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VEINS SYSTEM AND THEIR MINERALOGICAL AND MICROTHERMOMETRIC CHARACTERISTICS WITHIN THE HUMPA LEU EAST PORPHYRY COPPER-GOLD MINERALIZATION AT HU'U DISTRICT, SUMBAWA ISLAND, INDONESIA

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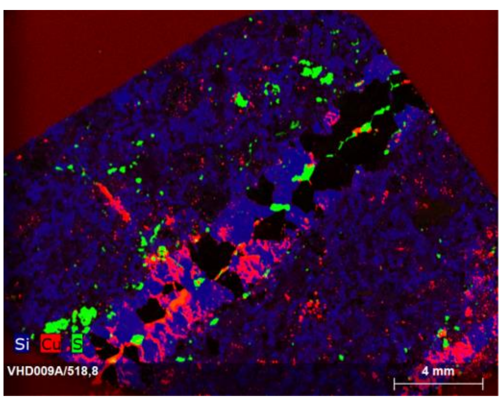
Graphical abstract



Abstract

The study area, i.e Humpa Leu East is a porphyry prospect located in Hu'u district, Sumbawa Island, Indonesia. This study is aimed to understand the characteristics of veins, the distribution of veins and mineralogy, microthermometric conditions of ore fluids, distribution of elements, and their implications for exploration and deposit model. The Hu'u district is a paleo-volcano member of the Miocene to Plio-pleistocene volcanic rocks. Hydrothermal alteration evolved to get out from the tonalitic body, consists of potassic, propyllitic and overprinted by phyllic and advanced argillic. The mineralization is dominated by chalcopyrite, associated with quartz±anhydrite veins, and hydrothermal breccia. Hydrothermal fluids temperature measured at the value of 109.9 °C - 525.3 °C and > 550 ° C with an averaging range of Th is 296.5 -329.7 °C, and salinity of 10.9 wt% NaCl eq. Quartz veins occur as a package or series of porphyry type veins designated as EDM-M1-A1, A2-A3-Apsb-anh, A3-A2, M2-Apsb-A2-A3, M1-B-C, C-D-anhydrite, and epithermal veins. Hydrothermal fluids possibly have mixed by high-temperature hyper-saline fluids to medium temperature low saline fluids. The Humpa Leu East can be identified as a 'push-up porphyry system' that still remains more extensive system underneath or in the side area. These results can be used for understanding the texture of veins as a vectoring to ore, metal distribution in veins and rocks. Early type veins such as type A have more intensive metal content and are followed by type B, C and weaken until the latest stage.

Keywords: Porphyry, ore fluids, mineralogy, Humpa Leu East, Indonesia

1.0 INTRODUCTION

The porphyry deposit type is one of the deposits that has an extensive mineralization system. It is always followed by other types such as epithermal, skarn, and sediment-hosted [1–4]. The alteration and mineralization of porphyry deposits are characterized by multiphase stockwork veins hosted by porphyritic igneous rocks [1, 3–5]. Hydrothermal systems generally formed in less than 1 million years, and it is tough to understand the time of their occurrence without proof of radiometric dating analysis [6–9].

This study takes place in Sumbawa island, administratively lies in Hu'u sub-district, Dompu district, Nusa Tenggara Barat province, Indonesia (Figure 1).

Figure 1 Location of the research area

In this district, there is a new discovery of Onto Cu-Au in 2013 [16]. The Humpa Leu East (HLE) is a porphyry prospect located only 2 km east from The Onto prospect, part of the Hu'u district. The Humpa Leu (East) prospect has 257 Mt resources potential with a grade at 0.2% Cu and 0.2 g/t Au [10].

The mineralization is located on the Tertiary or Oligocene to Pleistocene magmatic – volcanic belt of Sunda-Banda arc, especially at the eastern side [9], [11]. Hu'u complex has several detected prospects on the surface as low to medium metal's grade Cu-Au prospect, it is considerable as an epithermal style alteration. However, some detected prospects were associated with porphyry beneath the surface, such as Lere, Sori-Hiu and Humpa Leu (Aberfoyle 1997 in 12).

Hydrothermal fluid is an important factor in mineralization. It mostly form veins with various characteristics in each deposit. This study explores the characteristics of the veins as a result of hydrothermal processes in the porphyry system in HLE, based on drill holes data and laboratory tests. The purpose of this study is to understand the characteristics of veins, the distribution of veins and related mineralization, microthermometric conditions of the fluid, distribution of elements, and their implications for exploration and deposit models. The Humpa Leu porphyry is located in Hu'u that's have world class deposits that's have medium intens of the porphyry types mineralization. Therefore, the study of vein texture and hydrothermal fluids in the Humpa Leu East porphyry system as satellite porphyry associated with giant deposits can strengthen the existing model [5, 9], perhaps be a reference model to apply in other places, with related to island arc system, such as in eastern Sunda belt, Indonesia. This study is focused on the veins sample, which aims to determine the characteristics and paragenesis that occurs.

2.0 METHODOLOGY

The research uses several steps to interpret geological interpretation from surface alteration and lithological map. It is combined to subsurface from drillcore analyses and interpretation. First, samples were taken from 6 drill holes to analyze the geological model, focusing on 17 representative samples for fluid inclusion (FI), petrography, ore microscopy and micro-XRF elemental mapping analysis. The FI study was made on 182 inclusion data, including petrography and microthermometry using Freezing & Heating stage of Linkam TMS600 at the Laboratory of Mineralogy of PT. Antam - Unit Geomin, Jakarta. The stage unit can measure temperature between -190°C to 550°C, with 50 – 1,000 magnification. We use petrography and ore microscopy analysis with reflectance and polarized-light microscope at 40 – 1,000 magnification for textural and mineralogical analysis. Also, elemental mapping and qualitative mineralogy identification were analyzed by micro-XRF of Bruker M4 Tornado, which has an X-Ray beam size of about 20 microns and scanned at polished samples about 3 cm x 3 cm area for each sample. Observations of all fluid inclusions were carried out on the host mineral of quartz crystals in form of veins or veinlets associated with porphyry-type mineralization in HLE.

Table 1 Method types of laboratories analysis

No	Method	Equipment	Sample type	Resolution
1	Petrography	Olympus 31CX, Euromax reflectance microscop	Thin section	Max 1,000 times magnification
2	Ore microscopy		Polish section	Max 1,000 magnification
3	Fluid Inclusion	Lynsis 400	Double polished (<50 µm)	Tesr for -190°C to 550°C, max 1,000 magnification.
4	Micro-XRF	Bruker M4 Tornado	Polish section	20 µm in 3x3 cm area (1 million data each run)
5	Assay, geochemistry	ICP-OES/ICP-MS	Pulp	Major, trace element (ppm)

3.0 RESULTS AND DISCUSSION

3.1 District Geology of Hu'u

The Hu'u complex is a part of the eastern Sunda magmatic belt that has been known so far as the Oligo-Miocene belt [11, 13]. However, the latest research data shows the age of igneous rock from the Late Miocene to the Pleistocene. Especially, the ages of igneous rocks hosting several giant porphyry and high sulfidation epithermal deposits are younger than 5 Ma [9]. The relationship between the oldest rocks in the volcanic-magmatic rocks complex and ages of mineralization remain a question about the Sunda Arc system's geological evolution. The Hu'u district is interpreted as a paleo-volcano with the Upper Miocene Basaltic Andesite lava with radiometric dating shows 5 ± 0.2 Ma years old [14]. Regionally, all rocks in Hu'u area are the member of Old Volcanics Rocks Formation [15]. The earlier data by PT. Sumbawa Timur Mining shows that the volcanic rock possibly has developed as far back as 5.2 Ma. However, most ages for detrital zircons fall between 2.7 and 0.7 Ma. Meanwhile, the Onto mineralization in Hu'u complex is hosted in Pleistocene volcanic rock with age 0.838 ± 0.039 Ma to 0.038 ± 0.018 Ma [16].

The Hu'u complex is categorized as a paleo-volcanoes landform characterized by its evident remnant volcanic morphology and the drainage system. Hu'u is an ancient Caldera that creates explosions and makes several hummocky or volcanic single units that produce igneous-pyroclastics complex. Humpa Leu assumed that it occurs in the fourth phase of volcanic unit, that has built the lava to diatremes pipe and dikes of microdiorite in the surface. These are associated with an eroded stratovolcano (~40km²) within an NE-trending structural corridor. Pliocene andesitic volcanic rocks are intruded by diorite stocks. Argillic and advanced argillic lithocap alteration are extensive over an area >20 km² containing a minor outcrop of diorite porphyry. The Hu'u area and its surroundings are part of the remaining volcanic formations that have an experienced mature-level erosion, with an elevation of 0-1020 meters above sea level (masl). The topography of the Hu'u area is formed with rough relief, which is divided into plains, hills, to mountains with slopes influenced by lithology type, geological structure lineaments, and remnants of volcanic walls or escarpments. The Hu'u complex paleo volcanoes can be classified as Brigade, caldera-like remains volcanoes with several or multiple volcanic central eruptions in the post-stage of the caldera. At the west and north sides area, the morphology formed as plains, a slope of about 1-10°, which is on an elevation of 0-50 meters above sea level. This lowland is formed by alluvial deposits and coastal deposits and some undulating morphology composed of well-developed quaternary reef limestones on the west side of the distal part. The southern and eastern parts, especially those bordering the south coast, have slopes reaching 20-40° as a result of the control of resistant lithology such as lava formed in the southern part of the Brigade. The transition from plains to hills or mountains contrasts, by increasing slopes at elevations >100 masl. Some slopes are formed up to 50° due to river valley nicks and escarpments due to the structure. At the top, an elevation of 450-1020 masl, is a height with a topographic ridge pattern trending northeast-southwest where in the southwest, it has steep slopes reaching 50-67° in the Puma or Kajuji area (Figure 4.2b). The central part of the Brigade, or the central facies of the caldera, shows a local slope pattern of 30-50° increasing surrounded by random areas of slope <15°. That is influenced by lithological conditions, probably formed by lava flows, diatremes and pyroclastic deposits widely scattered in the middle and extensive hydrothermal alteration zones around Wadbura to Humpa Leu. The highest topography is in the elevation group >900 masl, which is the middle part of the remaining escarpment of the caldera, with a slope of 20-40°. This highest topography extends northeast-south and centred to the centre on an elevation of 1000-1020 masl.

The large lithocap in this area proves that giant deposits sleep beneath the surface, such as Onto deposits and still have several satellite mineralization such as Humpa Leu East. The relationship between the two prospects are obvious, even though it has very different characteristics. The Onto Deposits have very thick and large volume of intrusion and have retrograde alteration on top of the system; meanwhile, the Humpa Leu East is presented more simple. Both prospects are interpreted to have the same batholitic system that forms several porphyry kitchens at a shallow level. The concept of complex porphyry related to batholith with several porphyry kitchens is occurred in several deposits in the world [4]. Typically, each deposit has its degree of evolution to epithermal and degree of exhumation, for example, a large system of lithocap with or without epithermal mineralization.

3.2 Geology of Humpa Leu East

The Hu'u area and its surroundings are part of the remaining volcanic formations that have an experienced mature-level erosion, with an elevation of 0-1020 meters above sea level (masl). The topography of the Hu'u area is formed with rough relief, which is divided into plains, hills, to mountains with slopes influenced by lithology type, geological structure lineaments, and remnants of volcanic walls or escarpments. The Hu'u complex paleo volcanoes can be classified as Brigade, caldera-like remains volcanoes with several or multiple volcanic central eruptions in the post-stage of the caldera. The morphology of the plains area is located on the west and north sides that have a slope of about 1-10°, which is on an elevation of 0-50 meters above sea level. This lowland is formed by alluvial deposits and coastal deposits and some undulating morphology composed of well-developed quaternary reef limestones on the west side of the distal part. The southern and eastern parts, especially those bordering the south coast, have slopes reaching 20-40° as a result of the control of resistant lithology such as lava formed in the southern part of the Brigade. The transition from plains to hills or mountains is contrasting, by increasing slopes on elevations >100 masl. At the top, an elevation of 450-1020 masl, is a height with a topographic ridge pattern trending northeast-southwest, where in the southwest, it has steep slopes reaching 50-67° in the Puma or Kajuji area. The central part of the Brigade, or the central facies of the caldera, shows a local slope pattern of 30-50° increasing surrounded by random areas of slope <15°. It is influenced by lithological conditions, probably formed as lava flows, diatremes pipe, and pyroclastic deposits, widely scattered in the middle and extensive hydrothermal alteration zones around Wadubura Humpa Leu. The highest topography is on the elevation group >900 masl, which is the middle part of the remaining escarpment of the caldera, with a slope of 20-40°. The highest topography extends northeast-south and is centred to the centre on an elevation of 1000-1020 masl.

Humpa leu East (HLE) is part of the Hu'u volcanic system with typical lithology as volcanic product, lava, pyroclastic and diatremes, and spotted subvolcanic intrusion. The lithology of Humpa Leu East consists of andesitic domes, pre-volcanic unit (lava and pyroclastics), diorite, and quartz diorite to tonalitic intrusion at the depth (Figure 3). The lithological unit on the surface is seen as an interfingering of lava and pyroclastics; in lower elevations such as river or valley, the dioritic rock can be seen. Diorite of HLE has a porphyritic texture, with medium to fine crystal of groundmass, that's some position gradation to microdiorite and andesitic texture.

Igneous rock in the HLE prospect shows properties close to adakite (adakite-like), which has a fairly high Sr/Y ratio value with an average of 33.4 in the range of 2.6 – 221. Tonalitic intrusion or quartz diorite was founded by deep drilling in >100 m from the surface. The top of tonalitic intrusive rock only occurs on elevation 200 meters above sea level (m.asl) to the depth that's characterized pencil-like intrusive caused by the width of the intrusive body about 100-150 m narrow to depth. The early lithological system interpreted as pre-mineralization is formed by an intermediate or andesitic magma system, which can be seen from the distribution of volcanic rocks and andesite lava on the surface and below the surface. The presence of the diorite group is probably the product of early magmatic rocks that are similar to the lava and subvolcanic rocks-formed. The tonalitic intrusion phase indicates the presence of a later acid inclined magma system that is presented only as an intrusion below the surface, but does not produce extrusive rocks such as dacite or rhyolitic on the surface. The presence of quartz as a dacitic marker is seen as microcrystalline silica as a fragment in phreatomagmatic breccias, but it has not been found as single quartz characterizing acidic volcanic rocks. The tonalitic intrusion has a pencil-like shape or bulges above and thins inward, indicating the presence of magma movement controlled by tectonic.

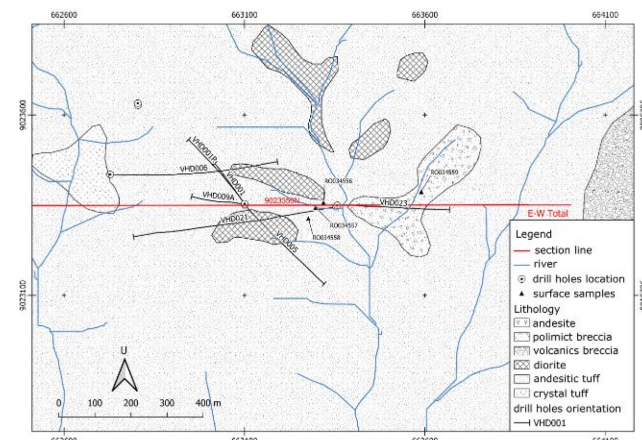


Figure 2 Geological map of Humpa Leu East, showing distribution of lithology, drill holes location and orientation, and east-west section of the red line [less modification from 10]

Geological structure plays a role in the porphyry system in Humpa Leu East. It is proved by many occurrences of micro and macro structures below the surface. The geological structure develops both before mineralization, along with mineralization and after mineralization. The direction and pattern of the structure were not observed in detail because there was no clear orientation data in the field. The number of wide gauge zones indicates the presence of the structure at several places. The present geological structures are also accompanied by alterations such as advanced argillic, sheeted veins, gypsum-quartz-carbonate veins, and strong fracture zones. The current geological structure is in the form of faults that tend to be vertical, in line with the direction of the intrusion and the direction of the phreatomagmatic breccia. Hydrothermal alteration processes generally follow the faults formed in the form of argillic and advanced argillic as a part of the epithermal mineralization system after the final porphyry phase.

3.3 Alteration and Mineralization

The Humpa Leu (East) prospect has 257 Mt resources at the grade of 0.2% Cu and 0.2 g/t Au [10]. The mineralization is affected by the distribution of veins which affects hydrothermal alteration zonation in intrusive rock bodies. Hydrothermal alteration evolved to get out from the tonalite body, consisting of potassic, propylitic, sericitic, argillic and advanced argillic.

Hydrothermal alteration developed as prograde alteration producing potassic and propylitic alteration, then overprinted by sericitic, argillic and advanced argillic alteration (Figure 3).

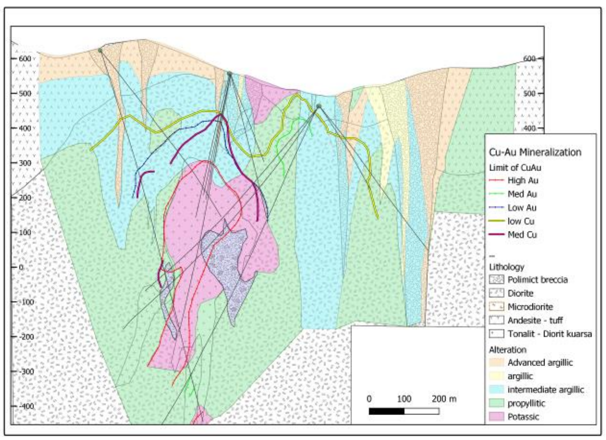


Figure 3 East – West section model of Humpa Leu East, showing alteration, lithology distribution and limit of Cu-Au mineralization [reinterpretation from 10]

The potassic alteration is characterized by mineral assemblage of biotite-chlorite-feldspar-sericite-magnetite followed by quartz-anhydrite-muscovite-sericite-chlorite-epidote-carbonate, with sulfide mineralization of chalcopyrite-bornite±digenite. Propylitic alteration is characterized by epidote-actinolite-chlorite-quartz and followed by phlogopite-sericite-magnetite-chalcopyrite and quartz-chlorite-sericite-calcite. The distribution of potassic and propylitic alteration is controlled by the distribution of tonalitic rock and several tectonized events in the bodies. The later mineralization was controlled by diatremes, fault zone alteration, and other destructive zones, which become the negative cone shape of sericitic – argillic and advanced argillic alteration. These alteration cut and overprint the earlier alteration in depth. Sericitic alteration is characterized by sericite-chlorite-illite and followed by epidote-anhydrite-gypsum-illite-kaolinite and sulfide minerals of chalcopyrite-pyrite±sphalerite. Argillic alteration is characterized by quartz-kaolinite-vermiculite-gypsum-calcite and sulfide minerals of pyrite-chalcopyrite. Advanced argillic alteration is characterized by alunite-dickite-pyrophyllite-kaolinite, and sulfide as pyrite-chalcopyrite-sphalerite.

The mineralization texture was controlled by the distribution of several veins and hydrothermal breccias, which have multiple phases of stockwork and parallel or sheeted veins. The veins are affected by ore hydrothermal fluids. The potassic alteration is strongly associated with mineralization in the HLE porphyry prospect. It is dominantly formed in tonalite rocks, hornblend quartz diorite and microdiorite. The potassic alteration comprises biotite-chlorite, plagioclase (albite-oligoclase), magnetite/hematite, quartz, and anhydrite, followed by muscovite/phengite, sericite, chlorite, epidote, and carbonate. The potassic altered rock has an average density of 2.66 g/cc with Cu content of 0.12% – 1.34%, Ag of 0.45 – 49 ppm, Pb <142 ppm, Zn < 845ppm, Na : 0.038 – 3.3% and the value of potassium (K) : 1.6 – 3.7%. The Sr/Y ratio in potassic altered rocks is 10 – 125, with Strontium values reaching 750 ppm.

The secondary biotite in HLE is mainly associated with chlorite, both in veins and disseminated in wall rocks. Chlorites occur as alteration minerals predate biotite. This biotite-chlorite replaces mafic minerals such as hornblende, primary biotite, and pyroxene in tonalite and diorite igneous phenocrysts and is scattered as granular crystals with quartz veins. Potassic alteration in HLE also appears to be associated with quartz-anhydrite and alumina-rich minerals such as feldspar (albite-oligoclase/plagioclase), muscovite, and some epidote. The presence of common anhydrite is associated with dispersed quartz both on the side rocks and in the veins. Chlorite is presented in the potassic system in HLE with clinochlore, chloritoid, and chamosite types interpreted to be presented with biotite alteration minerals, especially in the transition zone with propylitic. The overprint process is also seen by the addition of chlorite in the rock as a substitute for biotite and clay minerals such as vermiculite, kaolinite, illite as the final product. The characteristics of potassic alteration in HLE are similar to particular potassic alteration types in island arc magmatism, which are dominated by biotite and plagioclase, but have sulfate and carbonate systems as mineral associations. Carbonate minerals are presented by feldspar and anhydrite in moderate amounts. Biotite is visible in rock and quartz veins megascopically, petrographically and confirmed by XRD and SEM-EDS analysis. In XRD analysis, it was found that hydrothermal alteration biotite has biotite and phlogopite types associated with chamosite, chloritoids, clinochlore, magnesiochloritoid, as well as primary minerals that are presented as hornblende, ferro hornblende and diopside.

The dominant feldspar mineral present was plagioclase (albite-oligoclase), followed by potassium feldspar, which replaced the felsic minerals from the original rock, such as Tonalite and Diorite. Feldspar is spread in rock and veins, followed by minerals anhydrite, sericite, and some carbonates, which are visible on petrography and micro-XRF analysis. The presence of biotite is visible on SEM observations which appear to be closely associated with other alteration minerals such as sericite, plagioclase, and followed by metallic minerals such as magnetite, hematite and bornite. The type of biotite present is estimated as Fe-Mg biotite and Mg biotite (phlogopite), characterized by 5.5 – 11.5% Mg and 3.5 – 10.3% Fe in the minerals.

In the potassic phase, scattered biotite-feldspar alteration replaced the primary minerals, which formed chalcopyrite mineralization in the direction of type A quartz-anhydrite vein and biotite or biotite or EDM veinlet hairline. In some parts, potassic alteration is associated with the chlorite and epidote systems, which were formed simultaneously with biotite-feldspar and subsequent diagenetic. The distribution of chlorite appears to be strongly associated with biotite or phlogopite, which is then followed by the presence of sericite and clay minerals.

3.4 Vein Type and Package

Vein type tells more about the similarity of texture, physical characteristics, habits, and mineralogical assemblage. In the Humpa Leu East prospect, the quartz veins are divided into type A, type EDM, type M, type B, type C, and type D, followed by epithermal type or type E. The types A, EDM, M, are the types of veins interpreted as part of the initial phase to syn-porphyry, followed by mid to late phase of type B, type C and type D (fig 4). Type A is divided into several phases, namely A_1, A_2, A_3, and A_{psb} (pseudobanded), then type M is divided into M_1 and M_2. The epithermal type is divided into quartz-calcite, anhydrite-quartz and vuggy quartz. All of veins characteristics are distinguished by the difference in texture, distribution and crosscutting conditions. Each type A vein's area crosscuts each other in 2 to 3 times, then cuts but B, C and D veins.

The concept of "vein package" is a simple idea for an easy interpretation of paragenesis and sequences of mineralization. A vein package is a picture of veins groups that forms relatively at the same time. The quartz vein of HLE porphyry system has occurred as a package or series in the system, and it's interpreted from a simply crosscutting concept. This idea is based on the fact that not all mineralization is formed once involving vein-type from early to late phase. However, veins are formed several times and in condition that tend to be complex. In HLE porphyry, the package or series of quartz veins can be divided into EDM-M_1-A_1, A_2-A_3-A_{psb}-anh, A_3-A_2, M_2-A_{psb}-A_2-A_3, M_1-B-C, C-D-anh, and E-anh. Which "E" or epithermal vein and "anh" for anhydrite vein. The hydrothermal breccia possibly also controls the distribution of anhydrite and magnetite rich veins in mid and late stage of porphyry.

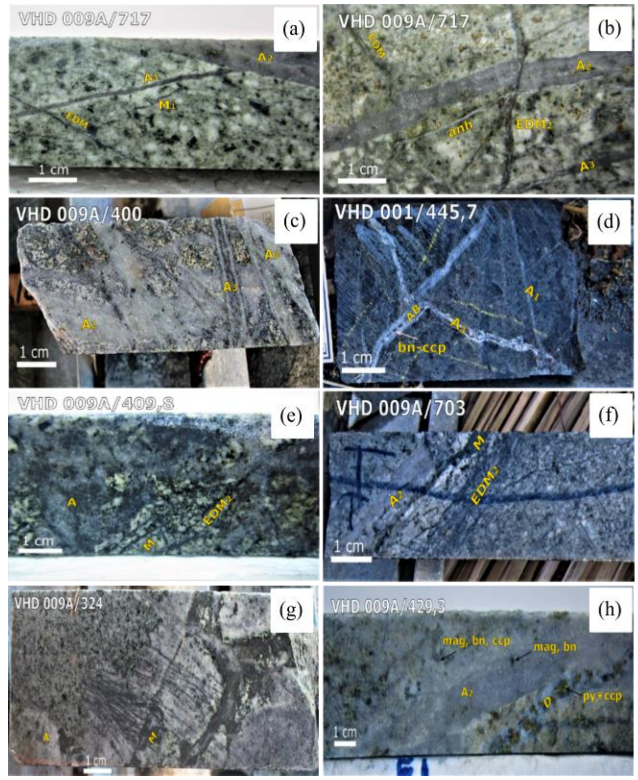


Figure 4 The vein types and the package or series of veining systems occurs in the Humpa Leu East porphyry mineralization. This package or series will be more complex if the hydrothermal system is more intensive. (a) Package of A_1-EDM-M_1 cuts buy A_2 in potassic alteration, (b) package of A_2-A_3-anh cuts by EDM, (c) thicks vein of A_2 cuts by A_2-A_3 parallel veins, (d) stockworks system of of A_1 and A_3 or AB, (e) package of A vein and EDM-M_1 veins, (f) parallel orientation of A_2-M-EDM, (g) package of A and M_1 veins, (h) the late stages of vein D with parallel orientation with A_2

3.5 Characteristics & Microthermometry of Quartz Vein

The mineralization is strongly influenced by hydrothermal fluids that form a quartz-anhydrite in HLE which is divided into quartz veins, anhydrite veins, hydrothermal breccias and epithermal veins. Quartz veins are an important part of the mineralization system of the Humpa Leu East area, that is common in porphyry type ore deposits. The definition of the vein itself in the porphyry type is all cracks filled with hydrothermal minerals such as quartz or sulfide, with dimensions in millimetres and centimetre scales. This is different from the definition of deep epithermal veins above 10 cm or even on a meter scale. The use of the term vein in this research refers to the sequence and type of vein in porphyry and its relationship to hydrothermal alteration by Gustafson & Hunt (1975), Masterman et al. (2005) dan Galanopoulos et al. (2018). In this paper, we use some modification for vein names to simplify the following explanation.

3.5.1 Type A

Type A is a part of early stage, as frequently encountered vein type in HLE porphyry, with granular or mosaic texture minerals associated with potassic alteration in tonalitic rocks. This type is the main type of porphyry mineralization associated with ore minerals such as chalcopyrite, bornite, digenite, covellite, and magnetite. This type is divided as type A_1, A_2, A_3 and A_{psb}, with the description as below.

(i). Type A_1 : is a thin quartz vein or hairline texture with less than 1 mm contained quartz-anhydrite and is surrounded by magnetite dan biotite (figure 5).

(ii). Type A_2 : is a common quartz type found in HLE. It's characterized by granular texture, the composition of quartz-plagioclase-anhydrite and muscovite-biotite-chlorite-chalcopyrite-bornite-magnetite±digenit±covellite (figure 6). These types are about 5-15 mm thick, with irregular to straight orientation cutting A_1 dan EDM or M.

(iii). Type A_{psb}; is the vein with a parallel structure to sheeted that is cutting all early veins. It is interpreted and controlled by geological structure at syn to mid porphyry stages. The vein's internal structure is characterized by pseudobands or laminated of oriented granula quartz and alignment of mafic minerals such as biotite, chlorite, magnetite, chalcopyrite, and bornite (figure 6g-i).

(iv). Type A_3 ; is the veins that are cut other type A vein such as A1 and A2, with granular oriented texture. It creates a pseudo line in centre part (centerlines); composed by quartz-anhydrite-chlorite and chalcopyrite-bornite±molybdenite mineralization. This type is called A family or AB in Gustafson & Hunt (1975), with less sulfide in the central part of the vein, on the other hand, sulfides are dispersed in between other minerals inside veins. The thickness of vein is approximate between 0.4 – 2 mm (Figure 7)

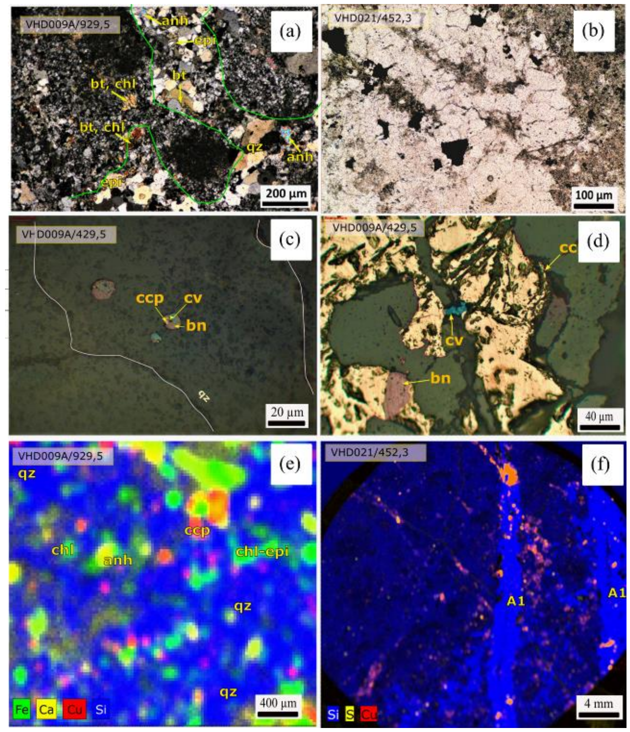


Figure 5 Mineralogy distribution of type A_1, showed by petrography, oremicroscopy and micro-XRF analysis. (a) in XPL view of quartz vein of VHD009A at 929 m depth, shows irregular vein margin with mineralogy composition consisted of quartz-biotite-chlorite-anhydrite-opaque, (b) PPL view of vein A1 of VHD021 at 452 m depth, shows distribution of opaque and mafic mineral inside vein, (c) ore microscopy of picture A, shows bornite-covellite-chalcopyrite in fine grain between quartz, (d) other view coexist mineral of chalcopyrite-bornite-covellite with quartz, (e) elemental distribution of Fe-Ca-Cu in vein, (f) distribution of silica as veins in potassic rock of VHD021 at 452 mm depth, shows distribution of copper sulfide both in vein and wallrock

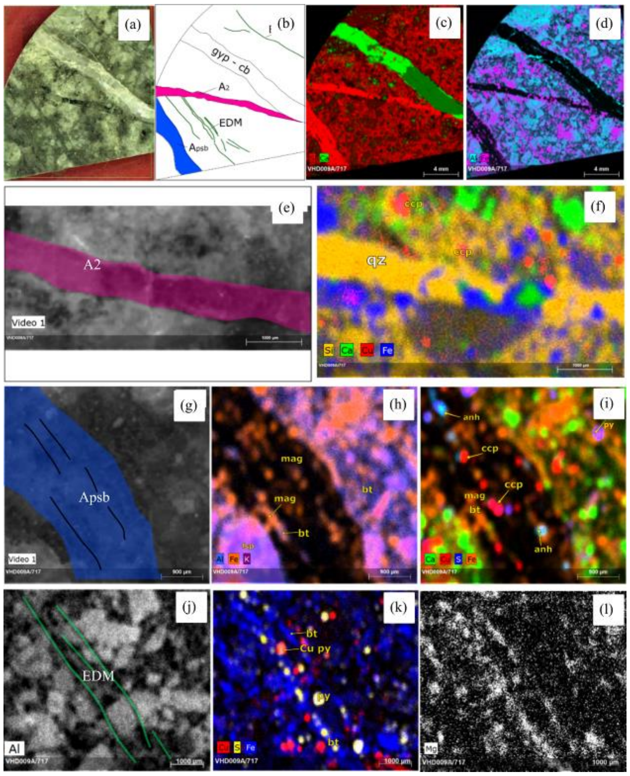


Figure 6 Stockwork of quartz vein series shows A_2 – EDM cuts by Apsb and late stage of epithermal (gypsum-carbonates). (a-b) shows the crosscutting of vein package and type of vein in HLE, (c-d) distribution of element associated with veins, (e-f) vein type A_2 with thicknes less than 1 mm, elemental distribution of silica and ferum as indicating quartz and Fe rich silicates or oxide and sulfides mineral inside vein, with dominant as disseminating mineral in altered hostrock , (g-i) vein type A_{psb} with thicknes 1-2 mm, shows elemental bands or lines of Fe-rich minerals such as biotite, magnetite, and chalcopyrite and spotted anhydrite inside veins. (j-l) vein-type EDM shows as very fine lines that's composed of Fe-silicates such as biotite-chlorites and Fe rich sulfides such as chalcopyrite and pyrite. Abbreviation ; qz (quartz), gyp (gypsum), mag (magnetite), py (pyrite), ccp (chalcopyrite), anh (anhydrite), bt (biotite)

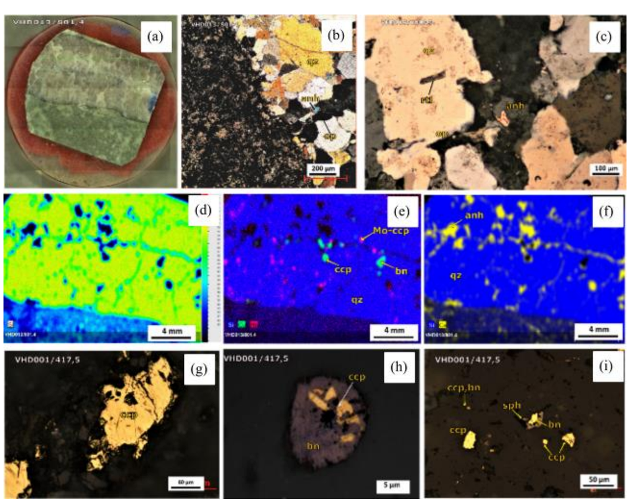


Figure 7 Texture and mineral assemblage of quartz vein type A_3. (a) samples of VHD013/801,4 shows granular texture with pseudo centerlines. (b-c) texture of granular quartz, followed by anhydrite and opaque minerals. (d-f) micro-XRF elemental mapping data of VHD013/801,4 shows mineral assemblage in vein quartz as chalcopyrite (ccp) – bornite (bn) – molybdenite (mo) and anhydrite (anh). (g-i) ore microscopy of VHD001/417,5 shows chalcopyrite as a single mineral and also coincides with bornite. Sphalerite (sph) occurs trace in this sample.

Fluids condition of quartz vein type A, as an early porphyry mineralization bearing veins, occurs as a high temperature mixing of fluids to medium temperature and from high salinity to medium and low salinity. This type A has a lot temperature of homogeneity upper than 550°C, characterized by occurrences of multiphase inclusion (figure 8). From data below 550°C, we can assume the temperature and salinity decrease at A_1 - A_2 - A_3 phase, then relative stable in Apsb about 286°C and 11 wt% NaCl eq. Both A_1 and A_2 have similar pattern of fluids, characterized by occurrences of hypersaline fluids and low saline fluids in the vein as a long range mixing of temperature (Table2, figure 9).

Table 2 The temperature of homogeneity and salinity data from the quartz vein type A in HLE porphyry

ThL-V (cal)	A_1	A_2	A_3	A_{psb}
Mean	303.0	300.7	296.4	286.6
Minimum	193.7	185.6	254.5	253.6
Maximum	475.0	470.7	489.4	369.4
wt% NaCl eq.	A_1	A_2	A_3	A_{psb}
Mean	26.5	15.3	14.3	11.0
Minimum	1.4	0.7	9.6	6.2
Maximum	57.8	60.4	24.2	18.6

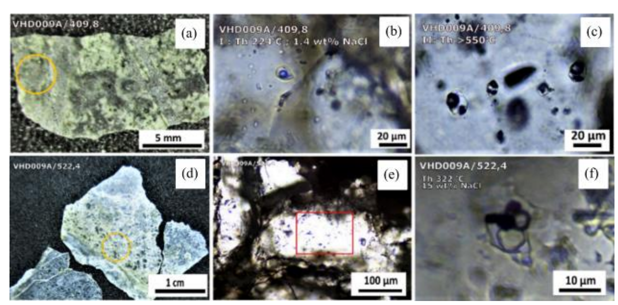


Figure 8 Fluid inclusion of vein quartz type A. (a-c) double polish samples of VHD009A/409,8 shows intensive veins A_2 and A_1, (b) biphase inclusion of medium temperature fluids, shows temperature of homogeinity about 224°C with only 1.4 wt% NaCl. It is possible as part of meteoric water influence in this system, (c) multiphase inclusion with 1 – 2 daughter minerals as chalcopyrite and haematite, with temperature more than 550°C. (d) Samples of vein A3 with granular texture of quartz and anhydrite. (e) trails of inclusion or bubble as primary inclusion in quartz crystals, (f) Multiphase inclusion with chalcopyrite and magnetite haematite as daughter minerals, show medium temperature and salinity, 332°C and 15 % wt NaCl equivalen

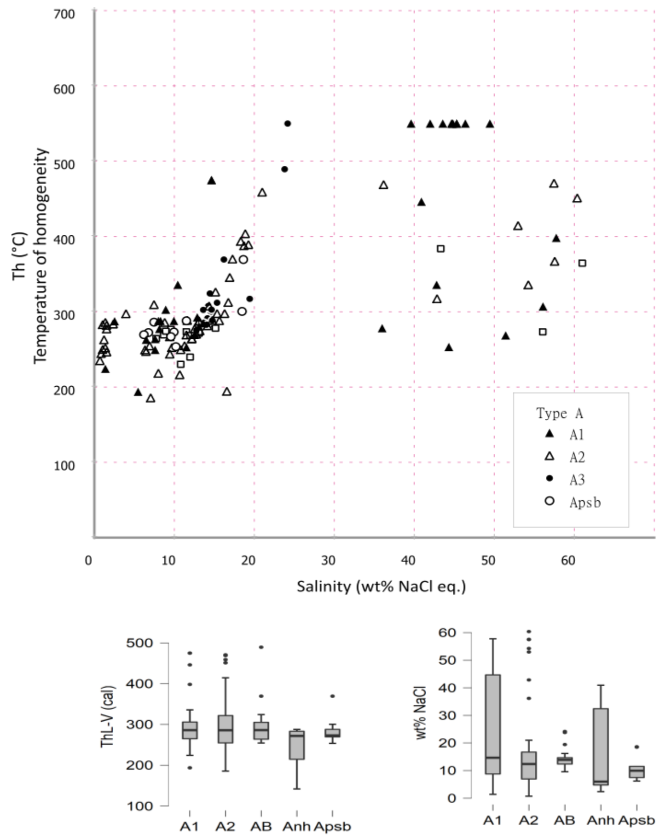


Figure 9 Quartz vein type A from fluid inclusion analysis of HLE porphyry, shows a relative derivation of temperature and salinity

3.5.2 Type M and EDM

Type M is a vein that dominantly composed by magnetite or hematite and other minerals that makes it darken the colors. This type is divided into two types. The first is type M_1 as a hairline magnetite veins (less than <1mm) composed by magnetite-hematitet±quartz±bornite-chalcopyrite, and type M_2 with 5-12 mm thick approximately, granular texture and centerline with arrangement of some ore minerals such as magnetite-hematite-chalcopyrite-bornite and some pyrite and sphalerite. The M_1 is associated with EDM and A_1. Meanwhile, M_2 is associated with some crosscutting relationship of A_2 (figure 10). Type EDM is part of the early stage veins system with and types, with less than 0.5 mm thickness (hairline) consisted of biotite-chlorite-magnetite and more minor quartz. It mostly appears as sheeted hairline texture and some irregular lines associated with magnetite rich hydrothermal (see figure 6, j-l). These veins occur in early to mid porphyry mineralization that occurs as a high-temperature mixing of saline fluids with opaque rich with temperature about >550°C - 320°C; high saline fluid is about 56 – 61 wt% NaCl equivalent to a medium temperature that is about 276 °C and salinity that is about 11.6 wt% NaCl equivalent. The veins type EDM – M_1 relatively occurs in lower temperature than M_2, or this M_2 possibly occurs in a different stage with M_1.

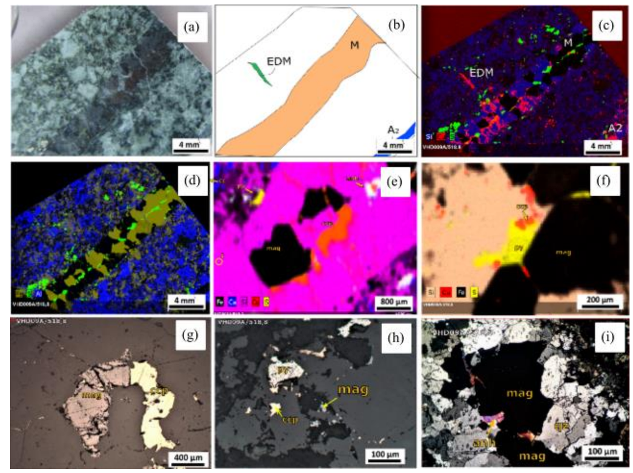


Figure 10 Quartz vein type M_2 cuts EDM and the distribution of associated element, in sample VHD009A/518,8. (a-b) sample and sketch of vein M_2 in tonalitic rock, show a parallel association with A_2 that is perpendicular with EDM, (c) Distribution of Cu-S and silica show mineralization distribution affected by veins, (d-e) Magnetite as pre-minerals in M_2 veins and chalcopyrite-pyrite growth in between magnetite. (f) it shows the sulfide distribution (green colour) inside the M_2 vein and it affects the wallrock. (g) Silica distribution is interpreted as a quartz, of M_2 vein and A_2 vein

3.5.3 Type B

Type B is a part of a mid-stage system characterized by continuous straight veins consisted of quartz-anhydrite±biotite±chlorite±carbonates and sulfide centerline (Figure 11a-c). The sulfide occurs as chalcopyrite-pyrite-bornite- sphalerite ± magnetite, some parts cut by pyrite veins (figure 11d-f). Gold was found as an inclusion in bornite associated with pyrite-chalcopyrite between quartz crystal. The characteristic of vein-type B looks the same as Apsb or A_2, with mozaic texture of quartz crystals and spotted anhydrite. In type B, the sulfides look to have an orientation placement in the central part of veins. Some parts have a massive chalcopyrite that fills the parallel lines between quartz crystals. Mineralization formed in vein B which is part of the mid-porphyry stage, looks more intensive than other types. It is proved by occurrences of high sulfidation state that sulfide such as bornite with gold inclusion will be followed by chalcopyrite. The ore minerals' size in this type looks coarser than the other veins. However, in general, because the accumulation of type B is not dominant in the HLE porphyry system, the Cu and Au mineralization are not affected.

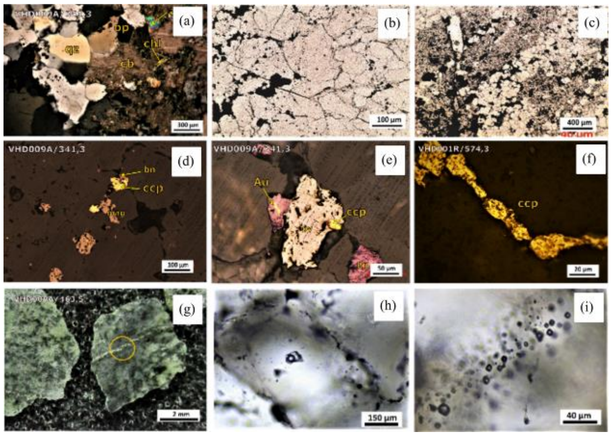


Figure 11 Microphotograph of quartz vein type B. (a) XPL view of VHD009A/341.3 shows quartz, anhydrite, chlorite, carbonates, and opaque mineral mineralogy. (b-c) PPL view od VHD009A/417.5, shows opaque mineral orientation in quartz vein, sample VHD009A/409 (d-f) ore microscopy of vein type B, shows chalcopyrite (ccp) parallel orientation with bornite, magnetite, pyrite. (g) megascopic sample for fluids inclusion analysis shows centerline of sulfide in quartz vein, (h) quartz crystal texture and the inclusion, (i) trail of monophase inclusion

Hydrothermal fluids condition of type B was dominated by a trail of monophase or vapour rich fluids even though there are still abundant of biphase or multiphase inclusion (Figure 11-i). From the analysis that is carried out on biphase inclusion type B veins, it was found that the temperature and salinity is 428°C and 37 wt% NaCl eq in average (Figure 12). The temperature and salinity of type B tend to be higher than A vein and other types. It's not common to be occured in a porphyry copper environment, it is possibly caused by dynamics of intrusion and tectonic in this area. The daughter minerals in multiphase inclusion consists of chalcopyrite and other sulfides associated with halite-sylvite and low-density vapour. Most inclusion occurs as a single inclusion in central quartz crystal, surrounded by monophase vapour rich inclusion.

3.5.4 Type C

Type C is a part of mid-stage system, that's characterized dominantly straight veins composed by copper sulfides such as chalcopyrite- pyrite ± bornite in 0.5 – 2 mm, cuts all early system (figure 13a). The thickness of this type is between 1 – 5 mm with narrow sericitic-chlorites alteration selvage. Chalcopyrite in this phase shows a single and massive mineral in veins, replacing early magnetite, also as enveloping and filling fracture or pores between pyrite crystals. The element distribution associated with veins is Cu-S-Fe as an evidence of chalcopyrite and pyrite, replacing the early mineral in wall rock (figure 13b-c). Distribution of mineralization shows the only chalcopyrite-pyrite package spotted with sphalerite. Another copper sulfide occurs as an early phase in wallrock and vein, such as type A and EDM. The mineralization effect of type C possibly occurs as a new veinlet and also replaces the centerline of other types (Figure 13d-f). For implication, it makes Cu content increased in samples. The vein associated with quartz spotted anhydrite and chlorite is replaced by minerals in vein contacts with wallrock (figure 13g). In the HLE porphyry system, this vein type is not common because of the low intensive mineralization in the mid to late system.

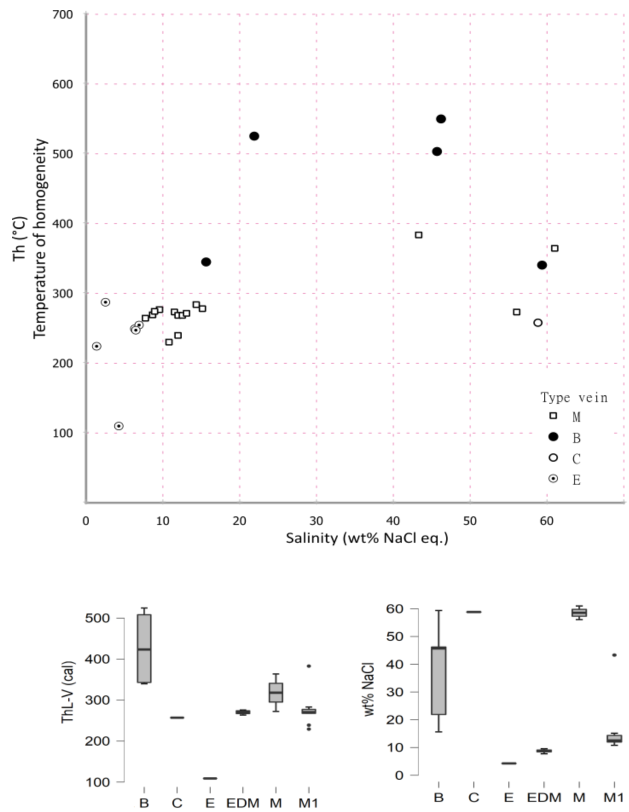


Figure 12 Temperature and salinity data of quartz vein type B, C, E and M of HLE porphyry. Type B shows a relatively high temperature than other types

Hydrothermal fluids in this type occur as a multiphase that is more dominant than biphase, with the daughter of opaque minerals and associated with halite-sylvite. The inclusion was a free inclusion in quartz crystal and a trail with monophase inclusion (Figure 13e-f). The temperature and salinity of this vein type are around 276 °C and 13 wt% NaCl eq. with one sample shows that hypersaline phase with salinity 58 wt% NaCl eq. This indicates that the temperature and salinity of the fluid are in the intermediate stage, which is close to the temperature of the most common type A in the HLE porphyry system.

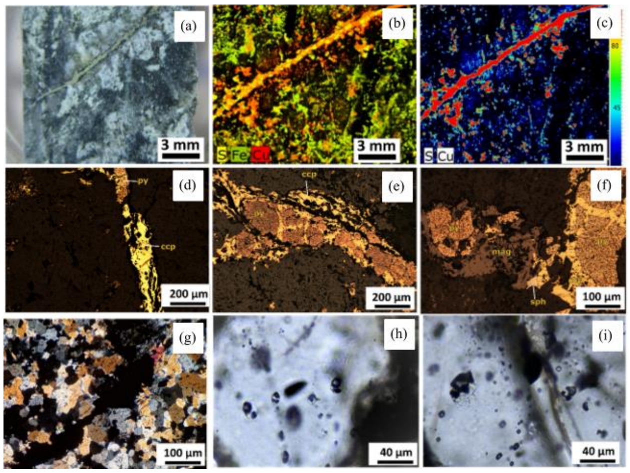


Figure 13 Characteristics of texture photography, mineralogy, and fluids of vein type C. Sample VHD009A/409.8, (a) megascopic view of polished samples shows that sulfide lines cut rocks and other early mineralization textures, (b-c) micro XRF analysis shows that elemental distribution of veins and copper ferrous minerals that are consistent with the distribution in veins and replaced some minerals in between, (d-f) ore microscopy of vein C, shows chalcopyrite – pyrite is associated and replaced earlier by the system such as magnetite, (g) XPL petrographic view of vein C, shows that mozaic or granular texture vein of type A was cut by irregular veins of opaque ± anhydrite, (h-i) characteristics of inclusion in type C

3.5.5 Type D

Type D is a part included as a final-stage system, that's characterized straight veins composed by pyrite – quartz – sericitic clays. This vein is characterized with narrow selvage of sericite - clays that are in contact with the wallrocks of vein and sulfide texture as a coarse grain to accumulate minerals (figure 14). Some samples look associated with chalcopyrite in the same quartz vein. Orientation of the distribution was irregular with the cut of 5 – 20 mm thickness at the earlier system. This type of vein is rare in depth of the system, possibly common in near surfaces associated with late porphyry stage in the upper system.

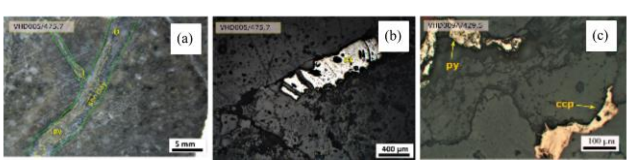


Figure 14 Characteristics of vein-type D in samples VHD005/475.5, (a) megascopic view of irregular vein in pyrite is surrounded by sericitic clays. (b-c) microscopy of vein type C shows massive pyrite in line with vein orientation and between the quartz crystals associated with chalcopyrite

3.5.6 Type E

Type E is an epithermal veins, with the composition of anhydrite-gypsum or quartz-gypsum-carbonates followed by argillic alteration and fragmented by vuggy quartz in an advanced argillic alteration. Mineralization in epithermal veins dominantly consists of pyrite and least of copper sulfide such as chalcopyrite. The thickness of epithermal veins is centimeter scales to meter scales followed by clay-alteration haloes. Hydrothermal fluids condition of epithermal vein has medium to low temperature with low salinity (see figure 15). The temperature and salinity of epithermal veins are between 190°C - 287°C and 1.3 – 6.9 wt% NaCl eq. These fluids are possibly a factor that the mineralization in epithermal stages of HLE seems to be a pyrite-dominant than base metal or copper sulfosalt, even though it occurs in acid alteration system that is characterized by the occurences of vuggy quartz and advanced argillic alteration.

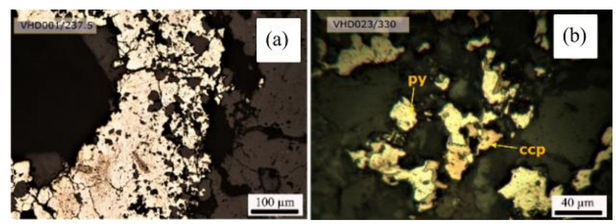


Figure 15 Ore microscopy analysis of epithermal mineralization, (a) vuggy quartz with pyrite, (b) disseminated pyrite – chalcopyrite

3.6 Other Types of Hydrothermal Texture

3.6.1 Anhydrite Veins

Anhydrite is a mineral that is always found in every phase of mineralization in HLE, either in dissemination on side rocks with quartz in veins, hydrothermal breccias, or as massive veins in the final phase. Anhydrite veins associated with quartz veins of types A and B have dimensions of 5-15 mm that cut across the previous system, whereas massive veins have 5 cm to 2 m thickness. Anhydrite veins cut the porphyry mineralization phase from the beginning to the end. Anhydrite veins in the early phase appear to be associated with barite, quartz, pyrite, sphalerite, and chalcopyrite which are also commonly recrystallized to gypsum. In the mid-phase, anhydrite veins look thicker and associated with hydrothermal breccia and bearing sulfides, such as pyrite and chalcopyrite. Analysis of anhydrite vein with micro-XRF and SEM-EDS shows variation of oxygen percentage in mineral calcium sulphate mineral interpreted as anhydrite and gypsum (table 3). Anhydrite is sometimes cut by gypsum in the next stage and growing together in veins.

Table 3 Geochemistry of anhydrite / gypsum, as vein and disseminated in wallrock

No	O	Si	Na	Al	S	Ca	K	Fe
1	74.2	4.10	0.80	1.10	10.7	8.99		
2	68.2	11.41		0.80	10.2	9.31		
3	77.3				12.2	9.70		
4	71.5	1.50	0.90		14.5	11.51		
5	12.2	0.05	0.00	1.46	21.7	28.84	0.01	0.01
6	30.6	0.02	0.00	2.18	16.2	20.11	0.05	0.00
7	48.9	0.04	0.00	0.39	19.3	20.93	0.00	0.02
8	40.7	0.03	0.00	1.15	17.2	21.02	0.37	0.03
9	76.3	0.00	0.32	0.71	15.0	14.06	0.22	0.00
10	63.0	0.01	0.42	0.63	16.4	17.53	0.25	0.00
11	39.4	0.25	0.86		21.3	38.7		
12	59.3	0.25	0.7		18.7	21.1		
13	69.4				14.2	15.54		
14	70.6	0.4		1.7	13.9	13.0		0.2
15	25.4	0.1		2.7	30.8	40.2		0.2
16	65.6	0.0		0.8	16.3	17.2		0.0
17	70.1	0.0		1.1	14.9	13.7		0.0
18	74.1	0.2		0.1	12.4	12.8		0.2

3.6.2 *Hydrothermal Breccia*

Several phases of hydrothermal occur in this system, including the hydrothermal breccia phase associated with complex fluids. The samples of hydrothermal breccia were taken from about 500 m on the surface or at -100 to 100 meters above the sea level. The hydrothermal breccia mineralogy is associated with potassic mineralogy, commonly consisting of feldspar, quartz, biotite, and magnetite. In addition, HLE hydrothermal breccia characteristics encounter high-temperature hydrous silicates, retrograde silicates, and sulfate minerals.

The hydrothermal cement of Humpa Leu East porphyry at least has three phases of mineralogical a `iop[]\s/emblages and possibly influences the mineralization. A mineralogical assemblage of hydrothermal cement in HLE consists of quartz-feldspar-plagioclase-biotite-magnetite as a high-temperature phase; followed by epidote-sericite-chlorites-anhydrite-carbonates in a medium temperature. There are aluminum-rich clay minerals interpreted as gibbsite. All three phases are associated with copper sulfide that is chalcopyrite-bornite, chalcopyrite-magnetite, and chalcopyrite-sphalerites.

The observed hydrothermal breccias showed the presence of two main components in the hydrothermal solution or fluids. The initial component is siliceous fluids that produce silicate mineral groups such as quartz-feldspar-biotite and disseminate copper minerals such as chalcopyrite and bornite. The second component is calcium-rich sulfate and less carbonate, which produces minerals, anhydrite, a little carbonate, and gypsum. The mineralization formed due to contact of the solution phases shows the oriented distribution of Fe-Mg-rich silicates minerals such as biotite-phlogopite-chlorite and the formation of chalcopyrite-magnetite and sphalerite mineralization. This contact phase shows the existence of an intermediate sulfidation state mechanism in the porphyry system.

3.7 Controls Veins

3.7.1 *Evolution of Fluids*

The veins are the product of the precipitation or crystallization process of hydrothermal fluids. Consequently, the veins are a trusted object in understanding the condition and evolution of fluids. From the detail study of each quartz vein types, we concluded the hydrothermal fluids that are characterized by a lot of magmatic water through meteroric water at shallow depth shows the temperature drop from >550°C with higher salinity of 61 wt% NaCl eq to 193°C with 1 wt% NaCl eq. Hematite and sulfide-bearing brine water followed by monophase of high-density vapor and complex types of biphase inclusion indicate the mixing and the boiling process. The mineralization starts from the magmatic stage characterized by a very high temperature - brine water, to intra-porphyry stage at 240°C - 400°C and 10-25 wt% NaCl. It is then overprinted by the epithermal stage. The data distribution shown in the temperatures and salinity tables shows a complex system where magmatic water with a high temperature and salt-content mixes with the meteoric system.

Almost all porphyry veins mix from high-temperature hyper-saline fluids to medium temperature low saline fluids, except vein type B that has a relative stability in medium-high temperature and bornite-content in a vein that is more abundant than the vein type A.

The mineralogical texture of vein of several types in HLE porphyry is similar to grain's size and mozaic texture. The differences between those types are thickness, orientation, and bands of other minerals such as biotite-chlorite, sulphide, magnetite-hematite. The unique characteristic of veins in HLE is a parallel distribution of type Apsb and anhydrite veins, possibly affecting the pressure of structural geology, diatremes or hydrothermal breccia explosion.

3.7.2 *Grade Distribution*

The copper mineralization of HLE porphyry occurs as two patterns, dissemination and inside veins. Both types are presented together with a certain dominance. Veins guide the distribution of sulfide, which may be influenced by fluid mechanisms and interactions with the side rock.

In the veins, sulfides are formed as single crystals or grains, randomly deposited crystal groups, oriented in the middle sector and the boundary of the vein and side rock contacts. In dissemination pattern, sulfides were formed as pores filling in between crystals, filling cracks in minerals, and replacing certain minerals.

Detailed analysis of each representative sample (Table 4) found that copper and gold were positively associated with type A, especially A_1, A_2 stockworks. Control of the distribution of vein type A on mineralization is to increase the copper-content on the side rock up to 20 times more than in the vein, which quartz not only occurs as veins, but also occurs as a replacement on the margin of primary interlocking texture. The increase of A_1 and A_2 veins' number will affect the intensity of dissemination and metal enrichment on the side rocks. The other vein types, such as A_3 and Apsb, affect the distribution of mineralization with the same percentage between veins and dissemination in rocks, sometimes the dissemination increases 2-3 times. The increase of grades in this system is influenced by the intensity and thickness of the vein but seen in rocks with A_{psb} and A_3 that have a level which is not as high as type A_2. In certain cases, such as EDM and M_1, it is seen that the mineralization is selective in the following orientation that has very fine veins and is not disseminated. However, this type may be replaced by other vein systems because it has iron-rich minerals.

In the early and syn porphyry systems, the vein type "A" was dominantly occurring as a stockwork and less straight than vein texture, which cut and altered the wall rock. From the distribution of element analysis (figure 16), we can assume that the early and syn system dissemination or replacement process tend to be more intense than the filling vein. It is possibly affected by the cooling and crystallization degree of fluids at the post-process fluids filling and permeating in fracture and permeable zones. In early and syn system, rate of cooling system is seen to be a longer duration process of metasomatism, it's possibly caused by the production of semi-solid and ductile phase.

In mid – late phase, mineralization tends to be in the veins and their contact zones, so mineralization is more affected by the number and thickness of the veins. In this phase, vein-type B, C, and D occur as a straight vein following shear joint or parallel fractures (figure 17). Types of M_2 have same characteristics with the mid-late stage, so this magnetite vein may occur as a transition in early to mid-stages of HLE porphyry.

The higher grade of copper and gold is in the vein type "C" or sulfide vein, where the copper-content up to 4.1% in veins and the replacement in margin or selvage of veins. The type C, and maybe also type "D" or pyrite-dominant veins, are characterized by hydrous silicate selvage and sulfide replacement. The distribution of these veins occurs in the late stages and follows the structural zones of HLE.

Table 4 Grade distribution in vein and wall rock based on selective micro-XRF analysis and bulk rock geochemistry with ICP-OES and ICP-MS.

No	Sample	Type	Cu (ppm) micro-XRF		Cu (ppm) ICP-OES	ICP-MS Drillcore interval 2m	
			in vein	*wallrock*	*bulk chip sample*	*Cu (ppm)*	*Au (ppm)*
1	VHD021/452,3	A2	1176	4196	6717	5910	1.4
		A2	3528				
2	VHD001/235	A1 hairline	-	1765	2904	3850	0.19
3	VHD009A/717	A2	174	395	664	2000	0.23
		Apsb	250				
		EDM	24				
		Anh	204				
4	VHD013/929,5	A2	519	1099	2792	2870	0.1
		Apsb	300	562			
5	VHD001/334	A1 hairline	-	6096	6242	5646	0.43
		Anh	397				
6	VHD009A/509.8	A2	781	4510	4508	1960	0.52
7	VHD009A/517.5	A2	134	118	5967	1200	0.44
8	VHD001/417,5	Carbonates	1006	-	5030	5930	0.47
		Anh-quartz	3383	-			
9	VHD009A/518,8	M2	3323	1023	1160	1200	0.44
		A2	3328				
		EDM	2989				
10	VHD013/1000,5	A2	11	1366	2351	1710	0.28
11	VHD021/523	Quartz	1317	-	2136	1920	0.12
		Margin	1985	-			
		Anh	858	-			
12	VHD023/330	diss ser	-	35	120	95	0.03
13	VHD013/801.4	A3	1361	-	-	5630	0.48
14	VHD009A/409,5	A2	781	2213	9669	9590	2.91
		C	41617	6718			

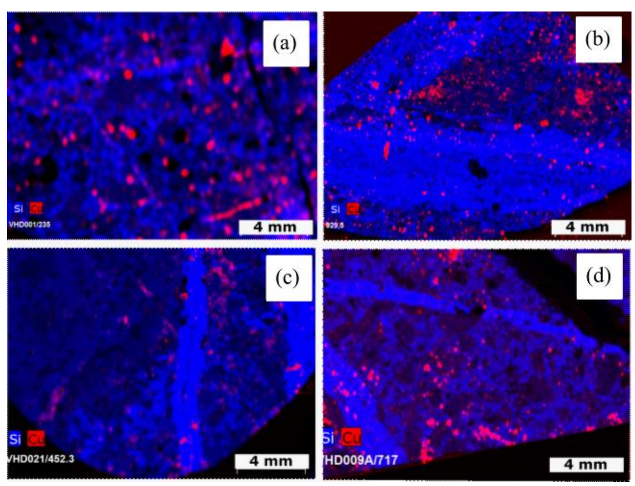


Figure 16 The pattern of copper distribution is affected by vein type "A". Dissemination process is more dominant than copper crystallization in veins. (a) Dissemination of copper in wall rock, surrounding the hairline or very thin quartz. From ICP-MS analysis of 2 meters intervals drillcore/bulk rock, this sample has grade for about 0.39 % Cu, 0.19 ppm Au, (b)

Characteristics of A_2 and Apsb vein. Distribution of mineralization is more dominant in wallrock than inside the veins, (c) characteristic of vein type A_3 spotted copper and less dissemination at the wallrock. Soft red lines show a replacement or copper distribution in EDM, (d) Strong copper dissemination in wallrock is more abundant inside the vein at type Apsb. From ICP-MS analysis of 2 meters intervals drillcore/bulk rock, this rock has grade for about 0.59% Cu, 1.4 ppm Au

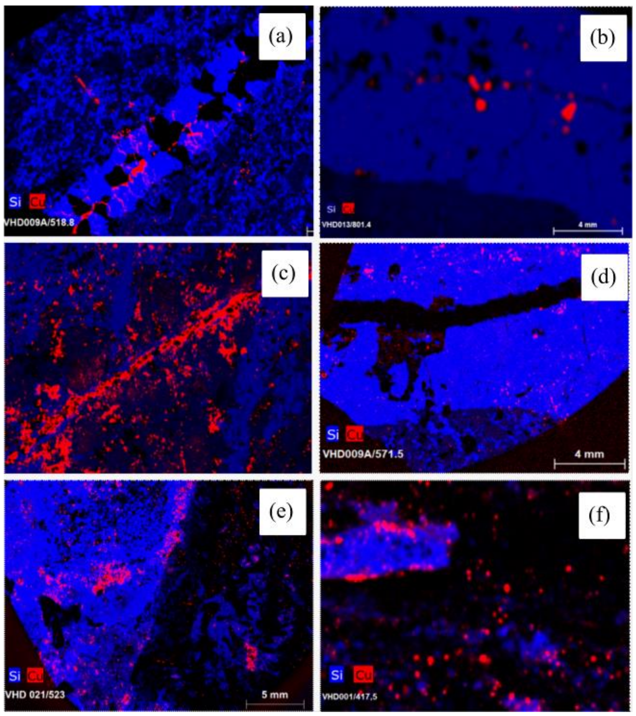


Figure 17 The pattern of copper distribution in HLE. (a) in type M2, (b) in A3 and B, (c) in type C, (d) in type A3 and epithermal, (e) in anhydrite-quartz hydrothermal breccia, (f) in anhydrite-carbonates-quartz rich hydrothermal breccia

3.8 Implications for Exploration and Deposit Model

The exploration of mineral deposits is an effort to find the ore with economic grades and dimensions. The concept "to find the ore" is stated by "vector" or "vectoring to ore". This concept allows geologists to understand deposits through special approaches, such as detail mineralogy, rock texture, geochemistry, biological tools, geophysics, etc. In this study, we propose the vectoring method to understand the package of veins and its fluids inclusion characteristics.

It is undeniable that interesting textures are often encountered in the world of exploration but do not end in the discovery. So, we have to be careful in determining whether a rock is good or not.

The key factor of vectoring is the density of vein type A_1 and A_2 in rock. From the pattern and behaviour of the vein type, the grade of mineralization in the porphyry system is strongly influenced by the distribution and density of vein-type A, especially the A1, A2, A3 with more copper-disseminated. The gold usually occurs as inclusions in bornite and other sulfides, so the distribution pattern will be proportional to the mineralization and more dominant in the middle and late phases of the system.

Otherwise, if we found other types in field or drill core, we must understand the behavior of veins. For example, in surface, we found only magnetite veins, the M1 or M2 vein, so we just found a part of mineralization that the copper is only detected in vein and its contact rims. So, the bulk of sample does not have a good grade.

The fluid inclusion analysis can be the main characteristic of the porphyry type exploration, and at the same time, look at its hydrothermal history. In the case of HLE, we see many multiphase inclusions with opaque contents such as hematite, chalcopyrite, and others. This indicates the presence of good fluid is formed in this district. The next process, if you see a significant meteoric mixing, such as in HLE, can affect the sulfidation stage in this area to be moderate which causes the copper content in the rock to decrease. On the other hand, there will be an increase in gold content. The fluid condition with this medium temperature will also affect the potassic alteration which contains a lot of chlorite and carbonate in HLE.

As mentioned in this research background, HLE can also be eventually used as the basis to discover the giant copper-gold mineralization systems such as the Onto Deposit. Although, it can still be economical individually if it is further detailed.

4.0 CONCLUSION

The "veins" are essential to porphyry deposits, occured as several packages with certain characteristics in each type of vein. From this study, we can conclude that porphyry prospect mineralization is controlled by the early to mid-stages. However, locally, the late stages of the vein can increase the grade by changing the minerals behaviour and distribution.

The hydrothermal fluids of the HLE porphyry prospect dominated by multiphase types, medium temperatures of 245˚C - 400˚C and medium-high salinity, but while still having many inclusions with temperatures of >550˚C. The fluids have a reasonably dominant mixing of meteoric water, resulted in a temperature drop and the boiling process. These results in the porphyry characteristics of HLE have an intermediate temperature and sulfidation stage. Possibly, it is caused by the tectonic process when the mineralization was formed. It is proved by the number of sheeted or parallel veins in this area. The Humpa Leu East can be identified as a 'push-up porphyry system' that still remains more extensive system underneath or on the side area. The general characters of HLE porphyry prospect is similar to other deposits in Indonesia, such as Batu Hijau, Elang, Tumpang Pitu, Brambang. This study results can be used as additional parameters related to texture and fluid in porphyry systems in Indonesia, or other similar places.

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