

Research and Practice of Goaf Management of An Open-Pit to Underground Iron Mine

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Abstract: In view of the local surface cracks and collapse in the collapse area of an open-pit underground iron mine, considering the safety and thoroughness of the goaf treatment, the scheme adopts the caving surrounding rock method to control the goaf area, and the implementation of this plan eliminates the high and steep slopes to form stable steps, effectively treats the goaf area while fully recovering mineral resources, and provides a guarantee for the sustainable development of the mine.

Keywords: From Open to Underground; Iron Ore Mine; Goaf Governance

1. Mine exploiting situation

The original mining method of the iron mine is open-pit mining. The shallow iron ore body forms two mining pits after open-pit mining, and no complete mining step is formed. The slope is too steep. The long-term rock stripping debt makes the open-pit stope unable to continue to extend, and then turns into underground mining of deep ore bodies.

There are three shafts in the underground mining system of the mine. Among them, SJ1 and SJ2 shafts mine ① ore body, which has been penetrated, and SJ3 shaft mine ② ore body. The wellhead elevation of SJ1 is 705 m, the well depth is 48 m, and two middle sections are mined. The elevation of the first middle section is 674 m, the length of the roadway along the vein is 233 m, and the goaf has been basically mined above the first middle section. The elevation of the second middle section is 657 m, and the length of the roadway along the vein is 207 m. SJ2 wellhead elevation 703 m, well depth 46 m, mining two middle sections, one middle section elevation 674 m, two middle section elevation 657 m ; SJ3 wellhead elevation of 679 m, well depth of 22 m, mining a middle section, the middle section elevation of 657 m, along the vein roadway length of 139 m, the middle section above the basic goaf.

The underground goaf and water accumulation of the mine lead to cracks and collapses on the surface of local areas in the subsidence area. Although the mine has taken a series of measures to isolate the subsidence area, the hidden dangers have not been eliminated. A scheme that can fundamentally eliminate the hidden dangers of the goaf is imminent.

2. Cause of ground pressure and purpose of goaf treatment

The mining of the deposit disturbs the balance of the initial stress in the surrounding rock mass and forms a secondary stress field in the surrounding rock mass. According to the lithology of the rock mass around the stope, elastic, plastic or viscous deformation can occur under the stress of the secondary stress field, resulting in different types of ground pressure activities, and the resulting consequence is the deformation and failure of the surrounding rock. From the current main causes of large-scale ground pressure activities in metal mines, most of them are caused by the existence of connected empty areas with considerable volume for many years ^[1].

The purpose of goaf treatment is to alleviate the stress concentration of rock mass, transfer the location of stress

concentration, or release the strain energy in surrounding rock, improve its stress distribution state, control ground pressure, and ensure the safe and sustainable production of mine. There are three common methods to deal with goaf, namely : caving surrounding rock method, filling goaf method and closed goaf method.

The basic condition for using the caving method is that the surrounding rock and the surface allow collapse. The purpose of caving surrounding rock to treat goaf is to release the strain energy in surrounding rock and reduce the degree of stress concentration ^[2]. Filling the goaf is a filling after the mining of the mine, which requires a strong seal on all the roadways or outlets leading to the goaf ^[3]; the closed goaf method is to build a partition wall of a certain thickness in the roadway leading to the goaf, so that the air waves generated after the collapse of the surrounding rock in the goaf are buffered, so as to prevent the casualties and damage of the impact air waves to people and roadways. Closed cavity method and caving method are very economical methods. Where conditions permit, it should be used as far as possible.

3. Goaf governance scheme

According to the current situation of the mine, considering the safety and thoroughness of the goaf treatment, on the basis of analysis and comparison, the scheme adopts the method of caving surrounding rock to deal with the goaf. Starting from the open-pit slope, the upper rock of the goaf is stripped from the top to the bottom. When the distance is about 15 m from the upper part of the goaf, a borehole is drilled to the goaf, and a blasting is carried out to make the caving surrounding rock fill the goaf. After the goaf collapses and fills, the ground pressure is released rapidly, which can create good working conditions for the next underground mining. The two ore bodies of the mine are about 200 m apart, which are two systems of mining. The goaf treatment is divided into two treatment schemes : No.① ore body goaf and No.② ore body goaf. The scheme also considers the full recovery of mineral resources.

3.1 No.① ore body goaf treatment scheme

The roof elevation of the goaf in the No.① orebody is about 695 m, and the highest distance from the surface is more than 40 m. The goaf is treated in the following steps.

(1) The elevation of open pit is low, the catchment area is large and it is not easy to flow out, which will cause water accumulation in open pit and underground roadway. The scheme is determined to open the southern slope with the help of excavator, so that the catchment in the pit can flow out smoothly.

(2)The No.① ore body above 720 m is quaternary weathered rock and soil layer, which is stripped by excavator. After stripping the Quaternary topsoil, the CTQ500 down-the-hole drilling rig was used to drill holes at a bench height of 10 m on the 720 m platform. In order to avoid the rock being thrown at the bottom of the open pit after blasting, the ditch was designed to be excavated at the eastern exit of the 720 m platform to 710 m, forming a free surface of 720 m-710 m blasting. Directional blasting was used to make the rock thrown in the direction of the eastern exit. The rock is transported out at 710 m level by the excavator with 10 t car.

(3) After the 710 m bench is formed and backed up, a drilling and a blasting are carried out on the 710 m platform, so that all the rocks in the upper part of the goaf fall and fill the goaf.

3.2 No.② ore body goaf treatment scheme

The roof elevation of the goaf in the No.② orebody is about 670 m, and the highest distance from the surface is more than 40 m. The goaf is treated in the following steps.

(1) The surface 5-10 m of the No.② orebody is the Quaternary weathered rock and soil layer. Excavators are used to strip the topsoil above 695 m. When encountering bedrock, rock drilling and blasting are used. After the 695 m step is formed, the CTQ500 down-the-hole drilling rig is used to drill the 695 m platform at a step height of 12 m. After blasting,

the rock is transported out by a 10 t car at a level of 683 m. In order to avoid the rock being thrown at the bottom of the open pit after blasting, the design is determined to dig a trench to 683 m at the eastern exit of the 683 m platform to form a free surface of 695 m-683 m blasting. Directional blasting is used to make the rock thrown in the southeast exit direction after blasting.

(2) After the 683m bench is formed and leans against the side, a drilling and a blasting are carried out on the 683m platform, so that all the rocks in the upper part of the goaf fall and fill the goaf.

3.3 Goaf management technology

CTQ500 open-pit down-the-hole drilling rig is recommended for perforation equipment. Before drilling, the elevation of the goaf should be found out, so that the bottom of the borehole is about 1 m away from the goaf. If there is a hole through the goaf, the bottom of the borehole needs to be filled and blasted once, so that all the rocks in the upper part of the goaf fall and fill the goaf. The medium-deep hole blasting was adopted, ammonium oil explosive and 2 # rock explosive were used, non-electric initiation system of detonating tube and artificial charge were used. The pre-splitting blasting is used near the slope, the hole spacing is 1.5 m, the decoupling charge is used, the decoupling coefficient is 2 ~ 2.5, the charge per hole is about 15 kg, and the number of detonation holes is 3 ~ 4. 1.0 m³ hydraulic excavator is selected for shoveling operation, 10 t dump truck is used for transportation, and one TY-220 front loader is used for auxiliary operation. Some of the original mine roads have been damaged, and they need to be repaired and reformed according to the actual situation to meet the requirements of the regulations and ensure the safe production of the mine. The treatment scope of the goaf is the open-pit hanging wall and the end slope, and the blasting rock is transported to the new industrial site.

There is no dumping site in the mine. All waste rocks are transported to the new industrial site of the mine, and the industrial site is leveled and constructed. Waste rocks are not allowed to be stacked in disorder.

In order to make full use of and recover mineral resources, if the rock with grade is encountered, the enterprise should actively recover it. The scheme is determined to adopt the method of crushing-dry separation, and the recovered rock with grade is processed and then milled to ensure that the mineral resources are not wasted.

The elevation of the open pit of the No.① orebody is low, and the water in the pit can flow out spontaneously after the southern slope is opened. The natural drainage conditions of the No.② orebody are excellent. According to this scheme, the stope does not need mechanical drainage.

3.4 Goaf governance schedule and results

Within the scope of goaf treatment, the rock mass in goaf 1 is 639000 tons, and the rock mass in goaf 2 is 391000 tons, totaling 1.03 million tons. Based on the conditions of goaf treatment and the actual situation of the mine, it is determined to use 3 excavators and 2 drilling rigs, with a treatment period of 1.5 years.

4. Conclusion

This scheme adopts the method of caving surrounding rock to control the goaf. Starting from the open-pit slope, the upper rock of the goaf is stripped from the top to the bottom, and a borehole is drilled to the goaf at a distance of about 15 m from the upper part of the goaf, and a blasting is carried out to fill the goaf with caving surrounding rock. The implementation of this scheme can not only eliminate high and steep slopes and form stable steps, but also effectively deal with goafs and fully recover mineral resources. After the hidden dangers in the goaf are eliminated, the next safe mining plan of the mine can be started, which is of great significance for the sustainable development of the mine.

References

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Projects funding: The 2023 innovation and Entrepreneurship Program of Liaoning University of Science and technology “Study on green mine construction and ecological restoration”(project number: 202311430122)