

Research of the Underground Filling Mining Technology of the Gently Inclined and Thin to Medium Thickness Phosphate Ore-body with Soft Interlayer

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Abstract. Taking the east mining area of sixth pit of Jinning phosphate rock of the largest open-air phosphate mining company of Yunnan Phosphate Chemical Group Co., LTD. (YPCG) as engineering background, the study of the mining technology of filling method of gently inclined and thin to medium thickness phosphate ore-body with soft interlayer has been done, according to the the actual technical and economic conditions of the phosphate mine, on basis of the comprehensive research method of field investigation, theory analysis and engineering analogy. The results showed that: For the two layers of ore body containing soft interlayer, slicing techniques should be used to achieve high resource recovery. Meanwhile, it could obtain good economic results that the high concentration paste-like slurry which was made from a mix of waste rocks, dinas, cement and water has been conveyed to the underground working face by the ground pumping pipes. Related research could provide technical and theoretical guidance for the underground mining engineering construction of Yunnan Phosphate Chemical Group Co., LTD. and a large number of similar occurrence conditions of phosphate mines which surrounding the area of Yunnan Dianchi Lake.

Introduction

Phosphate resources is one of the important strategic resources in China, which concerning the safety of Chinese grain production. The ministry of land and ministry of land and resources of China targeted phosphate as one of the twenty minerals can not meet the needs of national economic development beyond 2010. And the contradiction between demand and development of phosphate is becoming increasingly acute [1-5].

Phosphate resources in China are mainly distributed in Yunnan province, Guizhou province, Sichuan province, Hunan province and Hubei province. And its resources total is 16.7 billion tons, rank the second in the world. However, the average content of P_2O_5 is only 17%, the content of P_2O_5 more than 30% of the rich ore resources is shortage of the total's 6%, and more than 90% of the phosphate resources is low and medium grade which cannot be used directly. At the same time, China is the world's first big demand in phosphorus ore, it could consume 50 million tons of phosphate rock per year, and the total production volume of rich phosphate rock per year in China is 30 million tons of. The remaining rich ore can only keep mining for more than ten years [6-8].

Collophanite in China generally have the occurrence state of slowly inclined, thin layer and more interlining, the technical problems such as slicing mining and the stability of roof and pillar are existence, and the ore loss rate and dilution rate are both high. According to statistics, the annual loss amounts of low

grade phosphate ore is 150 million tons, it causes a great waste of phosphorus resources and induces lots of disasters for instance surface crack, collapse, landslide and rock burst [9-12].

Yunnan province is the largest phosphorus resources in China, with phosphate resources reserves of 3.959 billion tons, accounting for 23.59% of the whole country.

At the same time, Yunnan province is China's significant production base for phosphate fertilizer and phosphorus chemical industry. The annual output of the phosphate rock is close to 30% of the country's total, and the high concentration of phosphate fertilizer and yellow phosphorus production accounted are respectively 45% and 43% of China's total.

The efficient use of phosphate resources plays an important role in the construction of state-level base of phosphate & compound fertilizer and the implement of the strategy of western development [13-14].

Yunnan phosphate deposit features is typical and representative in China, with gently inclined, broken rock, fine ore mineral and the complex embeddings relationship. It can also be said that if the mining and beneficiation technology problems of Yunnan cellophane could be solved well, the key generic technology in the field of phosphorus resources development in China could be also solved.

Project Overview

The Selection Principle and Scope of Filling test Region

The project site selection of deep ore body mining method test should be comply with the following principles:

(1) It is unreasonable for open-pit mining operations area with high cost of coal mining and high stripping ratio.

(2) Experimental zone should be representative, and the ore body is gently inclined, thin to medium thickness, with soft interlayer.

(3) Pilot project implementation and open-pit mining production had no effect on each other.

The stripping ratio in N0.130 exploration line to N0.132 exploration line of 6# pit of Jinning phosphate mine of Yunnan Phosphate Chemical Group Co., LTD. is up to 7.00 m³ / t, and the comprehensive cost of the mining production reached 150 CNY / t. It has basic ally approached the limit index in current technical and economic conditions. And according to the drilling data of data N0.130 exploration line to N0.132 exploration line of 6# pit, the average angle of ore bodies in this region is 29°, and the average thickness of I + II phosphate is 6.83 meters. It is a representative mining zone of Jinning phosphate mine, and is the suitable location for the underground filling test project. The length of strike and tendency are respectively 200m and 100m, the mining elevation is range from +2230m to +2170m, and two middle and four standard rooms has been layout.

Mining Technological Conditions of Filling Test Area

Experimental zone's geological structure is simple and contains only a normal fault F₂₋₂₃. The F₂₋₂₃ normal fault across N0.133 exploration line, its strike is north to east, it is about 2000m length, and the fault displacement is about 16m [15].

Deposits mainly occur in the second and third section of strata of Meishucun Formation, and the third section of strata is the main rich deposits. Ore body's strike is 340° to 345°, east tilt, and its dip angle is 15° to 42° (the average dip angle is 29°). In the test section, the strike is 200m, the tendency is 110 - 120m, the vertical height is 60m, and the original depth is about 100 to 200m. The average thicknesses of the upper (average P₂O₅ is 27.8%) and lower seams (average P₂O₅ is 26.7%) in the test section are respectively 6.83 m and 4.83 m, and the interlining is argillaceous dolomite, which is 0.50 m to 1.20m.

Implementation Plan of Underground Mining Project

The Overall Plan and Mining Scale

In the test region, the phosphate deposit of rich and poor seams is continuous, the material is composition gradient, and the ore grade is gradual transition. According to the ore grades division, the

I grade phosphate ($P_2O_5 \geq 27.8\%$) is located in the upper part of phosphate seam, II grade phosphate (P_2O_5 is 15% to 25%) is located in the central part of phosphate seam, and III grade phosphate (off-balance-sheet ore, P_2O_5 is 8% to 15%) is located in the lower part of phosphate seam. The mining object in the test area is I and II grade phosphate, and through the scheme comparison, it is reasonable to implement slicing mining.

This experiment of the underground mining is the mining engineering for exploration method. The main purpose of the test for mining method is look for the suitable underground mining of the ore body, optimizing the structural parameters of ore block, analyzing and determining the safety hazard factors in underground mining, and calculating the economic index. The productive capacity of stope is the evaluation index of mining method test. The mining production capacity is 350 t/d, and the filling capacity: $63 \text{ m}^3 / \text{d}$. Due to the size of mine production scale is concerned with the scope of mining, equipment level and mining method. Therefore, the experiment mainly test the stope's production capacity, and the middle transport capacity and economic indicators in the trial period has been accounted on basis of the production scale of one hundred thousand tons per year.

Mining Method

The mining method of the phosphate orebody in the test section is slicing method, firstly mining the upper seam, then mining the lower seam. For each layer of phosphate orebody, it is suitable to adopting shallow hole room and pillar mining method and two step filling mining technology.

The process of mining technology contains five steps, first is forming the bottom of the chamber of cutting roadway according to the method of room and pillar mining design, then is mining the orebody which is in the location of designing cemented filling ore belt, and then is filling concrete cementation ore belt, and then is mining the residual ore in mining room, at last is tailing dry filling in goaf [16].

Filling System Design

According to the design of development system and the layout of working face mining system situation in the test area, the filling slurry stirred by the ground blender would be delivered to the filling mineral room through filling pipeline, the filling pipeline extends to underground wells through the return air, and has been erected along the roadway. Its aim is to avoid disturbance each other between the filling conveying systems and mine production, and assure the safety and high effective product of the phosphate mine [17].

The ground filling stations locates in the wind well industrial site (+2240m). The filling material source is main open-pit mining waste rock. Mine stripping waste has been shipped to filling station by vehicles, and would be prepared of -25mm stone and -3mm coarse sand material, and cement has been conveyed to cement silo storage by mine transport vehicle. The stone, sand and cement has been fixed supplied receiving hopper of blender, the filling slurry water is from the high water tank, the filling slurry that stirred well would be storied on concrete pump feeding funnel, and it has been delivered to the stope to filling after the pump pressure.

The production capacity of filling system is not only to meet the needs of the current production, but also should offer a certain filling capacity. Design of the mining production scale is one hundred thousand tons a year, working days is 300 per year, and the working days of filling system is also 300 per year. The filling amount of experimental zone is 19000 m^3 one year, and the filling volume of cement and concrete are respectively 63 m^3 per day and 20 tons per day.

The ground filling stations (+2240m) contains aggregate yard sand material yard, and could meet every filling materials required. Bulk cement has been storied on the 60t cement silo, which can satisfy the filling volume of 3 days. Crushing waste rock is 96 t on every day, class 1 per day, and 8 hours per shift. The finely quantity of a PEX - 150 type crusher is 12 ton per hour, and its discharging granularity adjusting range is 18 to 50 mm, processing power is 8.5 to 28 ton per hour, single motor power is 15 kw.

The theory production capacity of mixing station is 20 m^3 one hour, the ground blender is JZC500 type mobile mixer. And the corresponding facilities contain PLD1600 type mixer, a cement silo whose storage capacity is 60 t, one set of cement weighing system and one set of tiny station control system. The filling material has been put into stock bin by loader, and a radial gate feeder has been equipped in the bottom of

stock bin, the opening and closing of arc door has been controlled by air cylinder, and at the same time, with the helping of a microcomputer based control system, it can carry out precise ingredients.

Before feeding the concrete pump with slurry, the concrete should be mixed well-distributed, and it should ensure the pumping uniformly during feeding and discharging. It also should ensure the concrete in the hopper elevation is above the height mark line. In addition, for the position of the feed hopper of concrete pump, it must be equipped with wire mesh screen and scheduled monitoring, as to preventing blocking caused by the particle size of aggregate or foreign bodies.

Basis of the mining experiences, the filling ratio of concentration and pipeline test results has been determined, the inner diameter of the filling line should be selected 125 mm and aggregate graded should be below 25 mm, and the horizontal distance of filling system should be less than 450 m^[16-17]. According to the production capacity and delivery pressure, the HBT60-16-90s pump has been chosen as filling slurry transportation pipeline, and the theory of horizontal and vertical conveying distance of it are respectively 800 m and 200 m.

Advantages of the Filling System

The filling system mainly includes the following four advantages:

(1)Turning waste into wealth, the strip waste rock which has been discarded in a wide range, has been used as the main filling aggregate. And it reduces the amount of stack dump and save the cost of land requisition.

(2)Waste rock has been taken as filling aggregate, the strength of underground filling body is high, and it can ensure the safety of underground mining activities.

(3)The sources of waste rock is widespread, the filling stope distance is very close, and the cost of filling is low.

(4)Paste like backfill technology with high concentration slurry has been adopted, and it can use the latest filling mining technology and complete sets of equipment, with low operation cost and high system stability.

Summary

The gently inclined and thin to medium thickness phosphate ore-body with soft interlayer has many mining problem such as broken surrounding rock and roof, low security, high dilution rate and low recovery rate. The mining problem at present has become the technical constraints during the process of transferred underground mining from open-pit of phosphate mine in Dianchi region of China.

In this paper, based on the field condition of the east mining area of sixth pit of Jinning phosphate rock of the largest open-air phosphate mining company of YPCG, the underground filling mining technology has been studied. And a kind of waste rock cemented filling mining technology has been found out, which can resolve the mining technical problems of this kind ore body. The relevant research results have important building practical and guiding significance to promote the construction of green phosphate rock mountain.

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