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Research Article

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Study on goaf disposal of An Ping Zhuang mine area

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ABSTRACT

A great number of untreated underground mined areas caused huge security danger due to long-time iron ore mining in An Ping Zhuang Mine. With GTS ANSYS, the paper analyses the stability of the goaf area and get the distribution law of rock mass stress that before & after filling. Besides, this paper put forward the disposal method that confirms to the actual condition to the mine. Numerical stimulation result certifies that, it is the area of stress concentration between the goaf edge and the two side's juncture. The filling shaft engineering should be placed below the goaf and strengthen the spot inspection. After filling the goaf, part of the stress are moved to the filling bodies. The filling bodies support to the goaf ceiling and improved a lot to the surrounding rocks status. It makes the surrounding rocks towards to stable. Meanwhile, the number of the ground settlement is less & less to make sure the security of the ground buildings.

Key words: Mining engineering, mined-out area, goaf disposal, stress monitoring

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INTRODUCTION

An Ping Zhuang Mine is a intergraed by five mines, which are Qian Baolong Mine, Yang Mantang Mine, Hou Qingshen Mine, Hou Zhijiang Mine, Liu Zhenqi Mine. Due to coyoting for long time, too many irregular untreated goaf and remain orebody are left underground. That makes not only huge security danger but also too much difficulties to the residual ores [1-3].

It is many years after the Mine is opened. It is exploited by the five owners and the exploitation technology is chaotic. In the Mine area, there are eight mine bodies. Of which, six of them are surface mining in the early stage and change to underground mining after that. The current open-pit is not so deep and most of them are backfilled [4-6].

The formed goaf area is around 919, 700 m3. There is living area of Shi Ren Gou Mine on the goaf surface and most of the areas are locate in the subsided zone [7-9]. After general analyzing to An Ping Zhuang Mine, many main problems are as follows:

(1) The living area on the ground locates in the rock moving boundary so neither isolation method or caving method can meet the requirements.
(2) Vertical shaft locates within the move limit.
(3) It is hard to organize with a large area goaf construction in the same time.
(4) Disposal of goaf area and recycle of remain ore.

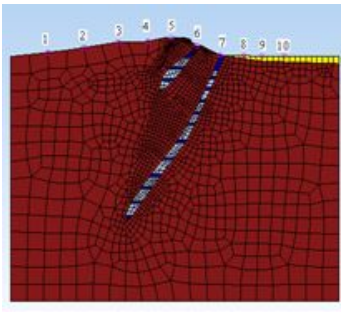
Given the above questions, the paper works on the numerical simulation and analyses the stability & the danger of the goaf area, proposed the scheme to reasonable goaf disposal plan on basis of study.

ANALYSIS TO DANGER AND STABILITY OF GOAF AREA

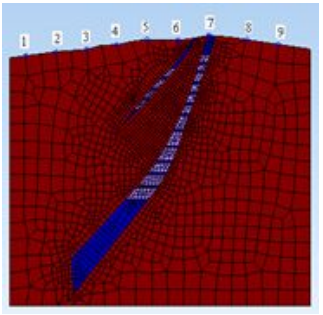
The Mine technique was open scope mining method in the past and it is 919, 700m^3 goaf without treatment. Both the vertical shaft and most living area of Shi Ren Gou Mine are within the rock-falling monitoring boundary lines. So the hidden danger is existing in all the vertical shafts & living areas due to the goaf. There must be person kills, property loss once if the goaf caving so disposal to the goaf must be enforced [10].

Computational model

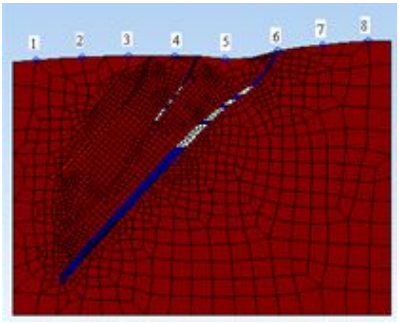
According to the exploitation status, take the three profiles of No.1, No.2 and No.5 detection lines in An Ping Zhuang Mine as typical profile and do numerical simulation calculation with GTS ANSYS. The mining area of No. 1 detection line is 160m, the longest distance from the goaf bottom to the ground is around 300m, model size for numerical simulation is 600mX500m, 28307 units; The mining area of No. 2 detection line is 140m, the longest distance from the goaf bottom to the ground is around 295m, model size for numerical simulation is 600mX500m, 29965units; The mining area of No. 5 detection line is 200m, the longest distance from the goaf bottom to the ground is around 146m, model size for numerical simulation is 600mX500m, 26875 units. As Fig.1.



No.1 detection line model and monitor spot layout



No.2 detection line model and monitor spot layout



No.5 detection line model and monitor spot layout

Fig.1: Numerical Model

Calculation parameters Determination

First of all, making the rock stress calculation, then do partial digging to make it underground goaf step by step. When calculating, it takes four steps to dig it as the current goaf area then back-filling the goaf with four steps. The calculation parameters are as Table 1.

Table 1: Numerical Simulation parameter

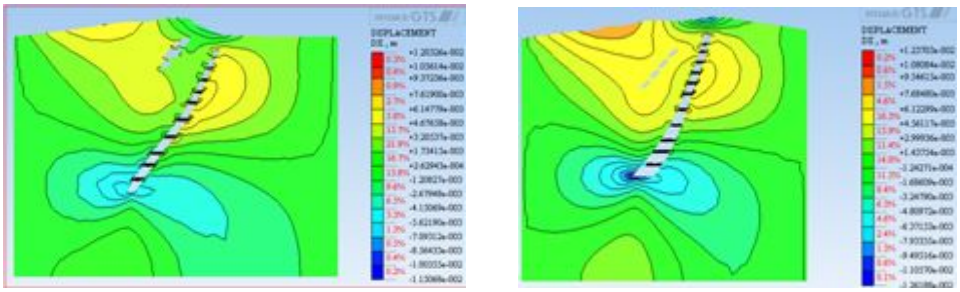
Term	γ(kg/m3)	E(GPa)	μ	C（MPa）	Φ（°）
Ore	3300	4.8	0.21	2.4	38
Rock	2700	4.31	0.22	2.29	36
Filling body	1820	0.71	0.24	0.65	28
Topsoil	1600	0.015	0.25		32

Calculation results & analysis

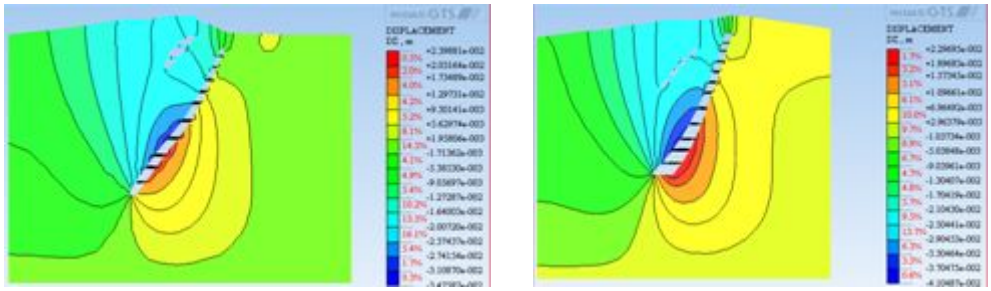
(1) Goaf stability calculation result & analysis

Surrounding rock displacement change is the foundation of judgment to goaf stability. By underground goaf working procedure simulation, recurring the displacement changes of the goaf surrounding rock and providing the basis to analyze the goaf stability in order to guide the goaf disposal projects placement. It is better to keep it away from the area that changed a lot of the surrounding rock or taking the necessary methods to make sure about the construction security. The horizontal & vertical displacement echogram to excavating of NO.1, 2, 5 exploration lines

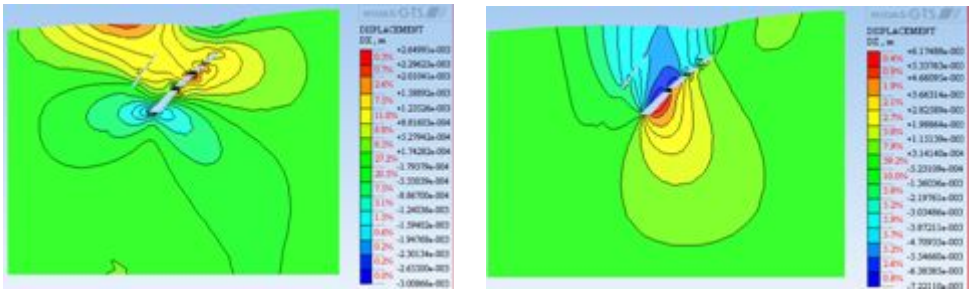
are as Fig.2 .



Horizontal displacement echogram to excavated ore of No.1&No.2 exploration line



Vertical displacement echogram to excavated ore of No.1& No.2 exploration line



Horizontal vertical displacement echogram to excavated ore of No.5 exploration line

Fig.2: Numerical simulation results of goaf stability

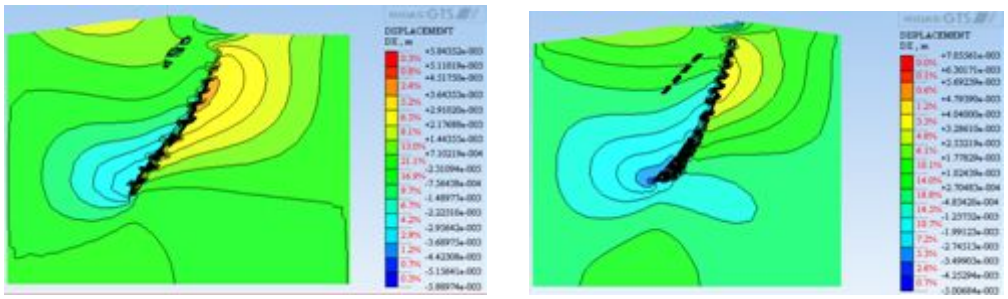
According to the calculation result of numerical simulation, under the exploitation condition of No.1, No.2, No.5 exploration lines, the Max. of horizontal displacement settlement is 7mm and the Max of vertical displacement settlement is 35mm of No.1 exploitation line. The Max. of horizontal displacement settlement is 12.6mm and the Max of vertical displacement settlement is 41mm of No.2 exploitation line. Max. of horizontal displacement settlement is 3mm and the Max of vertical displacement settlement is 7.2mm of No.5 exploitation line. The max horizontal displacement locates in the bottom of goaf, the max position of vertical displacement settlement locates in goaf hanging side, the larger the height of goaf, the bigger the displacement settlement; due to stress from surrounding rock, the lower position of goaf exists a small bulge phenomenon, displacement amount between 2mm and 23mm.

Through the analysis of numerical simulation result, the current underground goaf basically can be seen as the stable statement. However, safety attention should be considered when arranging the back-filling construction, as the stress concentration area between goaf boundary and edge of two sides of surrounding rock. Filling shaft construction should be placed under the goaf area and enhancing the monitoring of the spot deformation. When the construction is close to the goaf area, drilling in advance to vitrify the distance between construction and goaf area & the surrounding rock breaking status then make decision of the supporting measurement.

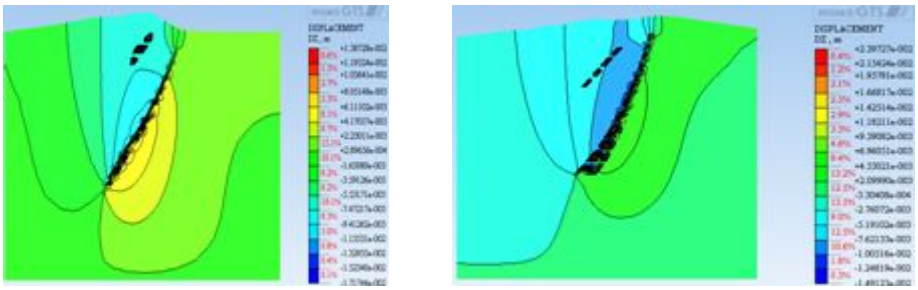
(2) Calculation result & analysis to the stability of goaf area back-filling

Simulating the surrounding rock displacement changes after back-filling of the goaf area in order to master the filling body and surrounding rock stress status after redistribution, especially know about the displacement changes after back-filling of the goaf area then master whether the ground buildings are in safety to make sure about the

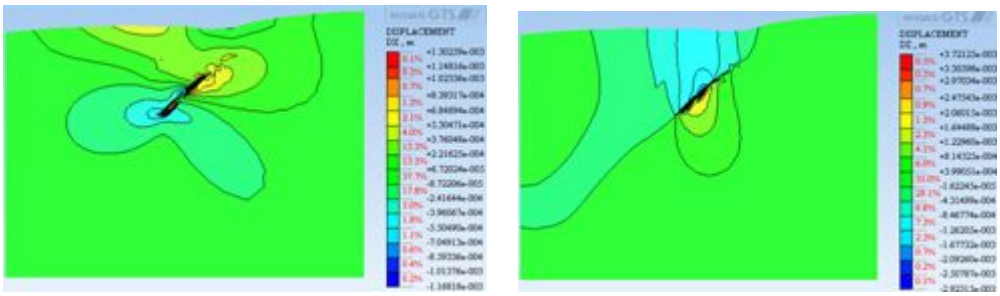
construction safety. The horizontal & vertical displacement echogram to excavating of No.1, 2, 5 exploration lines are as Fig. 3



Horizontal displacement echogram to back-filled ore of No.1 &No.2 exploration line



Vertical displacement echogram to back-filled ore of No.1&No.2 exploration line



Horizontal &Vertical displacement echogram to back-filled ore of No.5 exploration line

Fig.3: After filling the gob stability numerical simulation results

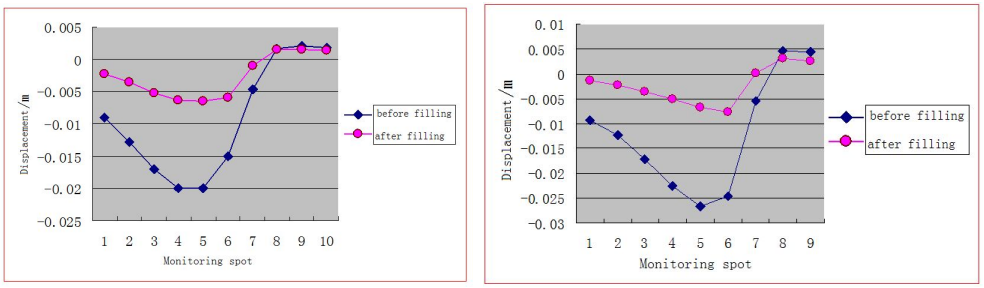
According to the calculation result of numerical simulation, under the back-filling of No.1, No.2, No.5 exploration lines, the Max. of horizontal displacement settlement is 3.7mm and the Max of vertical displacement settlement is 15mm of No.1 exploitation line. The Max. of horizontal displacement settlement is 5mm and the Max of vertical displacement settlement is 14.9mm of No.2 exploitation line. Max. of horizontal displacement settlement is 0.8mm and the Max of vertical displacement settlement is 2mm of No.5 exploitation line. It is no much difference of displacement settlement between the before back-filling and after back-filling. But it is decline trend in general, especially for the vertical displacement settlement. The uplift value of the goaf area under part decreased the displacement amount between 2mm and 4.5mm.

According to the calculation result, part of the ground stress is transferred to the filling body to make it bear the stress after back-filling. The filling body and goaf area supply with the support and improved the surrounding rock stress status.

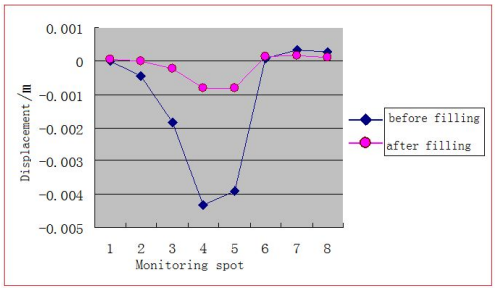
Therefore, the concentration stress area of the surrounding rock weak and part of the stress is transferred to the filling body to weak the surrounding rock stress then it is favorable to the stability of the surrounding rock.

(3) Monitoring spot displacement result analysis

The calculation procedure monitored the ground spot displacement to No.1, 2, 5 exploration line separately. The results are as Fig 4.



Comparison of displacement changes before filling and after filling to ground spot of No.1 &No.2 exploration line



Comparison of displacement changes and after filling to ground spot of No.5 exploration line

Fig.4: Goaf filling surface displacement before and after comparison chart

Before filling, the Max displacement amount of monitoring spot 4&5 of NO.1 exploration line is 20mm. It is 27mm of monitoring spot 5 of No.2 exploration line and 4.3mm of monitoring spot 4 of No.5 exploration line. After filling, the monitoring spot down-toward displacement trend is getting slow after getting the support of the filling body stress. The Max displacement amount of monitoring spot 4&5 of NO.1 exploration line is 4mm. It is 3mm of monitoring spot 5 of No.2 exploration line and 0.9mm of monitoring spot 4 of No.5 exploration line. It shows the filling body supply the support to goaf ceiling after filling, it improves the surrounding rock stress status to make the rock more stable and the ground concentration stress area of the surrounding rock weak and part of the stress is transferred to the filling body to weak the surrounding rock stress then it is favorable to the stability of the surrounding rock settlement decreased to make sure about the ground building in safety.

DISPOSAL TO GOAF

Choices to goaf disposal treatment method

The mine adopts the back-filling method to the goaf area. There are two methods, one is dry-back-filling and the other is wet-back-filling. The paper chooses the cemented filling with unclassified tailings to make sure the surface buildings and shaft are safe. There are prerequisites and advantages as follows to use this method.

(1) Make full use of the eight well mines to save a lot of input in the mine engineering. Though the shaft locates in the rock move limit, it is possible to solve the security problem through technology way. That is to filling the shaft start from the deepest and bottom on the way of ore extension direction.
(2) The tailings is the main back-filling basis. Many tailings are stocked in the concentrator tailings reservoir and it is no more than 1.5KM from the concentrator to the Mine area so that will save much transportation charge.
(3) Cementing Filling Body of Full Tailings is with certain strength and can reduce concentration of the goaf surrounding rock stess, and decrease the ground pressure. The stoping of deep-ore body could be carried out after some times in filling-concreting, which supply the security guarantee to deep-mining exploiting.
(4) Cementing Filling Body of Full Tailings can stop or slow down the top gushing water leaked into the deep and reduce the drainage cost.
(5) With Cementing Filling Body of Full Tailings, the ground could not be destroyed and it is favorable to the environmental protection.

Meantime, Cementing Filling Body of Full Tailings has its own disadvantages, first is filling charge is high, secondly, the filling time is long, thirdly, the construction technology is complicated.

Filling sequence

To make sure the goaf construction in safe, adopt the sequence from down to up, from outside to inside to gradually reduce then remove the goaf affection to the vertical shaft. That is, from the vertical direction, start filling with the

most deep goaf then to lower goaf. From the horizontal direction, starting filling with the surrounding goaf then central part.

Engineering quantities and scheduled plan

Filling engineering arrangement will make full use of the current projects. All the filling galleries are posted outside to the rock move limit of goaf ceiling. At least two emergency exits are needed in the filling engineering. The total volume of the goaf is 919, 700m3, 9448m/38187m3, four filling-stations are needed, parvis drive speed 60m/month. The filling schedule details are as per Table 2.

Table 2: Filling progress schedule

System name	Construction period(months)
7#cage shaft-11#filling shaft	13.09
6#cage shaft-10#filling shaft	35.23
3#cage shaft-4#filling shaft	41.22
Cage shaft-Blind Shaft -SJ2filling shaft	39.67

CONCLUSION

It is a hard work for mine to deal with the goaf disposal. It is not only affected to the daily regular production but has relationship with the security of the mine exploitation that has direct influence to the mine economic benefits.

(1) By disposal of the goaf, not only the existing hidden danger problem is solved, but also using the backstopping to remain ore. It helps to the resource utilization and get some economic benefits. The goaf ground new-added load makes the original stress of foundation changes. The new stress distribution law supplies theory evidence for new buildings in the gourd.
(2) The rock stress mainly gets linear greater with depth increase. The complicated changes to goaf rock stress happen after mine exploitation and the loading subsidiary stress distribution gradually decreased with depth. With numerical simulation, the distribution law is finally concluded for rock stress before & after filling.
(3) After goaf filled, from the displacement analysis of ground monitor spot, the filling bodies support to the goaf ceiling and improved a lot to the surrounding rocks status. It makes the surrounding rocks towards to stable. Meanwhile, the number of the ground settlement is less & less to make sure the security of the ground buildings.
(4) The simulated condition is simple and the result is initiatory. It needs further complemented and improvement.

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