Mineralization Style And Fluids Evolution Of The Randu Kuning Porphyry Cu-Au And Epithermal Au-Base Metals Deposits At Selogiri, Central Java, Indonesia

by Sutarto Sutarto

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Abstract

Based on the characteristics of many parameters such as pattern and type of hydrothermal alteration, veins type, gangue and ore minerals assemblages, fluid inclusions data, the mineralization type of the Randu Kuning prospect is a co-existing of porphyry Cu-Au to intermediate sulphidation epithermal Au-base metals. Not all porphyry vein types contribute in copper and gold mineralization. The early quartz-magnetite veins (particularly A and M veins) generally not contain Cu-Au or barren, while the later sulphide bearing veins such as AB, C and D types mostly are rich of copper and gold. Mineralization is also commonly occured as disseminated chalcopyrite within magmatic hydrothermal breccia associated with magnetite and actinolite. In epithermal environment, vein associated with golg and base metals mineralization particularly is pyrite+sphalerite+chalcopyrite+quartz±carbonate vein. Many sulphides within open space hydrothermal breccia also have important role in gold-silver-zinc-lead mineralization.

The hydrothermal fluid evolution from the deep porphyry to the shallow epithermal enviroment, can be devided into at least three stages. The early porphyry stage started at temperatures more than 600°C, when the singgle phase fluid separated into two phases that are a hypersaline fluid and a low-density vapor. The hypersaline fluid is representated by the present of type III inclusion (polyphase), while the second one is represented by the present of type II (two phase), characterized by vapor more dominant than liquid. In this stage, reaction betweem the fluid and wall rocks were pointed by the development of magnetite and quartz veins such as A, B and M type within mineral assemblages of potassic alteration. The veins mostly barren or very low grade of copper and gold.

The next stage or intermediate porphyry stage is represented by the present of single phase aqueous fluid with low-medium salinity at the temperature about 300°-350°C. During generating to the surface, this fluid react with the existing magnetite-quartz vein/veinlet stockworks and potassic alteration minerals, form sulphides bearing quartz veins (AB type and C type) and an alteration mineral assemblages particularly phyllic and chlorite-magnetite-sericite zone. AB and C veins are commonly associated with the porphyry Cu-Au mineralization.

Late porphyry to epithermal stage is the stage when the single phase aqueous fluid continue move the surface and laterally to the peripheral, react with meteoric and connate water more intense, the salinity became lower and the temperature also decrease (200°-350°C). This fluid react with the existing veins and altered rocks will form pyrite-chalcopyrite bearing carbonate-quartz veins (D type) and carbonate-pyrite-sphalerite-chalcopyrite and other epithermal style veins as well as the development of outer prophyllitic, intermediet argillic and lack of anvanced argillic. D vein also gave contribution in Au deposit, while some epithermal veins contribute in Au-base metals mineralization.

Key words: Porphyry; Epithermal; Mineralization style; Fluid evolution

1. Introduction

1.1. Background

The Randu Kuning Porphyry Cu-Au prospect area, situated in Selogiri, Wonogiri, Central Java Province, Indonesia (Figure 1). This location is reachable with four wheel or two wheel vehicle, about 40 km to the south-east from Solo city Central Java, or approximately 70 km east of Yogyakarta city. The Randu Kuning propect is one of several mineral prospects of the Wonogiri project area, located in the northern portion of the project area covers 3,928 hectares within mining exploration concession title "IUP" under PT Alexis Perdana Mineral. 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). Since 1995, the Randu Kuning 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 the IUP (the mineralization project area covers 3,928 hectares) in Selogiri, started exploration particularly on the Randu Kuning and others several prospects surrounding.

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).

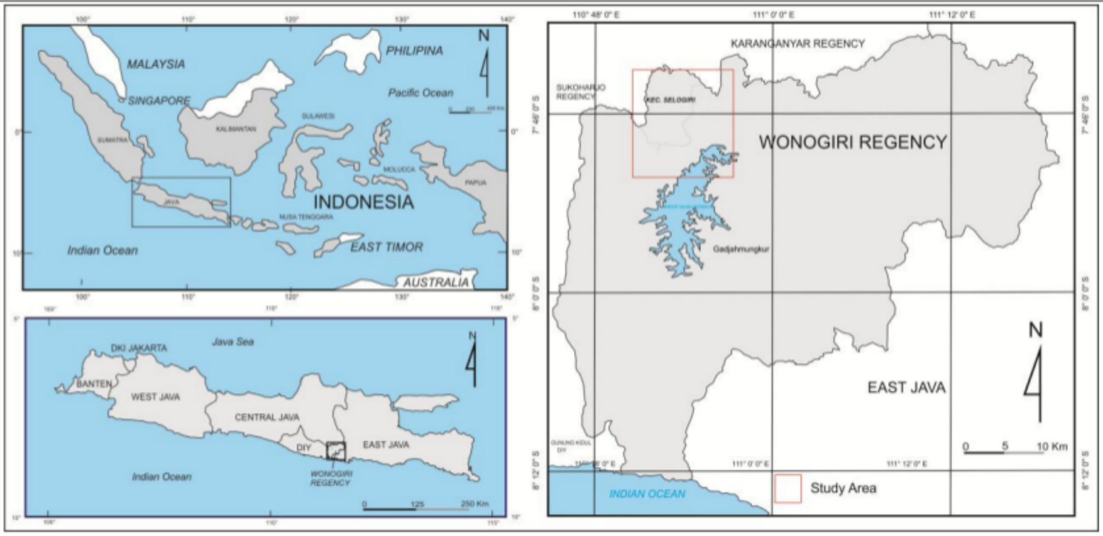


Figure 1: Figure 1: Location map of Selogiri area, Wonogiri

1.2. Materials and Methods

In this study, veins and rocks samples were collected systematically from both drilling and local mining tunnel as well as surface outcrops. Secondary minerals assemblages were identified from polarisation microscopic observation, X-ray diffractometer, Qemscan(Quantitative Evaluation of Minerals by Scanning Electron Microscopy) analysis. The X-ray diffractometer was conducted at the Geological Engineering Department of Gadjah Mada University using Rigaku RINT-2100. Petrographic, ore microscopic, QemScan and fluid inclusion analysis (used a Linkham T95 serie freezing and heating stage) analysis were carried out at Department of Mineralogy and Economic Geology, RWTH Aachen University, Germany.

2. Regional Geology

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). The western segment of the arc is abundance of low sulphidation epithernal vein system such as mineralization in Miwah, Sondi, Martabe, Way Linggo, Ojo Lali, Cibaliung, Pongkor and Banyumas. A marked change in mineralization style is seen in the eastern arc segment, in which many porphyry copper-gold mineralization were found (Charlile and Mitchell, 1994), such as in Batu Hijau, Elang, Tumpang Pitu (Hellman, 2010; Maryono et al., 2012) and Selogiri (Muthi et al., 2012).

Soeria-atmadja, et al. (1994) divided the Tertiary magmatism on Java into two periods, *i.e.* the Late Eocene-Early Miocene and the Late Miocene-Pliocene magmatism. 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 tholeitic, calc alkaline to high K calc alkaline series, distributed mostly on the northward from the Late Eocene-Early Miocene magmatism. Many Eocene-Early Miocene volcanic rocks have identified and observed in few areas especially in the the Southern Mountain of Java island, including Cikotok Formation (Bayah dome) and Jatibarang Volcanic

Formation in West Java, dioritic and diabasic intrusive rocks in Karangsambung Central Java and andesite intrusion (Besole Formation) Pacitan East Java. Whereas many Late Miocene volcanic rocks have also observed such as in Karangkobar Banjarnegara, Cilacap-Pangandaran, Pacitan and Selogiri (Soeria-atmadja et al., 1994).

The eldest igneous rock of the Late Eocene-Early Miocen magmatic arch of Java is a tholeitic lava andesite of Besole Formation found at Pacitan area, East Java has about 42,73 ±9,87 Ma in age (Soeria-atmadja et al., 1994) whereas the youngest one is the andesitiv lava in Pacitan has about 15.03±0.88 Ma (JICA-JOGMEC, 2004 in Setijadji et al. 2006). Intrusions and volvanic rocks within the Late Miocen-Pliocene magmatism are represented by Basaltic lava in Bayah, West Java which has 13.7±1.8 Ma in age (Soeria-atmadja et al., 1994; Sutanto et al, 1994) and basalt in Genting island Karimunjawa which has 2.5±0.1 to 1.8±0.3 Ma in age (Soeria-atmadja et al., 1985).

Ore mineralizations in Java island which are found ranging from Cibalium West Java to Tumpang Pitu east Java, mostly due to the magmatism-hydrothermal processes. Various types of mineralization mostly epithermal low sulfidationand porphyry Cu-Au are generally hosted on the "Old Andesite" volcanic rocks. Although other indication of mineralisation types such as skarn, volcanogenic massive sulphide, polymetallic, carbonate base metals and quartz sulphide veins are also found in some places (Setijadji et al., 2006) (Figure 4). The different crustal type and source components for the magmatism processes may produce a different type of mineralisation in West Java and East Java. West Java is dominated by low-sulphidation Au-Ag epithermal system associated with Neogen-Quartenary high K to shosonitic volcanism at continental crust setting, in the other hand, Eastern Java to Sumbawa is dominated by porphyry-related Cu-Au mineralisation system associated with low to moderate K, minimum crustal contamination Middle Tertiary-Neogen magmatism (Setijadji and Maryono, 2012).

3. Geology of The Randu Kuning

Randu Kuning area is situated in the at the center of the Selogiri area where porphyry Cu-Au and intermediate sulphidation epithermal Au-base metals occured,. The area is occupied by dioritic intrusive rocks and hydrothermal breccias as well as many veins/veinlets types. Intrusive rocks consist of hornblende-pyroxene diorite, hornblende microdiorite and quartz diorite, while the hydrothermal breccia can be classified as magmatic hydrothermal berccia and phreatomagmatic breccia (Figure 6). 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.

The Hornblende-pyroxene diorite is not associated with the ore mineralization (pre-mineralisation), occured prior to the microdiorite formation which is responsible for Cu-Au porphyry mineralization in the Selogiri area (syn-mineralisation). Previous researcher discribed this intrusive rock as hornblende diorite (Suasta and Sinugroho, 2011) and medium diorite (Muthi et al., 2012). On the surface outcrops, it mostly shows weathered condition, but in some locations, especially in river wall, the pyroxene diorite still relatively fresh. Generally it shows gray colour in fresh condition (lighter than hornblende microdiorite), porphyritic texture (moderate-strong), having medium crystal size (0.3-2 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 %) (Sutarto et al.2015b).

The hornblende microdiorite is characterized by fine grained phenocrysts size (0.1-1 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 hornblende-pyroxene diorite. It is caused not only the amount of mafic but also due to the abundant of the secondary magnetite. Most of the hornblende microdiorite intrusive body altered to potassic zone and lack of prophyllitic and phyllic alteration types. Contact between hornblende microdiorite and hornblende-pyroxene diorite commontly is characterized by the formation of intrussive contact breccia (magmatic hydrothermal breccia). The peak part of the Randu Kuning hill is a representative of this intrusion type (Sutarto et al.2015b).

The quartz diorite has the brightest colors and the coarsest crystals sizes (0.8-3.2 mm), equigranular to weak porphyritic texture, characterized by the abundant of plagioclases (40-55 percent) and small quantities of quartz (4-7 percent) and alkali feldspars (2-5 percent) (Sutarto et al.2015b). 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 intrusions (Sutarto et al.2015b).

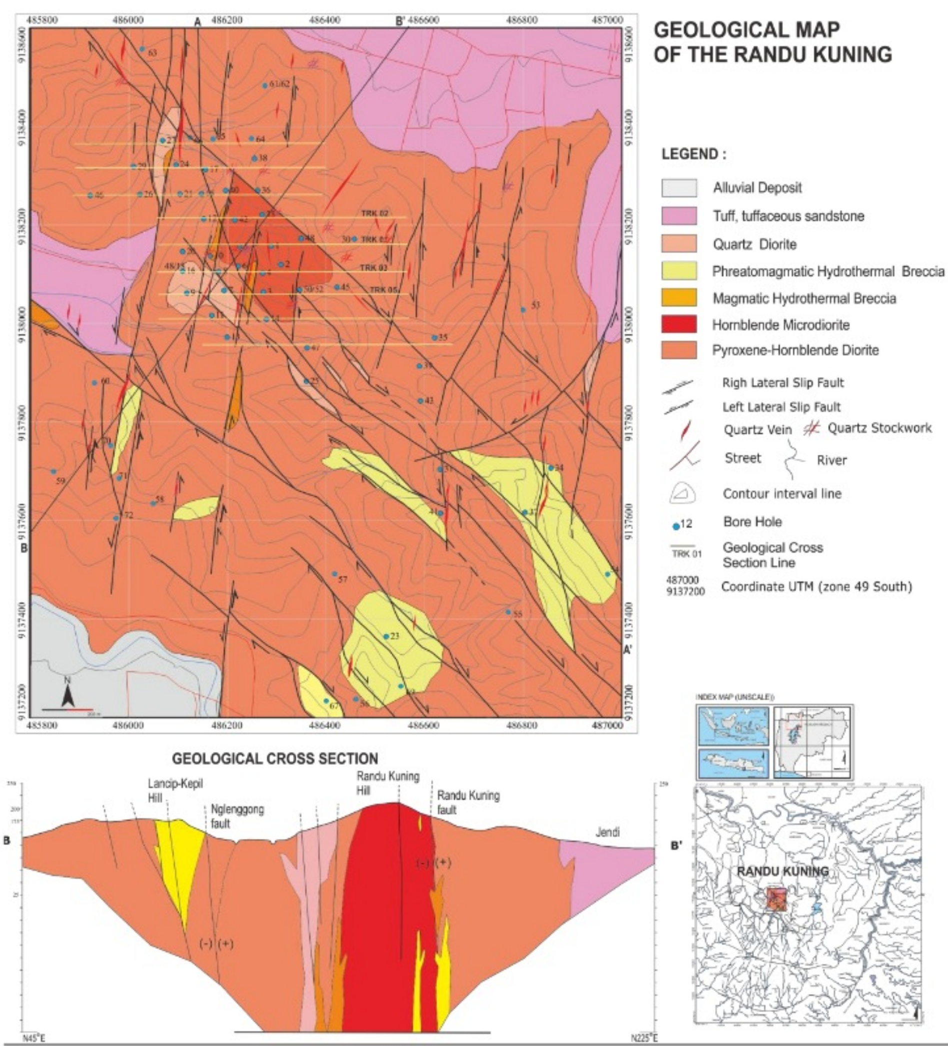


Figure 2. Geological map of the Randu Kuning area (Sutarto *et al*., 2015b)

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 in research area are characterized by various irregular body, 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. (Sutarto et al.2015b). Phreatomagmatic breccias exhibite, irregular dyke and pipe body, subvetical-vertical, fragments consist of polimictic 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 (Sutarto et al.2015b).

Major structures at the Randu Kuning area, dominated by relatively the NW-SE, NE-SW, and rare N-S trendings, cross cut all of the rocks in the area. The earliest and most dominant structures in the research area are the NW-SE dextral (right) lateral-slip faults, and commonly have a longer dimension rather than other trends. These structural trends then were crosscut by NE-SW and N-S sinistral (left) lateral-slip faults. The NE-SW and N-S trend mostly concentrated in the central area. Drilling 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 (Sutarto et al.2015b).

4. Hydrothermal alteration and Mineralization

4.1. Hydrothermal alteration

Alteration zones are generally controlled by the NE-SW and NW-SE trending structure. At least eight types of hydrothermal alteration at the Randu Kuning area had identified, i.e. 1). Magnetite+biotite±K-feldspar± chlorite (potassic) 2). Chlorite+sericite+ magnetite± actinolite 3). Chlorite+magnetite± actinolite± carbonate (inner prophyllitic) 4). Chlorite+epidote±carbonate (outer prophyllitic) 5). Sericite+quartz+pyrite (phyllic) 6). Illite+kaolinite±smectite (intermediet argillic) 7). Illite+kaolinite± pyrophyllite± alunite (advanced argillic) and 8). Quatz+chlorite (sillisic) zones.

The magnetite+biotite±K-feldspar± chlorite (potassic) 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 the present of secondary minerals assemblage i.e. one or both of secondary biotite and/or K-feldspar associated with magnetite, actinolite, quartz and lack of carbonate minerals (Suasta and Sinugroho, 2011; Corbett, 2011, 2012 and Muthi et al., 2012). Microscopically, biotite usually has dark-brown colour, fine grained, fibrous and present predominantly in the central part of the hornblende microdiorite intrusion and gradually will decrease to the edge part of the hornblende microdiorite and the part of pyroxene-hornblende diorite.

The chlorite+sericite+magnetite± actinolite is widespread on the upper part of the magnetite+biotite±K-feldspar±chlorite (potassic) characterizing by the dominant of chlorite and sericite, althought other secondary mineals such as magnetite, quartz, and sometimes actinolite are still found. The chlorite+sericite+magnetite± actinolite zone is developed on the small upper part of hornblende microdiorite. The chlorite+magnetite+±actinolit± carbonate alteration type is commonly recognised between magnetite+biotite±K-feldspar± chlorite (potassic) zone and chlorite+ epidote±carbonate (outer prophyllitic) zone. The zone mostly is widespread in pyroxene-hornblende diorite rocks, and within small part of hornblende microdiorite. In some places this alteration zones seen cut to minerals assemblage of the magnetite+biotite±K-feldspar±chlorite (potassic) zone and gradually outward changed to chlorite+epidote±carbonate (outer prophyllitic) zone. The chlorite+ epidote±carbonate, (outer prophyllitic) alteration zone is widespread on pyroxene-hornblende diorite rocks and small part of quartz diorite, gradually from the inner prophyllitic to least altered rock, comprising of chlorites, epidotes, carbonates and quartz. The illite+kaolinite ±smectite, (intermediet 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, kaolinite and smectite are the main minerals identified in the vein samples suggesting structural controlled argillic alteration (Muthi et al., 2012).

The illite+kaolinite± pyrophyllite± alunite (advanced argillic) is situated at the centre of Kepil hill, southwest of the Randu Kuning hill, comprising mostly illite, pyrophyllite, kaolinite, quartz and lack of alunite, carbonate and chlorite. The quatz+chlorite (sillisic) zone is restricted found at the fault zones, both within drilling core data and surface outcrop, consist of quartz, sericite, carbonate, clay minerals and opaque minerals. It is mostly related to the preatomagmatic hydrothernal breccia occurence of the epithermal system.
The sericite+quartz+pyrite (phyllic) alteration is commonly appear in the fault structure zones, locally overprint to the potassic alteration and inner 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).

4.2. Mineralization

Based on the characteristics of many parameters such as pattern and type of hydrothermal alteration, veins type, gangue and ore minerals assemblages, fluid inclusions, the Randu Kuning mineralization at Selogiri is likely porphyry Cu-Au to intermediate sulphidation epithermal Au-base metals. There are at least eight mineralisation prospects area at the Randu Kuning and its vicinity, they are Randu Kuning porphyry Cu-Au prospect and many intermediate sulphidation epithermal Au-base metals prospects including Bukit Piti-Tumbu, Gawe, Geblak, Jangglengan, Lancip-Kepil and Randu Kuning South prospects (Figure 10; Table 1). Most mineralizations in the researched area are associated with the present of some sulphides such as chalcopyrite, pyrite, pyrrhotite, bornite, sphalerite, galena, and chalcocite. The copper gold resource of the Randu Kuning porphyry prospect comprises 90.9 Mt at 0.35 g/t Au and 0.10% Cu, using a cut-off grade of 0.2 g/t AuEq (Nightingale, 2014).

4.2.1. Porphyry Cu-Au mineralization

Not all porphyry vein types contribute in copper and gold mineralization. The early quartz-magnetite veins (particularly A and M veins) generally not contain Cu-Au or barren, while the later sulphide bearing veins mostly are rich of copper and gold. Mineralization style recognised at the Randu Kuning area can be summarized as follows:

Figure 3. The landscape of some mineralisation prospect area in the Randu Kuning porphyry Cu-Au and its vicinity.

a) Quartz-sulphide veins mineralization. Some barren quartz veins are recognised in the deeper portion of some intrusions, and mostly associated with the present of magnetite but without sulphides (A and M veins) (Figure 4A-B). It may due to by the high temperature, during the veins were developed. Based on the fluid inclusions analysis of A and M veins, the temperature of hydrothermal fluid is at >600°C, it was not condition for gold-copper presipitations. 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 develope AB veins (formed by the filling at central termination within A veins by sulphides), C veins (chalcopyrite-pyrite veins) (Figure 4C,D,G,H). Stockwork AB vein cut by C style chalcopyrite vein in WDD8-1384m comprising 1 g/t Au; 2570ppm Cu (Corbett, 2012).

b) Disseminated sulphides mineralization. It were commonly found as disseminated chalcopyrite associated with magnetite-actinolite and magmatic hydrothermal breccias matrix (Figure 4E-F). Many of them comprising dessimination of chalcopyrite-magnetite-pyrite with quartz and actinolite. Disseminated magnetite-chalcopyrite mineralization in WDD18-336.9m comprising 102g/t Au;1080ppm Cu and in WDD8-148.3m contains 1.74g/t Au; 2550ppm Cu (Corbett, 2012).

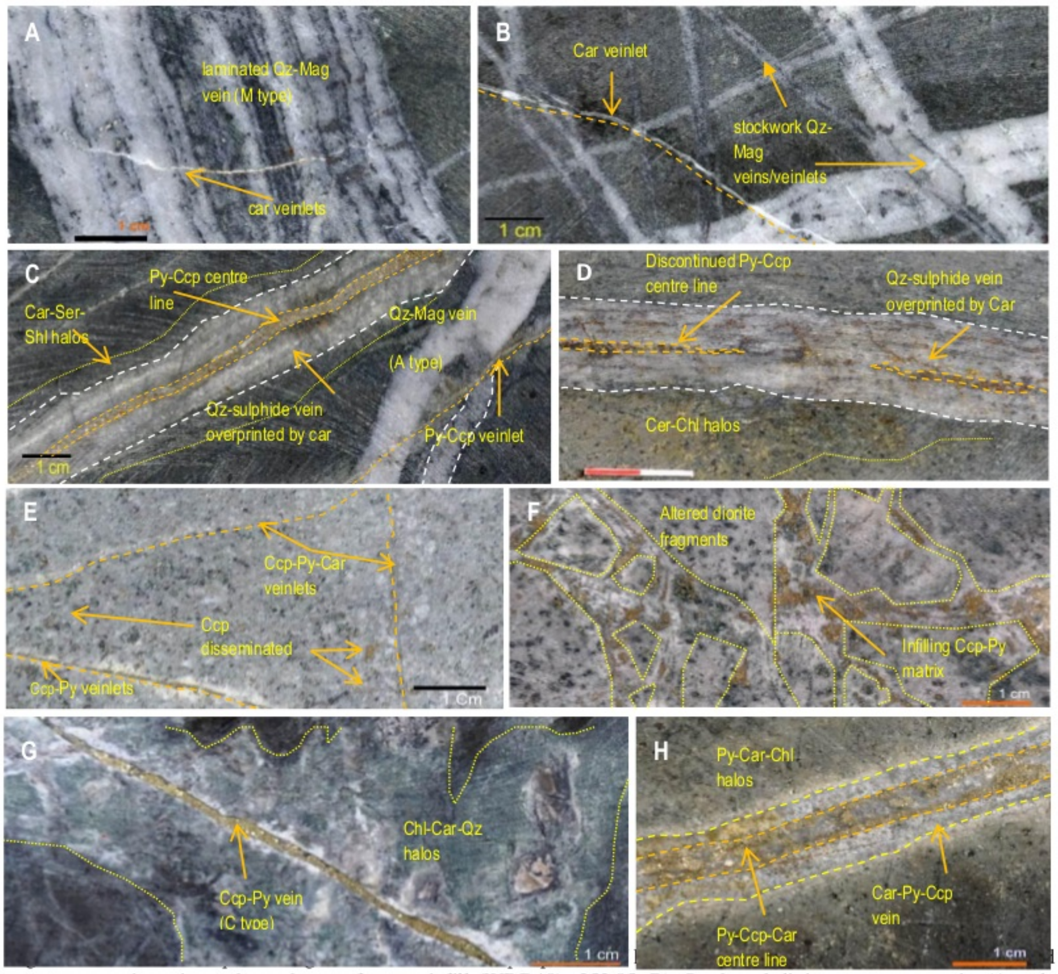
c) Quartz-sulphides-carbonate veins mineralization. This vein type comprise quartz, sulphides and carbonate or commonly is called as D vein with silica-sericite±pyrite alteration salvages (Figure 4H) . The D vein is distinguished to epithermal veins by width, banding/centre line as well as contact with the wall rocks. This vein is a latest vein in porphyry environment or may as a transition from porphyry to epithermal environment. The vein is commonly occured within fault zones, overprinting of earlier barren quartz+magnetite veins, quartz-sulphides veins and disseminated sulphides mineralization. It may contain Au to 5 g/t Au, 1.1 g/t Ag and 292 g/t Cu (in DDH WDD18-358.4m) (Corbett, 2011; 2012).

4.2.2. Intermediate sulphidation epithermal Au-base metals mineralization

In the Randu Kuning area, the intermediate epithermal deposits are co-existing with the porphyry deposit, therefore related to the intrusions rocks, abundant of the sulphides particularly sphalerite, pyrite, chalcopyrite and lesser of galena and tennantite, abundant many type of carbonate minerals (calcite, dolomite, magnesite). Vein associated with mineralization particularly is pyrite+sphalerite+chalcopyrite+ quartz+ carbonate vein.

Many sulphides, such as pyrite, chalcopyrite, sphalerite and lack of galena within open space hydrothermal breccia also have important role in gold-silver-zinc-lead mineralization, particularly in the epithermal environmment. Brecciated pyrite-carbonate vein in Geblag (WDD 54 depth 167-169m) contains 0.63-2.229ppm Au, 28.1-31.4ppm Ag, 784-1150ppm As, 0,45-0.65% Cu, 301-640ppm Pb and 0.054-0.57% Zn. In Jangglengan prospect, mineralization hosted both within altered hornblende-pyroxene diorite as well as hydrothermal breccia contain 0.82-20.8 g/t Au 3.5-20.7 g/t Ag, 0.38-0.62 % Zn, 0.02-0.14 % Pb.

Mineralization in this area was controlled by the present of quartz+pyrite+carbonate±sphalerite and epidote+carbonate±sphalerite ±pyrite veins associated with illite+kaolinite+quartz± smectite alteration zone. Gawe prospect, alteration and mineralisation was controlled by fault zone and hosted within hornblende-pyroxene diorite and hydrothermal breccia. Mineralization at the potential zone, comprising at about 0.2-0.5 g/t Au 0.05-0.12% Pb0.23-0.9% Zn and 1.2-8.0 g/t Ag associated with the present of quartz-carbonate veins and pyrite-carbonate-quartz-sphalerite cut of the earlier porphyry veins and pyrite-chalcopyrite dissemination. Whreas in Kepil-Lancip prospect, mineralisazation was associated with chalcopyrite-spaherite-quart-pyrite vein and carbonate centre line in Kepil area and quartz+pyrite+carbonate veins in Lancip area contain many precious and base metals in ranges 0.83-3.75 g/t Au, 1.3-4.2.g/t Ag, 0.05-0.28% Cu and 0.16-0.59% Pb. Drilling core sample in WDD 69 depth 87-88m comprising 0.89 Au, 2 ppm Ag, 895ppm Cu, 845ppm Zn, 51 ppm Pb and 117ppm As.



quartz-magnetite vein cut by carbonate fracture infill (WDD48) -252.85; B). Stockwork linier quartz-magnetite (A style veins) cross cut by carbonate veinlet (WDD48-227.20); C). B vein with pyrite-chalcopyrite centre line (left) and quartz-magnetite A vein cut by pyrite-chalcopyrite veinlet (C vein) (WDD30-427.30); D). AB vein with discontiued chalcopyrite-pyrite centre line (WDD19-84.55). Figure E and F are two type of disseminated sulphides mineralisation. E). Disseminated chalcopyrite-pyrite on prophylllitized hornblende-pyroxene diorite (WDD30-724.05); F). Disseminated chalcopyrite-pyrite within magmatic hydrothermal breccia (WDD 25-70.80). G).Prophyllitic-altered microdiorite cut by pyrite-chalcopyrite C style veinlets with silica-chlorite-carbonate halos (WDD26-273.15). H). Quartz-pyrite-carbonate D style vein with sericite selvage (WDD 45-335.50). Mineral abbreviations: Qz=quartz, Mag=magnetite, Car=carbonate, Ser=sericite, Ccp=chalcopyrite, Py=pyrite, Sph=sphalerite.

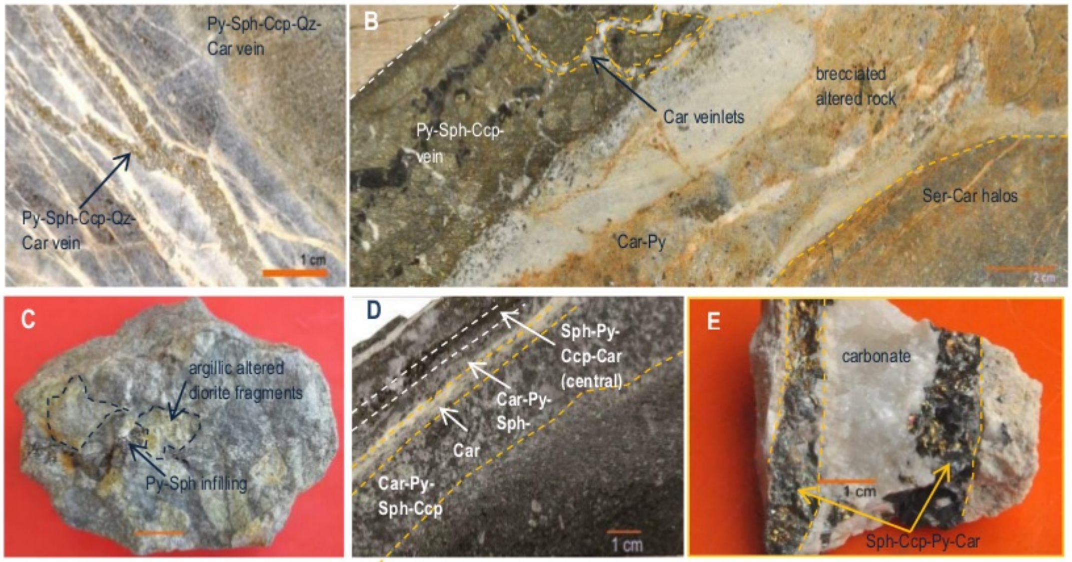


Figure 5. Epithermal veins type which contribute in Au-Ag base metals mineralization. A) Pyrite-chalcopyrite-silica-carbonate vein with sericite selvage (Location deep porphyry Randu Kuning, WDD 19-449.75). B). Pyrite-sphalerite-carbonate vein with sericite selvage (Location: Jangglengan, WDD54-156.80). C) Mineralization within the hydrothermal breccia at Jangglengan prospect; D) Sphalerite-pyrite vein with carbonate centre line (WDD 53-76.00) at Gawe prospect; E) Gold-base metals mineralization associated with chalcopyrite-spaherite-quart-pyrite vein and carbonate centre line at Kepil-Lancip prospect. Mineral abbreviations:, Qz=quartz, Mag=magnetite, Car=carbonate, Ser=sericite, Ccp=chalcopyrite, Py=pyrite, Sph=sphalerite.

5. Hydrothermal Fluid Evalution

The present type III fluid inclusion with the daughter minerals such as halite (NaCl), sylvite (KCl), hematite and possibly sulphide minerals suggest the increasing of fluid salinity. The salinity of type III are 16.24-74.01 NaCl wt.% eq. and the present type I (L+V) and type II (V+L) is a typical fluid inclusions found in porphyry environment (Nash ,1976). Temperature-salinity fields diagram below (Figure 15), pointed that temperature and salinity analysis of the Randu Kuning area ploted within porphyry and epithermal field. Vapor-rich two phase (type II) with temperature homogenous (Th) as high as type III that is from 318.4°C to >600°C, and has moderate salinity (16-24 Na Cl wt.% eq.), indicate that the singgle phase fluid separated into two phases i.e. a hypersaline fluid (brine) and a low-moderate density vapor. The present of liquid-rich two phase (type I) characterizing by liquid phase volume more dominant rather than vapor phase with majority homogenises at 250-350°C and salinity ranges 2.31-36.74 NaCl wt.% eq. indicated a boiling environment when fluid inclusions and minerals occurred. Based on the fluid inclusions data above, hydrothermal fluid evolution in the Randu Kuning porphyry Cu-Au, could be divided into three stag, that are:

Early Porphyry Stage

During generating to the surface, at temperatures around 600°C, the singgle phase fluid separated into two phases (liquid immiscibility) that is a fluid hypersaline (brine) and a low-density vapor. The hypersaline fluid is representated by the present of type III inclusion (polyphase), characterized by the present of liquid, vapor and solid (halite, sylvite, hematite and sulphides) phases with salinity around 16.24-74.01 wt.% NaCl eq, while the second one is represented by the present of type II (two phase), characterized by vapor more dominant than liquid with saliny range from 16 to 24 wt.% Na Cl eq. The existence of these two phases also have be identified from the fluid inclusions appearance in some porphyry ore deposit (Roedder, 1984), in which hypersaline fluid phase shows rich Na, K and Fe chloride elements liquid phase which characterize salinity between 35-70 wt% Na Cl eq. (Roedder, 1984; Nash, 1976), while the vapor phase is usually indicated by the content of acid volatiles, especially SO_2, H_2S, CO_2, HCl and HF (Giggenbah, 1992, 1997 in Sillitoe, 2010). The fluid related with the occurences of early stage quartz veins such as A type and M type and mineral assemblages of potassic alteration.

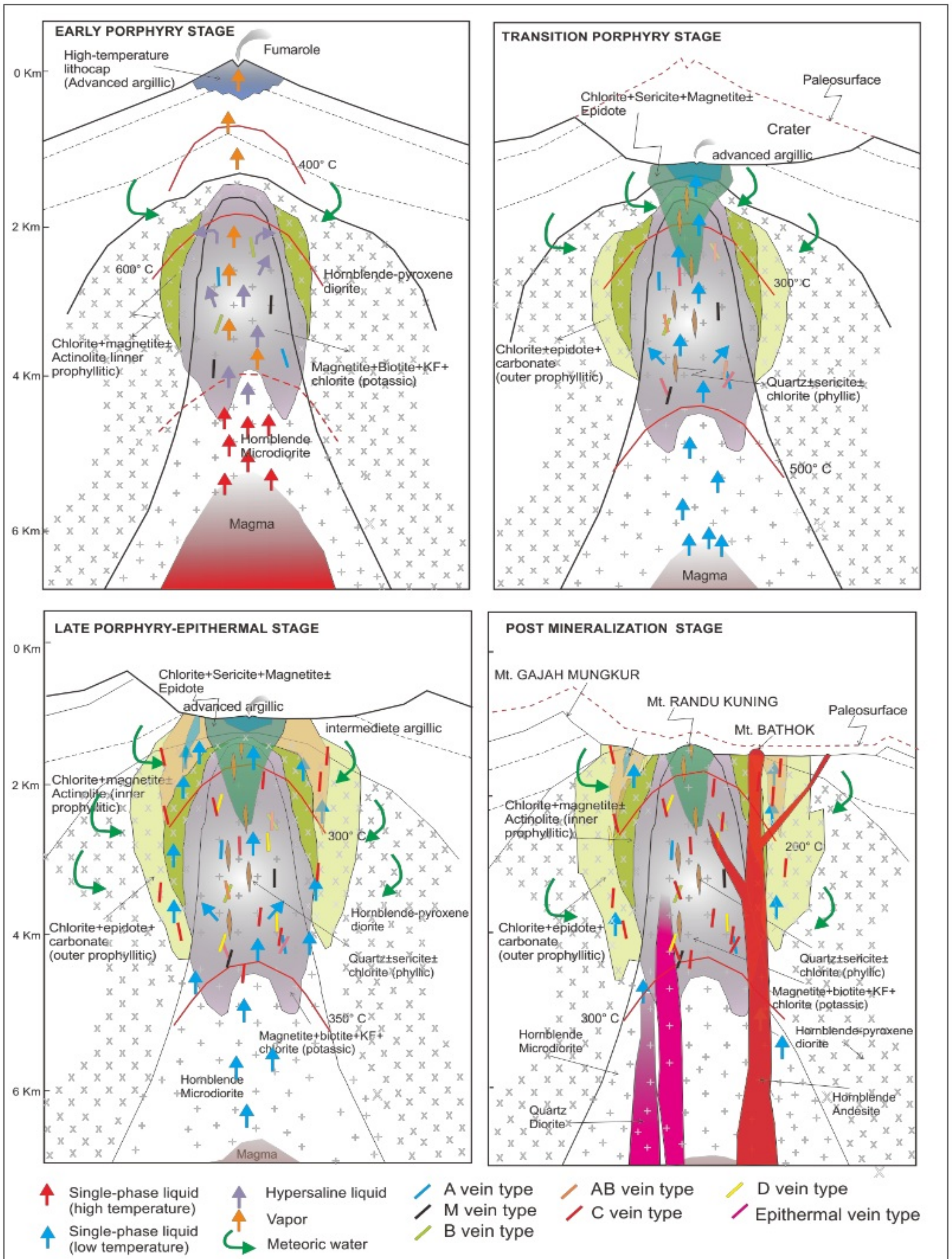


Figure 6. Schematic of hydrothermal fluid evolution, alteration zoning and veining development in the Randu Kuning.

Intermediate Porphyry Stage

Because of magma crystalisation continues to move to the deeper, and the magma fluid convection slowly disappears, characterized by reduced thermal fluctuations and fluid supply to the top, then the whole system will gradually grow colder, and igneous rocks that have formed on the top more widespread down and will be found many fracturing (Figure 6). In such conditions, single phase aqueous fluid (more water content) with low-medium salinity (16-48 NaClwt.%eq), the temperature began to drop (300°-350°C), then singgle phase immediately move towards the top, without separated to two phase. During generating to the surface, this fluid react with the existing quartz vein/veinlet stockworks, existing potassic alteration minerals, and rock permeability contrast will form sulphides bearing quartz veins (AB type and C type) and an alteration mineral assemblages particularly phyllic and chlorite-magnetite-sericite zone.

Late Porphyry Epithermal Stage

Due to the single phase aqueous fluid continue move toward the surface and laterally to the peripheral, reaction with meteoric and connate water more intense, the salinity became lower (2.31-36.74 NaCl wt.% eq) and the temperature also began to drop (200°-350°C). During generating to the surface, this fluid react with the existing veins and altered rock s will form pyrite-chalcopyrite bearing carbonate-quartz veins (D type) and carbonate-pyrite-sphalerite-chalcopyrite and other epithermal style veins as well as the development of outer prophyllitic, intermediet argillic and lack of anvanced argillic (Figure 6).

6. Conclusions

The mineralization type of the Randu Kuning prospect is co-existing of porphyry Cu-Au and intermediate sulphidation epithermal Au-base metals. The Randu Kuning porphyry Cu-Au is situated at the centre and surrounded by at least seven intermediate sulphidation epithermal Au-base metals prospects including Bukit Piti-Tumbu, Gawe, Geblak, Jangglengan, Lancip-Kepil and Randu Kuning South prospects.

Mineralization Cu-Au in the porphyry environment is associated with quartz-sulphide veins (AB and C veins), quartz-sulphides-carbonate vein (D vein) and disseminated sulphides, while mineralization in the epithermal prospect is pyrite+sphalerite+chalcopyrite + carbonate+ quartz veins and hydrothermal breccia matrix.

During generating to the surface, interaction hydrothermal fluid with wall rocks can be devided to three stages, i.e. early porphyry (hypersaline fluid at temperatures around 600°C) , intermediate porphyry (low-medium salinity at 300°-350°C), and late porphyry to epithermal stage (low saliniy at 200°-350°C).

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