# HYDROTHERMAL ALTERATION AND VEIN TYPES OF THE RANDU KUNING PORPHYRY Cu-Au DEPOSIT AT SELOGIRI AREA, WONOGIRI

*ALTERASI DAN TIPE URAT HIDROTERMAL ENDAPAN CU-AU PORFIRI RANDU KUNING DI DAERAH SELOGIRI, WONOGIRI*

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## ABSTRACT

Many Tertiary hydrothermal altered dioritic composition intrusive rocks were found at the Randu Kuning area and its vicinity, Selogiri, including hornblende microdiorite, hornblende-pyroxene diorite and quartz diorite. The hydrothermal fluids which responsible for the alteration and mineralization at the area is associated with the occurence of the horblende microdiorite intrusion.

The alteration zone at the Randu Kuning area and its vicinity can be divided into several hydrothermal alteration zones, such as potassic (magnetite-biotite-K feldspar), prophyllitic (chlorite-magnetite-epidote-carbonate), phyllic (quartz-sericite-chlorite) and argillic (clay mineral-sericite). The alteration pattern in the Randu Kuning porphyry Cu-Au deposit is tipically a diorite model characterising by the domination of potassic alteration and prophyllitic zone. Phyllic and argillic alteration types are restrictive found within the fault zones.

A lot of porphyry vein types were found and observed at the Randu Kuning area, and classified into at least seven vein types. The paragenetic sequence of those veins from the earliest to the latest respectively are 1). Magnetite-chalcopyrite±quartz-biotite veinlets, 2). Quartz±magnetite (A type) veins, 3). Banded/Laminated quartz-magnetite (M type) veins, 4). Quartz±K feldspar (B type)veins, 5). Quartz with thin centre line sulphide (AB type) veins, 6). Pyrite±chalcopyrite (C type) veinlets, and 7). Pyrite-quartz+chalcopyrire+carbonate (D type) veins. Gold and copper mineralisation of the Randu Kuning Porphyry Cu-Au deposit, mostly related to the presence of quartz veins/veinlets containing sulfide i.e. Quartz with thin centre line sulphide veins, Pyrite±chalcopyrite veinlets, and Pyrite-quartz+chalcopyrire+ carbonate veins.

**Keywords:** paragenetic sequence, porphyry, veins.

## *ABSTRAK*

*Beberapa batuan intrusi Tersier berkomposisi dioritik yang telah mengalami ubahan hidrotermal di temukan di daerah Randu Kuning dan sekitarnya, Kecamatan Selogiri, diantaranya adalah mikrodiorit hornblende, diorit hornblende-piroksen dan diorit kuarsa. Fluida hidrotermal yang bertanggung jawab pada proses ubahan dan mineralisasi di daerah telitian berkaitan dengan proses magmatisme yang membentuk intrusi mikrodiorit hornblende.*

*Zona ubahan hidrotermal di daerah Randu Kuning dan sekitarnya dibagi menjadi beberapa zona, diantaranya adalah potasik (magnetit-biotit-K. feldspar), profilitik (klorit-magnetit-epidot-karbonat), filik (kuarsa-serisit-klorit) dan argilik (mineral lempung-serisit). Pola ubahan hidrotermal pada endapan porfiri Cu-Au Randu Kuning adalah tipikal model* *diorite, yang dicirikan oleh luasnya sebaran zona potasik dan profilitik serta zona filik dan argilik yang hanya ditemukan terbatas pada zona sesar.*

*Sedikitnya terdapat tujuh macam urat tipe porfiri telah ditemukan di wilayah Randu Kuning dan sekitarnya, diantaranya berturut-turut dari yang paling awal terbentuk adalah 1). Magnetit-kalkopirit±kuarsa-biotit, 2). Kuarsa±magnetit (tipe A), 3). Kuarsa-magnetit berlapis (tipe M), 4). Kuarsa±K.feldspar (tipe B), 5). Kuarsa dengan sulfida di bagian tengah, 6). Pirit±kalkopirit (tipe C) dan 7). Pirit-kuarsa+kalkopirit+karbonat (tipe D). Mineralisasi tembaga dan emas sebagian besar terkait dengan urat kuarsa dengan sulfida di bagian tengah, urat pirit±kalkopirit dan urat pirit-kuarsa+kalkopirit+karbonat.*

***Kata Kunci:*** *porfiri, sekuen paragenetik, urat,*.

## INTRODUCTION

The Randu Kuning Porphyry Cu-Au prospect area is situated at Selogiri District, Wonogiri Regency, 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.

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). This study will focus on the paragenetic sequence of the porphyry vein type only.

Porphyry copper-gold deposits and epithermal gold-base metal deposits are both associated with subduction related at convergent plate margins and many are found and spread in the southwest Pacific rim (Corbett and Leach, 1996). Although the two deposit types have different alteration and mineralisation characteristic, but commonly show a close spatial and temporal relationship (Hedenquist *et al*., 1998; Corbett, 2008; Sillitoe, 2010). Related to the magmatic source, Corbett (2011) suggested the possible mechanisms for the formation of low sulphidation epithermal Au overprinting the porphyry Cu-Au system at the Randu Kuning, that are a). The gold-base metal epithermal were deposited from the cooling magmatic

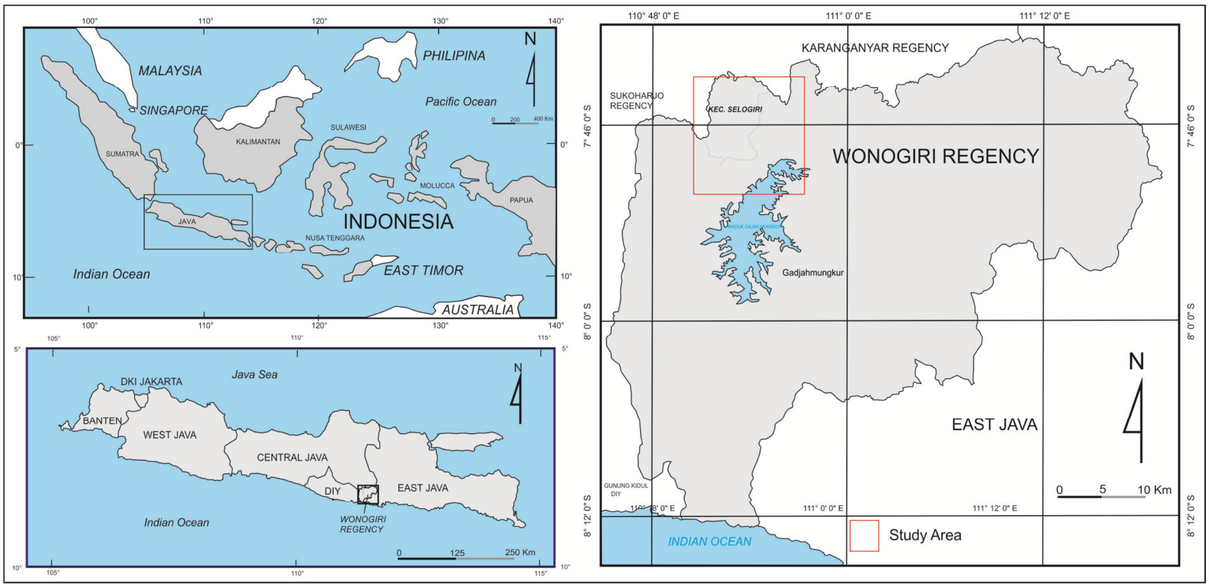


Figure 1. Location map of Selogiri area, Wonogiri

source at depth as a late stage event of the main porphyry Cu-Au system, and b). The epithermal Au related with the emplacement of new magmatic source at depth. Suasta and Sinugroho (2011), had identified four types of hydrothermal alteration, i.e. potassic, prophyllitic, argillic and phylic and reported that the hornblende microdiorite was potassic-propylitic altered and mineralize, otherwise the hornblende diorite was prophyllitic 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 is 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; 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.

## METHOD

This paper is a preliminary study and part of the dissertation research. This paper had also been presented in the HAGI-IAGI Joint Convention Medan 2013 with some modifications. The data used in the paper are limited on the field observation and drilling core logging as well as polarisation microscopic and megascopic observation.

## REGIONAL GEOLOGY

Magmatic arc of Java Island 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; Carlile 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 arc of Java is found at Pacitan area, East Java that showed age of about 42,73 ±9,87 Ma. 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 are 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 are believed as the final stage of volcanic activity in the Southern Mountains arc, which distributed 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 arc 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 western and the easternpart of the Southern Mountain, so there is contact between the Semilir Formation and Mandalika Formation, and it found at the Selogiri area.

**Geology of the Selogiri Area**

There are many rocks types found at the Selogiri area and its surrounding, such as volcanic breccias, andesite lavas, tuffs, and many igneous intrusive rocks such as diorites and andesites of the Miocene Mandalika and Semilir Formations, unconformably underlie Quaternary volcanic rocks of Lawu and Merapi Volcanoes. Most of the Tertiary rocks have been strongly hydrothermal altered; causing primary rock forming minerals (feldspars, hornblendes, pyroxenes), were replaced by secondary minerals (chlorites, carbonates, quartzs, hematites). These rocks lithostratigraphically could be grouped into 6 (six) rock units, i.e.: pumice breccia of Semilir, volcanic breccia of Mandalika, intrusive rocks, hydrothermal breccia, volcanic breccia of Lawu Volcano, and aluvial deposit. Based on the observation both on the surface outcrops and drilling core samples, the intrusive rocks at the study area consist of hornblende-pyroxene diorite (previous researcher called as medium diorite), hornblende microdiorite and quartz diorite.

*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.

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.

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.

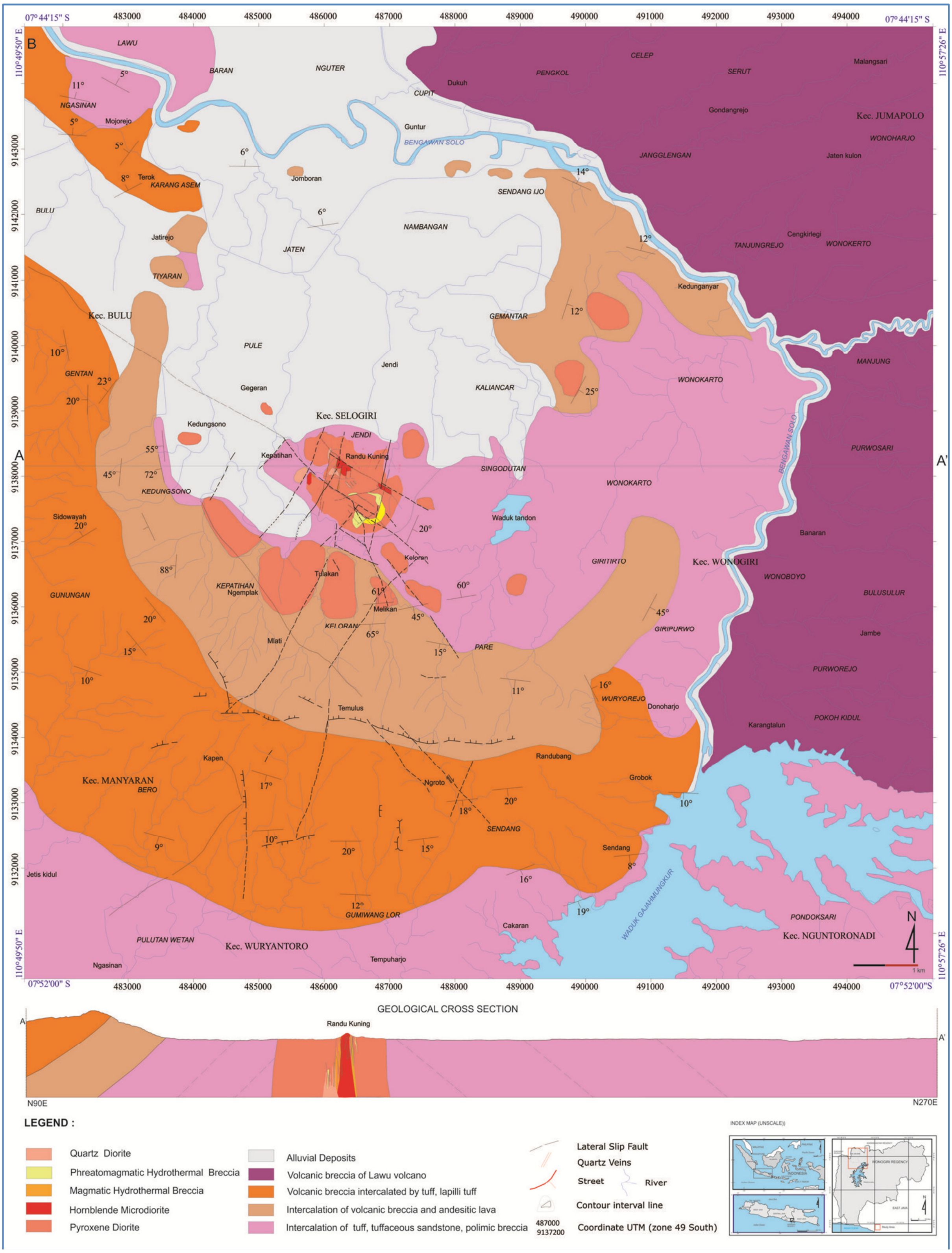



Figure 2. Geological Map of Selogiri area and its vicinity
(Modified from Hartono, 2010 and Suasta and Sinugroho, 2011).


Figure 3. Hornblende-pyroxen diorite of the Tumbu and Geblag hill intruded by hornblende microdiorite of the Randu Kuning hill. Both hornblende-pyroxene diorite and hornblende microdiorite cut by quartz diorite intrusive. Photo was taken from Lancip hill (top) and some drilling core samples: hornblende-pyroxene diorite left (WDD 02-128.50), hornblende- pyroxene diorite right (WDD 29-80.55), hornblende microdiorite (WDD 45-31.20) and quartz diorite (WDD 18-161.70). (Sutarto et al., 2013a)

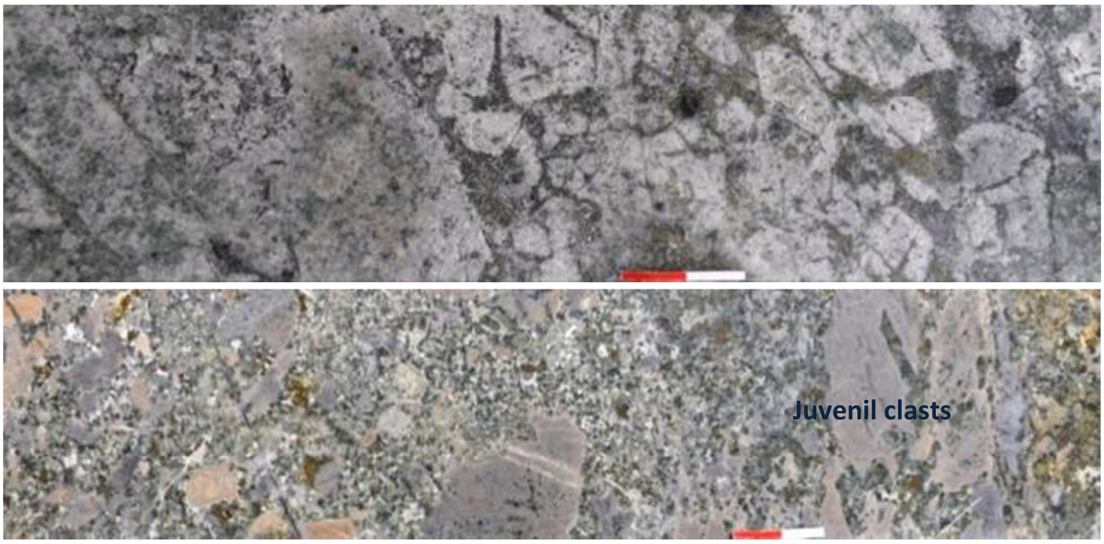



Figure 4. Magmatic hydrothermal jigsaw breccia infilled by magnetite-quartz-pyrite (sample WDD 02-84.00, top). Phreatomagmatic breccia of drilling core sample of WDD 31-135.25 (bottom).

*Magmatic hydrothermal breccia*: mostly occured in contact between hornblende microdiorite or quartz diorite and hornblende-pyroxene diorite. It is characterized by angular fragments/clasts supported or infilled by silica and sulfide matrix derived from hydrothermal fluids precipitation. *Phreatomagmatic breccia*: this breccia is characterized by abundant of the juvenil clasts, indicated contact between hot magma with fluid or water. The juvenil clasts usually compossed by volcanic glass, amorf and rounded-irregular shape. Phreatomagmatic breccia at the Randu Kuning area commonly intercalation with tuff and lapilli-tuff.

**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).

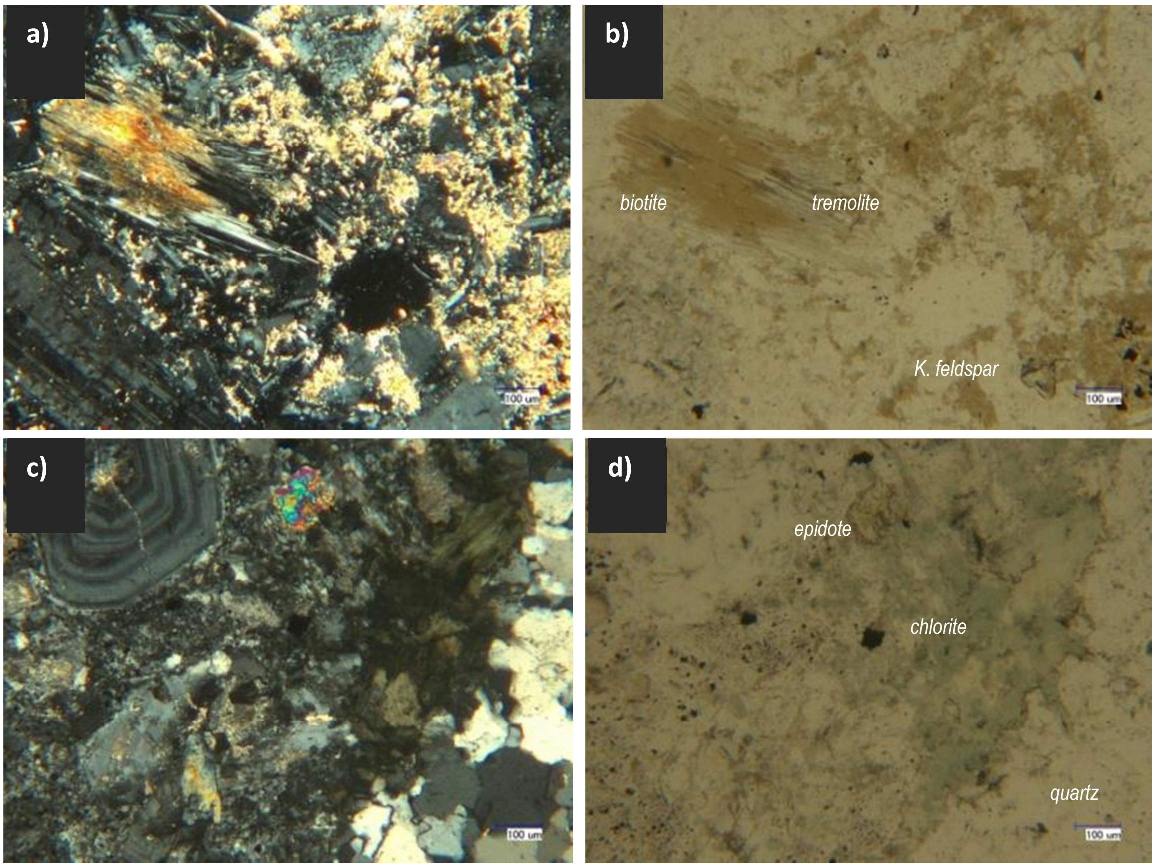



Figure 5. Photomicroscopic of many altered rock type at the research area. Top : photomicroscopic is a potassic (biotite-alkaline feldspar) type, which is overprinted by inner prophyllitic (tremolite-chlorite-silica). a) cross plane, b) lower plane. Sample WDD-09-77.90. Bottom: Prophyllitic (chlorite-silica-epidote) altered microdiorite. c). cross plane, d). lower plane. Sample: WDD-30-291.85.(Sutarto, *et al.*, 2013b).

**Vein Type**

An understanding of the veins and veinlets in the porphyry system is very important, especially in the Cu-Au porphyry deposit, as most of mineralization is associated with the presence of veins and veinlets. Various types of veins in porphyry-type ore deposit are 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 types were observed at the Randu Kuning area, both porphyry vein and epithermal vein types. Some of them are difficult to be grouped according to the classification of previous researchers above. Here are some vein types criterias that were found in the study area based on observations of drilling core samples and surface outcrops (using compilation of Gustafson and Hunt, 1975; Corbett, 2008; Sillitoe, 2010; Corbett, 2012). At least seven porphyry veins type have been observed, respectively from the earliest are:

1. **Magnetite-chalcopyrite±quartz-biotite veinlets**
   - Mostly occured as a stringer veinlets.

2. **Quartz±magnetite (A type)veins**
   - Comprising mostly saccharoidal and transparent quartz and minor or without magnetite.
   - Associating only with potassic alteration zones.
   - Vein shape commontly unsymmetry, irregular and discontinue.

- It is can be a single vein, ptygmatic vein, stockwork linier vein, sheeted vein and stringer vein.
- Disseminated chalcopyrite rarely present.

3. **Banded/Laminated quartz-magnetite (M type) veins**
   - Consist of magnetite and quartz with minor or without sulphide.
   - Showing banded or laminated structure.

4. **Quartz±K feldspar (B type)veins**
   - Characterized by centrally terminated comb structure quartz and/or felldspar in filled with lesser of fine sulphide. Some of them are not in filled by sulphide.
   - At Randu Kuning area this vein type is rarely recognized.

5. **Quartz with thin centre line sulphide (AB type) veins**
   - This vein types are formed by the filling at centra termination within A vein by sulphides (chalcopyrite-pyrite±bornite).

6. **Pyrite±chalcopyrite (C type) veinlets**
   - Comprising sulphide minerals (chalcopyrite-pyrite).
   - This veinlets generally narrow and there is no alteration selvages or halos.

7. **Pyrite-quartz+chalcopyrire+carbonate (D type) veins**
   - Characterized by coarse euhedral pyrite, quartz and carbonate.
   - Commontly followed by silica-sericite±pyrite selvages/halos.
   - Associated with phyllic zone toward to prophyllitic zone.

Based on the veins/veinlets observation data both field outrops and drilling cores indicates, there are two ore mineralizing systems in the Randu Kuning hills. Those are porphyry Cu-Au system and low sulphidation epithermal Au system. But this paper will concern on the porphyry Cu-Au system only. The deposit is characterized by the domination of potassic alteration (biotite-K feldspar-magnetite minerals assemblage), prophyllitic alteration and phyllic alteration within fault zone asssociated with the formation of several porphyry veins style.

The quartz-magnetite veins with lesser of sulphide-feldspar and biotite including 1). Magnetite- chalcopyrite ±quartz-biotite veinlets, 2). Quartz± magnetite (A type) veins, 3). Banded/ laminated quartz-magnetite (M type) veins, 4). Quartz±K feldspar (B type) veins occured on the early stage. Later veins formation were signed by the deposition of sulphides (pyrite-chalcopyrite infilling the centre line of quartz-magnetite veins, such as 5). Quartz with thin centre line sulphide (AB type) veins, 6). Pyrite±chalcopyrite (C type) veinlets, and 7). Pyrite-quartz+chalcopyrire+carbonate (D type) veins.

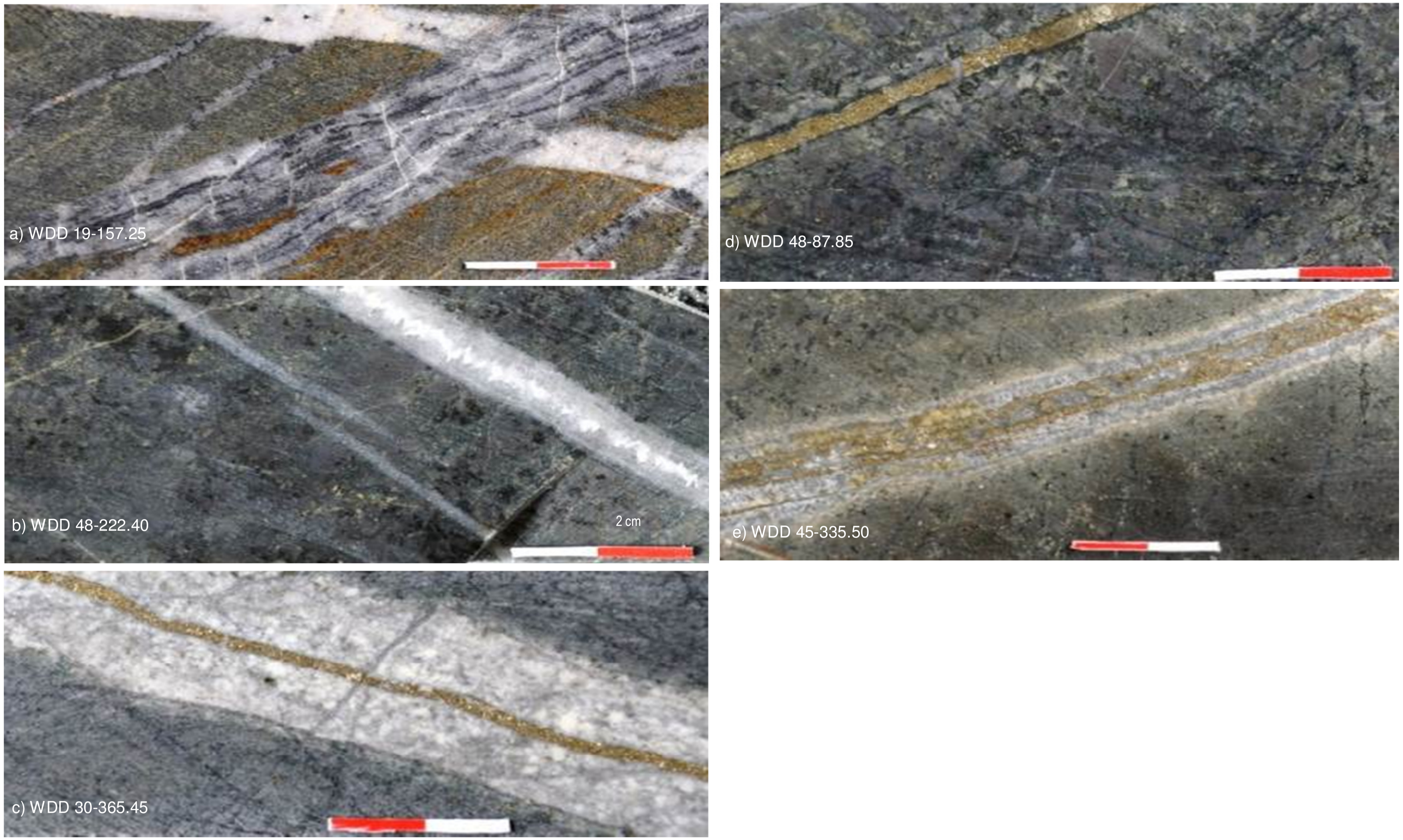



Figure 6. Some Porphyry veins type at the Selogiri area (Sutarto, *et al.*, 2013 b).
a) Quartz±magnetite vein cut by banded quartz-magnetite vein.
b) Quartz-K feldspar vein.
c) Quartz-feldspar vein infilled by pyrite vein in centre line.
d) Potassic alteration cut by pyrite vein.
e) Pyrite-quartz-chalcopyrite+carbonate vein.

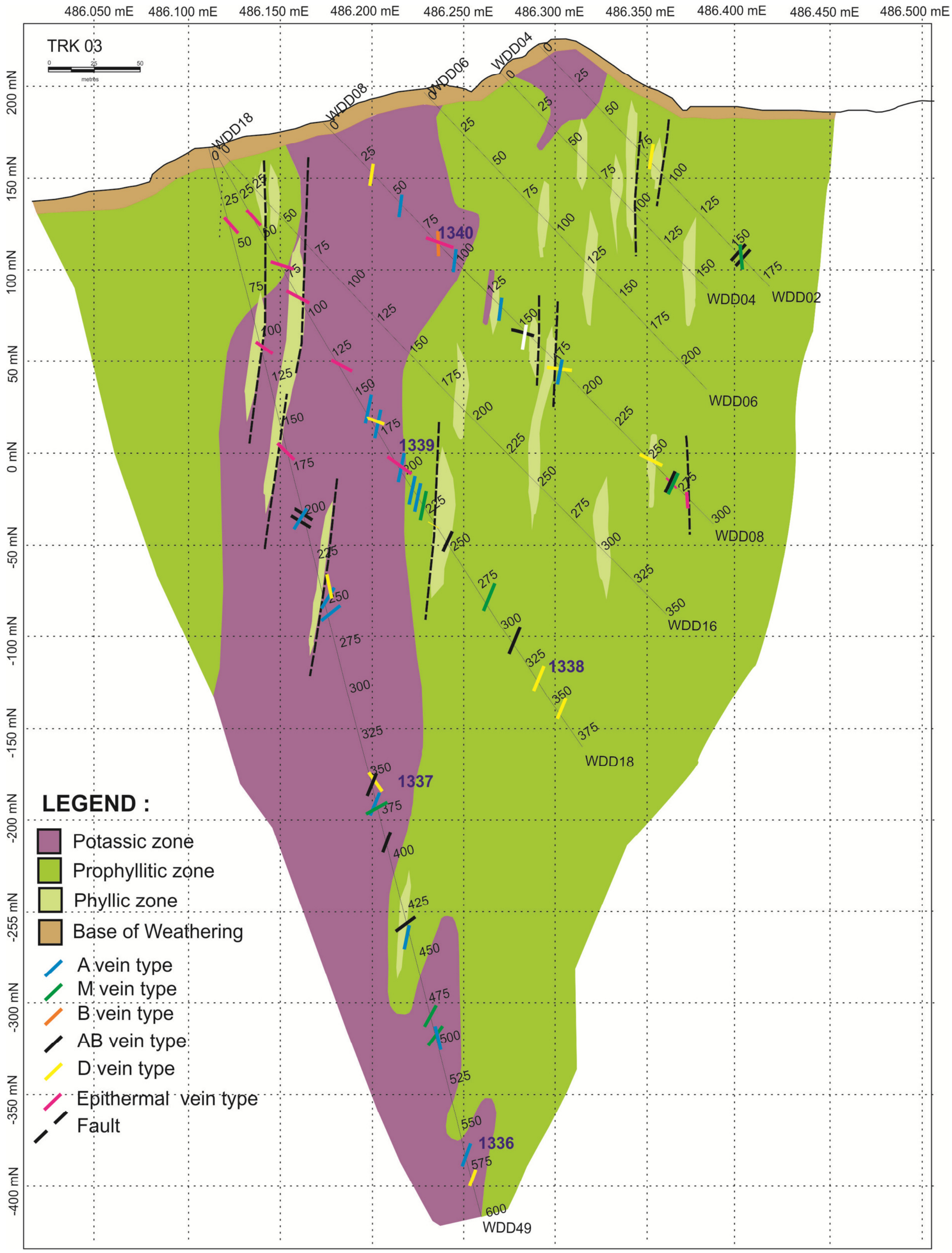
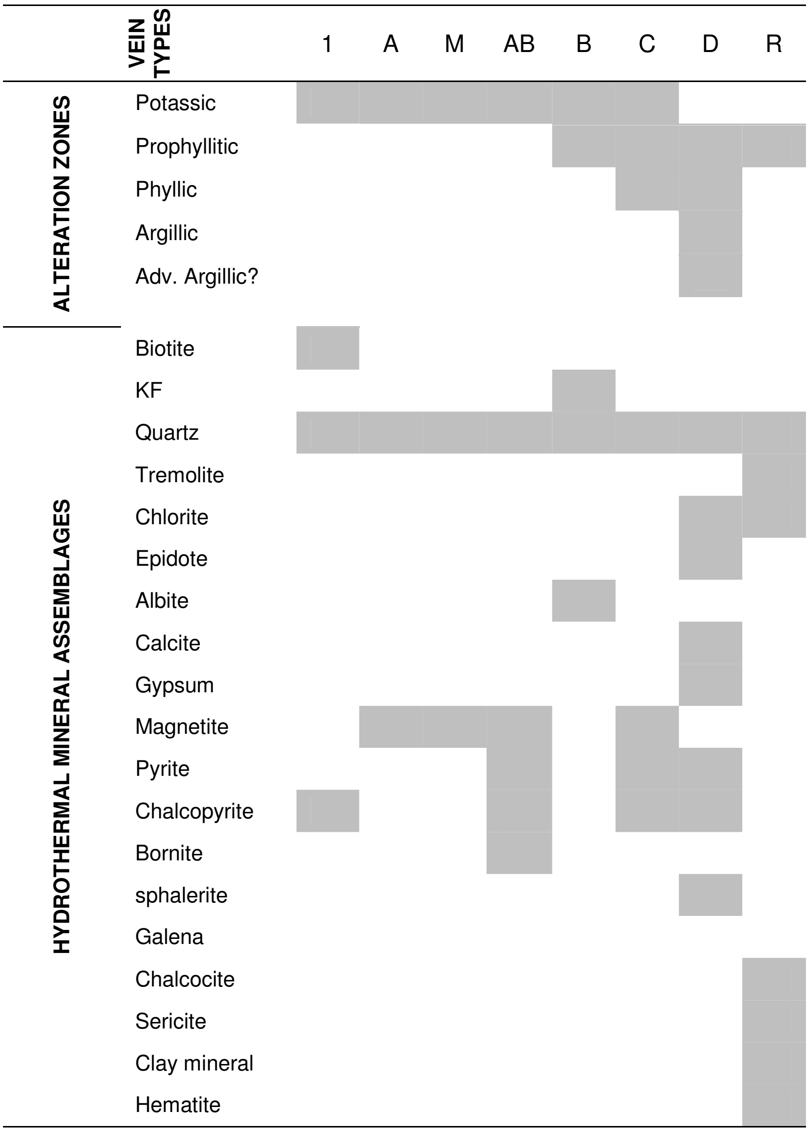



Figure 7. Many porphyry vein types and alteration zone of TRK 03 cross section

Table 1. Paragenetic sequence of alteration minerals and veins of Randu Kuning porphyry Cu-Au mineralisation.




## CONCLUSIONS

A dioritic composition range of the intrusive rocks type and the domination of the potassic and prophyllitic zone in the study area, suggested that the alteration model of the Cu-Au porphyry ore deposit is more similar to the diorite model rather than the quartz monzonite model. Phyllic and argillic alteration type also present, but in a limited area, especially within the fault structure zones.

Many vein type which related to the formation of porphyry deposit have been identified, respectively from the earliest are Magnetite-chalcopyrite±quartz-biotite veinlets, Quartz±magnetite (A type) veins, Banded/laminated quartz-magnetite (M type) veins, Quartz±K feldspar (B type) veins, Quartz with thin centre line sulphide (AB type) veins, Pyrite±chalcopyrite (C type) veinlets, and Pyrite-quartz+chalcopyrire+carbonate (D type) veins.

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