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Ore Deposit Mining with Goaf Stowing in Kazakhstan

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ABSTRACT: This paper presents the historical aspects and modem conditions of the filling method used to exploit deposits of non-ferrous metals at mines in Kazakhstan.

1 INTRODUCTION

Kazakhstan is a republic with a highly developed mining industry. Many deposits of non-ferrous metals (lead, zinc, copper) are part of our national resources. Unfortunately, many such deposits involve difficult mining and geological conditions. Mining science and practice has confirmed the expediency of the filling method used for ore extraction from such deposits. That is why in the last 20 years of the 20^{h} century, the filling method has become common in mining lead, zinc, copper and other non-ferrous metals in Kazakhstan.

2 HISTORICAL REVIEW

Filling operations were used first in Kazakhstan on a large scale at the beginning of the 1960s, when the first filling complex was built at Tekely mining and processing integrated works (Almaty region). The Tekely lead and zinc deposit is a thick steep (70-80°) ledge, located in the mountain massif Dzhungar Alatau. Its characteristic properties are high rock pressure and the tendency of enclosing rocks to self-ignition because of the active form of the pyrites present. Firstly, the deposit was mined by caving system, but after a large spontaneous fire in 1958-1959, a solution was proposed to change the mining system and further exploitation of this deposit continued with the filling method. Planned production at the Tekely filling complex was 230 thousand m^3 a year. The filling mixture contained crushed stone - 1400-1500 kg/m\ cement - 200-250 kg/m^3 and water - 450-500 l/m^3. During this filling complex exploitation, disadvantages and practical problems were brought to light, and the following filling complexes at other deposits were built taking these into account. At the end of the 1960s and the beginning of the 1970s, filling complexes with productivity of 100-500 thousand m^3 (and more) a year were built in Kentau (southern Kazakhstan region), Leninogorsk and Zyryanovsk (eastern Kazakhstan region). Since 1972, filling complexes have begun to operate in Zhezkazgan - the center of Kazakhstan's copper production, where the most copper deposits in Kazakhstan and one of the biggest copper deposits in CIS countries are located.

In 1968, at the Institute of Mining of the Kazakh Academy of Science, a new scientific research laboratory was set up to cany out investigations of filling problems. Such laboratories were also set up at otfier scientific research institutions İn the Republic of Kazakhstan. It was a period of intensive introduction of different variants of the filling method, different new compositions of filling mixtures and study of properties of man-made massifs in underground conditions.

3 MODERN CONDITION OF FILLING METHOD USED IN KAZAKHSTAN

At the beginning of the 1990s, modern political and economic tendencies were the cause of great changes in the mining industry of the Republic of Kazakhstan. In market economic conditions many mining enterprises had problems in financing their activities. In as much as profitability is now the main index of expediency in mining operations (excluding social and political factors, which were of great importance in the socialist economy), some mining enterprises stopped production because of very high product cost and the impossibility of selling their products at a profit in order to cover expenses. Some mining enterprises decided to change the mining

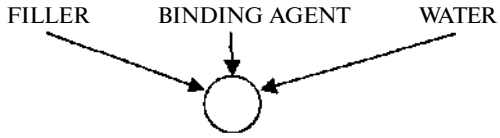
system to exclude filling operations because of the great expense. But a number of mining enterprises, having very tough mining and geological conditions, could not stop filling operations completely. That is why they tried to decrease the cost of filling operations and make cheaper filling mixtures. Investigations of filling problems are now carried out practically in two ways:

- improvement of technology of filling operations;
- working out filling mixtures with industrial solid waste.

The first method includes the creation of new types of filling equipment of high productivity and reliability and requires additional capital costs. However, worked-out new technological systems of filling massif forming, which have been suggested by our scientific researchers (Yedilbayev et al., 1999), ensure cement İs saved without decreasing die necessary technological characteristics of a man-made massif, while at the same time increasing the economic effectiveness of filling operations.

The second method consists of working out new filling mixture compositions with different solid waste utilization. This method also has an ecological aspect - decreasing the negative effect of the mining industry on the environment.

As is well known, filling mixture contains the components shown in Figure 1.



Figure! Composition of filling mixture.

As a filler, specially mined crushed stone and sand or different solid waste (shifted broken rock, ore tailings and so on) are used.

As a binding agent, as a rule, structural cement is used. To decrease cement consumption, active mineral admixtures are used: ash and metallurgical slag, which have some binding activity.

The majority of filling complexes of non-ferrous metallurgy in Kazakhstan use ore tailings as their raw material supply because of the following:

- large volume of ore tailings, both current and stored, in tailings piles, ensuring stable productivity of filling complexes;
- relatively stable granularity of ore tailings, having a significant effect on compressive strength of man-made massif;
- possibility of transportation of ore tailings from day surface up to worked-out space through pipelines.

Our investigations showed that the mineralogical composition of ore tailings has a significant effect on the compressive strength of a man-made massif. That is why cement consumption in different filling complexes is not the same, and to substantiate necessary cement consumption we may only work on the basis of experimental tests.

It is possible to use shifted broken rock to fill worked-out space. But in underground mining of deposits by chamber-and-pillar systems, the volume of such rocks is only 30-40% of worked-out space volume; therefore, they may be used only as admixture to save cement in chambers in the second stage of extraction

Introduction of new technologies of processing of ores causes the emergence of new types of solid waste. Consequently, heap leaching of copper ores İn Zhezkazgan required investigations with regard to the utilization of solid waste in mis process. The investigations showed that filling mixtures with waste from copper ore heap leaching have high indexes of compressive strength and may be successfully used m filling operations as filler.

As is well known for the preparation of filling mixtures, structural cement is used. It is now very expensive and the use of such a binding agent decreases the economic efficiency of filling operations. Investigations carried out (Yedilbayev et ai, 199?) showed that it is possible to make high quality cement for filling operations and also for civil-engineering purposes from local materials and solid waste. It İs one of the ways for the mining industry of the Republic of Kazakhstan to decrease the costs of filling mixtures at filling complexes.

To decrease cement consumption, some active admixtures may be used. Investigations carried out showed that boiler-room ash admixture in the range of 7-15% allows an increase in the compressive strength of the filling composition by 40% with a decrease at the same time in we cement content by 10-12%.

So we have a wide range of industrial solid waste, and it is possible to make filling mixtures with complexes using solid waste as shown in Figure 2.

Complexes of solid waste allow a wide supply of raw materials for filling operations, decreases the negative effects of solid waste - accumulation in dumps, tailings piles, ash dumps etc. - on the environment, and saves very expensive material, cement, when making filling mixtures.

CONCLUSIONS

The mining industry in Kazakhstan now has problems in financing the activity of mining enterprises. Underground ore mining and goaf stowing have become very expensive in spite of the low level of mining losses and ore dilution which are characteristic of these mining systems. To increase

the economic indexes of these systems, İt İs necessary to improve the technology of filling operations and to use complexes of solid waste to make filling mixtures. In addition, of course, mining systems with goaf stowing must be used when mining useful minerals that are in great demand in the world market and have a high selling price.

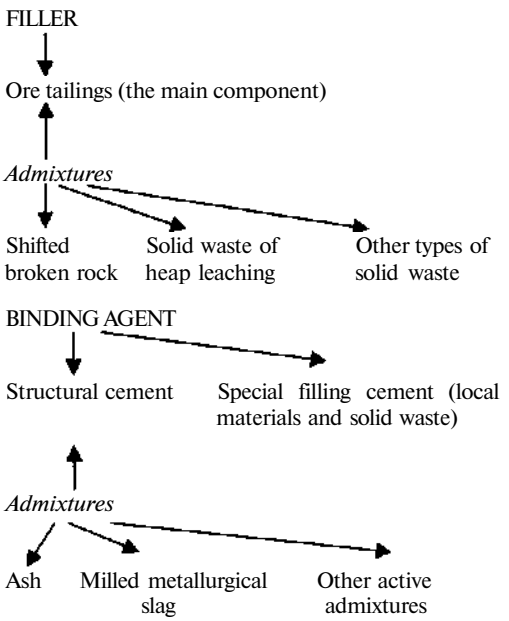


Figure 2. Scheme of complex solid waste used when making filling mixtures.

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