USING SPECIALISED MINING EQUIPMENT (EXCAVATOR) WHEN FORMING THE PIT WALLS

Dimitar Dimitrov, Daniel Dakov, Silvia Chavdarova

Mining Complex, “Ellatzite-Med” AD, 2180 Etropole; E-mail: dimitar.dimitrov@ellatzite-med.com; d.dakov@ellatzite-med.com; s.chavdarova@ellatzite-med.com

ABSTRACT. When working out open-pit mines and mining in depth, it is necessary to ensure safety, to clean and form (contour) the working (non-working) benches. Going through fault areas in the process of working out (a precondition for landslides and rock-falls), the achievement of the project angles of the walls is really difficult.
We use special mining equipment (excavators) in order to ensure production, to form and secure the walls, to achieve the walls’ project angles.
Both options – with and without using special mining equipment - have been considered and a comparative analysis of the results has been made.

Key words: shaping, specialised equipment, mine slopes

ИЗПОЛЗВАНЕ НА СПЕЦИАЛИЗИРАНА МИННА ТЕХНИКА (БАГЕР) ПРИ ОФОРМЯНЕ НА РУДНИЧНИТЕ ОТКОСИ

Димитър Димитров, Даниел Даков, Силвия Чавдарова
Рудодобивен комплекс, „Елаците-Мед“ АД, 2180 Етрополе

РЕЗЮМЕ. При разработване на открити рудници и извършване на минни дейности в дълбочина възниква необходимост да се осигури обезопасяване, почистване и оформяне (оконтуряване) на работните (неработни) бордове. В процеса на отработване, преминавайки през разломни зони (предпоставка за образуване на свлачища и срутища), се затруднява постигането на проектните ъгли на откосите.
За осигуряване на добивните минни дейности, оформяне и обезопасяване на откосите, постигане на проектните ъгли на бордовете, се използва специализирана минна техника (багер).
Разгледани са вариантите без използване на специализирана минна техника и с използване на такава.
Направен е сравнителен анализ на получените резултати.

Ключови думи: оформяне, специализирана техника, руднични откоси

Introduction

The *Ellatzite* Open-pit Mine is situated about 80 km east from the capital city Sofia, on the northern slopes of the Stara Planina Mountain, 14 km away from the town of Etropole.

The deposit consists of three main types of rock: Palaeozoic metamorphic complex, granodiorites, and dikes.

There are two main fault systems with regional characteristics. The first fault system arising from the implantation of the dike rocks stretches to ENE around 60˚ and declines to SE at an angle of 50˚- 80˚. The second system stretches to 110˚-130˚ and declines to SW at an angle of 80˚-88˚. This system is represented by two faults called “fault 1” and “fault 2” which are characterised by uplift and slip with a horizontal displacement of about 150 m and a vertical elevation of 150-180 m. In addition to the mentioned tectonic faults in the deposit area, a significant number of tectonic faults of a local character have been identified.

The *Ellatzite* Open-pit Mine is a dynamic system of components that change in time and space: tectonic faults, cracks (local, regional, hypergenic, technogenic), water entries, unstable areas with gravity deformations. The pit develops quickly in depth. The wall height in some areas is already significant which aggravates the wall stability even more. All this leads to the need of continuous monitoring, documentation and actualisation of these components. This need leads to the following: a modern automatic monitoring system has been implemented on the territory of the pit to supervise the wall stability. It consists of several automated total stations, receivers, geo radars and monitoring drill holes equipped with various geotechnical sensors.

The ore body is typhon shaped and is tied to the contact area of granodiorites and schists.

The mineralisation is typically vein ingrained. The main ore minerals are chalcopyrite, pyrite, bornite, molybdenite that mostly form thin veins 0.1 to 2 mm thick, nestlike concentrations or fine-grained insets.

The ore body does not have clearly distinguished geological contacts. It has irregular pillar-like shape with elliptical horizontal sections. Their long axis is maximum 1400 m and the short one – maximum 850 m. The mineralisation has been studied vertically to elevation 550, where the vertical range is from elevation 1420 to elevation 550 or 870 m.

The deposit is open. Certain quantities of ore and waste are excavated which leads to the formation of the open pit. Mining work moves horizontally at every bench which frees for opening-up and preparation of the bench below. This is how the working area (dynamic contour) of the pit is formed. The working area moves down in depth, taking up more volumes of ore and waste. In the process of working out, the angle of the working area changes its parameters as the maximum values are limited by the minimum width of the benches.

The opening-up of the deposit to elevation 1120 goes like this: with a sloping half trench in the western part, a spiral half trench in the eastern part and under bench 1120 – with a sloping half trench in the northern board to bench 855.

The roads inside the pit are temporary, 12-20 m wide, with a 10% inclination.

The main technological processes in the mine are:

- Production drilling performed by four drilling machines with a hole diameter of 250 mm;
- Pre-split drilling for board contour performed by four drilling machines with hole diameters of 142 mm and 165 mm;
- Blast works performed with emulsion explosives for mass blasting;
- Excavation work performed by nine hydraulic diesel and hydraulic electrical excavators, with a bucket volume of 11 to 15 m;
- Mine material transportation performed by dump trucks with 55 to 130 tonnage;
- The coarse crashing is done by Coarse Crashing Corps – KET-1 and KET-3 (two autonomous tracks);
- The formation and maintenance of the pit walls is done by two hydraulic diesel excavators with high lift booms, three front loaders, and dump trucks with a load-carrying capacity of 55-60 tons;
- Road construction and auxiliary works are performed by bulldozers (chain and wheel), as well as other specialised road construction equipment.

Option without using specialised mining equipment (excavator) when forming pit walls

Securing the wall stability of the benches and boards is of crucial importance for the open pits working-out throughout their whole life.

In The *Ellatzite* Open-pit Mine, the wall profile is bench shaped, consisting of production (non-production) benches whose parameters, depending on the physio-mechanical properties of the rocks, are as follows: project bench height with formed final contour H=15 m or H=30 m; safety berms width B=12-20 m, and bench slope angle α=65˚-75˚ (in areas with weak rock types α=55˚).

From elevation 1510 to elevation 1300, the production/non-production benches have a height of H=15 m. From elevation 1300 to 855, we have benches with a height of H=30 m. There are exceptions in a few areas with weak rocks, in areas containing roads, objects and equipment with long term of exploitation and rocks left as safety solids.

The current report looks at the ways to form the slope of a production (non-production) bench with height H=30 m without using specialised mining equipment (excavator with high-lift boom). We chose to describe this option since it is the most complicated and goes in two stages of working-out (first and second) with two sub-benches with a height of H=15 m each.

Contouring is made with pre-split holes in both stages of working-out. After drilling, a “typical” berm appears between the two sub-benches and along the whole bench length. It has a width of B=1.5-2.5 m. The designed length of the pre-split holes is L=16m and the designed angle is α=75˚ with a spacing of a=1.5-2.5 m.

After drilling and blasting from the first stage of the production (non-production) bench with a height of H=30m, employees check out the blasted area. They check for overhanging big rock blocks, peaks, broken contour areas, and so on. If they notice some of the above mentioned, they take measures to render those safe. If possible, they are immediately removed.

Some of the possible and applicable ways to handle overhanging rocks and peaks are the following:

- Blasting with sand blast;
- Using road construction equipment (bulldozer, excavator, front loader);
- Using alpinists for inbreak;
- Using coarse-grained material.

The processes that come next are loading and haulage of the already blasted mine mass. The production excavators are straight shoveled with upper loading. The extraction of material in the slope areas of the sub-bench is carried out very carefully and under strict supervision. The reason is the use of heavy and powerful mine equipment that can easily break over the designed contour. The height of the formed slope depends on the technical parameters of the production excavators. The most common issues after excavator work are the same as those described after blasting. They are handled the same manner. Another major problem is the formation of lumps (more than 0.5 m) in the design contour area for the second stage (second sub-bench) that interfere with the formation of the bench slope. The flattening happens in two ways: through a bulldozer (chain or wheel) with the help of a disintegrator and a loosely fastened ploughshare, or through extra drilling and blasting work. All the actions described in the first stage apply for the second sub-bench in order to form the final working (non-working) bench with H=30 m. The berm, formed between the two sub-benches and all along the bench after drilling and blasting, creates some extra difficulties. Its width of B=1.5-2.5 m allows some of the mine mass, big rocks, and peaks to stay on.

All the difficulties and shortcomings mentioned above are a premise for areas with not well-formed and broken slopes. Very often, this could lead to rock falls and, in rare occasions, to landslides.

Option with using specialised mining equipment (excavator) when forming pit walls

When working out the open pit and mining in depth, there is a need for safety, cleaning, dewatering, maintaining, and

shaping (contouring) the production (non-production) boards and benches.

Going through fault areas is a premise for rock falls and landslides which this leads to problems with achieving the designed slope angles.

In 2010, a decision was made to purchase specialised equipment for the improvement of the contour, stability, and safety of the pit walls. During the third trimester of 2011, the HITACHI 470 LCH excavator (reversed shovel) was implemented in the work flow.

In the next few years, the benefits of such equipment began to show. In 2017, a new department in the mine was created: Board Maintenance and Inbreak.

Primarily, it consisted of one manager, one excavator, one front loader and their operators. In the next two years, one more HITACHI 890 LCH excavator, two HITACHI 550 front loaders, and five dump trucks were bought, all with their operators and managers respectively.

In the present report, you can see the ways to form the wall of a production (non-production) bench with H=30 m by using a specialised mine excavator with a high-lift boom. Two stages of working-out with two sub-benches, each with a height of H=15 m, are necessary. The working slope angle is 42˚-46˚.

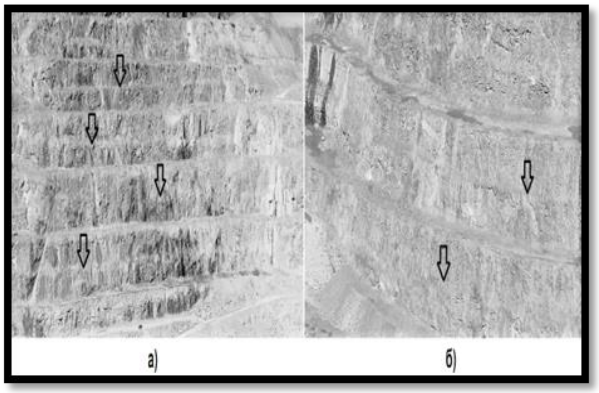

Fig. 1. a) Formation after using pre-split holes in the 1st and 2nd stage of working-out with sub–benches; b) Formation after using pre-split holes only in the 1st stage of working-out with sub-benches

Figure 1 shows a comparison between forming the walls of production (non-production) benches with pre-split holes in both stages of working-out with sub-benches (a) and with pre-split holes only in the first stage (b). With option (a), you can see the typical berm between both sub-benches along the bench length, whose width varies between B=1.5-2.5 m. The design length of the pre-split holes is L=16 m; the design angle is α=75˚, and spacing s a=1.5-2.5 m. With option (b), the formation of the production (non-production) bench with a height of H=30 m, the pre-split holes are done once. This model of forming the walls shows far better results with wall geometry formation. The berm that is seen in option (a) is no longer available.

Right after the design and the carrying out of drilling and blasting, loading and haulage of the blasted mine material is performed. The production excavators dig up the material but when they get near the sub-bench (bench) slope, they leave some of the blasted material, about 1-2 m wide all along the sub-bench height and along the bench length (Figure 2). This is done because the high powered hydraulic excavators can easily break the integrity of the bench and sub-bench slopes. In order to avoid going past the design contour, the left out material is broken down by a high-lift boom back digging excavator (HITACHI 470 LCH or HITACHI 890 LCH).

Fig.2. Part of the technological process of bench (sub-bench) formation

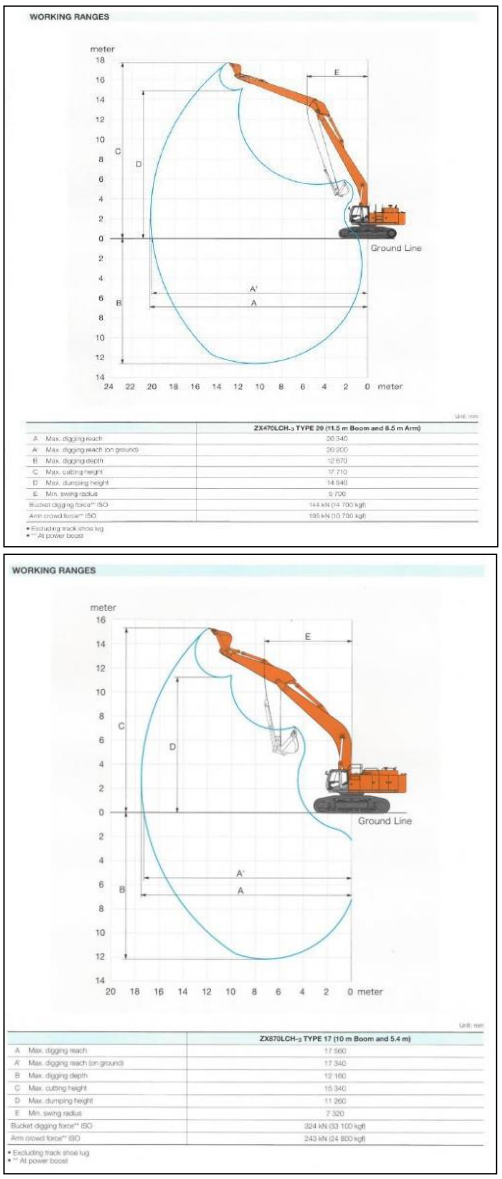

Fig.3. Technical parameters of HITACHI 470 LCH and HITACHI 890 LCH excavators

It can be seen from the technical parameters in Figure 3 that both excavators can work below, above and on the level that have been positioned. It is the manager's responsibility to decide how the formation of the slope will happen. After the decision for the particular area has been made, the operator prepares the bench near the board. They create a safety berm in front of the excavator and start breaking down and forming the slope. The action begins from the crest downwards to the toe of the sub-bench (bench). The material fallen on the toe is dug by the production excavators. Then the high-lift boom excavator goes in again to finalise the formation of the toe of the sub-bench. This is followed by the second digging, loading, cleaning, and haulage of the broken down material with the help of bulldozers, front loaders and dump trucks. Right after that, the designing and drilling and blasting works for the second stage (second sub-bench) begin. All actions are repeated in the same sequence for the second sub-bench in order to form the bench with a height of H=30 m. As an auxiliary option, the HITACHI 890 LCH high-lift boom excavator can be used that has an option for dismounting the back digger and replacing it with a hydraulic hammer.

After the production work is over at a certain bench, it is checked again by the HITACHI 470 LCH or HITACHI 890 LCH excavators and the HITACHI 550 front loader. The final slope check (all along the length and height of the bench) is carried out, and the safety ground (all along its length and width) is made. Also, a safety berm is constructed along the toe of the safety ground with the appropriate inclination to lead the water to the hardest rocks; ditches and drains are created. If there is an extra material left, it is taken to the ore or waste dump locations with a dump truck.

This whole technological process is repeated at every bench (elevation).

Comparative analysis of the results from both options

The comparative analysis of the options with or without using specialised mining equipment (excavator) when forming the pit walls shows their advantages and disadvantages. For this analysis to be correct and fair, a 30-metre high production (non-production) bench is taken.

For the pit working-out and mining activities with a similar bench height, it is necessary to provide security, cleaning, dewatering, formation (contouring), and maintenance.

The first and foremost aspect for the work out and mining activities in the *Ellatzite* Open-pit Mine is the safety of the processes and of the necessary personnel. This is hardly achievable without using specialised miming equipment. It is not always possible to remove peaks, big rocks, outstanding material, or broken contour areas. These difficulties slow down the design and work technologies, make them more expensive, and sometimes even change them.

With the use of a high-lift boom excavator of a back hoe type, the elimination of the above mentioned difficulties is fast, easy, and safe and leads to very well-shaped walls. There is no need for changes in the set design and working technology.

Formation (contouring) of the walls is another important element from the development of the deposit. This achievement is extremely difficult, sometimes even impossible, without specialised equipment (Figure 4. a).

The main problems with wall formation are as follows:

- Forming a typical berm after drilling and blasting between both sub-benches and all along the bench length;
- Not reaching or going beyond the design contour;
- Hanging big rocks, peaks and outstanding material;
- Landslides, rock falls and taluses.

a) **b)**

Fig.4. a) Benches formed without specialised equipment (excavator); b) Benches formed with specialised equipment (excavator).

This shows that the decision made in 2010 to acquire special equipment (excavator) was really right. With its implementation in the working process, the above mentioned difficulties with forming (contouring) the pit walls have been eliminated or reduced to the minimum (Figure 4. b).

Dewatering, cleaning, and maintenance of the slopes are of equal importance. In this case, though, the lack of a high-lift boom excavator does not have so strong and negative an impact because it can be replaced by a bulldozer or other auxiliary equipment.

Conclusions

This report examines the ways of forming pit walls of production (non-production) benches with a height of H=30 m with and without using specialised high-lift boom mine excavator. During the working-out of the pit and performing mining activities in depth, the need arises for safety, cleaning, dewatering, maintenance, and formation (contouring) of production (non-production) boards and benches. Going through fault areas is a premise for landslides, rock falls and taluses, which leads to difficulties in achieving the designed slope angles.

The conclusions that can be drawn after looking through the options are that using this kind of equipment is mandatory. This can be visually seen on the published pictures. With the HITACHI 470 LCH or HITACHI 890 LCH excavators, safety can be achieved for all machines, equipment and people, forming (contouring), and maintenance.

References

Minin, I. 2017. Mining and Construction Machines, ZIZI PRINT, Sofia, 438 p.