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MAGMATISM AND PORPHYRY Cu-Au MINERALISATION AT THE RANDU KUNING PROSPECT, SELOGIRI AREA, CENTRAL JAVA

SUTARTO^{1,2)}, Arifudin IDRUS²⁾, Sapto PUTRANTO³⁾, Agung HARJOKO²⁾, Lucas Donny SETIJADJI²⁾,

Michael MEYER⁴⁾ and Rama DANY¹⁾

¹⁾Universitas Pembangunan Nasional "Veteran" Yogyakarta

²⁾Universitas Gadjah Mada Yogyakarta

⁴⁾Augur Resources

⁴⁾RWTH Aachen University Germany

Contact: sutarto_geo@upnyk.ac.id or sutarto_geoupn@yahoo.co.id

Abstract

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

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, volcanoclastic rocks, siliciclastic rocks and also carbonate rocks. Magmatism-volcanism products at Selogiri area were indicated by the abundant of igneous rocks and volcanoclastic rocks of Mandalika and Semilir Formation and many dioritic intrusive rocks as part of the Late Eocene-Early Miocene magmatism. Porphyry Cu-Au mineralisation at Randu Kuning Prospect have strong genetic correlation with the Tertiary magmatism-volcanism processes. Three types of dioritic-andesitic intrusive rocks at the Randu Kuning Prospect, include hornblende-pyroxene diorite, hornblende microdiorite, and quartz diorite are distributed at the centre of a half-circular depression on approximately 8 km in diameter is thought to be a feeder of an ancient volcanic crater. Porphyry Cu-Au mineralisation at the area related with the hornblende microdiorite intrusion process.

The alteration type at the Randu Kuning area and its vicinity can be divided into several zones of hydrothermal alteration, such as the potassic zone (magnetite-biotite-K feldspar), prophyllitic zone (chlorite-magnetite-epidote-carbonate), phyllic zone (quartz-sericite-chlorite) and argillic zones (clay mineral-sericite). The alteration pattern in the Randu Kuning porphyry Cu-Au deposit is typically a diorite model which characterized by the domination of potassic alteration zone on the inside and propylitic type on the outside. Phyllic and argillic alteration type sometimes appear, although with a small volume commonly associated with the presence of fault zones.

At least two mineralization style recognised at the Randu Kuning area i.e. Cu-Au disseminated mineralization, mostly occurred associated with the present of chalcopyrite-pyrite dissemination within magnetite-actinolite-epidote±chlorite alteration (inner prophyllitic) and Cu-Au quartz-sulphide vein mineralization, including quartz-chalcopyrite veins, chalcopyrite-pyrite veins and pyrite-chalcopyrite-sphalerite-carboate veins. Quartz-sulphide veins mostly associated within the potassic and argillic alteration zone, but a few quartz veins also were found within prophyllitic zone.

Key words: magmatism, hydrothermal, Cu-Au mineralisation



1. 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, silicic clastic rocks and also carbonate rocks. Magmatism and vulcanism in this area is represented by Mandalika Formation consisting mostly volcanic igneous rock such as andesit-dacitic lavas, volcanoclastic rocks namely dacitic tuffs, and volcanic breccias. The rock unit was intruded by dioritic intrusive rocks. Volcanoclastic 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.

Magmatism and vulcanism play important role in developing many hydrothermal type deposit such as porphyry and epithermal mineralization. Magmatism and mineralization in east Java zone is unique and has several different geological characteristics comparing with those of Central Java and West Java zone, which are: a) Found many alkaline and shoshonitic magmatic affinity of back arc volcanos such as Ringgit Besar and Muria volcano, b). Found many acid composition igneous rocks (dacite, rhyolite and granitoid rocks), especially in Pacitan and Merubetiri area (was called as Mrawan Granite), c). Volcanic rocks in East Java geochemically has higher content of Sr and the ratio of Sr / Y (Setiadji et al., 2006), indicate the possibility of adakitic magmatism and d). At least two porphyry (Cu-Au) type were found within this arc segment, i.e. Randu Kuning Porphyry Cu-Au (Wonogiri) and Tumpang Pitu Porphyry Cu-Mo-Au deposit (Banyuwangi), while in West Java and Central are dominated by low sulphidation Epithermal (Au-Ag) type deposit.

Mineralisation type of Randu Kuning prospect was interpreted as 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 also found and crosscut into deeply porphyry veins and related potassic alteration (Suasta and Sinugroho, 2011; Corbett, 2012).

Suasta and Sinugroho (2011), had identified four types of hydrothermal alteration, *i.e.* potassic type, prophyllitic type, argillic type and phyllic type and reported that the hornblende microdiorite was potassic-propylitic altered and mineralize, otherwise the hornblende diorite was propylitic altered only. Retrograde phyllic (silica-sericite-chlorite-pyrite) only locally overprints prograde potassic-prophyllitic zone, mainly adjacent to fault zone and breccias (Corbett, 2012). In over all, the alteration zone are dominated by potassic and prophyllitic type, and lacking with argillic and phyllic type. A dioritic composition range of the intrusive rocks type and the domination of the potassic and prophyllitic zone, based on the porphyry alteration model (Pirajno, 1992; Pirajno, 2009) suggested that the alteration model of the Cu-Au porphyry ore deposit in the study area is more similar to the diorite model rather than the quartz monzonite model.

Many researcher have recognized the mineralization of the Selogiri area (Suprpto, 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, especially to develop the genetic model of hydrothermal deposit in the Selogiri area. The existing both porphyry Cu-Au type and low sulphidation epithermal Au-base metals type deposits at the Randu Kuning area provide an excellent opportunity to study the evolution of the hydrothermal fluids from the deep porphyry system to the shallow low sulphidation epithermal setting, by integrating petrographic-ore microscopic, rock and mineral chemistry as well as fluid inclusion data. Although researchs on hydrothermal evolution

of porphyry to epithermal mineralization 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.

1.3. Location and Accessibility

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

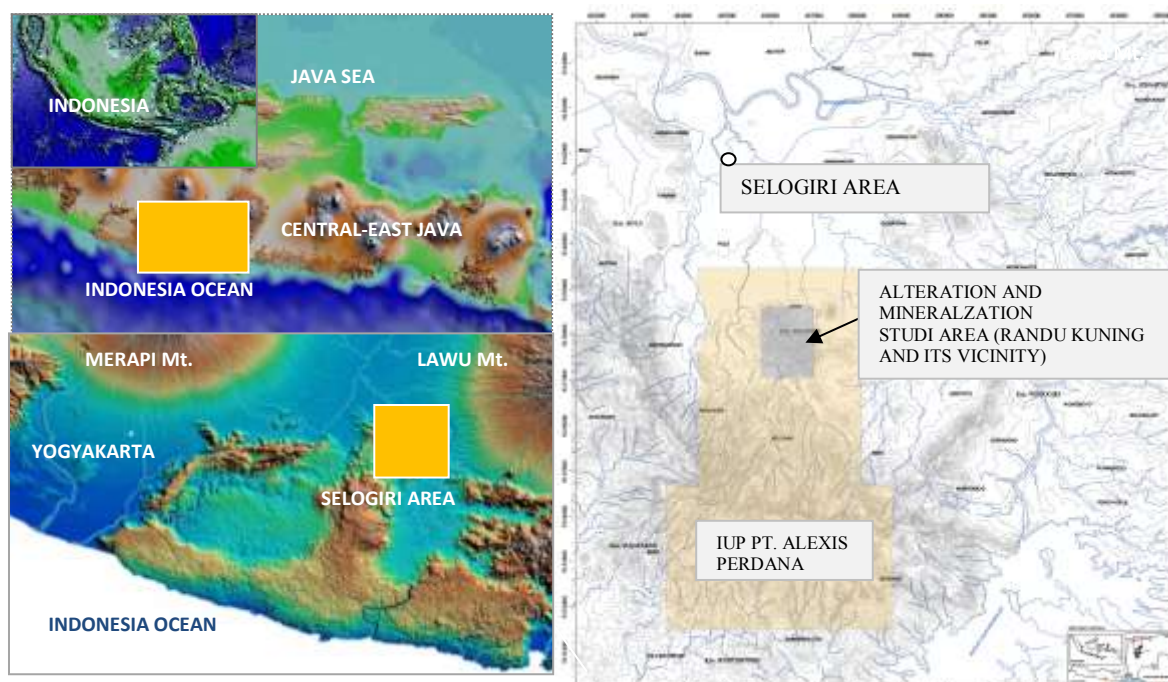


Fig. 1. Location map of the Selogiri area

1.6. Objectives

the objectives of the research is as follows:

1. Understanding the magmatism processes and tectonic setting of the pre-mineralization and syn-mineralization intrusive rocks.
2. Arrange the mineral paragenetic sequence of the Randu Kuning porphyry Cu-Au to low sulphidation epithermal Au deposits.

1.7. Methodology

This paper is a preliminary study and a part of the dissertation research. The research activities include literature study, proposal writing, field work, laboratory works, data analysis, data interpretation. Desk study including literature study, remote sensing analyses and secondary data collecting is a very important work to support the research activities especially to support fieldwork. Several secondary data are need to support this research, including reports or papers of previous investigations, geological regional maps, landsat imageries and aerial photos.

The fieldwork means geological mamping and drilling core logging, covers several works iincluding describing all of the rock types, hydrothermal alteration types,

describing all of the vein type and rock sampling for laboratory analyses purposes. Laboratory work still limited petrographic and ore microscopic analyses only, while the other laboratory analyses, are in preparation. Petrographic analyses using thin section preparation will help to identify primary (rock forming minerals) and secondary minerals that formed by hydrothermal alteration as well as their rock textures. This analyses will help to describe the kind of rock type and also the alteration hydrothermal type. Whereas ore microscopic analyses using polished section preparation used to identify opaque minerals (ore minerals), their textures and occurrences.

2. MAGMATISM

Magmatic arc of Java is part of Sunda-Banda arc, extending from Sumatra trough Java to east of Damar Island which has a length about 3.700 km, known has many potential 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). The Tertiary magmatism on Java could be divided into two periods, *i.e.* the Late Eocene – Early Miocene magmatism and the Late Miocene-Pliocene magmatism (Soeria-atmadja *et al.* 1991). The volcanic rocks of Late Eocene – Early Miocene magmatism are widespread at alongside southern part of Java, which usually has tholeitic affinity, while the Late Miocene-Pliocene magmatism has Calc Alkaline-High K Calc Alkaline series, distributed mostly on the northward from the Late Eocene – Early Miocene magmatism (Soeria-atmadja, *et al.*, 1991). The eldest igneous rock of the Tertiary magmatic arch of Java is found at Pacitan area, East Java has showed age of about $42,73 \pm 9,87$ m.a. This sample was taken from tholeitic lava andesite of Besole Formation (Soeria-atmadja *et al.*, 1994; Sutanto *et al.*, 1994).

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 depression 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 comparable 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), followed by the movement in Late Miocene-Pliocene arch activity to the north of the Late Eocene-Early Miocene of the Southern Mountain Arc.

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 vicinity will be described below, based on the 1: 100.000 Geological Map of The Surakarta-Giritontro Quadrangle (Surono, *et al.*, 1992).



Fig. 2. Regional Geological Map of Wonogiri area and vicinity (sources: Surono et al., 1992)

Many dioritic composition intrusive rock were found at the research area, include pre-mineralisation intrusive rocks, syn-mineralisation intrusive rocks as well as post-mineralisation intrusive rock. In reality, it's difficult to distinguish of the dioritic rocks type in the area due to their similar composition. Corbett (2012) suggested that the intrusions in the area may be distinguished in many ways such by differences in alteration style (*e.g.* K feldspar-secondary biotite or silica-sericite-pyrite overprint), quartz vein populations and presence or absence of disseminated mineralisation. Beside those above criterias, the intrusion type also can distinguish by crystal size differences, colour index as well as the porphyritic texture's phenocryst density. Based on the observation both on the surface outcrops and drilling core samples, the intrusive rocks at the study area consists of:

- a. pre-mineralisation intrusive rocks, including feldspar diorite (as a xenolith within pyroxene diorite) and pyroxene diorite (previous researcher called as medium diorite).
- b. syn-mineralisation intrusive rocks, *i.e.* hornblende microdiorite (previous researcher called as microdiorite) and quartz diorite (previous researcher called as coarse diorite)



Fig. 3. Pyroxene diorite of the Tumbu and Geblag hill intruded by Microdiorite of the Randu Kuning hill. Both pyroxene diorite and hornblende microdiorite cut by quartz diorite intrusive. Photo was taken from Lancip hill (top) and some drilling core samples: pyroxene diorite right (WDD 02-128.50), pyroxene diorite right (WDD 29-80.55), hornblende microdiorite (WDD 45-31.20) and quartz diorite (WDD 18-161.70).

Imai *et al.* (2007) have identified three different types of intrusive rocks, namely hornblende andesite porphyry, hornblende diorite porphyry and hornblende diorite. Muthi *et al.* (2012) recognized there are at least four types of diorite at the Randu Kuning area, *ie.* coarse grain diorite, medium diorite, microdiorite and porphyritic plagioclase diorite. Dioritic intrusive rocks from Selogiri area are characterized generally by wide variation of SiO₂ contents (50.93-66.06 wt.%), high amounts of Al₂O₃ (mostly 14-18 wt.%), low TiO₂ contents (<1 wt.%) and low Na₂O and MgO content (Warmada *et al.*, 2007; Imai, *et al.*, 2007). The dioritic intrusive rocks in Selogiri are genetically associated with the present uncommon porphyry Cu-Au deposit in Java, which gives a number of questions to many geology experts. Setijadji *et al.* (2006) reported the possibility of the occurrence of adakitic rocks in terms of the Sr/Y vs Y diagram in Central-East Java, Sunda-Banda arc, including the Selogiri area. Imai *et al.* (2007) in contrast reported that the dioritic intrusive rocks in Selogiri area show the characteristic of common arc rocks that are typical of Miocene igneous rocks in Central-East Java, and the development of porphyry Cu-Au deposit may be due to the intermediate to silicic hydrous magmatism.

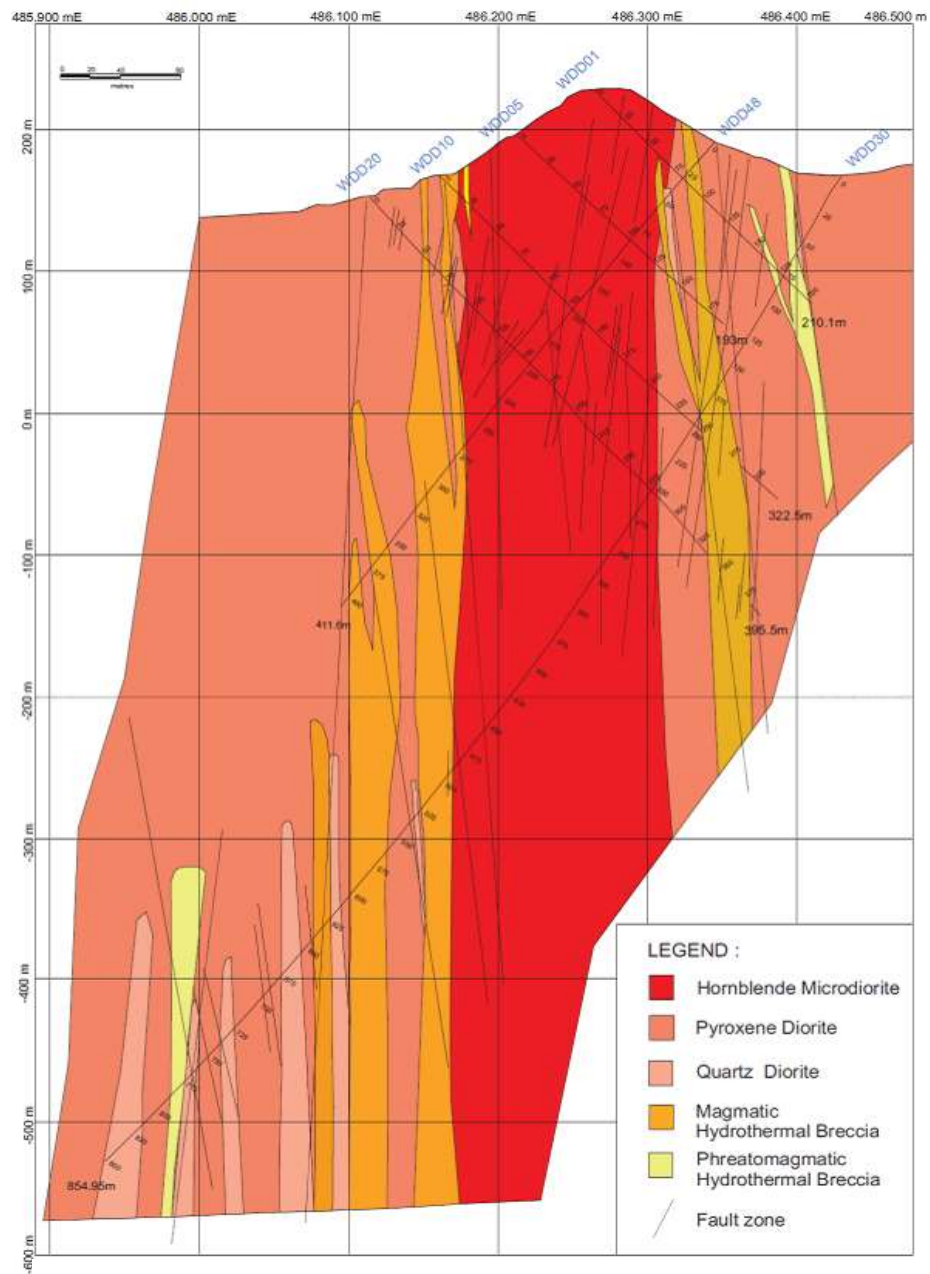


Fig. 4. Geological cross section based on drilling core data of TRK 01 cross section (Modified from Muthi, *et al.*, 2012)

3. ALTERATION HYDROTHERMAL AND MINERALIZATION

Most of hydrothermal deposit types recognized in Java arc are epithermal systems. Although the indication of the other mineralization type, such as porphyry type, skarn type and massive sulfide type are also found in several places. Epithermal mineralizations in West Java lie within and on flanks of Bayah Dome. Two noticeably different style of adularia-sericite epithermal gold deposits are found in the Bayah Dome, they are referred as Pongkor and Cirotan types (Marcoux and Milesi, 1994). Mineralization in Cibunasih, South Tasikmalaya showing gypsum and barite in green tuff, indicating the possibility of the massive volcanogenic type (Setiawan and Yudawinata, 2000). Indications of mineralization type Cu-Au Porphyry and skarn, are also found in several places, such as in Tumpang Pitu Banyuwangi, Pacitan, Lumajang, and Selogiri (Prihatmoko, *et al.* 2002, Muthi, *et al.*, 2012,).

Many experts have been reported about a magmatic related hydrothermal alteration at the Selogiri area. According to Suasta and Sinugroho (2011), had identified three type of hydrothermal alteration, i.e. potassic type, argillic type and prophyllitic type and

reported that the hornblende microdiorite was potassic-propylitic altered and mineralized, otherwise the hornblende diorite was propylitic altered only. Alteration zones distribution are generally more controlled by the direction of the NE-SW trending structure rather than NW-SE.

Quartz-sulphide veins mostly associated within the potassic and argillic alteration zone, but a few quartz veins also were found within propylitic zone.

The Porphyry Cu-Au mineralisation occurs in the Jendi village or Randu Kuning Prospect. There are many indications that reinforce this argument, such as quartz-sulphide-oxide vein stockwork, disseminated chalcopyrite and bornite, as well as the presence of malachite in the weathered zones. Most veins are B type and usually narrow (<1 cm) consisting of continuous, planar structures with parallel walls and usually with center line filled by iron and copper oxides after sulphide, vein selvages are commonly K-feldspar and sericite (Suasta and Sinogroho (2011). Iron oxide minerals and malachite are common exposed in the weathered rocks, especially in the surrounding quartz-sulphide veins. Epithermal Au-Zn-Pb mineralisation also found in the surrounding of the Randu Kuning Porphyry Cu-Au deposit, associated with crustiform-colloform quartz-carbonate veins, hosted within volcanic clastic rocks.

At least four types of hydrothermal alteration at the Randu Kuning area and its vicinity had identified, *i.e.* potassic type, propylitic type, argillic type and phyllic type. 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 characterized by secondary minerals assemblage *i.e.* one or both of secondary biotite and/or K-feldspar associated with magnetite (Suasta and Sinogroho, 2011; Corbett, 2011, 2012 and Muthi *et al.*, 2012). Propylitic alteration is less commonly recognised typically as actinolite or chlorite-epidote-magnetite alteration at the margin of the hydrothermal system (Corbett, 2012). Propylitic zone mostly is widespread in pyroxene diorite and quartz diorite rocks, both visible at the surface outcrop and in drill core samples.

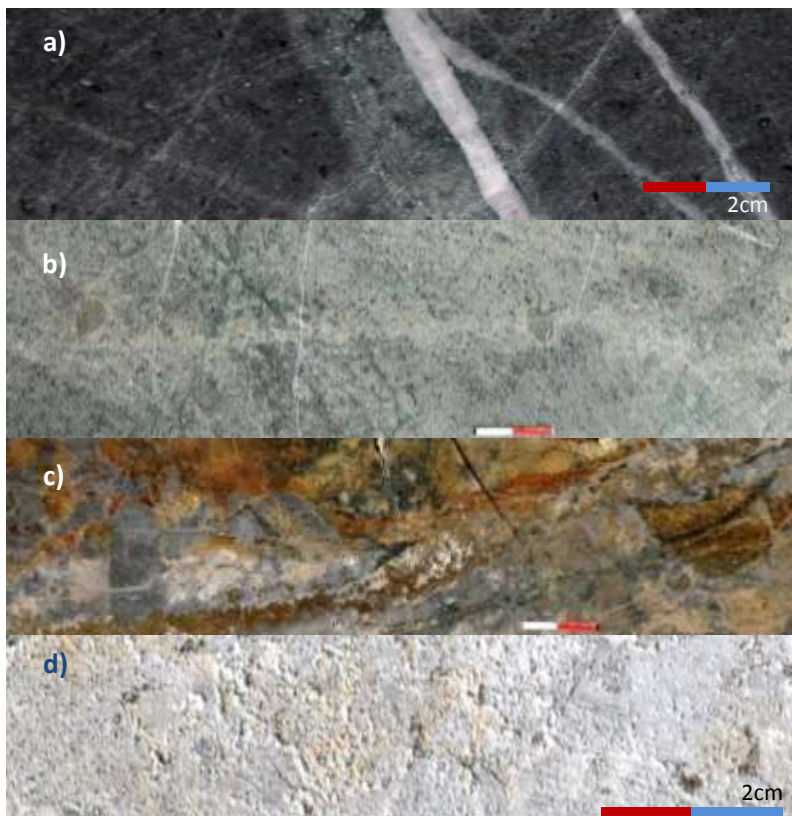


Fig. 5. Many altered rocks that were found at the Randu Kuning area. a). Potassic altered microdiorite cut by quartz vein and quartz-carbonate veinlets with chlorite-silica-epidote halos. Sample WDD 30-291.90. b). potassic altered pyroxene diorite overprint by propylitic alteration on Sample WDD 49-74.70. c). phyllic alteration associated with pyrite-quartz-carbonate vein. Sample WDD 49-248.80 and d). and argillitized crackle breccia sample of WDD 41-57.75

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

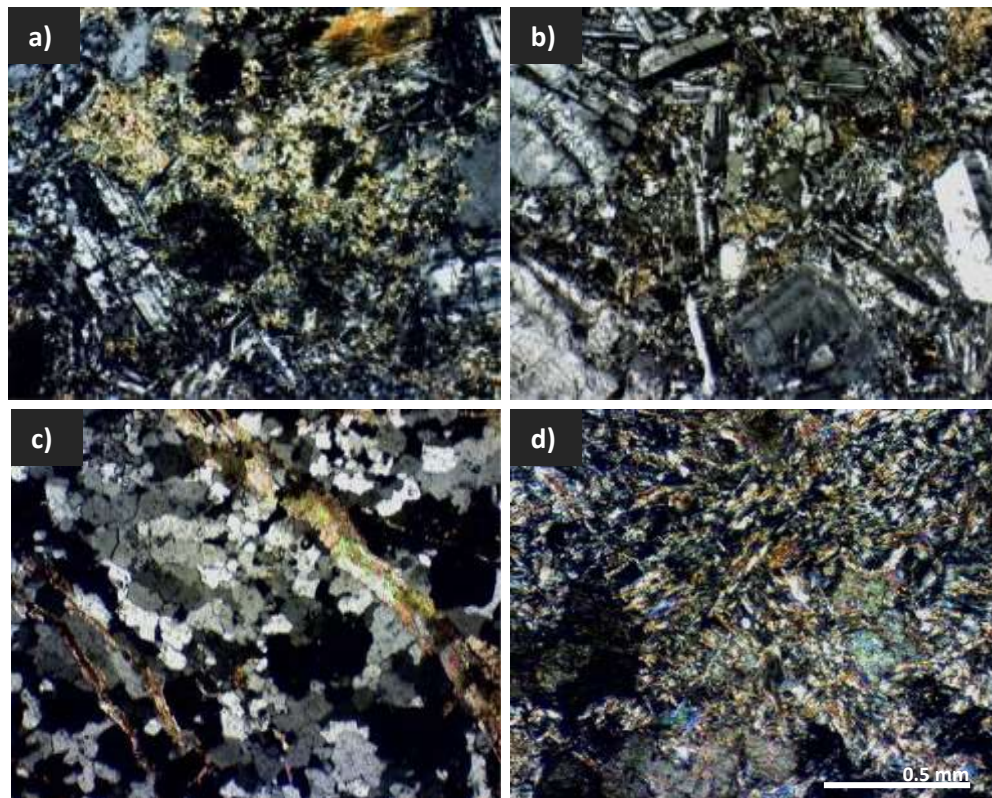


Fig. 6. Photomicroscopic (cross plane) of many altered rock type at the research area. a). WDD-09-157.65. Potassic (biotite-alkaline feldspar) type overprinted inner prophyllitic (tremolite-anhydrite-silica). b). WDD-27-426.00. Prophyllitic (silica, chlorite, sericite) altered diorite. c). WDD-49-249.20. Silicic (silica, carbonate, sericite, chlorite) type cut by carbonate-sericite veinlets. d). WDD-48-27.45 Pyrophyllite-chlorite-clay mineral-silica assemblage.

Corbett (2011; 2012) suggesting many mineralization style recognised at the Randu Kuning area, and can be summarized as follows:

- a) Cu-Au disseminated mineralization. This mineralisation style mostly occurred associated with the present of chalcopyrite-pyrite dissemination within magnetite-actinolite-epidote±chlorite alteration (inner prophyllitic) which overprint on potassic alteration. It were found as disseminations, clots, breccia matrix, fracture fill and locally sheeted fracture veins.

- b) Cu-Au quartz vein mineralization. Some barren quartz veins are recognised in the deeper portion of some intrusions, and mostly associated with the presence of magnetite but without sulphides. While in the upper portion and later stage or at the time of the ore fluids ascending, the quartz veins accompanied by minor sulphides and can develop AB veins (formed by the filling at central termination within A veins by sulphides), C veins (chalcopyrite-pyrite veins), and on the reactivated lamination parting of laminated M veins.
- c) D veins mineralization. This vein type comprises quartz, sulphides and carbonate with prominent silica-sericite±pyrite alteration selvages. D veins most commonly occur within fault zones, overprinting of earlier quartz veins and disseminated mineralization. It may contain locally elevated Au to 5 g/t Au, 1.1 g/t Ag and 292 g/t Cu (in DDH WDD 18, 358, 4m with typically low Ag:Cu ratios of 0.2. In the southern drill hole examined, still showing this style but generally have < 1g/t Au.

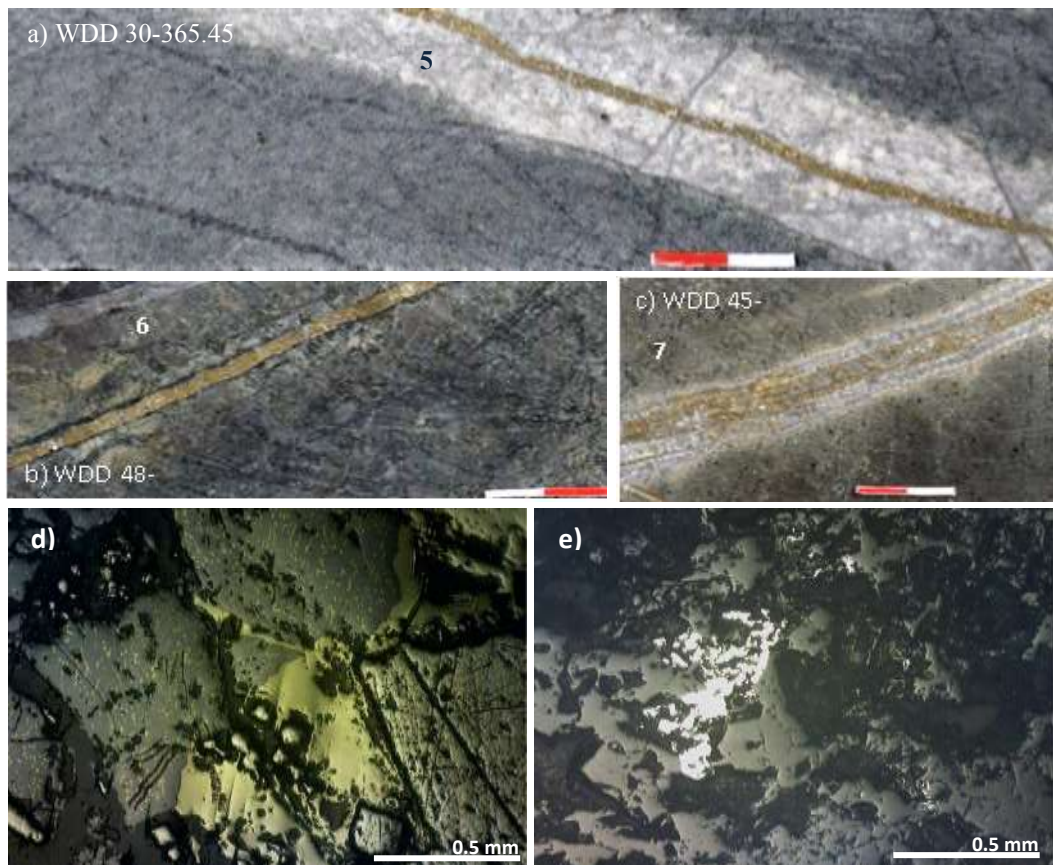


Fig. 7. Many vein mineralization styles recognised at the Randu Kuning area: a). quartz-feldspar vein infilled by pyrite vein in centre line, b). pyrite ± chalcopyrite-magnetite vein and c). pyrite-quartz-chalcopyrite-carbonate vein (D vein). d). Photomicroscopic exsolution texture of chalcopyrite-sphalerite (chalcopyrite blebs within sphalerite host), indicating deposited in high temperature e). Photomicroscopic of magnetites are replaced by pyrites.

Some D veins (quartz-sulphide veins) formed at deeper levels close and within intrusion source contain chalcopyrite and bornite but another D veins in same elevation contain yellow and sphalerite and contain no chalcopyrite and bornite, indicate a low temperature. Corbett (2012) gave explanation that lower temperature late stage occurred at a higher crustal level after substantial uplift and erosion, or as result of renewed deeper magmatism.

4. CONCLUSION

Two type dioritic intrusive rock controlling two hydrothermal type deposit. The earlier hornblende microdiorite responsible to the porphyry Cu-Au deposit occurrence, while the second one or the later quartz diorite was related to the one of many epithermal Au-base metals low sulphidation.

At least three mineralization style have recognised at the Randu Kuning area, *i.e.* Cu-Au disseminated mineralization style, Cu-Au quartz vein mineralization and D veins mineralization that contribute in copper-gold enrichment at the area.

5. ACKNOWLEDGMENTS

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