Metamorphic Rock-Hosted Orogenic Gold Deposit Type as a Source of Langkowala Placer Gold, Bombana, Southeast Sulawesi

Tipe Cebakan Emas Orogen pada Batuan Metamorf sebagai Sumber Emas Letakan Langkowala, Bombana, Sulawesi Tenggara

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Abstract

In 2008, placer gold was discovered in Langkowala area (Bombana Regency), Southeast Sulawesi, Indonesia, and more than 60,000 traditional gold miners in the early 2009 have been operating by digging vertical pits and panning active stream sediments. The grade of placer gold ranges from 50 to 140 g/t. Local geological framework indicates that the placer gold is not related to volcanic rock-related hydrothermal gold deposit, *e.g.* epithermal, skarn or porphyry. This paper describes a preliminary study on possible primary deposit type as a source of the Langkowala (Bombana) secondary placer gold. A field study indicates that the Langkowala (Bombana) placer/paleoplacer gold is possibly related to gold-bearing quartz veins/veinlets hosted by metamorphic rocks particularly mica schist and metasediments in the area. These quartz veins/veinlets are currently recognized in metamorphic rocks at Wumbubangka Mountains, a northern flank of Rumbia Mountain Range. Sheared, segmented quartz veins/veinlets are of 2 cm to 2 m in width and contain gold in a grade varying between 2 and 61 g/t. At least, there are two generations of the quartz veins. The first generation of quartz vein is parallel to foliation of mica schist and metasediments with general orientation of N 300^{o}E/60^o; the second quartz vein generation crosscut the first quartz vein and the foliation of the wallrock. The first quartz veins are mostly sheared/deformed, brecciated, and occasionally sigmoidal, whereas the second quartz veins are relatively massive. The similar quartz veins/veinlets types are also probably present in Mendoke Mountain Range, in the northern side of Langkowala area. This primary gold deposit is called as 'orogenic gold type'. The orogenic gold deposit could be a new target of gold exploration in Indonesia in the future.

Keywords: placer gold, orogenic gold deposit, Langkowala, Bombana, Southeast Sulawesi

Sari

Pada tahun 2008 ditemukan emas letakan di daerah Langkowala (Bombana), Sulawesi Tenggara, Indonesia, dan lebih dari 60.000 penambang emas tradisional beroperasi pada awal tahun 2009 dengan menggali lubang vertikal dan mendulang di sungai-sungai. Kadar emas letakan berkisar antara 40 sampai 140 g/t. Tataan geologi lokal menunjukkan bahwa endapan letakan tidak berasal dari endapan emas hidrotermal yang berhubungan dengan batuan vulkanik seperti epitermal, skarn, dan porfiri. Tulisan ini menjelaskan kemungkinan tipe endapan primer sebagai sumber emas letakan di Langkowala (Bombana). Data lapangan menunjukkan bahwa endapan emas letakan berhubungan dengan urat/uratan kuarsa dalam batuan metamorf, khususnya sekis mika dan metasedimen di daerah tersebut. Urat/uratan kuarsa sekarang ditemukan di Pegunungan Wumbubangka, pada sayap utara rangkaian Pegunungan Rumbia. Urat/uratan kuarsa yang tergerus dan tersegmentasi tersebut memiliki ketebalan dari 2 cm sampai 2 m dengan kadar emas antara 2 sampai 61 g/t. Paling tidak ada dua generasi urat, yaitu generasi pertama yang paralel fo-

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liasi dengan orientasi N 300°E/60° dan generasi kedua memotong urat/uratan generasi pertama dan foliasi batuan. Urat/uratan generasi pertama umumnya tergerus/terdeformasi, terbreksiasi, dan kadang-kadang sigmoidal, sedangkan urat/uratan generasi kedua relatif masif. Tipe urat/uratan yang sama kemungkinan juga hadir di Pegunungan Mendoke di sebelah utara daratan Langkowala. Endapan emas primer ini dikenal sebagai endapan orogenik. Endapan emas orogenik tampaknya dapat menjadi target baru dalam eksplorasi emas di Indonesia di masa mendatang.

Kata kunci: *emas letakan, endapan emas orogenik, Langkowala, Bombana, Sulawesi Tenggara*

Introduction

Currently, in Indonesia gold is mostly mined from volcanic-hosted hydrothermal deposit types including epithermal type, *e.g.* Pongkor in West Java (Warmada, 2003), Gosowong in Halmahera Island, skarn type *e.g.* Erstberg, Kucing Liar, Deep Ore Zone (DOZ) in Papua, and porphyry type *e.g.* Batu Hijau in Sumbawa Island (Idrus *et al.*, 2007; Imai & Ohno, 2005) and Grasberg in Papua. In Sulawesi Island, gold is also predominantly related to volcanic rocks, which are extended along western and northern Neogene magmatic arcs of the island (Idrus, 2009). However, gold has also been found in the southeast arm of Sulawesi Island, particularly in Langkowala area, Bombana Regency (Figures 1 and 2), in the form of placer and paleoplacer. Gold grain was firstly discovered in stream sediments

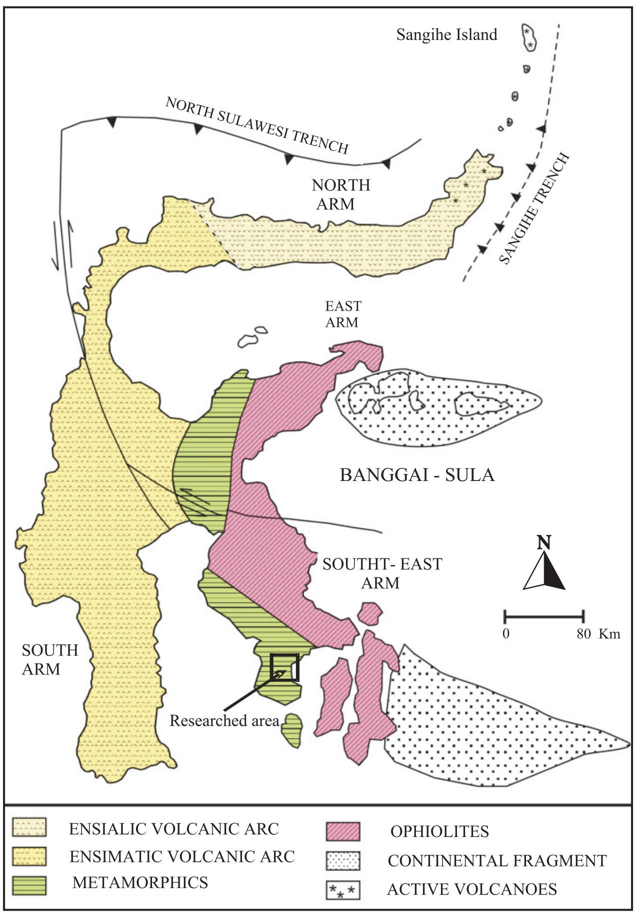

Figure 1. Geological setting of Sulawesi Island (modified from Hamilton, 1979) and location of the researched area in Bombana Regency, Southeast Sulawesi.

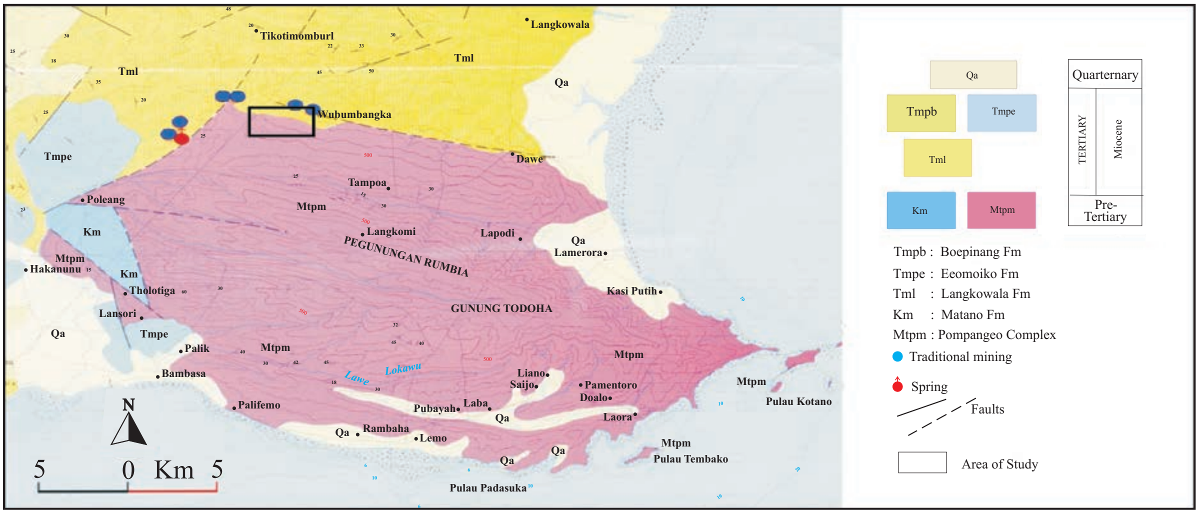

Figure 2. Geological map of Langkowala area occupied by Langkowala Formation (Tml) unconformably overlying Paleozoic metamorphic rocks (Pompangeo Complex; Mtpm) in the south (Wumbubangka and Rumbia mountain range) (Modified from Simandjuntak *et al.*, 1993).

of River Tahi Ite in 2008, and more than 20,000 traditional gold miners have been operating in the area (Kompas Daily, 2008). During January 2009, the number of traditional gold miners in Bombana Regency increases significantly and reaching the total of 63,000 people (Surono & Tang, 2009). The secondary gold is not only found in present stream sediments (placer), but also found within Miocene sediments of the Langkowala Formation (paleoplacer). The primary source of Bombana placer/paleoplacer gold is in controversy and it is still opened for discussion. This paper describes a preliminary study on possible primary deposit type as a source of the Langkowala (Bombana) secondary placer gold. This study is an important stage for the next exploration of gold in the area or other areas that have an identical setting of geology.

Geological Setting

Langkowala area where the placer gold found is characterized by a wavy-flat morphology and crosscut by some major rivers including Langkowala River, Lausu River, Lebu River, and Pampea River. The Langkowala area is located between Mendoke Mountain in the north and Rumbia Mountain in the south. The area is occupied by Early Miocene Langkowala Formation (Tmls) consisting of conglomerate and sandstone (Simandjuntak *et al.*, 1993). This formation is a part of Sulawesi Molasses, which were firstly described by Sarasin & Sarasin (1901; *in* Surono & Tang, 2009). 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 alternating limestone-marl-sandstone, and Boepinang Formation (Tmpb), comprising sandy claystone, sandy marl, and sandstone. Paleozoic metamorphic rocks consist of mica schist, quartzite, glaucophane schist, and chert. The metasediments and metamorphic rocks are of Permo-Carboniferous 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/veinlets with various widths up to 2 m. The quartz veins/veinlets are interpreted as a source of placer/paleoplacer gold in the Langkowala area. The geological map of Bombana area is shown in Figure 2.

Research Methods

As outlined before, this is a preliminary study, which is initiated by a desk study, fieldwork, and sampling. There are no previous studies in the area especially focusing on the primary gold mineralization as a source of the secondary placer gold. However, during the desk study few literatures related to Bombana secondary gold were reviewed, *e.g.* Makkawaru & Kamrullah (2009) and Surono & Tang (2009). 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 Makkawaru & Kamrullah (2009). A sample taken by PT. Panca Logam Makmur 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 Makmur located in the northern flank of Wumbubangka mountain range (Figure 2).

Secondary Placer Gold in Langkowala Area

Gold grain is present both in stream sediments of the present-day active rivers and in the Tertiary sediments of Langkowala Formation. A huge number of traditional gold miners have been operating by making 3 - 6 m vertical pit to dig out the material of Langkowala Formation and by panning the active sediments to recover gold grain. Some miners combine panning with sluice box method for recovering more gold. Gold location plotting indicates that the placer gold is distributed not so far from the metamorphic mountain range. A relative short distance of gold transportation is consistent with subrounded-angular form of gold grain panned (Makkawaru & Kamrullah, 2009). Preliminary data also exhibit that the abundance of gold grain decreases as its distance from the metamorphic mountain range increases. Gold is also found in the colluvial materials along Wumbubangka mountain slope and isolated valley of the mountain range. Geochemical analysis using XRF conducted by Makkawaru & Kamrullah (2009) of six soil and stream sediment samples taken indicates that gold (Au) grade ranges from 50 g/t to 140 g/t (Table 1). 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. The abundance of gold grain decreases as its distance from slope/spurs of the metamorphic mountain range increases. This may imply that gold grain was not so far transported from its primary source.

Some Key Characteristics of the Primary Deposit

Quartz Vein Characteristics

Field investigation shows that gold-bearing quartz veins/veinlets have been discovered in association with Paleozoic metamorphic rocks particularly mica schist and metasandstone in Wum-

Table 1. Chemical Data (XRF) of Gold and other Metals in Stream Sediments at Langkowala Area, Bombana Regency (Grade Unit of Elements is in g/t, except Fe in wt.%). Source: Makkawaru & Kamrullah (2009)

No.	Elements	Samples Code						
		A.001	A.002	A. 003	B. 001	B. 002	C. 001	C. 002
1	**Au**	**100**	**50**	**60**	**130**	**110**	**140**	**120**
2	Cu	70	50	80	120	80	90	50
3	As	50	20	50	220	60	180	140
4	Zn	70	87	50	120	120	200	100
5	Zr	70	40	70	110	100	40	70
6	Pb	40	20	30	40	40	20	10
7	S	10	20	107	20	10	170	30
8	Fe	6.69	4.06	4.19	4.77	5.46	7.89	5.44

bubangka Mountain, the northern flank of Rumbia Mountain Range. Quartz veins are mostly sheared/deformed, brecciated, and relatively parallel to the foliation of the mica schist (Figure 3a) with general orientation of N 300º E. Some quartz veins crosscut the foliation or the first quartz vein and relatively massive compared to the first one. The quartz veins parallel to foliation are commonly 2 cm to 2 m in width, whereas the second phase quartz veins have commonly less than 10 cm in width. It is sometimes observed that the first quartz vein is crosscut by quartz veinlet stockwork/stringers. The quartz veins have been rarely sigmoidal segmented in the form of 'boudin-like' parallel to the foliation of the metamorphic rocks. In metasediments, quartz veins are mostly paralel 'laminated' covering a width of up to 10 m. (Figure 3b).

Mineralization and Hydrothermal Alteration

A megascopic observation shows that quartz veins/veinlets contain very small fine-grained sulphide minerals (3 - 5 %). Pyrite, chalcopyrite, cinnabar (HgS), stibnite (Sb_2S_3), and possible small amount of arsenopyrite ($FeAsS_2$) are present in the quartz veins and silicified wallrocks. Cinnabar is typically pinkish red in colour and present abundantly both in the primary gold deposit and in secondary placer gold deposit. It seems that there is a positive correlation between the presence of cinnabar and the content of gold in both gold deposit types in the studied area. Ore chemical analysis conducted by Makkwaru & Kamrullah (2009) of two selected quartz vein samples from Wumbubangka Mountain with three times repetition of analysis displays a various grade of gold ranging between 2 and 134 g/t (Table 2). Calculated gold grade from processing plant indicates averaging Au of 40 g/t. Base metals Pb and Zn grades are relatively low. Fe grade is relatively high averaging 5.14 wt.%. This is consistent with the concentration of base metals in the soil/stream sediments. High Fe concentration is typical in the metamorphic wallrock of quartz veins/veinlets (cf. Groves *et al*., 2003).

The wallrocks (metamorphic rocks) are strongly weathered, so it is very rare to observe a good outcrop in the area. Fortunately, trenching along the spurs of metamorphic mountain range made by the company helps us to observe clearly the presence of quartz veins and hydrothermal altered rocks. In general, the wallrocks are weakly altered. A strong alteration zone is only restricted in the surrounding quartz vein (like halos/selvage). Hydrothermal alteration types recognized in the field includes silicification, clay±silica (argillic), carbonate alteration, and probably carbonization. Silicification is represented by silicified metasediment, clay±silica (argillic) is mostly present in the surrounding quartz vein or along the structural zone. Carbonate alteration is typified by the presence of calcite veinlets/stringers. Carbonization is probably represented by (rare) the occurrence of graphite with commonly black in colour in the quartz vein and altered mica schist.

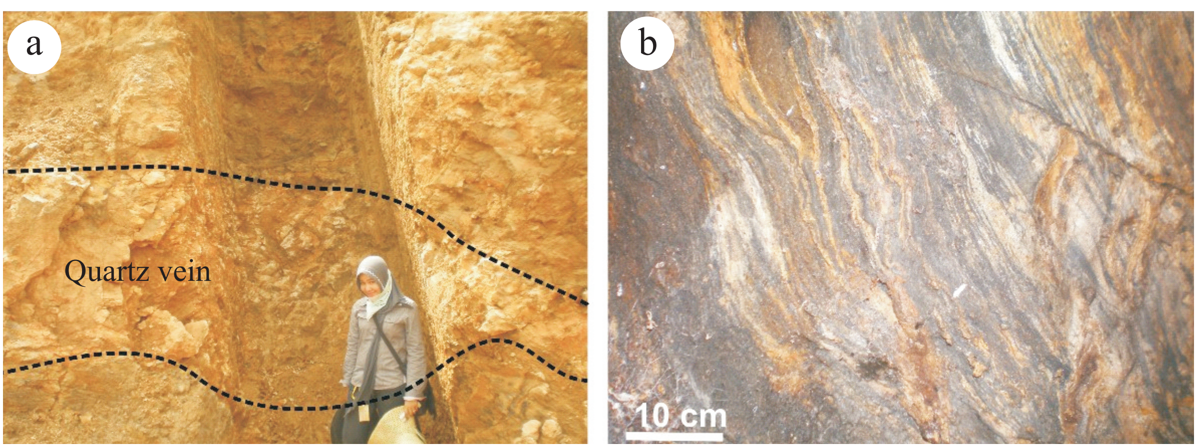

Figure 3. (a). Brecciated/deformed quartz vein (first generation) which is paralel to the foliation of the mica schist, and (b). A cluster of laminated sheared quartz veins hosted by metasediments.

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Table 2. Chemical Data (XRF) of sheared Gold-bearing Quartz Veins hosted by Mica Schist in Wumbubangka Mountain at the Northern Flank of Rumbia Mountain Range in the south of Langkowala Placer Gold Location. Source: Makkawaru & Kamrullah (2009), with exception of sample BVAL-1 from PT. Panca Logam Makmur and analysed by AAS

No.	Sample Codes	Analysis Repetition	Elements (in g/t, except Fe in wt.%)					
			Au	Zn	As	Pb	S	Fe
1	Sample 1 (Quartz vein in Wumbubangka Schist)	1	**3**	8	2	7	-	6.60
		2	**2**	7	2	8	-	6.57
		3	**2**	7	2	7	-	6.55
2	Sample 2 (Quartz vein in Wumbubangka Schist)	1	**61**	6	4	3	20	3.73
		2	**58**	6	3	3	25	3.76
		3	**60**	5	5	3	27	3.60
3	BVAL-1	1	**134**	-	-	-	-	-

Discussion

On the basis of field data, it is interpreted that secondary (placer) gold in Bombana is derived from “orogenic gold”, a hydrothermal deposit type for describing sheared gold-bearing quartz veins, which are hosted by metamorphic rocks particularly green schist (cf. Groves *et al*., 1998). The presence of cinnabar and stibnite genetically indicates that the orogenic gold deposit in the studied area is emplaced into a transition between epizonal and mesozonal within the conceptual model of an orogenic gold deposit (Groves *et al*., 1998, 2003). It implies that the deposit may form at a depth of approximately 5 km below a paleo surface. In addition, observed characteristics of gold-bearing quartz veins/veinlets meet the criteria of orogenic gold type *i.e.* sheared/deformed, segmented, brecciated, and occasionally sigmoidal, which are key indications of brittle condition of the epizonal-mesozonal transition. Some laboratory analyses, particularly fluid inclusion and Raman spectrometry of quartz veins/veinlets as well as metamoprphic facies study, are crucial to be done for a better understanding of the deposit type. The presence of gold-bearing intrusion is not necessarily outcropped on the surface. Hydrothermal fluid-derived intrusion in many cases of orogenic gold deposit worldwide is mostly buried subsurface. Shear zones/extensional structures are important geological components as channelways for ascending of hydrothermal fluids responsible for the formation of the gold deposit.

Conclusions

Some points are concluded from this study as follows:

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 metamorphic rocks, particularly mica schist and metasediments (member of Pompangeo Complex; Ptpm) occupying Rumbia Mountain that include Wumbubangka Mountain in the south and probably Mendoke metamorphic mountain range in the north.

At least two generations of gold-bearing quartz veins are recognized in the field. The first quartz vein phase is parallel to the metamorphic rock foliation (N 300º E/60), whereas the second quartz vein phase crosscuts the first one.

High abundance of cinnabar and stibnite associated with both secondary and primary gold deposits suggests that the orogenic gold deposit formed at the shallow level (~5 km below a paleo surface) between epizonal and mesozonal transition of the continuum model of the gold deposit type.

Gold grade in the primary orogenic deposit varies and reaches up to 134 g/t by AAS; the simple calculated Au grade from processing plant indicates averaging Au grade of about 40 g/t (very high). However, it faces problem in mining method due to discontinuity, highly deformed and relatively small width of the gold-bearing quartz vein.

The discovery of orogenic gold deposit hosted by metamorphic rocks in Wumbubangka Mountain range and its vicinity could be a new challenge and target for gold exploration in Indonesia in the future.

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