PROCEDURES FOR SURFACE MINING AND RECLAMATION IN AREAS WITH ACID-PRODUCING MATERIALS: AN OVERVIEW

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ABSTRACT

An overview of the newly-developed manual entitled "A Review of Procedures for Surface mining and Reclamation in Areas with Acid-Producing Materials" is presented. The paper contains sections on Acid Mine Drainage Prediction, New Developments in Acid Mine Drainage Prevention, and New Developments in Acid Mine Drainage Treatment Technologies. The purpose of this paper is to introduce the new manual, discuss the topics contained therein, and to identify subject areas where more research is needed.

INTRODUCTION

In 1978, David Callaghan, then the Director of the West Virginia Department of Natural Resources, called a meeting for the purpose of addressing the acid mine drainage (AMD) problem associated with the surface mining of the Kittaning coal seams in the Buckhannon, Tygart, and Middle Fork River watersheds. An inter-disciplinary committee was subsequently organized and named the Surface Mine Drainage Task Force. This committee worked for several months to collect information and identify "state-of-the-art" technology for the control and abatement of AMD. It should be emphasized that the technology sought was not for treatment of AMD but technology that would prevent acid from being formed. This work by the Task Force resulted in the development and publication of the 1979 Bulletin entitled "Suggested Guidelines for Method of Operation in Surface Mining of Areas with Potentially Acid-Producing Materials". This manual became the standard for all mining operations in potentially acid-producing areas of the state.

After several months of implementation of these guidelines on active sites, the results showed mixed success. There was a net effect of lower acid production, but nearly all operations were still producing acid. On some sites, there appeared to be no reduction at all. It was obvious that the AMD problem is very complex, and that the members of the Task Force, being a volunteer group with career and family demands, were unable to devote more time to developing sophisticated approaches to solving the problem.

In September of 1981, a petition was served requesting the Director to designate 500 square miles in a three county area (Upshur, Barbour, and Randolph) unsuitable for mining. Director Callaghan was faced with the possibility of being forced to lock up millions of tons of high quality coal because of the potential of AMD formation. This sparked a renewed interest in resolving the AMD problem.

Director Callaghan's approach to address the AMD problem was to form the Acid Mine Drainage Technical Advisory Committee (AMDTAC). This committee was made up of recognized experts in AMD research. The committee developed a proposal that it felt would lead to a solution of the problem, and with the Office of Surface Mining (OSM) paying the greatest share of the cost, initiated research aimed directly at stopping the formation of acid. The first set of proposals were funded from 1982 through 1985 at an approximate cost of $800,000. A second set of proposals were funded in 1985 at about the same level of funding.

In 1985, the Surface Mine Drainage Task Force determined that an update or revision of the 1979 Suggested Guidelines Manual was needed especially due to the information generated from the AMDTAC research. Dr. John C. Sencindiver, a member of the Task Force and AMDTAC, developed a proposal that was accepted by the Task Force and the West Virginia University Energy and Water Research Center. These two groups provided funding for the writing and publishing of the revision which is entitled "A Review of Procedures for Surface Mining and Reclamation in Areas with Acid-Producing Materials". Much information contained in this new bulletin is derived from research resulting from work conducted by the AMDTAC group. In addition, new material from other sources outside of Appalachia that are applicable to abatement of AMD have also been incorporated into the manual.

ACID MINE DRAINAGE PREDICTION

The first section of the Bulletin addresses AMD Prediction Methods. Many factors must be considered when estimating the amount and degree of AMD that will be produced on a site. Some of the more important factors may be:

1. physical and chemical properties of the overburden materials;
2. the method of mining, handling, and placement of overburden in the backfill;

3. the degree of compaction during backfill construction;
4. the length of time that acid-producing materials are exposed;
5. the hydrology of the backfill.

All of these factors are involved in AMD formation and prediction. The hydrology of a backfill and its effect on AMD generation is highly complex, and past research on the movement of water into and through a mine backfill has provided little information on how to control AMD. It is an important area where more research must be done.

We know that exposure of acid-producing materials results in oxidation of pyrite, and subsequent contact with water conveys the acid products out of the backfill. There is some evidence (Cathles 1982) that much of the AMD generated on a site may be due to the short time it was exposed during mining. Once buried in the backfill the acid-producing potential of the material is largely reduced, and the AMD flowing from the site is simply the transport of the AMD salts generated during mining.

We want to emphasize the importance of compaction, and suggest that proper compaction of the backfill would greatly reduce water movement and air convection into and through the backfill. This is probably another area of research which should be developed. For example, what density of soil or overburden material is required to reduce air and water influx?

The method of mining, handling, and placement of acid-producing materials encompasses the previous two factors; the amount of compaction during backfill construction, and length of toxic material exposure are both a function of mining methods. Appropriate handling and placement of acid-producing materials continues to be a crucial component in reducing AMD production. The equipment operators need to be sure that this important part of the mining and reclamation plan is conducted according to specifications.

Most of the work is AMD prediction has focused on methods of quantifying the chemical production potential of overburden layers through physical and chemical laboratory analysis. In the bulletin we review three methods of overburden characterization for AMD prediction: Acid-Base Accounting, Leaching and Weathering Tests, and Modeling Techniques. The bulletin explains these methods sufficiently and will not be detailed in this paper. Each of these methods have desirable characteristics for use in premining planning but they should not be used exclusive of the others. They should be <u>used together</u> to gain the best understanding possible of the overburden's AMD production potential. With the understanding of the overburden's AMD potential, mining and reclamation plans may be developed which would reduce the possibility of creating AMD, or at least reducing the amount of AMD. Again, all the overburden analyses and characterization available are useless unless the mining and reclamation plans are carried out as prescribed. As we already know, the most accurate prediction of overburden quality and AMD production is meaningless until the material is properly handled, placed, compacted, and revegetated, along with implementing appropriate water controls.

NEW DEVELOPMENTS IN ACID PREVENTION

The next section is "New Developments in Acid Prevention".

Hydrology

Understanding the movement of water into and through the backfill is an important aspect of controlling AMD. The traditional approach has been to keep water away from toxic material as much as possible, and this is our continued recommendation. However, experience has shown that it is impossible to keep water completely out and away from acidic materials. Specific techniques and different materials have been developed which retard the movement of water into toxic material.

Another approach is to increase the flow of water into the backfill which will cause the carbonate materials in the backfill to weather faster, thereby neutralizing more of the acid. Surface treatment of water with alkaline materials before it enters the backfill is a prevention/treatment technique that is being tested. Increased experience with this approach may prove to be an effective way to mitigate AMD.

Liners and Seals

Liners and seals is the second subsection. Compacted clay liners have demonstrated reductions of water flow into toxic material, and are an effective method of reducing AMD transport out of the backfill and may hinder AMD production.

Numerous types of synthetic liners are available, and have been used in the lining of treatment ponds. In West Virginia a 20 mil PVC liner was placed on 45 acres of acid-producing material. Water flow was reduced substantially. Our experience with plastic films is limited, however.

Oxygen Content

Oxygen content in the backfill does have an influence on the amount and rate of AMD generation. Total oxygen removal or depletement has not been demonstrated outside of the laboratory. However, there are areas located in the backfill which show lower concentrations of oxygen than other areas. Erickson and Ladwig (1986) developed a generalized model of different oxygenated zones in the backfill. Thickness and degree of compaction of the surface topsoil can effectively reduce the amount and rate of oxygen influx. Revegetated minesoils with active microbial populations seem to be a good oxygen control strategy.

Three techniques for oxygen control are (Cathles 1982):

1. The overburden materials should be buried and covered with topsoil as soon as possible after exposure.
2. The backfill must be compacted throughout construction, especially during toxic material placement, to reduce voids between rock fragments.
3. Compaction of the surface and outslopes is very important in decreasing oxygen diffusion and air convection into the backfill.

Bactericides

Anionic surfactants, organic acids, and food preservatives have been used as antibacterial compounds. Sodium lauryl sulfate, or SLS, has demonstrated 60 to 90 percent reductions in acid drainage during field experiments (Kleinmann 1983). However, SLS has not been registered with the U.S. Environmental Protection Agency (EPA) and cannot be used as a bactericide presently on mine sites.

Anionic surfactants are very soluble and degradable, which presents problems with widespread application to acid-producing materials. Treatment with SLS requires follow-up applications to avoid repopulation of the bacteria.

Several companies have developed timed-release formulas which include the bactericide inside of slowly-degradable products to extend the life of the bactericide, and these products are effective. Some of these have been registered by the U.S. EPA.

Metal Precipitating Agents

Removing or complexing the iron species to reduce ferric iron oxidation of pyrite is another prevention technique that has been demonstrated. Phosphate products have been tested and show considerable promise in preventing and reducing acid generation (Stiller et al. 1986). Other materials such as organic waste materials when applied to toxic material also have demonstrated some reduction in AMD production. The effect may be due to a reduction in iron-oxidizing bacteria populations, and also may be due to chelation of metal ions released during pyritic oxidation with organic molecules. More research is needed in understanding the potential of acid prevention with organic and phosphatic materials.

Mining Procedures

Improving techniques for segregation, handling, storage, and placement of acid- and alkaline-producing overburden layers in a backfill is a continual process during mining. Accurate premining data on overburden quality is important in determining the mining method and handling procedures. Operators can choose between blending of overburden materials if the alkaline materials are capable of neutralizing the acid materials, or segregation and isolation when toxic layers overwhelm the alkaline layers in the overburden. The choice between blending and special handling is primarily determined by overburden analysis, but mining experience in the area is also important in determining the appropriate mining procedures. The pavement is commonly found to be acid-producing and it should be cleaned of wasted coal after mining and covered with some ameliorating material.

Proper identification, handling, blending or treatment, and placement of acid-producing materials in the backfill are the key issues in controlling AMD. Correct identification of overburden materials and application of appropriate mining procedures would substantially reduce the production of AMD.

Topsoiling and Revegetation

Placing a suitable substrate on the backfill to enhance revegetation is an important final step in reducing the production of AMD. A good vegetative cover will take up water and air thereby allowing lesser amounts to move downward into the backfill. The plants will also help maintain the site and protect the surface from erosion. The topsoil should be selected for optimum water-holding-capacity, which aids in developing microbial populations and nutrient cycles. This final reclamation procedure greatly increases the potential for developing the desired post-mining land use capabilities.

NEW DEVELOPMENTS IN TREATMENT TECHNOLOGY

The bulletin also describes briefly some of the new treatment technologies that have been developed recently.

Chemical Injection into Mines

Injection into mine backfills or underground mine workings with alkaline materials has been tested by the Bureau of Mines (Ladwig et al. 1985). Some alkaline materials appear to be better suited for injection based on solubility. Injection techniques, whether using alkaline or phosphatic materials, requires a good understanding of rock composition and arrangement, and hydrologic characteristics of the backfill. Research is continuing with this technique, and it may prove to be an effective way to treat and retard AMD production in a backfill.

Anhydrous Ammonia

Interest in ammonia neutralization of AMD is growing because of the potential of reducing water treatment costs. The precipitates resulting from ammonia neutralization of AMD are also gelatinous and can be pumped easily.

There are some hazards associated with ammonia. The chemical itself is toxic, so special care must be taken when working around the substance. Also, unreacted ammonia in the water is toxic to aquatic life. There is also a potential of increasing nitrate concentrations in the water due to ammonium being nitrified to nitrate.

People utilizing ammonia for AMD neutralization have seen no evidence of toxicity downstream from unreacted ammonia or nitrate (Whitehouse and Straughan 1986).

In-Line Aeration and Treatment

A relatively new technique for aeration and treatment of AMD is the In-Line Aeration and Treatment System designed by the U.S. Bureau of Mines (Ackman and Kleinmann 1985). The water is pumped and converted into a high-velocity stream which aerates the water. Chemicals can be added to the water stream for neutralization. The advantages are:

1. effective mixing of water and chemical,
2. easily maintained,
3. the system is small and portable.

Wetland Treatment

The last subsection in the bulletin is treatment of AMD by wetlands. This method has become very popular during the past five years, and numerous individuals are developing construction criteria that will facilitate removal of iron and manganese. The size, shape, and type (meaning dominant plant species and microbial populations present) of wetland that will effectively treat AMD varies greatly from site to site. Continued evaluation and research will improve our understanding of the mechanisms which are operating in these acid-treating wetlands and will thereby increase our understanding of appropriate construction criteria.

APPENDIX

The Appendix contains examples of Acid-Base Accounting data from several overburdens. Interpretation is based primarily on the Acid-Base Accounting data, and a handling and placement plan is presented. This is mostly an academic exercise but it was included because the Task Force felt it was useful to include the appropriate and correct approach in interpreting an Acid-Base Account, and how it is used in reclamation planning.

References

Ackman, T. E, and R. L. P. Kleinmann. 1985. In-line aeration and treatment of AMD: performance and preliminary design criteria. In: Proceedings, Sixth West Virginia Surface Mine Drainage Task Force Symposium. Morgantown, WV.

Cathles, L. M. 1982. Acid mine drainage. Earth and Mineral Sciences 51:37-41. The Pennsylvania State University, University Park, PA.

Erickson, P. M., and K. J. Ladwig. 1986. Field observation of potential acid sources within surface mine backfills. In: Proceedings, Seventh West Virginia Surface Mine Drainage Task Force Symposium. Morgantown, WV.

Kleinmann, R. L. P. 1983. At source control of AMD: a progress report. In: Proceedings, Fourth West Virginia Surface Mine Drainage Task Force Symposium. Clarksburg, WV.

Ladwig, K. J., P. M. Erickson, and R. L. P. Kleinmann. 1985. Alkaline injection: an overview of recent work. P. 35-40. In: Control of Acid Mine Drainage. Bureau of Mines Information Circular 9027. USDI, Bureau of Mines, Pittsburgh, PA.

Stiller, A. H., J. J. Renton, and T. E. Rymer. 1986. The use of phosphates for ameliorization. In: Proceedings, Seventh West Virginia Surface Mine Drainage Task Force Symposium. Morgantown, WV.