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Fundamental Study on Support Systemat Cibaliung Underground Gold Mine, Indonesia

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Abstract

Geotechnical information is a key for underground design. The most important parameters are rock mass strength, geological structures, main stress and strain, rock mass classification, discontinuities, etc. All of these may have impact on underground stability, if some are suitable, and only just one is troubled, it can be due to instability in the underground.
The purposes of this study are to classify the rock mass and to introduced the support system in Cibaliung underground gold mine based on the rock mass classification. The characteristics of some geotechnical aspects of Cikoneng and Cibitung area are shown in this paper. Rock mass classification is measured, and the difference between both locations presented as a preliminary study for the next further research. Recommendation of support system policy of Cibaliung underground gold mine which compared to Pongkor underground gold mine also discussed in this paper.

Keywords:

1. Introduction

Geotechnical information is a key for underground design. The most important parameters are rock mass strength, geology structures, main stress and strain, rock classification, discontinuities, etc. All of these may have an impact on underground stability, if some are suitable, and only just one is troubled, it can be due to instability in the underground.

Considering the importance stability of the underground, determination of support system must be carried out by considering the geotechnical information.

Cibaliung underground gold mine where located in Banten province is one of the gold mines in western part of Java Island. This mine has one portal and two main shoot targets, Cikoneng and Cibitung. Cikoneng development is in the hanging wall and Cibitung development is in footwall of Cibaliung fault.

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The characteristics of some geotechnical aspects of Cikoneng and Cibitung areas are shown in this paper and the difference between both locations presented as a preliminary study for the next further research. Recommendation of support system policy of Cibaliung underground gold mine which compared to Pongkor underground gold mine also discussed in this paper.

2. Location

Cibaliung underground gold mine is located in Pandeglang regency, province of Banten. The location is west part of Java Island. From Jakarta as capital of Indonesia, Cibaliung underground mine is achieved by car for six hours towards to the southwest (about 200 km). The west part of the Java area is a famous epithermal gold silver metallogenic province, mainly centered on the Bayah Dome (Basuki et al., 1994, Marcoux and Milesi, 1994), Rosana and Matsueda, 2002). Cikidang (Cikotok) and GunungPongkor are two underground gold mines which located 70 km and 90 km east and east northeast respectively from the Cibaliung gold project.

2.1. Regional Geology

Java where Cibaliung underground mine located is in the Sunda-Banda volcanic arc extending from the northern tip of Sumatra through Java and Bali. This location is situated in the transition from oblique subduction (west) to normal subduction (east). The host rock of Cibaliung deposit is the Honje Igneous Complex. The unit of the Honje Igneous Complex seems to be quite similar to Bayah Dome where the GunungPongkor and Cikotok mineral districts are located.

The oldest rock unit of the Honje Formation is composed of a thick sequence of basaltic andesite to andesite flows and volcanic breccias with some intercalated sediments. They are extensively folded and faulted, and exposed in a north trending horst bounded by west dipping normal faults along the Java coast to the west, and east dipping normal faults below the sedimentary basin to the east (Marjoribanks, 2000).

2.2. Geomorphology

Geomorphology of Cibaliung is a hilly area about 30 – 300 m above sea level and the slope is around 10 – 25%. The highest hill is GunungHonje (620 m) where located in western of underground location.

2.3. Local Geology

The host rock of Cibaliung deposit is the Honje Formation which consists of basaltic andesite volcanic flows and volcanic breccias intercalated with tuffaceous sediments. Furthermore the Honje Formation is intruded by sub-volcanic andesite and diatreme breccia. All of the above are pre-mineral rocks which are unconformably overlain by the post mineral Cibaliung tuff, generally covering the NW trending graben area (Marjoribanks, 2000).

2.4. Geological Structure

The gold prospects in Cibaliung occur within a NW trending structural with 3.5 km wide and at least 6 km long. It is fault bounded and is considered to be a graben (Marjoribanks, 2000). Ore shoot in the Cikoneng and Cibitung areas occur in complex dilational jogs and cymoid bends formed at intersection between NW, NNW and NNE fault systems (Angeles, 2002).

3. Investigation

The methodologies of this study were observed in field location and analysis of secondary data from PT. Cibaliung underground mine.

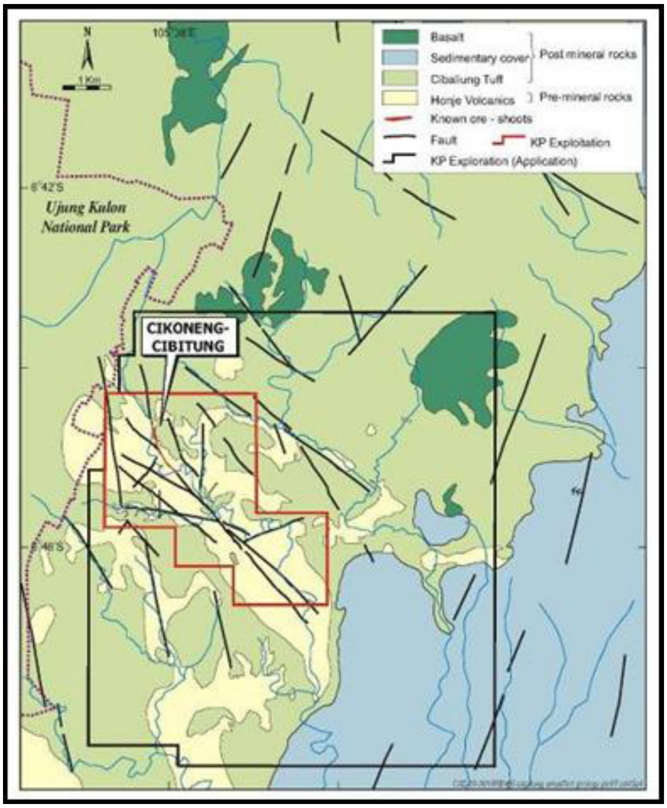

Figure 1. Regional geological setting of Cibaliung area (PT. CSD)

4. Cibaliung Underground Gold Mine

Cibaliung underground gold mine has two main prospect targets, Cikoneng and Cibitung, with Cikoneng portal as a decline access was excavated. The Cikoneng portal elevation is 1,179 MRL. The main access geometry is 5 m height and 4.2 m wide whereas the others access geometry is 4.8 m height and 4.2 m wide. Figure 2 shows the development of Cibaliung underground gold mine, where Cikoneng target development is in hanging wall and Cibitung target development is in footwall.

The host rock of Cibaliung underground gold mine is consisting of andesite. Petrographic analysis of andesite sample contains plagioclase and pyroxene dominated, and small of hornblende. Silicified and chlorite occur as altered minerals. The texture is porphyritic dominated by microcrystalline groundmass about 40%, with some alterations occurred. Existing crack is occurred and filled by silica mineral.

Mechanical properties of intact rock at Cibitung and Cikoneng area are shown in Table 1.

Table 1. Mechanical properties of intact rock of Cibaliung underground gold mine

Location	Cibitung	Cikoneng
UCS	42 MPa	50 MPa
Cohesion	2.02 MPa	0.44 MPa
Friction Angle	21.2^{o}	40.5^{o}
Young's modulus	2.95 GPa	3.21 GPa

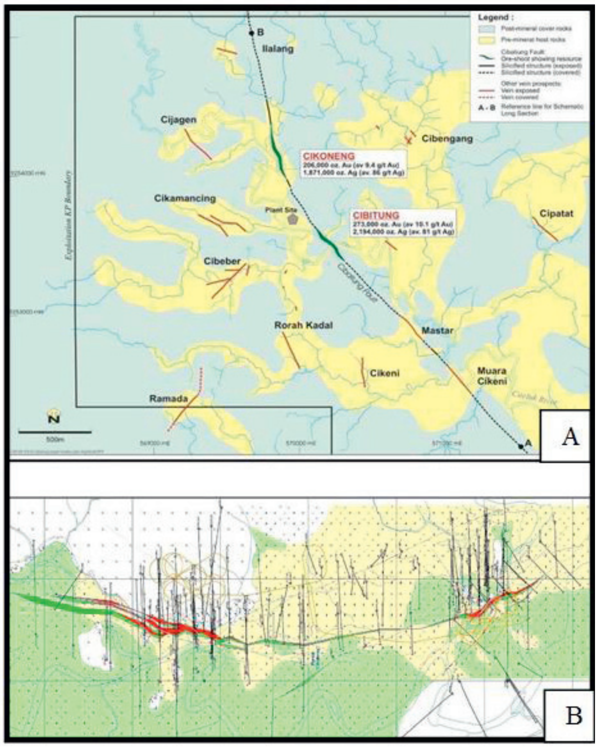

Figure 2.Cibaliung fault with NW striking and NE diping (A). Cikoneng development is in hanging wall, however Cibitung is in footwall (B) (source: PT. CSD)

4.1. Rock Mass Classification

The classification of rock mass in Cibaliung underground gold mine is based on RMR (Bieniawski, 1989). RQD is calculated by joint density measurement percentage on field area. On the field observation is also measured space of discontinuities, persistence, aperture, roughness, infilling and weathered of discontinuities. As well as groundwater condition, the discontinuity and underground orientation are measured.

Cibitung area could be classified into three classes (Table 2): good, fair and poor with the average values are 66, 51 and 37 respectively. Cibitung area, 22% is classified good, 46% fair and 32% poor conditions. Whereas Cikoneng area has also classified into three classes good, fair and poor with the values are 64, 45 and 35 respectively. The good condition in Cikoneng area is only around 2%, fair 57% and poor 41%.

Barton et al., 1974 proposed a Tunneling Quality Index (Q) for the determination of rock mass. The numerical value of the index Q varies on a logarithmic scale from 0.001 to a maximum of 1,000 and is defined by:

$$Q = \frac{RQD}{Jn} \times \frac{Jr}{Ja} \times \frac{Jw}{SRF} \quad (1)$$

Table 2. Comparison of RMR between Cibitung and Cikoneng area on Cibaliung underground mine

Cibitung		Cikoneng		Description
RMR	Area (%)	RMR	Area (%)	
66 (II)	22	64 (II)	2	good rock
51 (III)	46	45 (III)	57	fair rock
37 (IV)	32	35 (IV)	41	poor rock

Based on the Q indexes, the rock mass in Cibaliung underground gold mine is shown at Table 3. The rock mass in Cibaliung is classified into four classes: very poor, poor, fair and good. In Cibitung, 1.7% area is very poor, 21.1% is poor, 59.6% is fair and 17.7% is good with Q values are 0.64, 2.98, 5.96 and 14.4 respectively. Whereas Cikoneng,31.8% area is very poor, 46.9% is poor, 19.3% is fair and 2% is good, with Q values are 0.7, 2.21, 5.94 and 13.25 respectively.

Table 3. Comparison of Q index between Cibitung and Cikoneng area on Cibaliung underground mine

Cibitung		Cikoneng		Description
Q	Area %	[redacted]		
0.64	1.7	0.7	31.8	very poor
2.98	21.1	2.21	46.9	poor
5.96	59.6	5.94	19.3	fair
14.4	17.7	13.25	2	good

5. Discussion

In Cibaliung underground gold mine, four types of support system are classified.

- Type 1, Q > 4
- Type 2, Q = 2-4
- Type 3, Q = 1-2
- Type 4, Q = <1

The type 4 is used to anticipate the worse rock condition. The support is first layer shotcrete 30-50 mm, weld mesh and split set 1.8 m spaced 1.5 m, second layer shotcrete 30-50 mm, grouted split set spaced 2 m, forepolling 4m, spaced 30 cm diameter 25mm and cable bolt 6 m, spaced 2 m is required.

For type 3, the support is first layer shotcrete 30-50 mm, weldmesh and splitset 1.8 m spaced 1.5 m, second layer shotcrete 30-50 mm, split set spaced 2 m, and forepoling 4m, spaced 30cm, diameter 25 mm.

Based on the result of rock mass classification by Q system, mostly, rock supports used in Cibaliung underground gold mine are type 1 and type 2. For the type 1, which Q values more than 4, the support is introduced on the weld mesh galvanized and the split set galvanized 1.8 m, spaced 1.5 m and shotcrete 30-50 mm. For the type 2, the support is adapted on the weld mesh and the split set 1.8 m, spaced 1.5 m, first shotcrete 30-50 mm and 2nd shotcrete 30-50 mm, and also grouted split set, spaced 2 m are required. The Cibaliung underground support recommendation is shown in Figure 3.

Whereas in Pongkor underground gold mine, Sulistianto, et al., 2008 and 2009, on Ramp Down at Ciurug mine where located in Pongkor recommended the support system based on RMR classification and geological structure orientation is corresponding with direction of tunnel excavation (Figure 4).

The RMR classification at Ramp down, Pongkor is variation fair to good from 51-71 at Ramp down B, with 46-49 at Ramp down A. The UCS of intact rock nearby the Ramp down can be classified into medium high strength rock (57.92 – 70.09 MPa). Table 4 shows the comparison of Cibaliung and Pongkor rock mass condition.

Table 4.Comparisson of Cibaliung and Pongkor condition

Cibitung		Cikoneng		Pongkor	
RMR	UCS (MPa)	RMR	UCS (MPa)	RMR	UCS (MPa)
66 (II) 51 (III) 37 (IV)	42	64 (II) 45 (III) 35 (IV)	50	71 (II) 51 (III)	57.92 – 70.09

Support system in Pongkor underground mine is classified into four types for each orientation of geological structure (UBPE Pongkor, PT. Aneka Tambang). Type 1 is mostly no support needed. Type 2 of rock bolt on the roof, spaced 2-2.5 m and wire mesh is required. For type 3, rock bolt on the roof and wall, spaced 1.5-2 m and wire mesh are used. Type 4, rock bolt on the roof, spaced 2-2.5 m, and steel set in three pieces set are required.

Based on the RMR classification and orientation of geological structure and tunnel excavation, the support system is recommended using friction bolt combined with wire mesh but sometimes replaced with steel/timber in three pieces set type for the worse rock condition (Sulistianto, et al., 2009).

From the above point of view, Cibaliung underground gold mine supported by shotcrete even the condition of rock mass is good, whereas in Pongkor, the support system requirement is analysed by considering RMR and corresponding with direction of geological structure and tunnel excavation. Recommendation policy of Pongkor underground gold mine of the support system is mostly without shotcrete.

It is interesting to continue the research of Cibaliung underground mine condition and the shotcrete support system, since based on the field investigation some crack developed, than sustainable controlling is required.

To improve the support system in Cibaliung, the guidelines for excavation and support system suggested by Bieniawski (1989) could be used. Based on RMR classification, combination bolt and wire mesh are recommended with space various.

6. Conclusion

Cibaliung underground gold mine consists two main targetCibitung and Cikoneng. The location of both target has different position where Cibitung is in footwall and Cikoneng is in hanging wall of Cibaliiung fault.

Rock mass condition of Cibitung area based on the RMR is better than Cikoneng, which 22% area of Cibitung is good whereas good condition of Cikoneng is just only 2%. As well as rock mass classification based on the Q system, 17.7% area of Cibitung is good and just only 2% area of Cikoneng is good.

In Cibaliung, the whole access supported by shotcrete even the rock mass condition is good, which is not necessary in Pongkor underground gold mine.

From these points of views, a new supporting system has to be improved at Cibaliung underground gold mine by using combination bolt and wire mesh.

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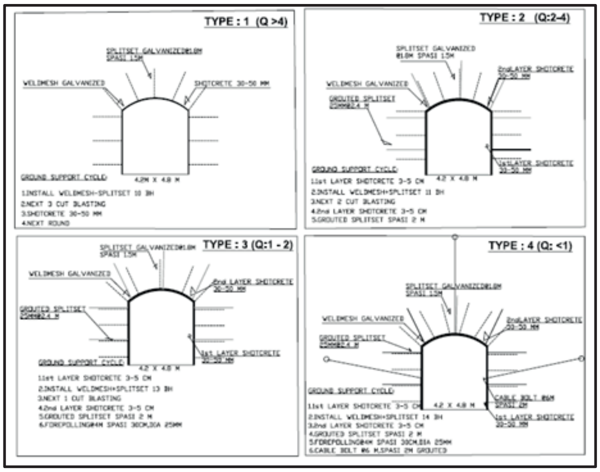

Figure 3. Support system recommendation in Cibaliung underground gold mine (PT. CSD)

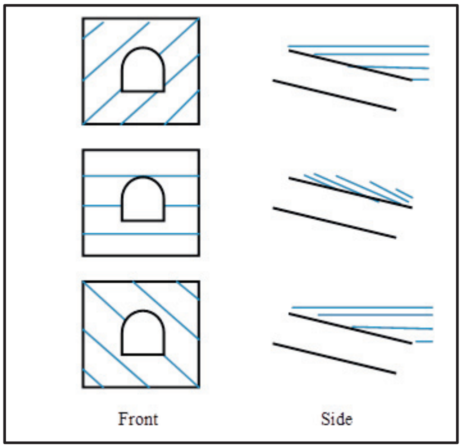

Figure 4. Geological structure and tunnel orientation for support recommendation on Ramp Down, Pongkor underground mine (Sulistiantoet.al., 2009).