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Taking care of our Earth for better future through green geological engineering practices

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Geophysical Characterization of Masbate Island, Philippines
STYLES AND CHARACTERISTICS OF PRECIOUS 
AND BASE METAL MINERALIZATION AT THE 
SOUTHERN PART OF WEST JAVA REGION, 
INDONESIA

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Abstract

This paper discusses the styles and characteristics of precious (gold, silver) and base metal (copper, lead and zinc) ore deposits at the southern part of West Java region, Indonesia. The hydrothermal deposits are tectonically hosted by west-east-trending Tertiary Sunda-Banda magmatic arc. Three most mineralized regions in the southern part of West Java identified consist of Horje Igneous Complex, Bayah Dome, and Southern Mountain zone of West Java. The oldest Cibulun is a representative of low sulfidation (LS)-epithermal deposits hosted by the Horje Igneous Complex. Two mineralization styles of LS-epithermal deposit identified in the Bayah Dome consist of ‘Pongkor-type’ and ‘Citratan-type’. Pongkor-type is typically represented by quartz-carbonate-manganese oxides-gold-bearing veins with common open space filling textures. The Citratan-type is typified by polymetallic (Pb-Zn-Sn-W)-rhodochrosite-rhodinite gold-bearing quartz veins. According to data up to date, the Bayah Dome and Horje Complex are favorable to be host of LS epithermal gold deposits. Some prospects of LS- and high sulphidation (HS)-epithermal as well as an indication of Cu-Au porphyry are discovered in Southern Mountain range. The epithermal deposits in the Southern Mountain range tend to be characterized by gold-silver-base metal-Te-bearing quartz veins compared to those in Bayah Dome. HS epithermal types are represented by Cijulang and Gading prospects in Garut and Gunung Gupit prospect in Magelang, Gunung Gupit prospect is a new discovery of HS epithermal situated in Kulon Progo-Menoreh mountain. Cihirip/Ciparay prospect (Papandayan district, Garut) represents the possible Cu porphyry deposit. Although it is needed to be furthertested, the current study indicates the occurrence of Cu porphyry type within the Southern Mountain of West Java region. Other Cu porphyry prospects are currently discovered including Selogiri (Wonogiri) in the central part of Southern Mountains and Tumpang Plu (Banyuwangi) in the most eastern part of Southern Mountains of Java Island. The current exploration data suggest that the occurrences of HS epithermal and Cu porphyry types, beside LS epithermal are still opened to be discovered in the region.

Keywords: Mineralization styles, epithermal, porphyry, southern part of West Java, Indonesia

Introduction

The Indonesian archipelago, 13,000 islands stretching for 5,200 km, contains an appreciable extent of Earth's Cenozoic volcano-plutonic arcs, and it is the location of 15% of its historically active volcanoes. These arcs total approximately 9,000 km in length, with some 80% comprising segments containing known mineral deposits [1]. Fifteen magmatic arcs are identified in Indonesia and have a total extent in excess of 15,000 km². However 98% of the country's precious (gold, silver) and base metals (particularly copper) are derived exclusively from six arcs of mid-Tertiary or younger age [1]. These six major Neogene mineralized magmatic arcs include the Sunda-Banda, Aceh, Central Kalimantan, Sulawesi-East Minandao, Halmahera and Medial Irian Jaya (Central Range-Papuan fold
and thrust belt) (Fig. 1).

The Sunda-Banda arc is the longest of the Indonesian arcs. It extends nearly 4,000 km from northern Sumatra through Sumbawa (Sunda arc) and onwards through Flores to its terminus in the Banda Islands (Banda arc). One of the most mineralized segments of the Sunda-Banda magmatic arc is the southern part of the West Java region. It covers the areas of the well-known mineralized Bayah Mountains/Dome and the Southern Mountains of West Java region (Fig. 2). This study is dealing with styles and characteristics of the ore mineralization in the studied area based on the literature review as well as current field works and laboratory analysis of the Gunung Gupit HS epithermal prospect.

Figure 1 Mineralized Tertiary magmatic arcs in Indonesia (modified from [1]). This study is focused on the southern part of West Java belong to Sunda-Banda magmatic arc. Note: Arrows indicate the dip direction of the subducting crust.

Figure 2 Physiographic map of West Java region where the study area situated at the southern part of region (Bayah Mountains and Southern Mountains of West Java) [2].
Regional Geology

Geology of Sunda-Banda Magmatic Arc

The basement of the Sunda-Banda magmatic arc consists of Mesozoic to late Paleozoic sedimentary rocks in Sumatra, Cretaceous to Tertiary melange and ophiolite in western and central Java as well as oceanic crust in the Banda arc [3]. The sedimentary basement in Sumatra is intruded by granites. A latest Oligocene to earliest Miocene magmatic arc extends through much of western Sumatra and Java forming “Old Andesites” [2] and continues eastwards into the Banda arc. The Neogene arc is characterised by calc-alkaline andesitic to dacitic volcanic rocks and their intrusive equivalents in Sumatra, and basalts to andesitic volcanic rocks and intrusions of calc-alkaline and tholeiitic affinities in the Java-Flores and east Banda sectors ([3]; [4]). Dacitic to rhyolitic suites occur locally and are particularly abundant in the Alor, Wetar and Romang sectors. The dextral Sumatra fault follows the arc and is inferred by [3] to have been active since the late Oligocene (Fig. 1).

An andesitic arc of Middle Miocene to Pliocene age, together with overlying Quaternary volcanic rocks, extends through the Barisan Mountains Range of Sumatra and continues through Java and the western part of the Banda arc. Magmatic rocks in the arc are predominantly eruptive, but include 12 and 15 Ma intrusions in Sumatra and undated intrusions in Java. The Neogene arc magmatism was clearly related to subduction in or near the present Java trench. Clastic and carbonate sedimentary rocks are intercalated with the volcanic sequences of the arc. Quaternary basaltic to dacitic, and locally rhyolitic, volcanism actively covers older volcanic rocks throughout the arc ([3]; [4]).

Geology of the Southern Part of West Java Region

Bayah Dome/Mountains

The West Java gold deposits partly lie within and on the flanks of the Bayah Dome/Mountains, southwest of Jakarta (Fig. 3). This geological unit, exposed over an area about 40 x 80 km, consists of Oligocene to Quaternary calc-alkaline rhyolitic to andesitic rocks and small intrusive stocks with a few intercalations of Miocene limestone and sandstone ([2]; [5]). The Citorek area, in the northern part of the dome, is a large (60 km²) depression, possibly a caldera, filled with dacitic ignimbrite and intruded by andesite-dacitic plugs. Most of the important gold deposits of the Bayah dome occur in a N–S striking structural corridor, which is defined by a system of conjugate NNW–SSE right-lateral and NNE–SSW left-lateral strike-slip faults. The fault zones are related to a N 208 E directed compressional regime, and some of the faults are interpreted as mega tension cracks [5].

Southern Mountains of West Java

Physiographically, the Southern Mountains of West Java region belongs to the Sunda-Banda magmatic arc (Fig. 2). This arc has been formed since Early Tertiary and still active until now. The area is a part of southern slope regional uplift [2]. The southern mountains, some 50 km wide, extend from Pelabuhan Ratu Bay to Nusakambangan Island. These represent the southern flank of the Java synclinal structure, an uplifted crustal block dipping to the south. Rocks of Tertiary to Recent age occur in the study area and consist of andesitic to basaltic intrusive and extrusive rocks, such as tuff, breccias, and lava flows [6]. It is sometimes difficult to distinguish intrusive and extrusive rocks from different ages since the mineralogical composition of those lithologies are similar. The volcanic rocks are suffered pervasive hydrothermal alteration [7]. Most of the primary minerals in the volcanic rocks of the Early-Middle Miocene Jampang Formation are altered. The Jampang
Formation (early Middle Miocene) consists of lava, andesite breccias and propylitic tuff, being a part of the intruded by quartz diorite (late Middle Miocene). The older rocks are unconformably overlain by conglomerate and tuffaceous sandstone with interbedded claystone of the Bentang Formation of Late Miocene – Early Pliocene age. The volcanic rock unit is dominantly composed of glassy tuff, tuff breccia and andesitic dyke is unconformably overlain by Pliocene. The youngest rocks are Plio- Pleistocene consisting of glassy tuff, scoria tuffaceous breccia, breccia and andesitic lava.

Figure 3 West Java gold deposits. (a) Exposure of Precambrian basement (stippled area); Belitung alone is shown for the Tin Islands. (b) Geology of North Bayah dome with main gold deposits including Pongkor and Cirotan [2].

**Styles and Characteristics of Mineralization**

**Bayah Dome/Mountains**
The Bayah Dome/Mountains in the western part of the Sunda-Banda arc is mostly mineralised by low-sulphidation epithermal vein systems including Gunung Pongkor, Cikidang and Cirotan. Minor sediment-hosted gold sulphidation also occurs in the Cikotok district. The precious and base metal ore deposits identified as mostly epithermal-styles lie within and on the flanks of the Bayah dome, southwest of Jakarta. The epithermal gold mineralisations in Bayah Dome are hosted by strike-slip faults cutting Miocene to Pliocene volcanic and plutonic formations. Based on vein patterns, the mineralisation consists of two major styles: (1) Discordant gold-bearing quartz veins or crustiform banding veins of the “Gunung Pongkor” type, and (2) Breccia veins of the “Cirotan” type [8] (Fig. 4).
Figure 4 Geological map showing the location of the Ciroton Au–Sn–W deposit, as well as other epithermal Au deposits in the region. Insert shows the location of major epithermal gold deposits of Indonesia within the plate-tectonic setting of the region (after [8] and [9]).

The Gunung Pongkor deposit is a typical low-sulphidation ("adularia-sericite") epithermal vein deposit containing approximately 6.02 million metric tonnes ore reserves at average grade of 17.14 g/t Au and 154.28 g/t Ag [10]. Gunung Pongkor-type including Pongkor, Cawitali district, Cikidang, Cibarengklok and possibly Nirmala is typically characterized by quartz-manganese oxides-gold-bearing veins [8]. It is hosted by Miocene andesitic tuffs and breccias, and a subvolcanic andesite intrusion. The mineralization is associated with four main northwesterly trending veins i.e. Ciurug, Kubang Ciguh, Ciguh and Ps. Jawa, which define a northeasterly corridor. The corridor extends through the Bayah dome to the southwest, where it controls the distribution of several vein systems in the historic Cikotok mining district. The Bayah dome is occupied by volcanic and clastic sequences, which locally are truncated by pre-mineralisation dacitic stocks [11]. The adularia K/Ar isotope indicates age of low-sulphidation vein mineralisation range from 2.1 to 1.5 Ma, post dates the Miocene igneous host rocks (5.7 to 2.0 Ma) [8]. In Ciurug, it is presently reported the occurrence of bornite at level 515 m. Electrum decreases as increasing of base-metals at depth of Ciurug vein [12].

The Cikidang gold deposit (2.4 Ma; [10]; [13]) is also a typical low-sulphidation deposit comprising four major sub-parallel quartz-adularia-sericite-calcite veins. The veins vary from 0.5 to 2.7 m in width and extend for up to 1,000 m in length trending roughly north east and dip 60° to 86° towards the west. The deposit contains ore grades varying from trace to 74.9 g/t Au and 1.2 to 225 g/t Ag. The ore minerals are represented by
electrum, argentite, aguilarite and pyrite [13]. The Cibodas gold epithermal is situated approximately one km south of the Cikidang deposit, which is mineralized by electrum, argentite, pyrite, chalcopyrite and sphalerite formed at temperature range of 200-300°C [14].

The Cirotan deposit, located 80 km SW of Jakarta, is the most prominent example of this unusual epithermal vein deposit type (e.g. [8]; [15]). Cirotan, along with other epithermal deposits in the district, is characterized by extensive formation of polymetallic hydrothermal breccia, culminating in complexly banded cockade breccia [9], and progressive enrichment in Sn, W, Au, and Ag in the late stages of mineralization. Deposits of the Cirotan type occur within mineralized fault zones, up to 30 m wide, which contain abundant breccia hosting fairly complex polymetallic ore mineral assemblages. These deposits are very rich in pyrite and base metal sulphides, and the gold-rich ores are associated with anomalous enrichments of Sn, W, and Bi ([16]; [15]). The Cirotan vein cuts Miocene rhyodacite ignimbrites (K–Ar: 9.5±0.3 Ma), older dacitic to andesitic lavas (K–Ar: 14.3±0.7 Ma), and a stock of weakly propylitized Pliocene quartz microdiorite (K–Ar: 4.5±0.3 Ma), which has intruded the Miocene volcanics ([15]; [8]). Hydrothermal adularia from the Cirotan deposit has been dated at 1.7±0.1 Ma [8]. Hydrothermal alteration is dominated by intense silicification, particularly in the footwall, and is accompanied by weak to intense sericitization; both types of alteration are superimposed onto regional propylitic alteration. Based on relative age relationships, five distinct mineralization/alteration stages can be distinguished: (1) wallrock silicification; (2) siliceous breccia with minor sulphides; (3) polymetallic cockade breccia in which cockades are characterized by numerous concentric rims of rhodochoelite, quartz and base metal sulphides; (4) high-grade precious metal ore breccia; and (5) late drusy quartz ([16]; [15]). The bonanza veins have average gold grades of 9–12 g/t (locally gold grades can attain 700 g/t), and anomalous concentrations of Sn, W, and Bi. Ore textures demonstrate that electrum is spatially associated with wolframite, cassiterite, and scheelite [15].

Another low sulphidation epithermal gold deposit currently discovered in the most western part of Java Island is Cibaliung deposit. The Cibaliung deposit is situated in the Miocene Honje Igneous Complex in the southwestern part of Java Island approximately 70 km west of Bayah Dome, a gold district at western Java [17]. Some low-sulphidation type epithermal gold deposits have been discovered in the Bayah Dome complex, such as Cikotok, Cikidang [13], Cirotan, Ciawitali, Gunung Pongkor (18, 19); [12, 20]) (Fig. 4). The exploration work at the Cibaliung deposit suggests that the extent of the quartz veins is approximately 1.4 km with an average width of approximately 10 m. The resources are estimated to be 1.3 million tonnes at 10.42 g/t gold and 60.7 g/t silver at a 3 g/t Au cut-off. This equates to approximately 435,000 ounces of gold and 2.54 million ounces of silver [21]. The host rocks of this deposit are volcanic rocks, comparable to those at the Bayah Dome complex. They consist of Oligocene to Miocene basaltic andesite of the Honje Formation intruded by dikes and are unconformably overlain by the Cibaliung tuff [21]. The K-Ar dating on the andesite lava and the Cibaliung tuff suggested ages of ~11.4 and 4.9 Ma respectively [22], while the 40Ar/39Ar dating on adularia collected from the veins suggested an age of mineralization of about 11.18-10.65 Ma [22]. In contrast the mineralization ages in the Bayah Dome complex are much younger than that of the Cibaliung deposit. They range from 2.4 to 1.5 Ma ([8]; [5]; [13]), and the ages of the host rocks range from 14 to 2 Ma [8]. Therefore, the Cibaliung deposit is the oldest known epithermal deposit in western Java.

**Southern Mountains of West Java Region**

Some precious and base metal mineralizations are also currently discovered within the
Southern Mountains of West Java region, including low sulphidation epithermal systems e.g. Gunung Subang prospect, Cianjur [23], Cigaru prospect, Sukabumi [24], Tanggeung prospect, Cianjur [25], Arinem prospect, Papandayan district, Garut [7], Cineam prospect, Tasikmalaya [26], Cijulang high sulphidation prospect, Garut ([27]; on progress study). Cihurip/Ciparay porphyry prospect, Garut ([28]; [29]) and Gunung Gupit HS epithermal in Magelang (Fig. 6; [30]). Figure 5 shows the location of Cijulang HS epithermal, Arinem LS epithermal and Cihurip porphyry types.

![SRTM map of the location of Cijulang HS epithermal, Arinem LS epithermal and Cihurip porphyry types in Papandayan district, West Java](image)

The Gunung Subang LS epithermal prospect is located in the Cianjur District, West Java Province, approximately 120 km Southwestern of Bandung, capital city of West Java Province (Fig.1). Physiographically, the study location belongs to the Southern Mountain Zone. Lithology of the area is composed of tuff and andesitic rock unit that took place as host rock of mineralization. The NW-SE fault trending is the major fault in the area. Based on lineament analysis, there is coincident similarity of trending between extension pattern and vein in NE-SW direction. The mineralization is associated with quartz vein which has NNE-SSW trending. The alteration consists of silicification, argilic and propylitic-types. The major elemental data show the adularia (K-feldspar) – sericite alteration tendency. The mineral assemblage consists of galena, sphalerite, pyrite, and chalcopyrite and quartz as dominant gangue mineral. The hydrothermal fluids temperature has interval between 210-286 °C and neutral to alkaline fluids. The salinity of fluids is ranging from 0.3 to 2.7 wt.% NaCl eq. while the estimation depth of formation is about 305 to 445 m below paleowater table. Boiling condition may be present at Cicelak vein, which is indicated by the occurrence of bladed calcite and the occurrence of vapor rich together with other phase in fluid inclusion samples [23].
One of other gold-base metal prospects in the area is Cigaru prospect, Sukabumi [24]. It might tend to be included within the Southern Mountain zone of West Java region as its location is out of Bayah Dome/Mountains and the host rocks of mineralization are comparable to the Southern Mountain stratigraphy (i.e. Early Miocene Jampang Formation). Gold resources is 0.63 million oz from 8 million tones gold in grade 2.4 gr/ton in their 3 drilling zones [24]. Geology of this area consists of andesitic rocks and dacite aged Miocene and layered by tuff volcanic. Gold mineralization in Cigaru mineralized in main vein system with some minor veins in N320°E – N345°E and 75° – 90° dips. The thickness of Cigaru veins vary from 3 to 100 cm. Cigaru veins show N320°E – N345°E orientation and 75° – 90° dips. Quartz veins show colloform and hydrothermal breccias textures. Main alteration minerals are dominated by montmorillonite, illite, and clinohlore. Pyrite assemblage is abundant, and base metal mineral is predominantly composed of chalcopyrite, sphalerite, tetrahedrite, galena, and covellite. Digenite and tennantite are minor minerals. Gold is identified as free grain and associated with other minerals, such as pyrite and galena. Fluid inclusions result shows two dominated-phases (vapor and liquid). Homogenization temperature is 200°C – 280°C and salinity range from 0.2 to 0.8 wt% NaCl eq. Thus, it is considered that mineralization in Cigaru area is divided into two areas. The locations are the base metal Pb, Cu±Zn mineralization and precious metal mineralization. Both mineralization styles are categorized into low sulphidation epithermal system [24].

The Tanggeung LS epithermal gold prospect is located about 50 km from Cianjur, or about 120 km southeast of Capital City, Jakarta. The prospect lies within the Southern Mountain Zone, where several hydrothermal gold deposits are located. The area is mainly covered by Late Miocene sandstone and claystone of Koleberes Formation, and overlain by Pleistocene-Pliocene pyroclastic tuff. Koleberes Formation was intruded by Late Pliocene homblende andesite. The gold bearing quartz veins in Tanggeung prospect are trending mostly NW-SE and hosted by mainly tuff of Pleistocene-Pliocene ages. The mineralized quartz veins exhibit fine-medium crystalline, vuggy, saccharoidal, colloform banding and massive textures. The mineralized zone occurrences are classified into vein type and hydrothermal breccias. The Cicelak type vein consists of six mineralized quartz veins, they are Cicelak, Cigadobras, Pasir Bedil, Cilangkap, Honey Hole and ST-7 veins. The mineralized gold bearing quartz veins occur within the illite zone for about 3.1 km x 4.5 km. The ore minerals consist of chalcopyrite, pyrite, sphalerite, galena and oxide minerals such covellite, chalcocite and hematite. Based on fluid inclusion studies Cicelak type exhibits a homogenization temperature range of between 260° to 278 °C and a salinity from 0.57 to 2.7 wt % NaCl eq, whereas the Cicingal type indicates a homogenization temperature range of between 291 to 319°C and salinity from 8.4 to 10.4 wt % NaCl eq., respectively [25].

The Arinem gold-silver-base metal deposit is located in Papandayan district, Garut regency [7]. Physiographically, it is situated within the Southern Mountain range of West Java region. The main vein of Arinem has orientation of N20°W to N10°E and dipping 68-83° westward. Total length of the main vein Arinem is up to 5,900 m and 3-5m width. The Bantarhuni vein has a zone length about 2,300 m, and width of 3-5 m showing gold grade of 2-5 g/t [7]. The Au-Ag-Te-bearing hydrothermal deposit of Arinem is hosted by andesitic tuff, tuff breccia and lava of Miocene Jampang Formation. Hydrothermal alteration zones are classified into quartz-illite-pyrite (siliification), smectite-illite-kaolinite-quartz-pyrite (argillic), and chlorite-smectite-kaolinite-calcrete-pyrite (propylitic). Ore mineralization is strongly controlled by geological structures. There are five major post-mineralization normal faults trending N-S and NE-SW within the area. Those faults cropped out the Arinem, Bantarhuni and Halimun quartz veins. The Arinem deposit has a
typical polymetallic mineral association (Fig. 2), composed mainly of sulfide minerals such as sphalerite, galena, chalcopyrite and pyrite with some minor and trace minerals of arsenopyrite, marcasite, pyrrhotite, bornite, argentite, electrum, and Te-bearing minerals of hessite, stutitzite, petzite, tetrahedrite and altaite, with occurrences of hematite, enargite, tennantite and tetrahedrite in later stage. The secondary minerals are covellite, chalcocite, Mn oxides and goethite-limonite. Microthermometric study of fluid inclusions in the quartz veins indicates temperature of homogenization (Th) ranges from 155° to 325°C (average 194° to 267°C) and 0.2 to 4.3 wt.% NaCl equiv., respectively [7].

Another important ore deposit type discovered in this region is Cihurip/Ciparay porphyry Cu-Au prospect, Papandayan district, Garut regency, West Java ([28]; [29]). The Cihurip deposit is hosted by sedimentary volcanioclastic-pyroclastic rocks of Jampang Formation (early Middle Miocene) consisting of lava, andesite breccias and propylitic tuff, being a part of the intruded by quartz diorite (late Middle Miocene). The porphyry Cu-Au occurrence is characterized by the presence of quartz vein/veinlet stockwork within altered mineralized host rock. Mineralization is dominated by quartz, magnetite, pyrite and chalcopyrite veinlets with cross cutting (<1 mm to 3 mm). In addition, opaque mineral veinlets including magnetite, pyrite, chalcopyrite; quartz and tremolite veinlets as well as disseminated sulphides are also recognized. The assay results of altered/mineralized host rocks have variable grades ranging from 0.11 to 0.49 g/t Au and from 0.01 to 0.1 % Cu, respectively [28].

Locally, two main lithological units consisting of andesitic volcanics and lava as well as intrusive rocks cover the Cihurip area. The andesitic volcanics unit dominantly comprises andesite lava, volcanic breccia, tuff, pyroclastic breccia, tuffaceous breccia, dacite lava and andesite pyroxene lava. Stock or dyke of diorite and andesite intrude the both units. Diorite stock/dyke is the dominant intrusive rock in Cihurip area characterized by porphyritic texture and composed of interlocking plagioclase, hornblende, pyroxene and biotite. The diorite contains moderate to strong magnetite and is frequently associated with pyrite and veinlets cross cut magnetite as dissemination and fractures filling. At the window of Ciparay River, the diorite is associated with low to moderate density of quartz veinlets stockwork and cross cut magnetite-actinolite. Five hydrothermal alteration types including potassic, propylitic, phyllic, sub-propylitic and argillic are temporally and spatially recognized in the prospect area. The presence of potassic alteration in the area is important as it is a typical alteration type characterizing the porphyry Cu-Au system. However, the potassic alteration event seems to only suffer the volcanioclastic rocks and probably predates the emplacement of the porphyry dykes. The potassic alteration in the area is manifested by three phenomena including (1) conversion of mafic minerals to biotite-actinolite, (2) an irregular stockwork of hairline black biotite+magnetite veinlets, and (3) quartz+magnetite veinlets. Moderate potassic-altered rocks are cropped out in S. Ciparay. Although all characteristics mentioned above meet a part of diagnostic criteria of porphyry Cu-Au deposit, but it is absolutely needed a further study particularly on mineralization-bearing porphyritic intrusion, the presence of typical sulphides such as bornite, hypogene digenite, covellite and chalcocite as well as mineralizing hypersaline magmatic hydrothermal fluids [28].

The last, two HS epithermal gold prospects including Cijulang and Gunung Gupit will be reviewed in this paper. Cijulang HS epithermal prospect is situated in Papandayan district, Garut, West Java (Fig. 5). Alteration and mineralization is found in volcanic rocks of Jampang and Bentang formations. Alteration types are identified as advanced argillic (kaolinite, dickite, pyrophyllite, alunite, sericite-pyrite), massive silica-vuggy quartz and propylitic (chlorite, smectite, pyrite). Ore mineralization occurs as dissemination and
fracture filling by pyrite, enargite, gold, tennantite, sphalerite, galena and chalcopyrite associated with advanced argillic and massive silica-vuggy quartz (Fig. 6). Ore grade within advanced argillic is more than 0.4 g/t [27].

Figure 6. Cijulang HS epithermal: (A). Outcrop of oxidized massive silica with partly vuggy texture, (B). Microphotograph of enargite (En) and hematite (Hem), and (C). Free gold grain (Au) surrounded by quartz (Qtz).

Gunung Gupit HS epithermal prospect is situated in the northern part of Kulon Progo-Menoreh mountain range, Magelang, Central Java. Lithologically, the prospect area is occupied (from oldest to youngest units) by andesitic lava and dacitic lava of Kebobutak Formation (member of Old Andesite Formation), authoclastic breccias and andesitic breccias of Young Gunung Sumbing deposit. Field work indicates that the area has been intensively altered by hydrothermal activities. This is proven by the occurrences of NE-SW trending quartz vein/veinlets and silicified host rocks. This is consistent with the mineralization orientation which may strongly be controlled by relatively NE-SW strike slip post mineralizing fault in the area. Hydrothermal alteration recognized consists of silicification (silicified host rocks), advanced argillic, argillic and propylitic types (Fig. 7). The typical alteration type, advanced argillic, is characterized by the presence of alunite, jerosite, native sulfur, pyrophyllite, dickite and halloysite. Vuggy silica texture is the most abundant and typical ore texture identified (Fig. 8). Ore mineralization is typically represented by enargite, chalcopyrite, native gold, pyrite, magnetite and hematite. Ore chemistry data of 28 rock, quartz vein, silicified rock and soil samples show a very erratic grade of gold and silver ranging from 0.006 to 42.4 g/t Au and <1 to 112 g/t Ag as well as up to 304 ppb Au and 980 ppb Ag in three stream sediment samples. Based on those key features, the gold mineralization is interpreted as a high sulphidation epithermal gold deposit. This is a new discovery of high sulphidation epithermal gold prospect in the Kulon Progo-Menoreh mountain range. Considering the deposit type genetically closed to porphyry copper deposit, the 'hidden' porphyry type might be still opened to be discovered in the mineralizing district.
Figure 7. Hydrothermal alteration map of Gunung Gupit HS epithermal prospect

Figure 8 (A). Outcrop of massive silica with partly vuggy texture (insert is the hand specimen of the outcrop). (B). Hand specimen of quartz vein with vuggy texture, strongly oxidized containing alunite, jarosite and native sulfur (grade of 42.4 g/t Au and 112 g/t Ag; analysed by FA-AAS).

Concluding Remarks

The west-cast-trending Tertiary Sunda-Banda magmatic arc is widely known as one of the most mineralized volcanic belts in Indonesia hosting various ore hydrothermal deposit types. In the southern part of West Java region, at least three mineralized sub-regions from west to east including (1) Honje Igneous Complex, (2) Bayah Dome/Mountains, and (3) Southern Mountain zone of West Java region are well recognized.
Cibaliung gold deposit is a representative well known low sulphidation epithermal style occurred within the Honje Igenous Complex. Up to now, this deposit is the oldest one among the discovered epithermal deposits in Java. In Bayah Dome/Mountains, two mineralization styles of low sulphidation epithermal deposit identified consist of 'Pongkor-type' and 'Cirotan-type'. Gunung Pongkor, Cikidang, Ciawi tali district, Cikidang, Cibarengkok and possibly Nirmala resemble of the Pongkor-type. Those deposits in general have similar characteristics with minor differences. Typically, they are represented by quartz-carbonate-manganese oxides-gold-bearing veins with open space filling textures e.g. colloform, crustiform, cockade, etc. The Cirotan type is represented by Cirotan, Cipanglessaran, Lembak Sembada, Sopo, Cinem, and Cikotok deposits situated in the central Bayah Dome. These deposits in general are typified by polymetallic (Pb-Zn-Sn-W)-rhodochrosite-rondotite gold-bearing veins. The polymetallic hydrothermal breccia, culminating in complexly banded cockade breccias are the characterizing textures of this Cirotan type. It seems that the Bayah Dome is a favorable region hosting a number of economic low sulphidation epithermal gold deposits.

In Southern Mountain range of West Java region, some prospects of low- and high-sulphidation epithermal deposits as well as an indication of porphyry Cu-Au deposits are discovered. The low sulphidation epithermal style is represented by Gunung Subang and Tanggeung (Cianjur), Cigaru (Sukabumi), Arinem (Papandayan district, Garut), Cineam (Tasikmalaya). High sulphidation epithermal type may be represented by Cijulang and Gading prospects, Garut and Gunung Gupit, Magelang, whereas Cihuru/Ciparay prospect (Papandayan district, Garut) represents the possible porphyry Cu-Au deposit. In comparison to the low sulphidation epithermal types in Bayah Dome, the epithermal deposits in the Southern Mountain range tend to be represented by gold-silver-base metal-Te-bearing quartz veins. Although it is needed a furthertested, the preliminary study of [28] indicates the possible presence of porphyry Cu-Au deposit type within the Southern Mountain of West Java region. The occurrences of porphyry Cu-Au deposit types within the west-east-trending Southern Mountains of Java Island are currently discovered, for instance, Selogiri (Wonogiri) in the central part of Southern Mountains ([31], [32]) and Tumpang Pitu (Banuwangi) in the most eastern part of Southern Mountains of Java Island [33]. Moreover, the current discovery of HS epithermal gold prospects in Garut (Papandayan district) and Magelang (Kulon Progo-Menoreh mountain range) may support the opportunity to discover ‘hidden’ porphyry Cu type in the mineralizing district since HS epithermal spatially and genetically is closed to the porphyry system.

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