Part of Gunung Sewu (East Java), Publikasi Teknik-Seri Geologi Umum No. 1 Direktorat Geologi Bandung, 95 p.

Suprapto, 1998. Model Endapan Emas Epitermal Daerah Nglenggong, Kecamatan selogiri, Kabupaten Wonogiri, Jawa Tengah. Tesis Magister, Program Studi Rekayasa Pertambangan, Fakultas Pasca Sarjana, Institut Teknologi Bandung, 47 p.

Surono, Toha, B., and Sudarno, I., 1992, Geological map of the Surakarta-Giritontro Quadrangles, Java, Geological Research and Development Centre, Bandung.

Sutarto, Idrus, A., Putranto, S., Harijoko,A., Setijadji,L.D., Meyer, F.M, and Danny, R. 2013, Veining Paragenetic Sequence of The Randu Kuning Porphyry Cu-Au Deposit at Selogiri Area, Central Java. *Extended Abstract: CD Proceeding of The 38th HAGI and 42nd IAGI Annual Convention and Exibition Medan*, 28-31 October 2013.

Sutarto, Idrus,A., Meyer, M., Harijoko,A., Setijadji,L.D., , and Danny, R. 2013, The Dioritic Alteraation Model of The Randu Kuning Porphyry Cu-Au, Selogiri Area, Central Java. *Proceedings International Conference on Georesources and Geological Engineering, December 11-12, 2013 Yogyakarta*, ISBN 978-602-14066-5-6. p.122-132.

Prihatmoko, S., Digdowirogo, S., and Kusumanto, D., 2002, Potensi Cebakan Mineral di Jawa Tengah dan Daerah Istimewa Yogyakarta. *Prosiding Seminar Geologi Jawa Tengah dan Daerah Istimewa Yogyakarta*, Ikatan Ahli Geologi Indonesia Pengda Yogyakarta, p. 87-108.

TABLE

Tabel 1. Characteristics of the hydrothermal breccia at the Randu Kuning area and its vicinity.

		Magmatic Hydrothermal	Phreatomagmatic (Porphyry level)	Phreatomagmatic (Epithermal level)
Geometry of breccia body		Various irregular body	irregular dyke	pipe body?, irregular dyke
Contact to the wall rock		Subvertical to vertical	Subvertical to vertical	Subvertical to vertical
Fragment /clast	Composition	Monomic: various altered diorite	Polimics: Juvenil-wall rock fragments (various altered diorite, veins, sandstone, quartzite, conglomerate, schist)	Polimics: Juvenil-wall rock fragments (various altered diorite, veins, sandstone, quartzite, conglomerate, schist)
	Size	0,5-8.4 cm	0.2-4.0 cm	0.2-4.5 cm
	rounding	Angular-subrounded	Rounded (particularly juvenil fragments) to subangular (wall rock fragments)	Rounded (particularly juvenil fragments) to subangular (wall rock fragments)
Matrix		Mostly hydrothermal minerals as open space infilling (magnetite, chalcopyrite, pyrite) as well as sand sized clatic grains	Sand-granule sized clastic grains, rarely hydrothermal minerals as open space infilling (magnetite,chlorite, chalcopyrite)	Sand-granule sized clastic grains, rarely hydrothermal minerals as open space infilling (sphalerite, pyrite,epidote carbonate)
Fragment/matrix ratio		60-90 vol % fragments, predominantly fragments supported	10-65 vol % fragments, matrix supported	10-65 vol % fragments, matrix supported
Textures/structures		Milled intrusion clast matrix, crackel, jig-saw	Milled matrix	Milled matrix, bedded,graded bedding, rebrecciated clasts, cut by microbreccia dyke, cut by carbonate-sphaerite-pyrite vein/veinlets
Fluidization		no	yes	yes
Alteration		Potassic, phyllic, prophyllitic	potassic, prophyllitic	Argillic, prophyllitic
Mineralisation		open space infilling, overprintting veins	Dessimination within both fragments and matric, open space infilling, overprinting veins	Dessimination within both fragments and matric, open space infilling, overprinting veins

FIGURES

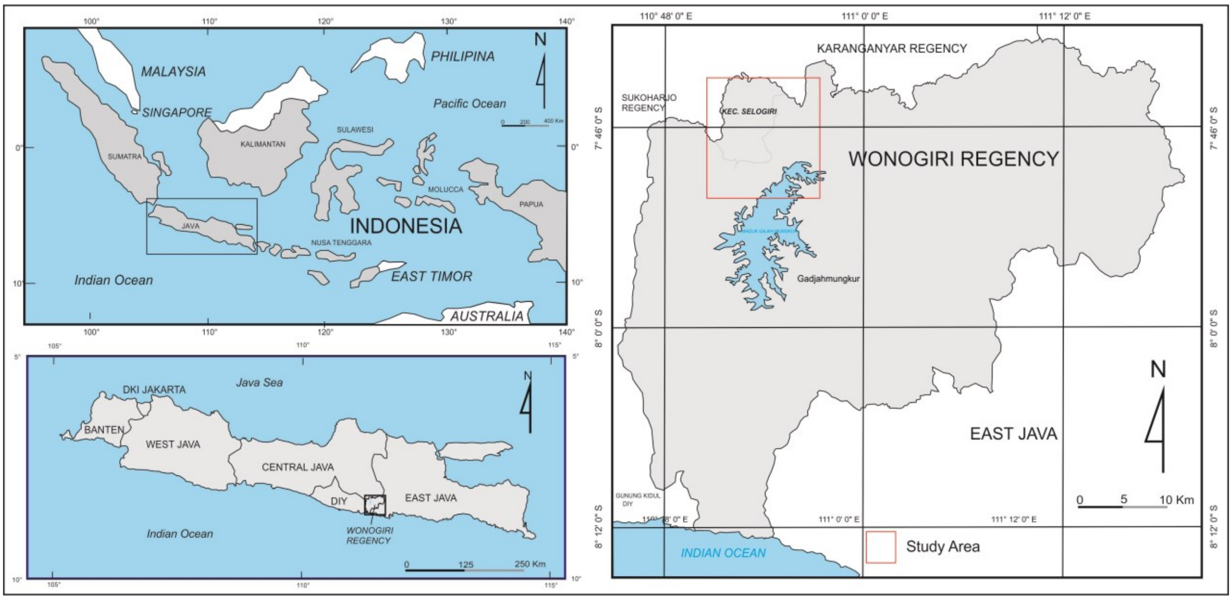

Figure 1. Location map of Selogiri area, Wonogiri

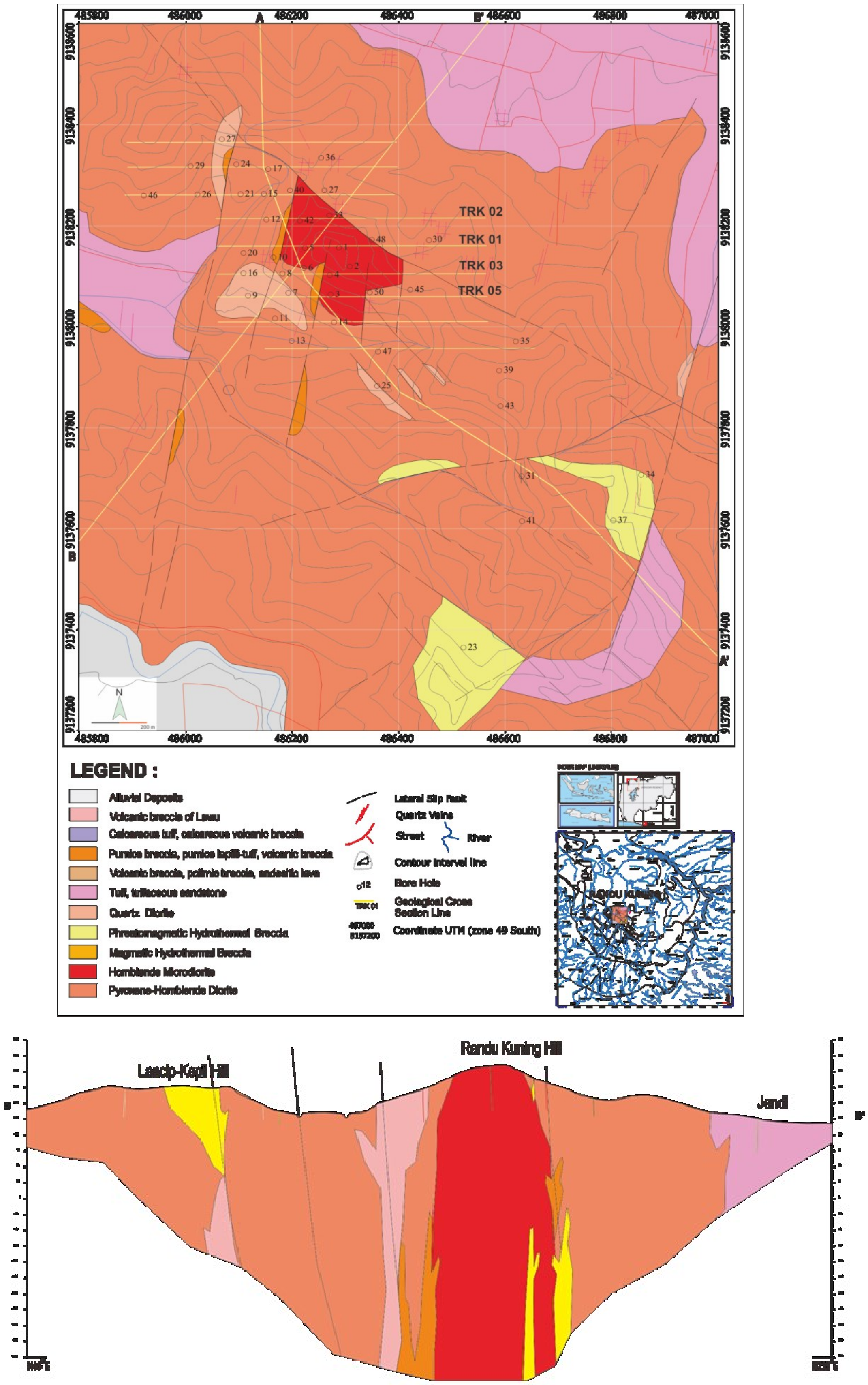

Figure 2. Geological map of the Randu Kuning area and geological cross section (B-B')

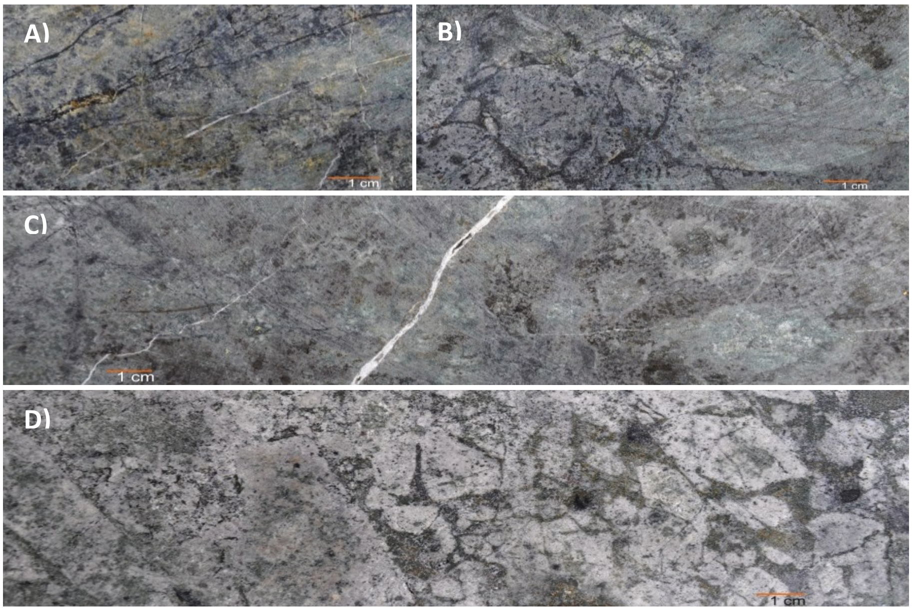

Figure 3. Magmatic hydrothermal stages. A). Hydrothermal fluids infilling rock fractures as magnetite-silicate veinlets (WDD2-49.80), B) magmatic hydothermal crackel breccia (WDD 02-51.30), C). Magmatic hydrothermal crackel-rotate breccia (02-67.00), D). Magmatic hydrothermal breccia with magmetite infilling pore space between fragments as matrix (WDD 02-84.00).

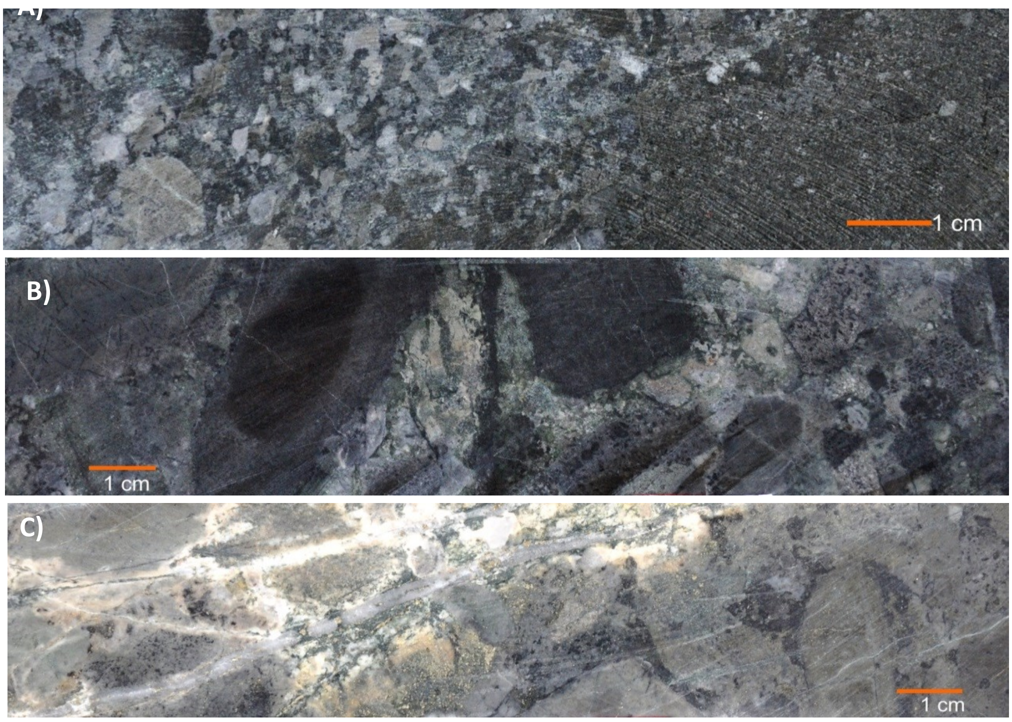

Figure 4. A).Contact hornblende-pyroxene diorite with Phreatomagmatic breccia (WDD48-391.70), B). Phreatomagmatic breccia (WDD 48-374.74), C). Porphyry preatomagmamatic breccia cut by carbonate-pyrite veins (WDD 30-520.40).

Figure 5. A). Preatomagmatic breccia. Fragments/clasts consist of juvenil, altered diorite. Location: Jangglengan prospect, B) phreatomagmatic breccia with clast diorite, juvenil, quartzite, schist, cut by carbonate-sphalerite-pyrite-galena vein c). phreatomagmatic breccia with clast diorite and juvenil (WDD 34-124.50).