ABATEMENT OF POLLUTION FROM ABANDONED COAL MINES BY MEANS OF IN-SITU PRECIPITATION TECHNIQUES

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BACKGROUND OF PROJECT

Coal, as we all know, has been mined in Pennsylvania for decades, leaving many underground caverns into which ground water percolates and eventually flows out into the streams. This water during its course through the mine workings becomes acidic.

Today, more than 2,500 miles of Pennsylvania's streams are polluted by mine drainage from abandoned mines, estimated at close to one billion gallons per day (plus an additional estimated half-billion gallons per day from active mines).

Before 1963, little hope was held for a comprehensive solution to what was an ever-increasing problem. However, in 1963, the Pennsylvania Department of Mines and Mineral Industries launched an intensive research program to ascertain the extent of the problem and to develop economical methods for abating stream pollution from both active and abandoned coal mines. Studies were initiated to establish the mechanism of formation of acid mine water, and to investigate its treatment and control. Means were sought for preventing water from entering coal mines, by diverting water flow, backfilling mine voids, etc. Much progress has been made but much remains to be done.

In 1968, the Parsons-Jurden Corporation received a contract from the Department of Mines and Mineral Industries, Commonwealth of Pennsylvania, for the development and demonstration of the use of in-situ precipitation of sludge resulting from the reaction of acid mine water with low cost additives in an abandoned coal mine to prevent mine drainage pollution. The work is supported in part by the Federal Water Pollution Control Administration, U.S. Department of the Interior, through a grant to the Commonwealth of Pennsylvania under Title II, Section 6 (a) of the Federal Water Pollution Control Act, as amended by the Clean Water Restoration Act of 1966. The demonstration mine would be the Hastings Fuels Company Mine No. 1 in Cambria County, Pa. The work would proceed in two phases, first in the laboratory, then in the field at the selected mine.

EXISTING APPROACHES TO POLLUTION CONTROL

Acid water pollution from coal mines manifests itself in the form of a large drainage outflow consisting of sulfuric acid, dissolved iron, and other mineral impurities, similar in character to waste pickle liquor from the steel industry. The acid stream is generated by water contacting the mine workings in the presence of oxygen and reacting with pyrites contained in unexcavated pillars and other surfaces of the deep mines.

Numerous approaches have been taken for reducing this acid water pollution, among which have been:

1. Air sealing of the mines.
2. Flooding the mines by sealing the exits.
3. Neutralizing the acid outflow with alkaline materials.

4. Diversion of subsurface waters from mine entrances.

5. Injection to underground strata.

6. Chemical sealing of surfaces within the mine.

PARSONS-JURDEN APPROACH

The in-situ precipitation approach proposed by Parsons-Jurden offers benefits of lower cost and ease in use and should have wider applications to mines of varying geological features.

The in-situ precipitation concept consists of injecting water slurries of low cost alkaline reactants (such as limestone, lime, and fly ash) directly into acid water contained in the mine voids, through bore holes drilled from the surface. Numerous reactions occur during the neutralization of the acidity, resulting in precipitates. In addition, as the pH goes up, various mineral constituents in the water (notably iron) precipitate as a gelatinous, voluminous sludge. Our proposal postulated a bulking ratio of 30:1, that is the sludge resulting from injecting a ton of reactant into the mine water would occupy 30 times the volume occupied by the same ton injected into pure water. Subsequent laboratory work has indicated that bulking ratios as high as 150:1 can be achieved, although practical considerations indicate such large ratios have limitations.

In-situ precipitation, as a technique for elimination of pollution from abandoned coal mines, is of interest from three standpoints:

(1) Filling of mine voids, to restrict entry and passage of water thru the mine;

(2) Sealing drainage openings to restrict outflow from the mine; and

(3) Continuous neutralization of any effluent acid mine water.

Use of this concept for filling mine voids is based on forming "bulking-type precipitates" (as mentioned above), thus providing an economic advantage over simple backfilling on a one to one ratio. This concept is also useful from the standpoint of sealing drainage openings because the water-borne precipitates so formed seek out the flow points (being carried by the water flow) and plug them, an action similar to "blinding" a filter cloth. Finally, in-situ precipitation is expected to be an efficient, economical means for continuous neutralization of effluent mine waters, without the usual waste sludge disposal problems.

The feasibility and economics of continuous external neutralization of acid mine water drainage from active coal mines has been demonstrated. However, the problem of disposal of the resultant sludge remains. When applied to abandoned coal mines, the sludge does not present any problem. The sludge is formed in the mine voids and gradually settles to the lower portions of the mine. The mine provides an extensive retention basin for the sludge. When the mine eventually fills up with sludge, the continuous neutralization station is no longer needed as the pollution problem no longer exists.

PRESENT STATUS OF PROJECT

Shortly after the Commonwealth of Pennsylvania issued its contract to us to proceed with this project, an unforeseen obstacle developed: one of the landowners refused to sign a release permitting access to the Hastings mine. A second mine was then considered, located in the Prince Gallitzen State Park. However, the water flow at this mine was deemed to low to be useful for the demonstration. A third mine was then considered, and presently is expected to be the demonstration site: the Driscoll No. 4 Mine at Vintondale. This mine was active until January 1967, at which time the pump and fan were removed. The mine has subsequently been filling with water. When the water level reaches 1405 ft., the water will flow out of the mine through the entrance, at an anticipated rate of one million gallons per day. As this paper is being prepared, the water level has reached approximately 1376 ft. It is anticipated that by the time this paper is delivered (April 1969), the water will be flowing from the mine.

LABORATORY INVESTIGATIONS

The laboratory phase of this project is designed to serve two functions: first to develop data for laboratory confirmation that the in-situ precipitation concept can achieve what is expected of it; and second, to establish what materials and methods will be used at the demonstration mine. Because of problems in selecting the mine to be used for the field demonstration, the laboratory to date has been limited to developing data of a general nature. A synthetic acid mine water, consisting of ferrous sulfate, aluminum sulfate and sulfuric acid, was used to evaluate various types of materials rather than specific candidate materials. Laboratory tests were devised to determine the bulking ratios for precipitates produced, sealing properties (and conditions necessary for such sealing) of precipitates, and effectiveness of continuous neutralization of effluent mine water.

To determine the bulking ratio for a given reactant, a water slurry of the reactant was added to synthetic acid mine water at a specified ratio. The resultant mixture was allowed to stand for 18 hours at which time the volume of the precipitate was noted and compared to the volume obtained in pure water; pH was also measured. As previously noted, bulking ratios as high as 150:1 were achieved.

To evaluate the sealing properties of the precipitates, a glass tube 2 inches in diameter and 4 feet long was used to simulate a mine adit. The tube was placed in a "horizontal" position, with a 1% slope towards the effluent end. A wire gauze, backed up by a layer of coarse sand and one of fine sand was placed at the effluent end to simulate a rubble obstruction. Acid mine water was supplied to the tube at a controlled rate to simulate the flow of mine water in the adit. A water slurry of reactant material was injected, through a vertical side tube located a short distance behind the sand layers, at a controlled rate to maintain a fixed ratio of mine water to slurry. Reduction in flow rate, and pH of effluent was measured over an extended period of time. In most cases, the flow rate was reduced significantly, and in some cases stopped completely; pH of effluent was raised to acceptable levels, and could be brought up to the range of 12-13 without any difficulty (initial pH was 3).

To study the continuous neutralization of acid mine water, the "horizontal" tube set-up was used except that the tube now sloped away from the effluent end. Under these conditions, the precipitate formed rolled back down the tube to accumulate at the lower end. The pH of the water could be raised to and maintained at any desired level.

When the demonstration mine is finally selected, specific laboratory tests will be performed based on the actual mine water and on economically attractive, locally available alkaline reactants. Shortly thereafter, the actual field demonstration will be undertaken.

CURRENT CONCLUSIONS

At this time, it is too early to draw any definite conclusions as the actual demonstration has not started, but from the preliminary results of the laboratory investigations, we are extremely optimistic concerning a successful demonstration. It is also felt that after the completion of the program, we will be able to demonstrate the economic soundness of using this method of preventing stream contamination from most abandoned mines and some operating mines, utilizing the in-situ precipitation techniques. However, each individual mine must be evaluated to determine which one or more of the three results is the most economic, i.e.:

(1) filling of mine voids,

(2) sealing drainage openings,

(3) continuous neutralization of mine water.

ACKNOWLEDGMENT

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