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The Ground Control Management Plan of a Mine: Ovacık Gold Mine Example

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ABSTRACT: In order to reduce accidents, eliminate hazards and improving productivity it is essential to compile a best practice document whereby employees can perform their duties in a safe and healthy manner. The ground control management plan (GCMP) was drafted to describe the requirements of the rock mass control system in the Ovacik Gold Mine-Turkey. GCMP is regarded as part of mine's strategic plan to combat falls of ground and provide safer underground and open pit environment for the life of the mine. The principal aim of this study is to provide assistance to management in their formulation of strategies aimed at reducing the incidence, severity and damaging effects of possible rock-related hazards. This paper is briefly describes what kind of method of approach has been adopted at the Normandy Madencilik AŞ - Ovacik Gold Mine in terms of managing possible rock-related risks.

1 INTRODUCTION

The Ovacik Gold Mine is located 110 km north of Izmir-Turkey, and 12 km SW Bergama in western Turkey (Fig. 1).

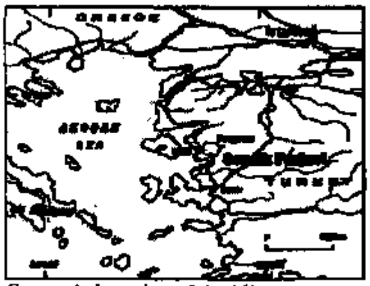

Figure 1. Location of the Mine

Past mining at Ovacik includes near-surface underground mining dated to Lydian and Roman times. The potential of the area was first discovered by Eurogold Madencilik in 1989, and economic mineralization has been identified on 2 outcropping epithermal veins, namely M and S vein. The mine is now owned by the Normandy Madencilik AŞ Company, a 100 percent owned by subsidiary of Newmont Mining Corporation.

2 GEOLOGY

The Ovacık area consists mainly of porphyritic biotite andésite with minor andésite breccia and debries flow, fluviaitle epiclastics followed by subaquesous shallow water dacite-rhyolite dome complex faciès. The dome complex faciès comprises a coherent lava hyloclastite mass flow and accrelionary lapilli, a subaerial andesitic dacitic lava dome complex faciès of coherent lava, autobreccias, volcanoclastics debris flows and fluvialile epiclastic debris flow with the latter fades hosting the Ovacık Gold deposit. The deposits comprise 4 outcropping epithermal veins transecting a large outcrop of silicified and argilised porphyritic andésite of early Miocene age. The veins dip steeply northwards and trend from NE-SW to E-W. At present M and S veins are known to contain economic gold bearing mineralisation. Average vein widths are 60m for M vein and 8m for S vein, however widths can occasionally exceed 20m(After Kara 2002).

The 4 epithermal veins have strike extends in the order of 400m and extend down dip for at least 300m. Orebody contacts are sometimes sharp but more often will be surrounded by a silicified transition zone or mineralized andésite of quartz veins.

3 GROUND CONTROL MANAGEMENT PLAN-GCMP

The main purpose of the GCMP in the Ovacik Gold Mine was to establish principles for the design and monitoring of the layout and support of mining excavations, so as to maximize their safety, stability and cost-effectiveness.

The GCMP is purely a description of the methods to be applied and procedures to be followed in conjunction with all aspects of mining and support strategies which can contributes towards the avoidance of rock-related accidents.

In order to maximize the clarity of he document, the main body has been broken into 6 main parts as follows:

- The mining environment, geology, seismological, and geotechnical properties of the rockmass enclosing the orebodies mined;
- The results of the rockmass response to mining as measured by an assessment of rock-related injury statistics;
- Rock-related hazards and risk management system based on all the above;
- Based on all the foregoing, the description of minimum performance standards by line management and the planning department to determine and enforce strategies to reduce and manage rock-related risks;
- A set of acceptable rock mechanics references that should be used in determining mining and support strategies to minimize and control rock-relate risks;
- Rock engineering services, monitoring quality controls and training

The GCMP for Ovacik God mine was intentionally non-technical, since it must be understandable by all employees of the mine. The technical aspects remained to province of the mining and planning departments, which will apply the acquired skills of their respective disciplines to the mining problems at hand. The main thrust of the GCMP was therefore at human systems: *management and communication.* These aspects require a lot of attention to implement and enforce good rock mechanics practice throughout the mine.

3.1 Fall of Ground Accident Analysis

The rock-related safety statistics for Ovacik Gold mine have been analyzed since underground and open pit came into operation and found that no rock-related accident has occurred during this period. Although the risk rating is very low under current conditions incidents may happen as the volume of mining operation in underground and open pit increase and poor ground conditions intersects.

Table 1. Rock-related accident statistic in Ovacık GM. 2002

Lost Time Injury Frequency Rate	**Serious Injury Frequency Rate**	**Fatality Rate**
0	**0**	0

3.2 Rock-Related Risk Management System

The rock-related risk management provides the basis for decision -making and enables management to create a safer environment. The principal purpose of rock-related risk management system in Ovacik God mine was as follows:

- to identify and assess the hazards to safety to which employees may be exposed while they are at work;
- to record the significant hazards to cerate safer and long term establishment.

Three types of rock-related risk management techniques were introduced for Ovacık GM namely:

/. Base line Risk Assessment

This will be done to identify major risk for future risk control such as analysis of historical data, accident reports, internet, information, sharing info between mines etc. These studies need to be comprehensive, and may well lead to further, separate, more in-depth risk assessment studies.

2. Issue Based Risk Assessment

As circumstances and needs arise, separate risk assessment studies will be conducted when, for example: a new support is introduced into the mine, after an accident or near miss incident, new knowledge comes into to light and information is received which may influence the level of risk to employees at the mine etc. The suppliers in Ovacık GM must ensure, as far as reasonably practicable, that the article is safe and without risk to health ad safety when used properly.

3. Continues Risk Assessment

This is the most important for all of risk assessment, which will take place continuously, as an integral part of day-to-day management of the mine. This will mainly be used by the front line supervisors in the Ovacık GM. for example checklists, audits, planned task observations, daily workplace inspection etc.

The baseline risk profile for rock engineering is presented in Table 2, followed by the risk-ranking scheme used for this overview. This profile will help define the objectives of the mine's mining department, against which achievement targets will be set and reviewed. It also highlights the rock-related safety issues that need to be addressed by other departments in the future.

After a baseline risk profile has been established highest priority risk areas are addressed in more detailed risk assessment. The method, which has been used widely in mines, is the ***WRAC (Workplace Risk Assessment and Control)*** technique. Using this technique, assessment can be done by a group or vertical slice of people from the workplace ranging from the person undertaking a given task to a higher level supervisor and is facilitated by personnel from Mine Planning Department. Hazards are identified by considering each step in the completion of a task and ranking the risk according to the probability of an incident happening and the likely consequence, as indicated by the rusk ranking matrix illustrated in Table 2.

Table 2 Risk Matnx-f (CxP)

	PROBABILITY				
CONS.	A	B	C	D	E
(1) Fatality-1					11
Serious Injury-2			8	12	
Disabling Case-3		9	13		
First Aid Case-4	10	14			
No Injury-5	15				

PROBABILITIES:

Common- (Dailv)-A. Likely- (VYeekly)-H, Happens- (Manlhly)-C, Unlikely- (Yearlj)-D. Rarely (1-3 >ears)-E

A risk ranking of 1 is the most serious and 25 the least serious. Thus all rankings from 1 to7 are critical and require urgent consideration, rankings 8 and 15 are serious and 16 to 25 are of lesser severity and should be addressed only when the more serious risks have been eliminated or controlled.

Table 3. Example of risk assessment using the WRAC techniques in Ovacık GM

Step	**Hazard**	**P**	**C**	**R**	**Svstcm**	**RP**
Application of support slandaids	**Unsafe working areas**	-	-	-	GCMP	PE

When the current system fails or is insufficient then recommended action needs to be developed in order to eliminate risk.

3.3 Rock-related hazards

Each rock type in Ovacık GM has been carefully identified and analyzed in order to develop strategies to combat rock-related hazards on site.

The hazards that have been identified in the geotechnical areas that were mined are summarized in Table 4 for decline development.

Table 4. Rock-related hazards associated with development rock types in Ovacık GM

ROCK TYPE	STRATEGIES
Hemalilic Quartz Breccia **(HBX)**	Hazaid levels are increased for all rock types where tunnels and decline aie developed or mined through faults and dykes due to presence of ground disturbed by lomting or smaller scale fracturing on the margin of these discontinuities
Hydrothermal Breccia composed predominantly of andésite in a siliceous to silica clay matrix **(ADX)**	Steelarch units in conjunction with 2.4m grouted swellex + 50mm fihrecrete with wire mesh to be applied wheie poor ground and self-mining conditions are intersected

4 EXCAVATION DESIGN

The underground mining method will be by decline access to the ore zones and the ore is then probably mined out by mechanized cut and fill sloping methods. The decline has a gradient of 1:7 and a cross-sectional profile of 5,2mx5.2m. The total length of the decline is estimated to be 1100m. Ore is accessed by crosscuts from the decline at 20m intervals. There are at least 2 crosscuts per level to enable multiple work areas and facilitate productivity. Other developments include vent drives, stockpiles and drill cuddies. Waste development drives have a cross sectional profile of 4mx4m and total length is 1200m.

Although *no final decision* has been made with regards to mining method, Ovacık mine intends *to **trial longhole open sloping using up-hole benching.*** The purposed sub-level interval is 20m (backs to backs), resulting in an approximately 25m stoping height (for a single sub-level). No final assessment has been made on the mining method. The principal extraction mining method will be based upon 100% extraction with complete recovery while allowing no perceptible surface subsidence. A crown pillar is planned to be left in order to protect underground environment from flooding.

According to up-hole benching method, the ore is developed by driving strike access drifts with a cross section of 25m^2 along the hangingwall or footwall or in the center of the ore body to the boundaries. Stope preparation is carried out by driving sill drifts across the strike to the hangingwall or footwall. The dimension of the sill drifts can vary, which depends on the thickness of the ore body, and the location of the strike access drifts (example: 7m wide by 5 m high 35m length).

Slop production comprises the extraction of the for instance 25 high bench between two sill drifts. A drop raise is driven between sublevels at the end of the sill drifts. The raise is widened out to as slot, to create free breaking surface. The remainder of the beeches is blasted towards the open slot. The ore is mucked from the lower sill drift using LHDs. The open stope is then backfilled to the floor level of the upper sill drift. The backfilled floor becomes the mucking floor for the next lift. Once two adjacent primary stopes are completely backfilled, the intermediate primary pillar can be mined as a secondary stope. The primary slopes then become backfill pillars. The secondary stopes are also backfilled uppermost sill drifts in each main level are tightly backfilled to the back to support the back.

All other possible mining options are also being evaluated in order to determine optimum mining method.

4.1 Design considerations

The following issues were taken into account when determining method of mining: -

- Define Ground condition: Geology, drill hole data, lithology, mapping, ground water regime, seismicity
- Mineral occurrence: Continuity of ore zones within mineralized strata, grade, resources and mining reserve
- Ore body configuration: Dip, strike and shape
- Safety & regulatory: Labor intensity of method, degree of mechanization, ventilation, requirement, ground support regime, dust, gas and noise control, subsidence, air & water control
- Economics: Mineable ore tonnage, ore body grade, mineral value, capital cost, operating cost
- Political risks

4.2 Stope Ground Support

The objective of support system is to provide sufficient confinement to prevent management on joints and limit the growths of the fracture zone around the excavation so that displacements remain within stable limits during initial tunnel development and subsequent possible stress changes that characterize sub-level mining. The fracture zone will be protected by the support system from erosion by mining activities.

Support on the extraction level will be designed to ensure excavation stability during tunnel and draw points and as the sloping is moves backward. Thereafter, support must withstand erosion by mining activities over a period of several years.

The ground support system for in-stope development may consist of fibrecrete (FC-100mm), galvanized diamond mesh (M-5mm x5mm), standard rock bolting (RB) fully grouted split set (SS) 2,4m or Swellex (S) and 7m cable bolting (CB) in large excavations and intersections.

All waste drifts to be supported with FC or FC+M and Swellex. The hangingwall, footwall and central ore development access drifts may be supported with SS or S and additional RB. In addition, 7m long fully grouted CB must be installed in a pattern of 3-4 bolts per row depending ton the size of the excavation.

4.3 Blast design and practice

Blasts are designed by the mine's mining and planning departments. Notes with the detail of all blast designs will be supplied to the responsible shift boss. Smooth wall blasting techniques is highly recommended in jointed and fracture rockmass condition. In extreme cases JCB-rock breaker or rod header to be used for rock breaking purpose.

4.4 Large excavations

Such excavations must be sited in competent andésite where they will not be affected by stress changes associated with mining operations or adjacent excavations. Such an excavation should be at least 50m from the vein contact or 15m from an adjacent, large excavation. Such excavations are usually in use for several years and support must be designed to ensure the long-term safety of men and equipment in the excavation. Support design is aimed at preventing block fallout. Where excavation width exceeds 2,4m-rockbolt lengths must be increased to 3m with bolts installed on 1 m spacing. Fully grouted steel rope anchors should be interspersed with the rock bolts and installed on 2m spacing. Rockbolts and cable anchors (250kN) must be fitted with faceplates. If deemed necessary the area can be additionally supported with wire mesh, steel tendon straps and fibrecrete.

5 DECLINE DEVELOPMENT

The decline portal was established in a shallow 'box-cut' into the side of the hill. The portal floor elevation is I045RL.

The decline development takes place in jointed and clayed andesitic formation. A 5,2m x 5,2m wide decline access was developed and fully meshed and shotcreeted (100mm) in conjunction with swellex

(2,4m) bolts. Steel sets (2m toi, 5m apart) were also installed and encapsulated in shotcrete.

Cross cut development (lateral) in the decline system will commence once decline system is sufficiently advanced to permit initial driving on ore and establishment of underground exploratory drilling positions. The main ramp system is currently developed at 1:7 gradients down with a cross section of 25 m^2.

5.1 Support Design considerations

All designs for the support of excavations will take into account the following 4 factors: -

- Site investigation: geological data, rockmass characteristics, area! coverage, dynamic loading requirements-yieldebility, stiffness, support resistance concept and economics
- Initial design: Nominate designed units
- Installation: excavation, site inspection and design check
- Monitoring: feed back from production personnel

5.2. Ground control analysis in Ovacık site

5.2.1 Life of excavation

All long term establishment will be supported by fully grouted CT or Swellex bolts or other corrosion resistance units in conjunction with fibrecrete. Split sets will be installed in all temporary excavations in conjunction with 100mm thick of fibrecrete. Steel arch units will be installed when intersecting bad ground conditions.

5.2.2 *Discontinuities*

Support density, areal coverage (wire mesh, fibrecrete and washer for rockbolts) and resistances will be increased when approaching weak ground and mining through dyke structures.

5.2.3 Potentially unstable blocks

Any potential wedge and block failures are stabilized with a combination of fully grouted CT bolts, fibrecrete and mesh and RSJ sets. For large excavations and intersections 7m long cable bolts will be used to stabilize potential large failures.

5.2.4 Ground water control

Corrosion will be associated with ground water within the rock mass, particularly geological structures such as faults and dykes. In these circumstances consideration will be given to use special corrosion resistance steel materials or protective coalings. All rock bolts will be fully grouted to reduce the effect of corrosion. Additional drainage holes, sumps and pumping system will be used for this purpose.

5.2.5 Failure mechanism

Support units will be capable of eliminating the risk of both sidewall slabbing due to clay nature of the formation, wedge and block fall outs, tie and hold fractured or broken rocks and dynamic loading absorption (seismicity and blasting).

5.2.6 Monitoring and quality control

In order determine the actual performance of the support units pull test and visual inspections shall be carried on rock bolt units. Static and dynamic load tests on fibrecrete system will also be carried out to determine shear and axial strengths.

The pull tests will be performed on rockbolts that are as close to right angles with the development face. The supplier along with a mine's representative will carry out all test works, and all records will be kept in the office of the Mine Planning Engineer.

Table 5. Pull test work in Ovacık GM

Support unit	Bolts /month	Number to be tested
Split set	-	1%
CT bolt	-	1%
Swellex	-	1%
Cables	-	1%

Table 6.Recommended failure & test loads m Ovacık GM

Unit	Failure loadkN	Application kN
SS-39 (2.4m)	!30kN	80 % of FL
Super Swellex-4.1-52mm	200kN	80% of FL
CT bolt- (2.4m)	250kN	80 % of FL
Cables- (6m)	260kN	80 % of FL

Regular shotcrete tests are carried by the local university and supplier as part of quality management plan of the GCMP. The testing procedure was also designed in accordance with the provisions of European specification for sprayed concrete in order to achieve best result.

Table 7. Recommended test works on shotcrete Afttr every 50m³ of shotcrete sprayed in the excavation

Type of **control**	**Optimum value**
Compressive .strength	IOMPa24houis. 17MPa7days, Min25-30MPa28days
Energy absorption	Min. 500J
Quantity	Aggregate, accelator. cement, water and fibie content
Tensile strength	Min.2 MPa-28 days
Bond	Equal to tensile strength
Thickness	As designed--!-lOOmm

Table 8 Short summary of geomechanical classification in Ovacık GM

(1) Parameter	***(,2)* Range of values**					
Strength of intact rock material- UCS-Mpa	> 25(1	11» 250	51)- KH>	25- 50	5- 25	1-5
Rating	15	12	7	4	2	1
RQD-%	90- 1(H)	75- 90	50- 75	25- 5(1	<25	
Rating	2(1	17	n	S	1	
Spacing of discontinuities-mm	>2	(16-	2(H)	r,0- 2(KI		
Rating	2(1	15	10	«	5	
Condition of discontinuities						
Rating	.1(1	25	20	10	0	
Ground water-L/min	C- dry	<KI Dj mp	10- 25 Wc (	25- 125 Du ppı ng	>125 Flowing	
Rating	15	10	7	4	0	

Table 9. Risk rating for rockmass

RATING	CONDITION
100-R3	Excellent
75-90-R3	Good
50-74-R2	Fair
26-49-R1	Poor
0-25-R1	Very poor

It should be noted that the performance of a support element within a support system is highly dependent on the interaction between the support element and the rock mass.

In Ovacık Gold Mine, the tunnel support systems will be made up of reinforcing elements, (such as grouted split sets, swellex or CT bolt and cable bolts) that act directly with the rock mass to increase its inherent: and support elements, fabric support or coatings (such as steels sets, mesh and shotcrete) which act to contain the inherently unstable rock mass between the reinforcing units.

Table 10. Design table based on RQD values

Condition	**Primary Support** System	**Secondary Support System**
(2) **RQD** < 50-R1	lOOmin fibrecrele and mesh +2,4m fully grouted SS with combi washer	CT Bolt + steel arch where dead weights are expected
RQD-50-75-R2	70mm fibrecrete +split sets	2.4m tully grouted rockbolts where necessary + steel arch
RQD > 75-R3	50mm fibrecrete	2.4m fully grouted rockbolts

6 OPEN PIT STABILITY

In order to improve the stability of a slope in the open pit area. Ovacık mine has established a reliable prediction of the slope behaviour up to including the final failure so that appropriate action can be taken to minimize the danger to men and equipment.

There arc different systems of measurements to measure displacements in the open pit area, which will depend upon the magnitude of the anticipated movements, local site conditions and availability of staff and equipment. Ovacık GM has sufficient resources to establish the system of displacement monitoring. Mine planning department in conjunction with the survey department will carry out monitoring of displacement measurements in the pit area.

(n order to determine surface movements as a result of mining activity 35 ground control monitoring stations on permanent critical locations-*hot spots* have been established, and topographic record of each station.

Monitoring shall be carried out once a month or such shorter intervals, as the mine-planning department may deem necessary.

7 CONCLUSION

The Ovacık Gold Mine is the only operating role model gold mine in Turkey. In terms of rock engineering point of view all safety concerns (both employees and environment) have been taken into account when designing excavation and support requirements. The current ground control management plan-GCMP was purely designed to combat and eliminate possible rock-related hazards on site. Therefore, the GCMP must be implemented and annually reviewed by the mine management at all time. The same approach needs to be designed for all other mines as well.

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REFERENCES

Department of Minerals and Energy of South Africa 1996. *Guideline fur Compilation of a mandatory Code of Practice to Combat rm kfall and Rm kbttrsl Acı idents*

Kara. Z. 2002. Geology Review & Identified Mineral Resouices in Ovacık GM, *Norımmdv Madencilik AŞ*

Koldaş. K.S 1992. *Rock Meclıanks works and studies in Goldfields of SA Westdriefontem Gold Mme. RPA.*

Koldaş, K.S. 1995. *Rock mechanics and Production works in JCI-Westernarea Gold Mine.* Republic *of South Afrit a.*

Koldaş. K.S. 1999. *Rock-Related Risk Management System for Mines.* Ministry of Minerals and Energy Affairs of South Africa.

Koldaş. K.S. 2002. *Ground Control Manaffement plan of Ovacık Gold Mute* Normandy Madencilik A Ş