Metamorphic Hosted Low Sulphidation Epithermal Gold System at Poboya, Central Sulawesi: A General Descriptive Review

Sistem Emas Epitermal Sulfidasi Rendah dalam Batuan Metamorf di Poboya, Sulawesi Tengah: Tinjauan Deskriptif Umum

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ABSTRACT

Poboya Prospect is located in Block I of PT. Citra Palu Minerals Contract of Work Generation VI, 12 km northeast of Palu City, Central Sulawesi. The prospect was discovered in 1993 by Rio Tinto. It occurs on the east margin of a major pull-apart basin related to the Palu Koro sinistral strike slip fault system that forms part of the Neogene Northern Sulawesi Island Arc. Mineralization at Poboya is interpreted as a low sulphidation epithermal gold system hosted in/by metamorphic rock units. The vein Zona system comprises a series of gently southwest dipping sheet-like, low sulphidation epithermal quartz-carbonate vein Zona. Mineralised quartz-carbonate Au-Ag vein Zona shows epithermal textures such as colloform-crustiform banding, bladed calcite pseudomorphs, chalcedonic quartz, to cocks comb banded quartz with evidence of multiple fluid phases and brecciation. With no volcanics associated and study on alteration assemblages, it is suggested that the best possibility for mineralization in this area rests with the retrogressive chlorite stage which is likely to have generated its own hot water circulation system as the heat source cooled. The extensive development of low to intermediate grade mineralization Zones associated with some minor banded chalcedonic quartz-carbonate stockworks with commonly grey sulphide lines at the edge of the veinlets are regularly found adjacent to the main veins and interpreted formed in the same (?) mineralization stage. Furthermore comprehensive exploration work is required and now being undertaken by CPM to get better understanding of mineralization regard to structure, validate the ore bodies model, and reliable resources estimation.

Keywords: low sulphidation, epithermal gold system, Poboya, Central Sulawesi
INTRODUCTION

PT Citra Palu Minerals Minerals (PT CPM) Contract of Work (CoW) is located in Sulawesi, Indonesia (Figure 1), covering a retained total contract area of 138,889 hectares made up of five blocks in Central Sulawesi and one block in South Sulawesi. Block I where the Poboya occurs, is the focus of the exploration beside several regional and prospect scale exploration programs undertaken by the company. Poboya is administratively situated in Palu Timur Subregency, Palu Regency, Central Sulawesi Province.

REGIONAL GEOLOGICAL SETTING

Sulawesi is situated in the northern Indonesian archipelago that is associated with the interaction complex of the Southeast Asian, Pacific, and Indian-Australian plates (Kavalieris et al., 1992). The numerous occurrences of several precious and base-metal porphyry and epithermal mineralization in Sulawesi are associated with this tectonic setting. The eastern margin of the Southeast Asian Plate was involved in at least three major subduction events, which has contributed to the evolution of Sulawesi. The earliest Early Cretaceous event (110 Ma) is represented by basement complexes preserved in southern and central Sulawesi (Kavalieris et al.,1992). The second mid-Oligocene event (28 - 31 Ma) is attributed to blueschist and ophiolite complexes in Eastern Sulawesi (forming the east and southeast arms of the island). In Central Sulawesi, basaltic and andesitic volcanics of the Tinombo Formation, and potentially coeval basaltic dykes, are also related to this subduction event. The third subduction event during the Lower Miocene (16 - 24 Ma) produced calc-alkaline magmatic intrusions and associated porphyry and epithermal mineralization in North Sulawesi (Figure 2).

Carlile (1983) divides Sulawesi into two distinct Zones; eastern and western geological Zones. The western Zone is dominated by calc-alkaline volcanic and intrusive rocks of the Miocene magmatic arc. The eastern Zona, including the east and southeast island arms, is characterized by metasediments and ultrabasic units, and obducted ocean floor ophiolites, predominantly related to the second event above. The company’s project areas are located in the western Zona which include the north and south arms of the island and the ‘neck’ of Sulawesi. This Zona hosts several well mineralized porphyry Cu-Au, Mo-Cu and epithermal Au-Ag type mineralizations. On regional scale, the deposition of gold mineralization at the Poboya prospect is likely to have been associated with the early history of the Palu Fault; a sinistral transfer fault.

HISTORY AND CURRENT EXPLORATION OVER THE BLOCKS

Prior to the 1990s, exploration of Central and Northern Sulawesi focussed on the potential for porphyry copper-gold style mineralization. The neck of Central Sulawesi around Palu received little exploration attention as previous explorers considered that the active Palu-Koro fault system and
Figure 1. Tenement location map of PT. Citra Palu Minerals CoW areas.
apparent absence of any related volcanic activity made this area less favourable.

However in 1992, Rio Tinto undertook regional bulk leach extractable gold (BLEG) Au/Ag sampling across accessible areas of Central Sulawesi and identified the Poboya area for follow-up sampling, based on a 27ppb Au, 51ppb Ag BLEG anomaly. The Poboya Prospect was discovered in 1993, when a large clay alteration area was outlined and quartz vein outcrops in the Palu river valley were chip sampled returning highly elevated gold grades including 55 m at 47 ppm Au and 115 m at 15 ppm Au.

Summary of what have already been undertaken are:

- Ground magnetic and orientation induced polarisation (IP) surveying in 1993.
- Evaluation of the Palu mineralization with 11 diamond drill holes completed for 2.861m in 1996. Additional mapping, sampling and ground magnetic surveying were also carried out.
- A 22 diamond drill holes campaign totalling
- 4494 m, were carried out in 1998, leading to preliminary resource estimations for the Poboya mineralization.
• Controlled source audio-magneto teluride (CSAMT) surveying was also conducted over the Poboya Prospect, with 18 lines totalling 27 km collected. This survey resulted some highly potential for such mineralization type down dip from the existing Zona.

Since Bumi legally took control PT CPM, the company has conducted several exploration activities. These include:
• Relogging of the Poboya drilled holes in Block I; for better understanding of lithology, alteration, and mineralization at Poboya prospect.
• Light Detected and Ranging (LIDAR) surveying in over area of the Block I and IV, to get an accurate elevation and topography contouring.
• Desktop study on the deposit including resource calculation and come up with more conservative numbers than the one claimed by previous company.
• Induced Polarization survey (IP) covering epithermal gold prospect Anggasan in Block IV.
• Follow up ground mapping, grid soil sampling in Block IV and V.
• Regional surface geology mapping and geochemistry sampling over Block I, II, IV and V.

While the systematic resource and reserve delineation drilling campaign at Poboya was started on early September 2011 and is planned to be completed in the mid 2012.

METHODOLOGY

This paper is the result of a review and evaluation of the data that has been available since the prospect of Poboya was discovered. The data used comes from a variety of field activities and laboratory analysis; mapping of alteration / mineralization, geochemical analysis and geophysical analysis, and drilling program.

POBOYA PROJECT

Location and Property Background

Poboya Prospect is located in Block I of PT CPM CoW Generation VI, 12 km northeast of Palu, Central Sulawesi. In general, Central Sulawesi forms a thin north-south trending mountain range with rugged topography and elevations ranging from 1470 to 1764 m above sea level. Steep, short rivers directly flow into the ocean.

The prospect was discovered by Rio Tinto in 1993, explored and drill tested in 1994, 1996, and 1998. Rio Tinto decided to divest the project in 1999 and Newcrest Mining put forward a proposal to purchase PT CPM hopeful that it could gain access for both exploration and future mining. However, Newcrest also divested the project in late 2004 due to the concentration of the resources to the new discovery in Halmahera, having completed very limited exploration, none of which was associated with the Poboya Prospect. PT. Bumi Resources TbK, lately converted to PT Bumi Resources Minerals TbK (Bumi) acquired the project at this time and is now seeking to advance exploration.

Geology

The Poboya Prospect is located on the east margin of a major pull-apart basin related to the Palu-Koro sinistral strike-slip fault system that forms part of the Neogene Northern Sulawesi island arc (Kavalieris et al., 1992). This basin and associated infilled with molasse-style conglomerates largely occurs to the southeast of P:lu, possibly related to the termination of a releasing bend in the fault system (Marten, 1999). The local geology is complex, represented by the Tinombo Formation sediments and metavolcanics to the west of vein and gneissic and metamorphic rocks of the Toboli Complex to the east. Structural observations interpreted that the the Poboya vein system formation is along
gently SW dipping normal fault that most likely formed in the transtensional stress regime associated with the opening of the Gulf of Palu. The fault is interpreted to be postdated the mineralization event.

Mineralization at Poboya is interpreted as a low sulphidation epithermal system hosted in/by metamorphic rock units. The vein system was formed within a north-northwest trending belt of Toboli metamorphic rocks to the east of the Palu Fault. The Toboli Complex comprises gneissic and metamorphic rocks, including biotite gneisses intercalated with schists. These have been intruded by granodiorite, feldspar porphyry, and monzonite to form the basement (Figure 3) which makes up the highlands along the spine of the northern arm of Sulawesi (Muhardjo and Kaschul, 1999). The prospect itself is interpreted to be located close to the base of the uplift essentially at the molasse unconformity (Figure 4). Clasts of vein material are noted within the molasse suggesting mineralization is at least in most part, pre-molasse in timing (Marten, 1999). Interestingly, the Poboya Prospect is notable in its absence of volcanic or sub-volcanic rocks that are normally closely associated with epithermal systems. Instead the vein Zona, which do show classical low-sulphidation epithermal textures, are generally hosted by biotite gneiss, foremost in lithology contact Zona with schist as underlie rock (Figure 5). The Poboya vein Zona system comprises a series of gently southwest dipping sheet-like, low sulphidation epithermal quartz-carbonate vein Zona. Our current relogging over historic drill holes concluded with general agreement with the geology interpreted of previous workers particularly related to alteration and mineralization. Moreover, beside the better known LS epithermal highly mineralized main quartz vein from the re-logging we identified quite extensive development of low to intermediate grade mineralization Zonas associated with some minor banded chalcedonic quartz-carbonate stockworks Zona with commonly grey sulphide lines at

Figure 3. Poboya geological interpreted map (modified from RTI).
the edge of the veinlets (Figure 6). The minor veins and veinlets are in the range of 1 cm to 5 cm in thickness and 0.60 g/t to 3.8 g/t gold in grade. The Zonas are commonly found/mapped adjacent to the main veins. The Zonas could reach up to 20 meters beyond
Stockworks

Au mineralization associated with quartz-carbonate stockworks, locally found grey sulphide line at the edge of veinlet, sets in altered gneiss.

Banded (crustiform-collaform-bladed)

Au high grade mineralization associated with banded chalcedonic quartz-carbonate vein, dominantly composed by quartz (70%), shown strong grey sulphide line at the edge of vein. Note locally found multiphase veining.

No.   Core Photo   Texture   Description

1     Bladed within weakly banded   Au mineralization associated with bladed-weakly banded quartz-carbonate vein and stockworks set in silicified monzonite.

2     Bladed within weakly banded   Au mineralization associated with bladed quartz-carbonate vein and weak stockworks, note show weak grey sulphide at the edge of veinlet. Altered gneiss as wallrock.

3     Bladed-massive   Au mineralization associated with chalcedonic quartz-carbonate stockworks, locally found grey sulphide line at the edge of veinlet, sets in altered gneiss.

4     Banded (crustiform-collaform-bladed)   Au high grade mineralization associated with banded chalcedonic quartz-carbonate vein, show strong grey sulphide line at the edge of vein.

5     Banded (Crustiform-collaform-bladed)   Au high grade mineralization associated with banded chalcedonic quartz-carbonate vein, dominantly composed by quartz (70%), shown strong grey sulphide line at the edge of vein.

6     Stockworks   Au mineralization associated with quartz-carbonate stockworks, shown weakly banded quartz-carbonate vein, locally found multiphase veining. Chloritised shot as wallrock.

Figure 6. Textures and mineralization showing at Poboya.
the main vein and preliminarily interpreted formed in the same mineralization stage but could probably otherwise. There is no clear crosscutting relationship between those two and no specific dating undertaken to date.

**Alteration**

Petrology study (Lan Zhang and Ray Merchant, 1996) outlined the summary which are:

- Four samples from one diamond drillhole into the Palu prospect, Central Sulawesi were studied (Figure 7)

  - At the top of the hole, the rock is a quartz pyroxene monzonite and the three other samples downhole are mafic poor quartz monzonites
  - The rocks have undergone an early albitisation which is well developed and probably relates to the deuteric or late magmatic processes in the intrusive host rocks. In all of the samples, this is postdated by the development of contact metamorphism; the samples show the development of strain fabrics, shearing, and mineralogies typical of contact metamorphism. This sees the formation at 87.2 m of epidote, of allanite at 101.8 m, of garnet + allanite at 103.35 m, and of garnet + allanite + sphene at 117.3 m. This variation downhole suggests that the hole is drilled towards the source of the contact metamorphism.
  - The prograde mineralogies are in most part replaced by retrogressive epidote and then retrogressive chlorite reflecting cooling of the system. Later stages see the development of relatively strong veining consisting of quartz + chlorite + pyrite, and later calcite, chabazite, and chlorite-smectite.
  - It is proposed that the area was the site of original potassic intrusion and that there original subsequent reintrusion; this reintrusion contact metamorphosed the older intrusives creating both prograde and then retrograde assemblages. This gave rise to retrograde observed replacement series of garnet-epidote-chlorite-calcite.
  - It is suggested that the best possibility for mineralization in this area rests with the retrogressive chlorite stage which is likely to have generated its own hot water circulation system as the heat source cooled. The presence of quartz in this assemblage is testimony to the development of an aqueous system and, at the likely lower temperatures of this phase of the evolution, epithermal/ mesothermal mineralization could well have developed in the fracturing of this generation, clearly evident in these samples.

**Mineralization**

The main mineralization is hosted within a biotite gneiss. Surface alteration is not
well documented due to cover sequence of molasse obscuring much of the surface projection of the prospect. Several vein Zona areas are described termed the Hill Zona and River Zonas, they are:

- Hill Vein Zona 1, strike length 2.5 km, apparent width up to 200 m.
- River Vein Zona, located 500 m south of Hill Vein Zona 1 comprising two quartz vein Zonas.
- Hill Vein Zona 2, located 1.2 km north-east of Hill Vein Zona 1, with strike length of 1.5 km and slightly steeper dip.

Mineralised quartz-carbonate Au-Ag vein Zona shows epithermal textures such as colloform-crustiform banding, bladed calcite pseudomorphs, chalcedonic quartz, to cockscomb banded quartz with evidence of multiple fluid phases and brecciation (Figure 7). Gold mineralization is interpreted to be hosted within bladed and banded chalcedony quartz-carbonate veins with variable thickness ranging from 1 cm to >10 m and having a wide range of orientations (Figure 4) and grade. Mineralization textures and mineralogy are typical of low-sulphidation epithermal systems with elevated Ag, Sb (antimony), and As (arsenic) levels and low base metal values.

Gold occurs as anhedral crystals up to 50 microns in size and as inclusions in pyrite. Preliminary metallurgical testwork was undertaken by Rio Tinto, 1997 and the results indicated that there was general agreement between metallurgical and geological assays carbon in leach Au recoveries varied from 63 to 94%, with six of the 13 composites achieving Au recoveries >85%.

DISCUSSION AND CONCLUSIONS

The deposit characteristics of Poboya Prospect indicate the vein formed at low temperature and near netral pH condition, typically of low sulphidation epithermal deposit. Structurally, Palu-Koro Fault has formed a host structure and fluid conduits (pathways) for the mineralization. Metamorphic rocks of Toboli Formation is the dominant host rock of mineralization. The mineralised Zona is associated with quartz-carbonate vein and vein breccia within dominantly banded, chalcedonic, and bladed textures. The vein contains multiple episode of quartz-carbonate phase.

With no volcanics associated and study on alteration assemblages, it is suggested that the best possibility for mineralization in this area rests with the retrogressive chlorite stage which is likely to have generated its own hot water circulation system as the heat source cooled. The presence of quartz in this assemblage is evident to the development of an aqueous system at the likely lower temperatures of this phase of the evolution which in this environment of epithermal/mesothermal mineralization could well have developed in the fracturing of this generation.

Significant additional potential in Poboya could be represented by the extensive development of low to intermediate grade mineralization Zonas associated with some minor banded chalcedonic quartz-carbonate stockworks Zona with commonly grey sulphide lines at the edge of the veinlets. The Zonas are commonly found/mapped adjacent to the main veins and preliminarily interpreted formed in the same mineralization stage but could probably otherwise.

Further comprehensive exploration work is required to get better understanding of mineralization regard to structure, validate the ore body model, and reliable resources estimate.

AKNOWLEDGEMENT

May thanks to CPM management for use and publish the internal data, all of personnel at Block I who
have contributed and assisted in providing information and for all of my colleagues for the discussion and support.

REFERENCES


