METHOD AND APPARATUS FOR INDUCING HARDENING OR CEMENTING IN
A MASS OF BACK-PILL IN A MINE OPENING

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Fig. 1

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METHOD AND APPARATUS FOR INDUCING HARDENING OR CEMENTING IN A MASS OF BACK-FILL IN A MINE OPENING

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ABSTRACT OF THE DISCLOSURE

In mining, back-fill is reacted with a suitable reagent passed therethrough to harden or self-cement the material and form a rigid mass of back-fill.

The present invention relates generally to the filling of subterranean cavities and more particularly to a method and apparatus for strengthening back-fill materials used in closing mine openings.

According to present practices in an underground mining operation after a large area or stope has been mined out it is often necessary to refill this opening to provide support for the walls and roof of the cavity and to allow mining in adjacent areas. The materials used for back-filling operations are frequently sand, often produced by desliming mill tailings, which may be mixed with gangue materials from the normal crushing operation. The material is packed into the open stope area and the area closed off. These materials are not bound together to form a solid mass and may in rare instances partially be eroded by underground streams, thus lessening the support for the walls and roof of the cavity. The disadvantage of this procedure involving the use of unconsolidated material are readily apparent to a mining engineer.

There is a great need in the mining industry for an economical firmly-set back-fill of considerable strength for these stope cavities. A back-fill which is desired in mining operations is one which may easily be placed in mine openings or cavities and which will set into a rigid mass sufficient to fill the mined-out area. The preferred mass or back-fill should be able to support the filled opening in approximately its original dimensions and able to later support such weight which may come upon it when further mining is carried out adjacent or near the area.

Broadly speaking, in order to fill the need mentioned above, the present invention employs back-fill comprising in part materials which may be reacted with a suitable reagent to form a rigid mass of back-fill which not only has settled and the reaction completed. For example, back-fill sand containing amounts of sulphide materials, developed through the desliming of milled tailings may be oxidized by the passage therethrough of air to provide a strong and rigid back-fill structure.

Thus, by one aspect of the present invention there is provided a method of forming a rigid mass in a subterranee cavity which comprises charging said cavity with fill material and passing a reactive agent through the material whereby hardening or self-cementing of the material is induced.

This and other aspects of the invention will become apparent from the following detailed description and drawings wherein:

FIG. 1 is a diagrammatic longitudinal section of the backfill with a cross-section portion of the scrap drift; FIG. 2 is a schematic representation of the entire backfill system; FIG. 3 is a plan view of the lower stope area showing one arrangement of the gas outlets; and FIG. 4 is a schematic cross-sectional view of the overall stope area.

To prepare the mined-out area for back-filling in accordance with the invention, a scrap drift 1, as shown in FIG. 1, and stope cavity generally indicated at 2 are sealed off by concrete bulkheads 3. Drainage units 4 are installed along the scrap drift 1 to drain any surplus water from the area through pipes 8 which pass through the bulkhead 3. Pipes 8 may be connected to the main pumping system of the mine (not shown) or discharge to a gravity flow ditch and may be closed by drain valve 9 as indicated later in the description. A main air line 5, controlled by a flow valve 10 and meter 11, also passes through the bulkhead 3. The air line 5 extends the length of the scrap drift and is branched to form a plurality of lines 12. The air lines 12 extend upwardly entering the draw points 13 of the stope. The lines 12 terminate in valve 14 which is a one-way valve allowing air to pass through into the stope area.

As indicated in FIGS. 2 and 3, the piping system 5 and 12 is so laid as to provide a system of air outlet points 14 a few feet higher in elevation than the drainage units 4 and in a grid pattern over the plan area of the stope to provide a substantially uniform air flow over the stope area. The branched air line 12 may be of any desired length and may extend just into the draw point 13 or may be extended to form additional branches 16 and 17 as indicated in FIG. 2 or branches 18, 19, 20 and 21 as indicated in FIG. 3. Each of the lines terminate in a one-way air valve 14 so designed that the back-fill material cannot enter through the valve when the system is not pressurized.

When the bulkheads 3 have firmly set, filling of the stope cavity 2 will commence. After the stope has been back-filled, for example with deslimed mill tailings containing sulphide, any water from the mass of the fill will be removed through drainage units 4. When the flow of draining effluent has become relatively negligible, the drain valve 9 is closed. Compressed air is introduced through the air line system 5 and 12 by opening of valves 10 and 15. Suitable instruments installed on the air line 5 will meter the flow at 11 and indicate the air pressure at air outlet points 14. A pressure gauge 22 installed will indicate the air pressure build-up in the fill behind the bulkhead 3.

Flow rates may be controlled in accordance with previously made calculations in which factors such as percentage of voids in the fill, plan area of the stope, percentage of sulphides in the fill material and the reactive characteristics of the sulphides, particularly as to their affinity for oxygen would be taken into account. The means of determining these factors is well known to the skilled engineer and therefore need not be discussed in detail here.

Provision is also made to determine temperatures within the fill material. For example, at a suitable distance behind each bulkhead and if desired at other predetermined points within the mass of the fill thermocouples as indicated at T, FIG. 4, or other apparatus for indicating or determining temperatures, may be located during the filling of the stope cavity or later if desired. These thermocouples or other apparatus which may be located at a point a few feet from the bulkhead or even at the centre of the mass will be effective to keep the operator informed of temperatures within the mass during the gradual reaction of the fill. It is considered that the present method will be effective on back-fill having a sulphide content as low as about 5% and of course 2% sulphide content has been tested and is known to be practical. The upper range of sulphide content may be as high as 100%. The reaction may of course be greater.
with a higher sulphide content but by controlling the air flow the reaction in the mass may be maintained and controlled. In controlling the reaction within the mass it is not necessary for the flow of air to be continuous. Instead in certain situations it may be found desirable to shut off the air supply completely and add water to the stope from the top thereof. The presence of some water in the mass is essential to the successful operation of the method, and this water addition may be relied on if the reaction conditions in the mass so dictate.

Air introduced under adequate pressure through the air line system 5 and 12 and valves 14 travels upwardly through the fill material as indicated generally by the arrows in FIG. 4. It would be desirable to obtain the most uniform air flow pattern throughout the mass to effect a uniform reaction therethrough. The sulphide minerals react with the oxygen in the air and residual water in the back-fill and may be assisted by the presence of a bacteria such as Thio-bacillius Ferro-oxidans which may be incorporated either with the fill material at the time of placing or introduced in an aqueous solution through the air line 5 or by pumping the solution back through the drain line and through the drainage devices into the back-fill. This reaction results in the formation of various sulphates, sulfitestes, oxides and associated compounds.

As indicated the air flow may be so controlled that the reaction will not be rapid enough as to generate undesirable gas or heat. The rate of reaction will be indicated by the temperature changes shown by the thermocouples T. Gas or air is allowed to emerge freely from the top of the stope 23 and escapes into the exhaust air system 24 of the mine openings.

In any case where a filled stope had not been equipped prior to filling with the air-introduction equipment or in any case where the air system had been rendered non-operative through accident or failure, the air can then be alternatively introduced through the drainage system after equipping the water drainage pipe with valves, flow meters, and like apparatus. This is an important alternative method of achieving the introduction of air (or oxygen) and hence the hardening or cementing of the back-fill mass.

The exhausted gases may be checked for temperature and analyzed for oxygen, SO2, and other gas content in the usual manner.

When the reaction has proceeded to the point where through core drill tests or experience it is believed a sufficient degree of cementing has taken place within the mass, the flow of air may be turned off and conditions within the fill material will, in due course, become relatively stagnant. In some instances, and rigidity of mass may be obtained prior to completion of reaction within the mass. It is expected that the gradual oxidation envisaged in this method may take several months to complete depending on the volume of mass involved. The cemented mass of the fill constitutes a firm support for the walls of the back of the stope and it will, in these circumstances, be possible to mine pillars of ore on any side of such fill.

Therefore a feature of this invention of inducing hardening or cementing in back-fill material is accomplished by the introduction of a reagent into and within the material in such a way that it is able to work its way completely through the fill thereby causing oxidation and producing compounds from the minerals contained in the fill which act as cementing agents. However, although the use of oxygen and a sulphide containing fill has been used in the example herein, it is clear that the concept taught may be applied to fill containing material other than sulphides. Where a liquid reagent is used instead of a gas, this would be hydraulically pumped into and form below the mass through a system consisting of flowmeter, valves, pipes and one-way valves, all of which are conventional items and require no explanation as to purpose and function and which is similar in most respects to the system for air introduction. By way of example dilute sulphuric acid may be used as a liquid reagent in the application of the present method to a sulphide-containing mass of back-fill. The reagent would, of course, be diluted at the point found most satisfactory for the mass being treated. It will be apparent that the piping used will be selected on the basis of the most desirable type and material of piping to carry any specific reagent and careful regard must be had to the choice of pipe in the case of the use of a reagent such as dilute sulphuric acid. In other words, the piping should not be deteriorated by contact with the reagent transported there-through. Other types of gas or reactive solutions may be applied to masses of back-fill to induce hardening of self-cementing and likewise would be introduced by the same method. The type of gas or solution employed would, of course, depend upon the nature of the back-fill material used. The suitability of a particular reagent to a particular mass may be determined by tests within the knowledge of the man skilled in the mining art. The use of air is proposed where the back-fill materials contain sufficient amounts of sulphides containing the desired cementing action will be effected. Where the fill may be more inert a more chemically active gas or solution may be employed to induce hardening.

It is clear that the foregoing development will fill a definite need in the field of mining.

I claim:

1. A method of forming a substantially rigid mass in a mine opening which comprises:
   (a) charging said opening with a fill material such as rock or gravel and which contains a reactive substance; and
   (b) passing a reactive fluid upwardly through said material which is capable of reacting with the substance in said material in a volume sufficient to induce hardening and cementing of the material.

2. A method as claimed in claim 1 in which:
   (a) the reactive fluid is air which is passed through said material by introducing the air to the base of said mass;
   (b) permitting the air to percolate upwardly there-through; and
   (c) said air being introduced in a volume sufficient to induce hardening and cementing of the material.

3. A method as claimed in claim 1 wherein:
   (a) said opening is charged with sulphide containing materials; and
   (b) the reactive fluid is an oxygen-containing gas.

4. A method in accordance with claim 3 wherein the sulphide materials are destined milled tailings.

5. A method in accordance with claim 3 wherein an additive is introduced into the back-fill to increase the oxidation in the mass.

6. A method in accordance with claim 3 wherein Thio-bacillius Ferro-oxidans are introduced into the back-fill to enhance the oxidation therein.

7. A method as claimed in claim 1 wherein the back-fill material contains reactive material in the proportions of between 2% and 100% of said fill material.

8. A method as claimed in claim 3 wherein the sulphide content of said back-fill material is between 2% and 100% of said material.

9. A method as claimed in claim 1 including the steps of:
   (a) removing excess water from said mass while retaining sufficient moisture therein to effect oxidation of said back-fill material;
   (b) passing a reactive fluid through said material sufficient to induce hardening and cementing of the material; and
   (c) wherein the sulphide content of said back-fill material is between 2% and 100% of said material.

10. A method as claimed in claim 1 wherein said fluid
5 is a liquid which is pumped hydraulically through said mass.

11. A method as claimed in claim 1 wherein said reactive fluid is dilute sulfuric acid.

12. Apparatus for hardening and cementing a mass of a fill material in a mine opening such as rock or gravel and which contains a reactive substance comprising:
   (a) means for sealing the lower area of said opening;
   (b) means for draining said opening;
   (c) means for passing a reactive fluid through the material within said opening;
   (d) said fluid being capable of reacting with the substance in said material;
   (e) said fluid being present in a volume sufficient to induce hardening and cementing of the material; and
   (f) means for exhausting gases from said opening.

13. Apparatus as claimed in claim 12 including means for controlling the flow of said reactive fluid to and through said mass.

14. Apparatus as claimed in claim 13 wherein said con-

6 trol means is adapted to control the flow into said mass in a substantially uniform manner.

15. Apparatus as claimed in claim 12 including means for quickly determining the temperature within the back-fill material.

16. Apparatus as claimed in claim 12 wherein:
   (a) the fluid is a liquid; and
   (b) hydraulic pumping means for pumping said liquid through said mass from the lower area thereof.

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