

Ground Control Problems and Roadheader Drivage at Ombilin Coal Mine, Indonesia

K. Matsui & H. Shimada

Department of Earth Resources and Mining Engineering, Kyushu University, Fukuoka, Japan

H. Furukawa

Japan Coal Energy Center, Tokyo, Japan

S. Kramadibrata

Department of Mining Engineering, Institute of Technology Bandung, Bandung, Indonesia

H.Z. Anwar

Indonesian Institute of Sciences (LIPI), Bandung, Indonesia

ABSTRACT: In 1998, an agreement on the "Incline Project at Ombilin III" was made between JCOAL (Japan Coal Energy Center) and PTBA (PT. Tambang Batubara Bukit Asam). In this project, a development system of an incline was introduced to open a new underground coal mine, or Ombilin III that will begin mining operations in the 2000s to meet the necessary demand for increasing the production of Indonesian domestic coal. This paper discusses the ground control problems and the development performance of two main inclines at Ombilin Coal Mine.

I INTRODUCTION

Indonesia produces over 80 million tons of clean coal annually and is the third largest coal exporter to Japan, about 13 million tons annually. 99% of the total production of coal is from opencut mines. It is anticipated that more opencut mines will be developed and more coal will be mined underground to fill the great demand for coal in Indonesia and the rest of the world.

In 1998, the development of a new underground coal mine began at Ombilin Coal Mine in Indonesia in order to meet the necessary demand for increasing the production of Indonesian domestic coal in cooperation with JCOAL. In this project, a development system of an incline was introduced to open a new underground coal mine, or Ombilin III that will begin mining operations in the 2000s

A joint research work at Ombilin Coal Mine that has been conducted since 1998 by Kyushu University, Japan, the Institute of Technology Bandung (ITB), Indonesia, and the Indonesian Institute of Sciences, Bandung (LIPI), Indonesia is directed primarily towards the optimal underground support system and the development of optimal underground mining methods in Indonesia. Some results of the joint research have already been reported (Shimada et al., 1998, Anwar et al., 1998, 1999a and 1999b, Matsui et al., 1999, and Kramadibrata et al., 2000).

This paper describes the ground control problems at Ombilin I and also discusses the development performance and ground control of two main inclines at Ombilin III.

2 COAL MINING INDUSTRY IN JAPAN AND ITS POLICY

Japan is dependent on overseas suppliers for the coal it uses (over 150 million tons). Japanese annual domestic production output is only about 1 million tons. At present, there are only one underground coal mine (Kushiro Coal Mine) and several small opencut mines in Japan.

It is anticipated that the coal extraction conditions in the coal-producing countries will deteriorate in the future. A 'Five-year Plan for Coal Technology Transfer' started in 2002 in order to achieve greater stability in the supply of coal from overseas. Under the five-year plan, Japanese advanced technology such as safety technology will be transferred in an intensive and planned manner to coal-producing countries, especially Indonesia, China and Vietnam.

Considering the necessity of development of new underground coal mines in Indonesia, an agreement on the 'Incline Project at Ombilin III' was reached between JCOAL and PTBA in 1998. In this project, a development system of incline for a new underground coal mine (Ombilin III) was introduced, consisting of a roadheader and transport system that were manufactured in Japan. From this project, it is expected that Japanese coal mining technology will be transferred to the Indonesian side.

3 OMBILIN COAL MINE

Ombilin Coal Mine is located at Sawahlunto Region of West Sumatra Province. Historically, the mine was established by the Dutch Company in 1892. At present Ombilin Coal Mine is owned by PTBA, which operates open pits and underground mines. The total annually production is about 1.0 million tons and 10% of the overall production is from underground mining.

The geology of coal in Ombilin Mine is Paleogene sedimentary and belongs to the Sawahlunto Formation, which consists of a sequence of brownish grey shale, siltyshale and siltstone and interbedded brown-dense quartz sandstone and coal (Koesumadinata, et al., 1981).

The existing underground coal mine is now operating at the Ombilin I, Sawahlung. Two coal seams of A and C seams are being extracted by retreat longwall caving method and room-and-pillar method. The longwall face width varies from 70 to 150 m, and the panel length is up to 400 m. The depth cover varies from 50 to 300 m. Geotechnical problems identified at Ombilin I were discussed in some previous research works (Rai, 1999 and Kramadibrata et al., 1999).

Since 1985, underground development in coal and soft to medium hard rock has been done by using roadheaders. On the other hand, drilling and blasting methods have been used for tunnel development in harder rock formations, including siltstone and sandstone

The Siaalut area, so-called Ombilin III, is being

constructed and prepared to mine A and C coal seams at a depth of about 800 m below the surface. There are two inclines, Incline 1 and Incline 2, being developed as shown in Figure 1.

4 GROUND CONTROL PROBLEMS AT OMBILIN MINE

The result of the geological investigation presents that the coal bearing strata at Ombilin basin consist of low strength coal shale, interbedded siltstone/shale, siltstone/sandstone and silt overlain by sandstone. In general, the immediate roof is structurally competent, but low strength from 25 to about 50 MPa. In this category, they can be classified as weak rocks. It also shows severe slaking behavior when it comes in contact with water. Nevertheless, the strength indicates an increase with an increase of distance into the roof. The immediate floor consists of interbedded sandstone/siltstone and a siltstone layer. Some problems identified at Ombilin I have been associated with uncontrollable factors such as rock mass behavior i.e. intact rock behavior, geological structure and in-situ stresses.

These coal measures rocks showed the severe deterioration of the mechanical properties and slaking behavior due to water (Anwar, et al., 1999 and Matsui et al., 2000). These effects cannot be neglected considering the roadway maintenance and the support system design.



Figure 1 Portal of Incline 1 at Ombilin •

According to Rai (1999), the deformation of the coal bearing strata in the Ombilin area has a time-dependent behavior that follows the Burger elastoplastic rheology model. At Ombilin I the roof deformation occurred varies from 7.7 mm to over 120 mm at about 300 m depth below surface, which was measured by means of extensometer (SCT, 1994). In the level of the maximum deformation, the deflection of the steel support is likely expected. This study shows that the majority deformation occurred in the clay-rich immediate strata. It is related to the shale/siltstone behavior which is found in the immediate roof, which is very weak in wet conditions.

Figure 2 shows the mechanism of roof failure at Ombilin I described by Rai (1999). Figure 2A shows a rock failure due to the laminated structure, whereas Figure 2B depicts a rock failure due to a slickenside plane, which is frequently found in laminated sandstone or siltstone. Furthermore, Figure 2C and 2D show rock failures due to joint and wedge-form

structures. Figure 2E is a representation of the inward movement of sidewalls and failure of roof rock due to the weakness of the rock mass. The inward movement can reach the order of 40-60 cm and the falling rock block can be of 20-80 cm diameter. Moreover, Figure 2F shows the inward squeezing of swelling or creeping siltstone, which causes a bending to steel support. The inward squeezing is 50-90 cm at each side.

Up to now, many measures have been tried to control the large deformation and to prevent the failure of roadway roof. Of these, roof bolting is effective and economic support system. The effectiveness of roof bolting was shown in the poor roof conditions clearly according to tell-tale monitoring and field observation. From the long-term field observation and laboratory test, however, it was revealed that although roof bolting prevented the roof fall, it could not control the roof failure and the large deformation of the poor roof.

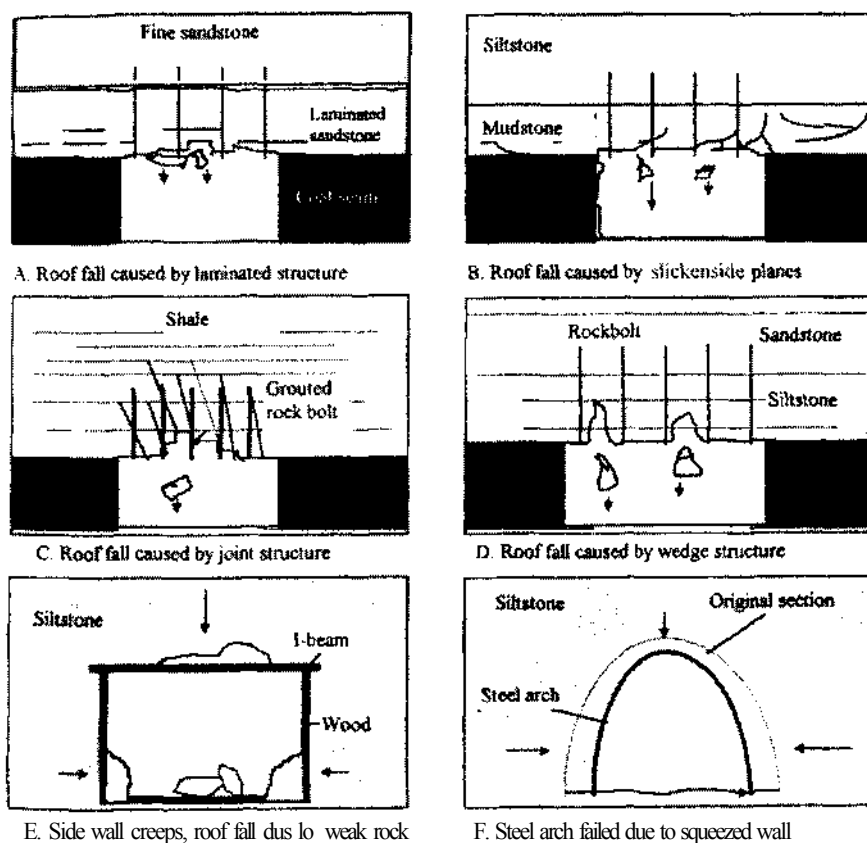


Figure 2 Failure patterns at Ombilin Coal Mine.

5 DRIVAGE SYSTEM OF INCLINES 1 AND 2 AT OMBILIN III

At present, serious ground control problems such as roof fall and large deformation are occurring at the two mains which are main roadways for development and extraction of the Longwall Panel 6 of Coal Seam A. The bolted main roadway is suffering from large roof deformation and roof severe falls occur in another main roadway that is supported by the three-piece-set. And rib failure is also occurring at the maingate and tailgate of the Panel 6.

Figures 3 (a) and (b) show the bolted main roadway where severe roof deformation occurred due to time-dependent and slaking behaviors of roof siltstone. It is noted that after excavation and roof bolting, the deformation of the roadway at the site was small and stable according to the tell-tale readings. However, after long stable period of about two years, the roadway roof started deforming gradually and reached to the magnitude of over 100 cm of roof settlement. According to the recommendations, three-piece-set with I-beam and wood props was installed in order to control the deformation. But the additional support could not stop the behavior. The wood props were broken and finally in order to keep the roadway open, steel arches were installed after back ripping as shown in Figure 3 (b). The height of the roof ripping was about 100 cm. The exposed bolts were seen like bamboo shoots in the same figure. The part of exposed bolt was cut off later.

It is not clear whether the installation of longer bolts or cable bolts could control the deformation in the site or not. However, it is recommended that longer bolts or cable bolts should be installed during stable period when the strata are expected to show severe time-dependent behavior.

Basically rib bolting is not used at Ombilin. From the observation, the rib was stable after excavation. About one year later or so, however, the rib started tailing gradually. Rib failure has become a serious problem at the both maingate and tailgate of the Panel 6.

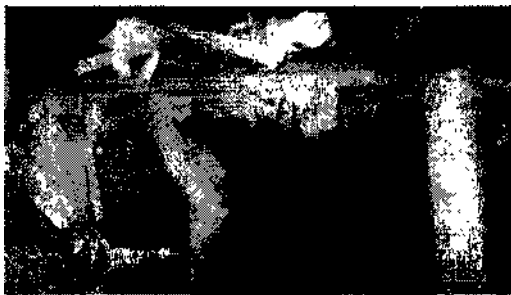
Inclines 1 and 2 at Ombilin III are being developed to drive 1550 m long inclines at a 12 degree gradient. Incline 1 will be used as a main ventilation inlet and haulage incline for underground mining. The drift of Incline 1 was started with a roadheader MRH-S220M from the surface with an open cut in July of 1998. The roadheader was manufactured at Mitsui Miike Mining Machinery Co., Ltd., Japan. The machine is capable of cutting hard rock up to 130 MPa UCS (unconfined compressive strength).

Figure 4 shows the drivage system used in Incline 1. The debris is now transported to the surface by a chain conveyor and a belt conveyor. Incline 1 is an arched shape, being of 5.0 m wide and 3.5 m high. A three-piece rigid steel arch was installed to support the roof and sidewalks at 2.0 m centers. Between the steel arches, three sets of 6 rock-bolts/W-straps were installed to reinforce the roof. The bolt was fully resin-grouted being of 2.4 m long and 22 mm in diameter. Each bolt was installed at 0.8 m centers. Toussaint-Heinzmann yielding arches were also installed at 15 m centers without roof bolting.

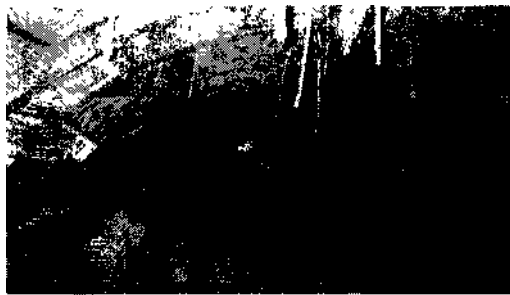
Incline 2 will be used as a main ventilation outlet incline. At the beginning, Incline 2, parallel to Incline 1, was developed by the drilling and blasting method. The distance between the two inclines is 50 m.

Concerning the support system, the shape and size of Incline 2 are almost the same as those of Incline 1. The number of blast holes that were drilled with a Jet-hammer drilling machine was 45, being 12 m long and 27 mm in diameter. It took about 2.5 hours to drill the blast holes. A medium-duty roadheader Dosco-1 is now being used in order to increase the development performance.

The development of Incline 1 so far has not been progressing well due to the presence of a soft immediate roof and floor. Floor softening and heaving is not something that can be ignored. The



(a)



(b)

Figure 3 (a) Failure of roof bolted roadway and (b) resupported by steel arches

roadheader tends to slip and sink in the softened

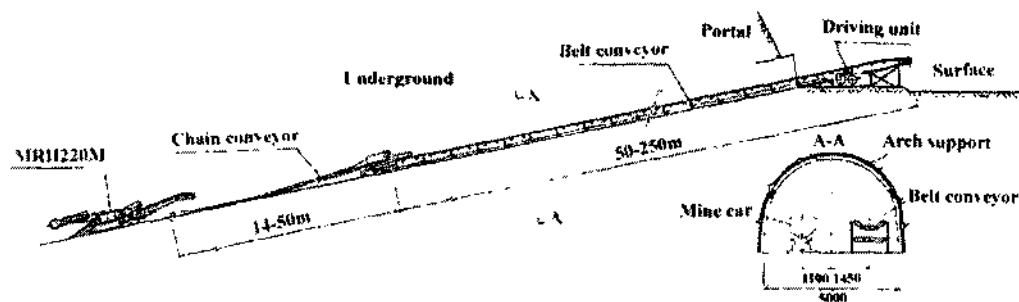


Figure 4 Drivage and transport system of Incline I at Ombilin'

floor. In relation to the poor roof, roof falls at a distance of about 121 m from the portal were apparent, and it was exaggerated at 10 m from this point when the C coal seam intersected the incline, in fact, the water trapped above the seam came out through cleats. Immediate measures were taken by reinforcing the roof by means of a double support system, including roof bolts, steel arches and cribbing. It took a couple of months to go through the fall area. During that period, heading had to be stopped. The reasons for this situation may be summarized as follows:

- 1) It is not possible to effectively predict the type and behavior of rock materials ahead.
- 2) Drainage system is not properly constructed.
- 3) Standard operating procedures are not properly practiced.

The development of Incline 2 has also not been progressing well mainly due to the drilling and blasting method. The introduction of the medium-duty roadheader Dosco-I contributes much toward satisfactory development of the operation.

6 RECOMMENDATIONS

According to the results of the strength tests and slaking tests, it is very important to keep the surrounding rocks dry or to reduce the water content in order to keep or increase the mechanical properties of the rocks and the rock masses. Therefore, it is important to get accurate information of the groundwater conditions at the planning stage. Advanced drilling at the heading face is quite useful for checking the groundwater and geological conditions.

Drainage is considered to be the most economical and simplest method to ensure a stable tunnel and

safe working conditions.

In order to achieve a good driving performance and good ground control of Inclines 1 and 2, the following measures should be done:

- 1) Surface geological mapping, including geological structure mapping.
- 2) Scan line survey in Inclines 1 and 2.
- 3) Progressive horizontal drilling within the inclines.
- 4) Getting rock samples around the opening for geotechnical laboratory tests.
- 5) Re-analyze the roof support requirement.
- 6) In situ stress measurements.
- 7) Establishment of a drainage system.

7 CONCLUSIONS

Detailed geological information is necessary in the drivage of the new inclines, Inclines 1 and 2 at Ombilin III in order to obtain good performance and ground control.

Geological disturbances such as the presence of discontinuities, faulted zones and the presence of groundwater cause problems during drivage.

Stress conditions also affect the stability of the incline and safe drivage.

Problems associated with drivage can be reduced through detailed geological and geotechnical investigations, forward planning, proper selection of measures and equipment and strict supervision.

The results obtained from this study could also be useful for controlling the stability of the incline portal and the inclines of the open pit mines because the strata tend to deteriorate when it rains.

ACKNOWLEDGEMENTS

The authors are grateful to the managers, engineers and miners of Ombilin Coal Mine for their assistance in this study. Many thanks also go to JCOAL for giving us some important information.

This joint research work was funded by the Kyushu University Interdisciplinary Programs in Education and Projects in Research Development.

All the opinions stated in this paper are those of the authors themselves and are not necessarily those of JCOAL and the coal mine.

REFERENCES

- Anwar. H.Z., Shimada. H., Ichinose. M and Matsui. K. 1998. Fundamental studies of the improvement of coal mine shales behavior. *Proc. of Regional Symposium in Sedimentary Rock Engineering*. Taipei. Taiwan. R O C pp.45-50.
- Anwar. H.Z., Shimada. H., Ichinose. M and Matsui. K. 1999a. Roof bolting application in longwall mining in Indonesia and Japan. *Proc. of 10th Int. Conference on Ground Control in Mining*. Morgantown. WV. USA. pp.256-262.
- Anwar. H.Z., Shimada. H., Ichinose. M and Matsui. K. 1999b. Slake-durability behavior of coal mine shales. *Proc. of '99 Int. Symposium on Mining Science and Technology*. Beijing. China. pp.343-346.
- Koesumadinata. R.P., Koesumadinata. R.P., and Matasak, T. 1991. Stratigraphy and sedimentation Ombilin basin. Central Sumatra (West Sumatra Province); *Presented at the 10th Annual Convention of the Indonesian Petroleum Association*. Jakarta. Department of Geology, Institute Technology Bandung.
- Kramadibrata. S., Novi. P. and Rivai. A. 1999. Determination of long term strength of silicified coal pillars by means of multistage creep test. *Proc. '99 Japan-Korea joint Symposium on Rock Engineering*. Fukuoka. Japan. pp. 371 - 380.
- Kramadibrata. S. and Matsui. K. 2000. Rock engineering problems in Indonesian mining industries. *Special lecture at National Institute for Resources and Environment*. Tsukuba. pp. 20.
- Matsui. K., Shimada. H., Ichinose. M. and Anwar. H.Z. 1999. Reinforcement of slaking-prone mine tunnel floor by grouting. *Proc. Mine Planning and Equipment Selection 1999 & Mine Environmental and Economical Issues 1999*. Dnipropetrovsk, Ukraine, pp.253-260.
- Matsui. K., Shimada. H., Ichinose. M., Kramadibrata, S., Anwar. H.Z., Furukawa. H. 2000. Drive of a new incline with roadheader at Ombilin Coal Mine. Indonesia. *Proceedings of the 10th International Symposium Mine Planning and Equipment Selection*. Athens. Greece : 83-88.
- Rai. M.A. 1999. On the assessment of tunnels stability and role of field measurements in Ombilin underground coal mines. *Proc. '99 Japan-Korea Joint Symposium on Rock Engineering*. Fukuoka, Japan, pp. 101-111.
- SCT (Strata Control Technology Pty. Ltd.) 1994. *Ombilin mines - Initial Investigation. Report No. OMB 0236/2*.
- Shimada. H., Matsui. K. and Anwar. H.Z. 1998. Control of hard-to-collapse massive roofs in longwall faces using a hydraulic fracturing technique. *Proc. 10th Int. Conference on Ground Control in Mining*. Morgantown, USA. pp.79-87.