Assessing Acid Loads of Coal Mine Overburden as Related to Grain Size Distribution

by

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Introduction

The quality of mine drainage produced by a sequence of rocks comprising the overburden of a strip mine site is determined by numerous and complex variables. Many of these variables may interact to produce secondary affects that add to the complexity of the problem and confuse attempts to predict the mine drainage quality. Attempts to predict the nature of the drainage must consider the hydrology of the area (both pre and post mining), the geochemistry of the ground water regime, the chemistry of the overburden and their interactions.

Work has been completed and several studies are being conducted the Committee to adequately define the hydrologic regime within a backfilled mine and the nature and character of the ground water geochemistry. In addition, an understanding of the chemistry of the overburden and methods of analysis are being addressed in other studies. Current overburden analytical techniques offer a projection of the <u>quality</u> (acid, alkaline or neutral) of drainage or leachate that would be expected from a rock body with a particular chemistry. However, the <u>quantity</u> (load), as well as the quality, of the effluent must be known to predict, with some degree of accuracy, the nature of the mine drainage that could be expected from a mine site.

Specifically, an assessment of the rock-water interaction that takes place within the voids of a completed backfill is in order inasmuch as the voids greatly affect the character of the drainage. The study discussed here deals primarily with the relationship between the voids of a rock mass and the quality and quantity of acidity that the rocks would be expected to produce.

Whole rock analyses generally express the composition of the material in terms of a weight percent; which is related to the volume of the material (Volume = mass/density). However, the mineralogic components exposed on the surface of the particle are the ones that weather and affect the leachate quality. Thus, the particle size distribution and the porosity of the backfill material determine to a large extent the amount of acid material placed in contact with the water. The intrinsic permeability of the rock material is assumed to be small and negligible when compared to the permeability of the backfill mass, i.e. water will flow around the rock particle and not through it. It is also assumed that the chemical diffusion of ions does not penetrate the entire rock mass but is restricted to the near surface layer.

If the surface-area to volume ratios of various particle sizes and shapes were known, it would be possible to relate the surface area produced by the various size fractions to the manner in which a rock breaks apart. This could be done through digitization of the various shapes and sizes of particles of different rock types and analyzing the surface-area volume ratios unique to each rock type.

In turn, the variations in surface area for each chemical rock group could be related to the quality and quantity of leachate produced by each group. This could be done by leaching various size fractions of one chemically similar rock sample. By knowing what percentage of the total rock pile is made up by each size fraction, the acid load generated per unity weight (or thickness) of rock can then be anticipated by adding the loads produced by each fraction.

Samples of sandstones and shales were chosen for a preliminary study because these rocks have a tendency to break apart into two distinct shapes yet having shapes common to the particular rock type. Sandstones, for example, tend to break into angular and massive blocks, while the shales tend to break along planar features and produce slabs. By taking photographs of these rock types and digitizing their shapes a surface area to volume (size) relationship can be derived.

The objectives of this study, now being evaluated at the Island Creek Coal Company Ten Mile Operation, are: 1) to field test the laboratory leaching tests used to predict rock weathering behavior and determine its applicability to field conditions and analysis and 2) to develop "loading indices" for the groups of sandstones and shales having varying pyrite and calcareous material contents for different sizes and shapes.

Methodology

The two rock types used in the preliminary study are the binder material and the acidic sandstone. Each rock type was collected from an active site, crushed and sieved through screens. The six fractions screened and being evaluated include: the less than 1" fraction, the 1"-2" fraction, the 2"-4" fraction, the 4"-6" fraction and the greater than 6" fraction.

During July and August, 1982 the samples of sandstone and binder were placed in large (8' x 4' x 2') plastic lined containers which are open to precipitation events and provide free drainage of water from the containers to 55 gallon collection barrels. Following each significant rain event, the drainage from each of the ten containers is being monitored for flow and a host of chemical parameters which include: temperature, pH, specific conductance, acidity, alkalinity and sulfate.

One container was also fabricated to collect rainwater in order to determine the rainwater chemistry at the site.

Prior to sieving, each pile of rock type, was photographed in order to be digitized to determine the surface area to volume relationships. Photographs of each rock filled container were also taken and these surface area to volume ratios, in combination with the total weight of each tub, will be used in the interpretation of acid loads from each size fraction.

Representative samples of rock from each container were collected during the container filling process. These samples were analyzed for total and pyritic sulfur contents and alkaline production potential (APP). A portion of the sample was also used for laboratory leaching tests at the University of South Carolina. These analyses will be evaluated in conjunction with the data from the tubs to integrate the field and tub data.

Preliminary Field Data

Following each significant precipitation event our field assistant, Mrs. Linda Patterson, measures the total volume of water that has drained in the barrels and collects a sample of the effluent for detailed chemical analysis. The volume of the sample, coupled with the acid concentration, is used to calculate the acid loads produced by each size fraction.

At the present time the study continues to be in the monitoring phase and many of the laboratory and field results are still in the process of being evaluated and analyzed. Two sets of results, however, are noteworthy and are presented as preliminary data and initial results.

The samples discussed relate to the samples of binder collected from a part of the highwall above the coal. The binder was crushed to sizes ranging from less than 1 inch, I to 2 inches and 2 to 4 inches. The composition of these samples is summarized in Table 1.

Table 1

Pyrite and Calcareous Material Content
of Binders Used in Field Study

Binder (shale)	Sulfur	APP*/500g
<111	1.33	0.80
111-211	0.93	1.20
211-411	0.96	1.0

*Cold acid digestion of sample using HC1 to determine carbonates present. All values indicate paucity of calcareous material.

The acid load produced by the various size fractions for the volume of effluent is shown in Figure 1. It is readily apparent that the finer sized rock particles produce greater amounts of acidity per equal volumes of effluent than the coarser grained fractions.

Plotting these values as cumulative acid loads (total acidity/ kg of sample) for various time intervals again reflects the affect that grain size has on the amount of acidity produced by the various size fractions. For a given time period, approximately 85% of the total load of acidity produced by all three size fractions, is generated by the less than 1" size particles.

(Figure 2.)

Based on these preliminary data, it can be stated that a significantly greater amount of acid is produced by the finer sized fractions than equal weights of coarser fragments.

Forthcoming Work

Monitoring of acid loads is continuing and these data will be coupled with the laboratory leaching tests to derive conversion factors which will permit laboratory derived data to be extrapolated to field results.

The field results for the sandstone portions will be further evaluated to compare the affects of rock types in addition to grain size variations. Ultimately, these data will be integrated, through the surface area/volume digitized studies, toward enhancing the acid load assessment model.

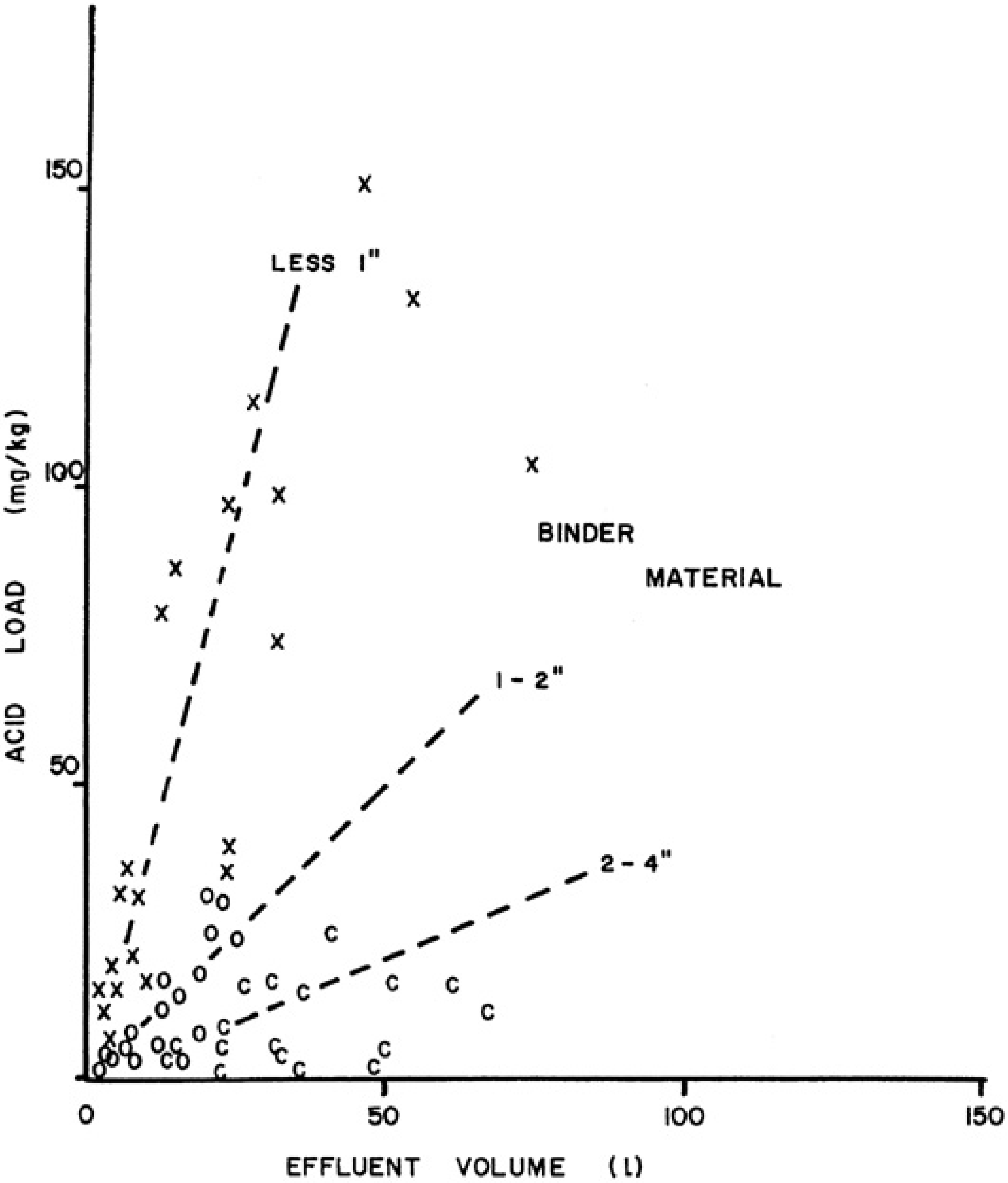

Figure 1 - Acid Loads of Three Size Fractions of Binder Material for Various Effluent Volumes.

Figure I - Acid Loads of Three Size Fractions of Binder Material for Various Effluent Volumes.

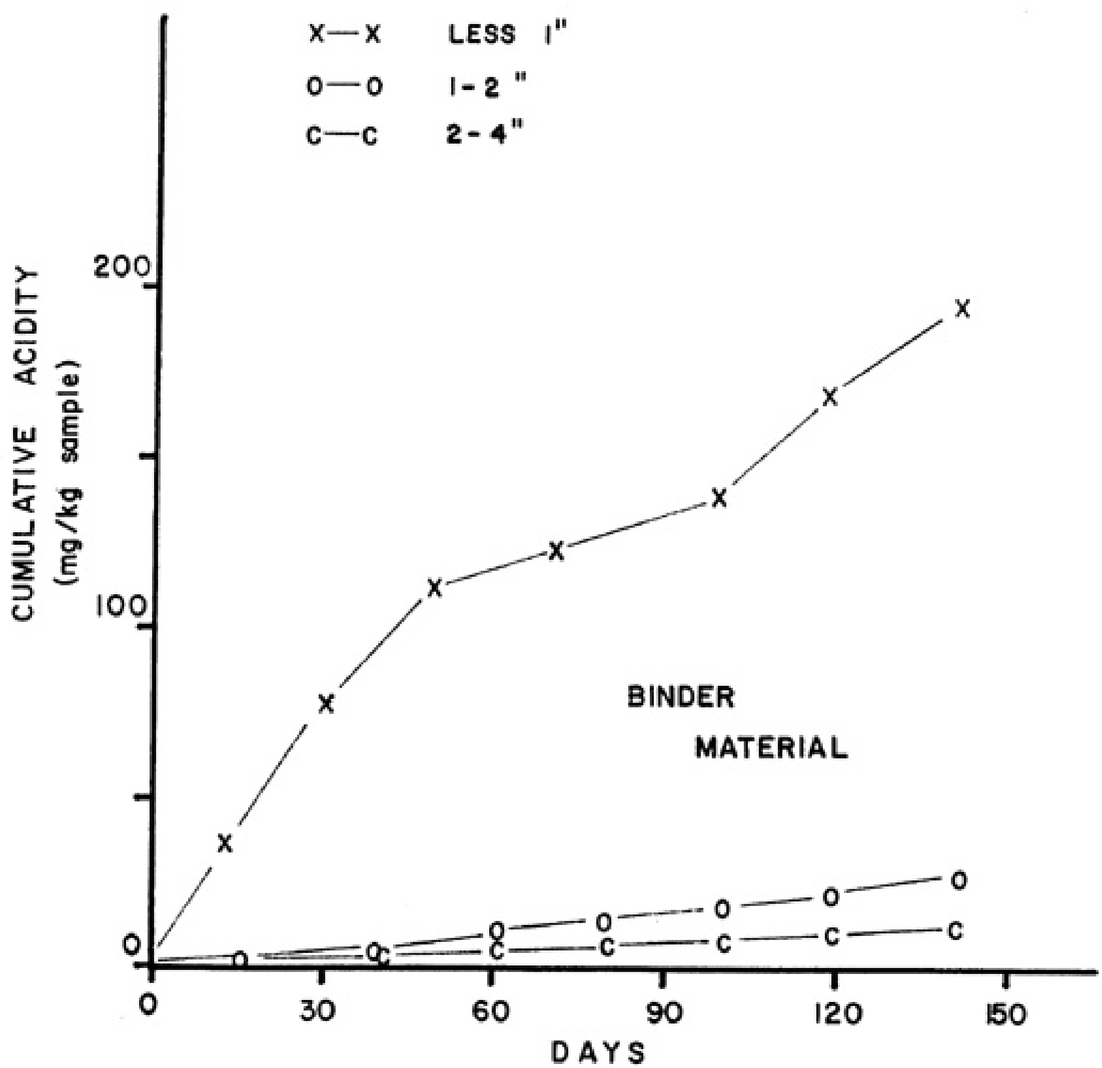

Figure 2 - Cumulative Acidity (Adjusted to 1% Sulfur) for Three Size Fractions of Binder Material

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