Preliminary Study Gold Mineralization Hosted By Metamorphic Rocks In The Southeastern Arm Of Sulawesi, Indonesia

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Abstract - This paper is intended to describe an preliminary study of geological setting and gold mineralization hosted by metamorphic rocks in the southeastern arm of Sulawesi. The stratigraphy consists of three constituent rocks are continental terrain composed of metamorphic rocks, ophiolite complex are dominated by mafic and ultramafic rocks and Sulawesi Molasse composed of clastic sediments and carbonate. The origin of gold mineralization at Mendoke and Rumbia mountains only preliminary studies. A field study indicates that the Langkowala placer/paleoplacer gold is possibly related to gold-bearing quartz veins hosted by metamorphic rocks particularly mica schist, phyllite and metasediments in the area. These quartz veins are currently recognized in metamorphic rocks at Wumbubangka Mountains, a northern flank of Rumbia Mountain Range. At least, there are three generations of the quartz veins. The first generation of quartz vein is parallel to foliation of mica schist, phyllites and metasediments in up to 10 m wide zones. The second quartz vein generation crosscut the first quartz vein and the foliation of the wallrock. The third is of laminated deformed quartz-calcite veins at the late stage. The first veins are mostly massive to crystalline, occasionally brecciated and sigmoidal, whereas the second veins are narrower than the first and relatively brecciated. Gold grades in the second and third veins are relatively higher than that in first veins. The similar quartz veins types are also probably present in Mendoke mountain range, in the northern side of Langkowala area. The wallrock are generally weakly altered. Alteration types include argillic, silification, carbonate and carbonization alteration. This primary gold deposit is called as orogenic gold type and product of hydrothermal activity. The orogenic gold deposit is one of the new target of gold exploration are being developed in Indonesia.

Keywords : metamorphic rocks, placer gold, primary gold, orogenic gold deposit, Rumbia moutains, Mendoke mountains, Southeastern Arm of Sulawesi, Indonesia.

INTRODUCTION

In Indonesia commonly gold is mostly mined from volcanic-hosted hydrothermal deposit types including porphyry type *e.g.* Batu Hijau in Sumbawa Island [11,14] and Grasberg in Papua , skarn type *e.g.* Erstberg, Kucing Liar, Deep Ore Zone (DOZ) in Papua, and epithermal type, *e.g.* Pongkor in West Java [21], Gosowong in Halmahera Island. In Sulawesi Island [1,4], gold is also predominantly related to volcanic rocks, which are extended along western and northern Neogene magmatic arcs of the island [9]. However in 2008, gold has also been found in southeasterm arm of Sulawesi, particularly in Langkowala area, Bombana Regency (Fig. 1), following the discovery in the form of placer and paleoplacer.

The primary source of secondary (placer) gold in Langkowala area is an orogenic gold deposit type in the form of sheared/deformed quartz veins/veinlets hosted by Pompangeo Metamorphic Complex (PMC). The PMC particularly consists of mica schist (dominant rock type), phyllite and metasediment (commonly metasandstone and marble) occupying the Rumbia mountain range occupying Rumbia Mountain that include Wumbubangka mountain in the south and probably Mendoke metamorphic mountain range in the north [10, 12].

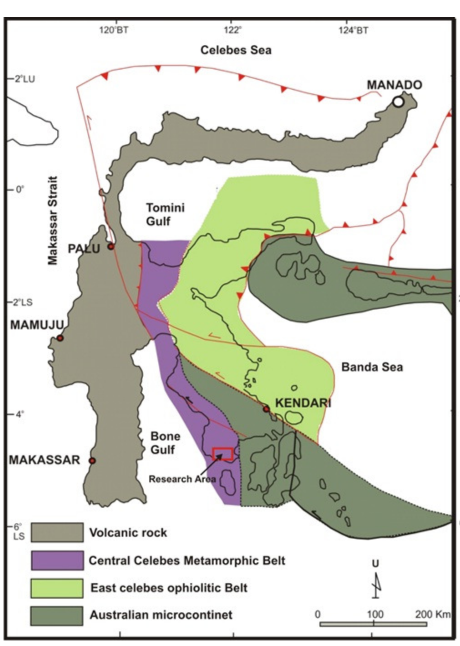

Figure 1. Geological setting of Sulawesi Island and location of the researched area in Mendoke dan Rumbia mountains, southeastern Arm of Sulawesi [20].

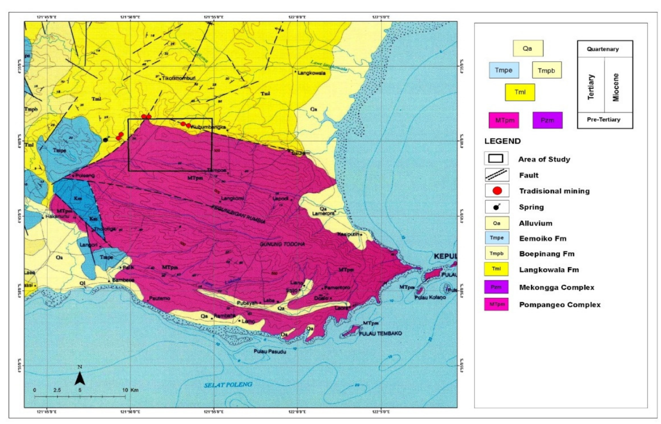

Figure 2. Geological map of Langkowala area occupied by Langkowala Formation (Tml) unconformably overlying Paleozoic Metamorphic rock (Pompangeo Complex; Mtpm) in southeastern Arm of Sulawesi (Wumbubangka and Rumbia Mountain range) [18].

Gold grains were firstly discovered in stream sediment of River Tahi Ite and after that, more than 20,000 traditional gold miners have worked in the area [15]. During January 2009, the number of traditional gold miners in Bombana Regency increased significantly and reaching the total of 63,000 people [19]. The secondary gold is not only found in recent stream sediment (placer), but also occurred within Mio-Pliocene sediments of Langkowala Formation (paleoplacer). The genetic type of primary source of the Bombana placer/paleoplacer gold is thought to be hosted by Pompangeo Metamorphic Complex (PMC), but is still in controversy and open for discussion.

GEOLOGICAL SETTING

The stratigraphy in the southeastern arm of Sulawesi consists of three constituent rocks are continental terrain composed of metamorphic rocks, ophiolite complex are dominated by mafic and ultramafic rocks and Sulawesi Molasse composed of clastic sediments and carbonate. Langkowala Formation is a part of Sulawesi Molasses, which were firstly described by Sarasin and Sarasin [18]. Langkowala area where the placer gold found is characterized by lowland morphology, and it is flows by some major rivers including Langkowala River, Lausu River, Lebu River and Pampea River. Langkowala area is located between Mendoke Mountain in the north and Rumbia Mountain in the south. The area is occupied by Middle Miocene Langkowala Formation (Tmls) consisting of sandstone, shale and conglomerate of shallow marine to terrestrial deposition [18]. The area is subsequently occupied by metamorphic rocks (Pompangeo Complex, Mtpm) consisting of mica schist, quartzite, glaucophane schist and chert. The metasediments and metamorphic rocks are of Permian-Carboniferrous in age and occupy the Mendoke and Rumbia Mountains. Mica schist and metasediments particularly meta-sandstone and marble are commonly characterized by the presence of quartz veins various width up to 2 meters, containing gold in some places. The Langkowala Formation is unconformably underlain by Paleozoic metasediments and metamorphic rocks (Pompangeo Complex, Mtpm) and conformably overlain by the Eemoiko Formation (Tmpe), which is composed of corraline limestone, calcarenite, marl and sandstone; and Boepinang Formation (Tmpb), which is composed of sandy claystone, sandy marl and sandstone. The Eemoiko and Boepinang Formations were reported having Pliocene age.

RESEARCH METHODS

This paper describes the result of preliminary study, which is initiated by a desk study, fieldwork and sampling on possible primary mineralization type as the source of the Langkowala (Bombana) placer gold. Based the field investigation and data analysis in Mendoke and Rumbia and surrounding area. The study has been emphasized on some key characteristics of the primary deposit including host rock petrology, quartz vein texture and structure, hydrothermal alteration and mineralization.

However, during the desk study some literatures related to Mendoke and Rumbia mountains secondary gold were reviewed, *e.g.* [16], [19], [17] and [10, 12, 13]. The initial fieldwork was focused on the reconnaissance of the studied area and sampling. Few stream sediment and quartz vein samples were taken to be geochemically analyzed in a laboratory. X-Ray Fluorescence (XRF) has been used for the whole-rock geochemical analysis for the samples taken by [16]. A sample taken by PT. Panca Logam Group was analyzed by AAS. However, this paper is predominantly written on the basis of data and results from the fieldwork in the mining concession area of PT. Panca Logam Group located in the northern flank of Wumbubangka Mountain range (Figure 2).

PLACER GOLD IN LANGKOWALA FORMATION

Gold is recovered from both stream sediments of the present-day active rivers and in the Tertiary sediments of Langkowala Formation. Gold location plotting indicates that the placer gold is distributed not so far from the metamorphic mountain range. Gold grains have subrounded to angular shapes [16] and preliminary data also exhibits that the abundance of gold grains decreased as its distance from the metamorphic mountain range increased. Geochemical analysis using XRF conducted by [16] of six soil and stream sediment samples taken indicates that gold (Au) grade ranges from 50 g/t to 140 g/t. Base metals including Cu, Zn, Pb, and other elements such as As, Zr, S, Ti, V, K, and Ca are relatively low, with exception of Fe grading between 4.06 and 7.89 wt.%. The low content of base metals and S implies a weak mineralization of base-metal-bearing sulphides in the primary deposit. This may imply that gold grain was not so far transported from its primary source.

Gold is also found in colluvial material on the northern slopes of the nearby Rumbia Mountain range [12]. This area is underlain by various metamorphic rocks, including mica schist, amphibole schists, metasediments and serpentinized periodite, which have undergone greenschist facies metamorphism and in places contain Au-bearing quartz veins [10, 17]. Geochemical analysis using AAS (Atomic Absorption Spectrometry) of 18 stream sediment samples (minus 160 mesh) from Langkowala area indicates that gold (Au) grade is relatively low ranges from 0.005 to 0.033 g/t, with average of 0.01 g/t Au 9recalculated from Prihatmoko *et al*., 2010 in [10]). However, other laboratory analyses of three selected stream sediment samples from the studied area exhibit significant gold grades i.e. 18 g/t, 10 g/t and 913.5 g/t Au, respectively.

Results of interpretation of Landsat citra combined with digital elevation model (DEM) shows that the primary gold deposits is likely to come from altered sedimentary and metamorphic rocks which form the mountains Mendoke and Rumbia Mountains. This is confirmed by the presence of a circular rock formation in the body of the mountain (Figure 2) [19].

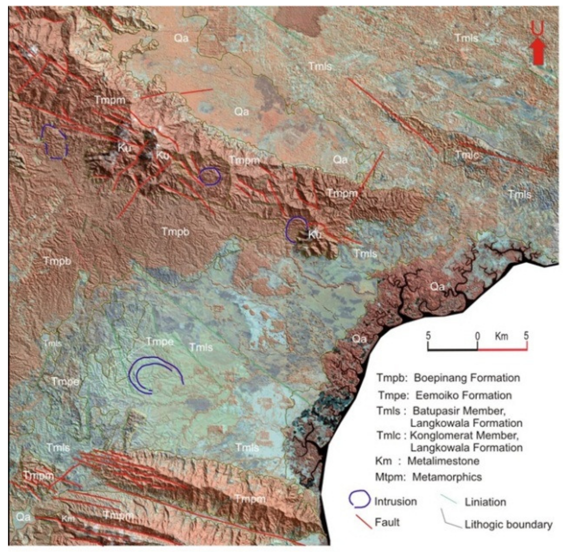

Figure 3. Geological map of Mendoke and Rumbia Mountain result interpretation of Landsat imagery combined with DEM [19].

QUARTZ VEIN CHARACTERISTIC, HYDROTHERMAL ALTERATION AND MINERALIZATION

There are at least three generations of quartz veins. The first generation consist of 2 cm to 2 m thick veins that are roughly parallel to the foliation of mica schist, phyllites and metasediments in up to 10 m wide zones (Fig.4A). The second generation is composed of narrow less than 20 cm, more massive quartz veins that cross cut the first generation of veins and foliation (Fig. 4B). They show a fair degree of brecciation and contain rare bladed carbonate pseudomophs. The third generation consist of laminated quartz-calcite veins, which are interpretated to be late stage hosted by metasediment are mostly parallel to the 'laminated' structures, identified in zones up to 15 meters wide (Fig. 4C).

Figure 4. Gold-bearing orogenic vein characteristics : (A). Breccited quartz vein (first generation) which is parallel to the foliation of the mica schist, (B). Quartz vein cross cutting foliation, (C). A cluster of deformed laminated quartz veins hosted by metasediment.

The wallrock are generally weakly altered. The hydrothermal alteration types recognized in the field includes argillic, silification, carbonate and carbonization alteration. Argillic (clay-sericite±silica) alteration is mostly present surrounding quartz veins or along structural zones, whereas silicification is represented by silicified metasediment and mica schist. Carbonate alteration is characterized by calcite veinlets/stringers and carbonization by the rare presence of graphite within or adjacent to quartz veins and carbonization is considered to be one of the alteration type characteristics, associated with orogenic/metamorphic-hosted gold deposit. [17] interpreted the mineralization to postdate the regional metamorphic event as indicated by the crosscutting relationship of the second generation veins with the foliation of host rocks and by the replacement of muscovite by epidote and quartz by calcite adjacent to the veins. They link it to post orogenic magmatic/hydrothermal activity.

Those sulfides could be pathfinder minerals for the exploration of the metamorphic-hosted gold deposit. Bulk-orechemistry analyzed by AAS (Atomic Absorption Spectrometry) indicates a very broad and erratic variation of gold grade ranging from below detection limit (0.005 g/t) to 84 g/t Au (based on present study and Prihatmoko *et al*., 2010 in [10]). Gold is mostly very fine-grained, but is occasionally visible as free gold in quartz veins. It appears to be erratically distributed with grades varying from below detection limit 0,005g/t to 134 g/t. Available evidence suggests that the bulk of the gold is associated with the second and third generation veins.

DISCUSSION

The gold in the alluvials and paleoalluvial is likely to be derived from the quartz veined metamorphics because of : 1). The juvenile nature of the alluvial gold grains, indicating limited transport, 2). Increasing abundance of gold grains in the colluvial material in an up slope direction and decrease in gold content in present stream sediments away from the metamorphic rock outcrops [13].

Based on the quartz vein characteristics discussed above, it is interpreted that the secondary (placer) gold in Langkowala, Bombana is likely derived from "orogenic gold", a hydrothermal deposit type based on its (spatial) association with greenschist facies metamorphics and the sheared/deformed, segmented, and locally sigmoidal nature of the first generation quartz veins [7].

The primary gold mineralization is discovered in Wumbubangka area, at the northern flank of the Rumbia mountain range. From the petrology study it is concluded that the host rock is categorized into greenschist facies. This type of metamorphic facies mostly hosts the orogenic gold deposits worldwide, e.g. Mt. Charlotte, Lancefield and Golden Mile [3].

The existence of primary gold mineralization much more work is required to again a better understanding of the mineralization in Mendoke and Rumbia Mountains.

CONCLUSIONS

The primary source of secondary (placer and paleoplacer) gold in Langkowala area is an orogenic gold deposit type in the form of sheared/deformed quartz veins hosted by Pompangeo Metamorphic Complex (PMC), particularly mica schist,phyllite and metasediments occupying Rumbia Mountain that include Wumbubangka Mountain in the south and probably Mendoke metamorphic mountain range in the north.

At least three generations of the metamorphic rockhosted quartz veins are identified. The first is parallel to the foliations, the second crosscuts the first generation of veins/foliations, and the third is of laminated deformed quartz+calcite veins at the late stage. Gold grades in the second and third veins are relatively higher than that in first veins. The veins contain erratic gold in various grades from below detection limit (0.005 g/t) to 134 g/t.

The wallrock are generally weakly altered. Alteration types include silification, argillic, carbonate and carbonization alteration.

The discovery of orogenic gold deposit hosted by metamorphic rocks in Wumbubangka Mountains range and its vicinity are one of the new target of gold exploration are being developed in Indonesia.

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