AVOID PROBLEM SPOILS Through OVERBURDEN ANALYSIS

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ABSTRACT

During strip mining of coal and subsequent grading operations, indiscriminant placement of toxic overburden strata at the spoil surface creates reclamation problems that are difficult and expensive to correct. Evaluation of overburden material before mining is begun is suggested as the most reliable means of predicting spoil quality and devising a reclamation plan. This can best be accomplished by core-drilling the proposed area and submitting the recovered core samples to a laboratory for chemical analysis. Color, pyrite content, and pH are field guides used to determine the potential toxicity of exposed overburden strata. Such guides can be used to select samples of potentially toxic strata for additional laboratory testing.

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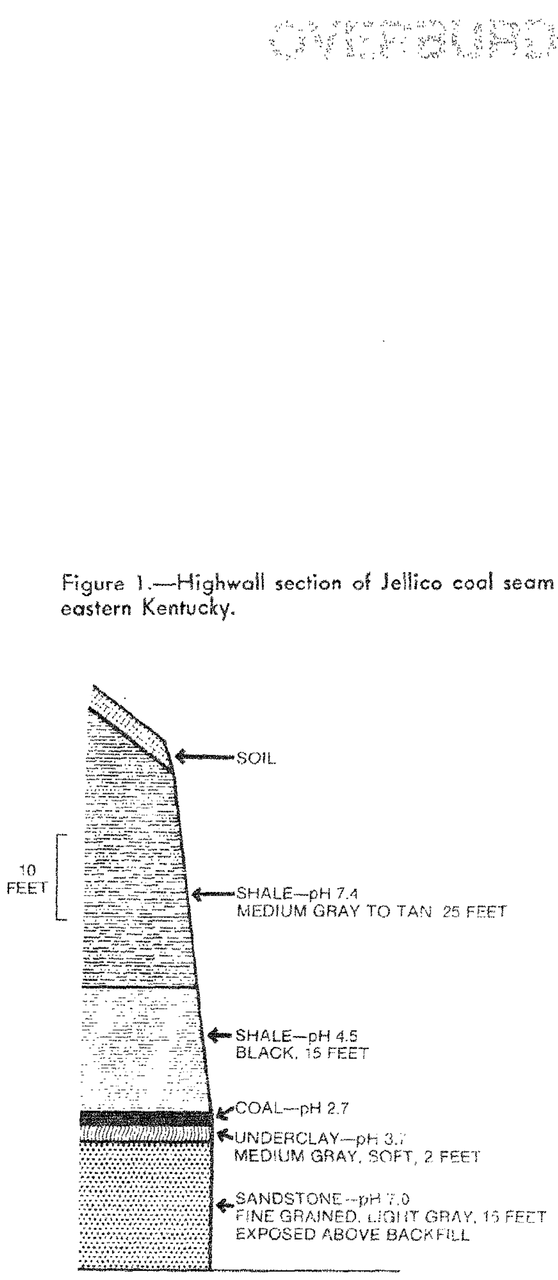
Figure 1.—Highwall section of Jellico coal seam in eastern Kentucky.



WHEN SOME COAL seams are mined, acid strata are encountered in the overburden. If this acid material is left at the surface, the spoil may be difficult or impossible to revegetate. Failure to establish vegetation and exposure of acid material at the surface lead to rapid erosion and leaching of toxic material. These processes result in increased sedimentation and chemical pollution of adjacent streams.

Because of these problems, most states concerned with strip-mining now have regulations requiring the operator to bury acid overburden material under non-acid spoil. Obviously, it is impossible to comply with such regulations if the acid strata are not recognized. After mining has been started, it is too late to identify these troublesome strata — the damage has already been done.

Figure 1 shows the highwall remaining after a mining operation on the Jellico coal seam in eastern Kentucky. The highwall is composed predominantly of medium gray to black shale, a light gray sandstone, and a thin rider coal seam. The uppermost 25 feet of shale and the sandstone at the bottom have pH of 7.4 and 7.0, respectively. The shales immediately above and below the rider seam have pH of 4.5 and 3.7. The thin rider seam is extremely acid, having a pH of 2.7.

In studying this area, we found that many spoil samples tested had a pH range of about 3.0 to 7.0. This situation could have come about by indiscriminant placement of the various highwall strata. Had the operator known the composition of the overburden before-hand, he could have selectively handled the overburden so that the acid shale and rider coal would have been buried under the upper shale and the sandstone. If the operation had been so planned and carried out — based on information obtained before mining — it is probable that spoil more amenable to reclamation would have resulted.

It is also very likely that the extra costs of pre-mining evaluation would have been considerably less than the increased costs of attempting to rectify a problem that need not have existed. Also, in this age of increased awareness of the environment, the public relations resulting from the quality of reclamation is a factor not to be regarded lightly even though its exact monetary value is difficult to evaluate.

It is apparent then, that to formulate an adequate reclamation plan for a new mining operation, it is necessary to know beforehand what the overburden is like. One way this information can be obtained is to examine existing highwalls on the same seam in the vicinity of the new operation and to formulate a tentative evaluation of expected conditions. However, to project information from other areas is precarious. Immediately after the first cut has been made, exposing the overburden strata, the new highwall should be examined; and any modifications necessary should be made in the projected evaluation.

HIGHWALL SAMPLING

To identify strata that may produce acid spoil, it is necessary to systematically sample the overburden. When collecting highwall samples for testing, one should give strict attention to making such samples representative of the different rock types present in the highwall. If black shale, gray shale, and brown sandstone are present, representative samples should be taken from the entire thickness of the bed. Thin beds should be chipped over the entire thickness; thicker beds can be spot-sampled from top to bottom at intervals appropriate to the thickness.

Care should be taken to label the samples, and a sketch should be made of the overburden strata, showing the type of rock and its thickness and the sample location (fig. 1). Careful attention should be given to thin clays in or adjacent to coal or rider seams because these are usually highly acid. If even small quantities of such material mix in the spoil surface, very acid conditions can result.

CORE-DRILLING

Core-drilling is the most reliable method for collecting samples to evaluate the overburden on a proposed new operation. This is the only adequate sampling method in an area where existing operations are not close by. In this way, samples can be collected and tested, and an evaluation can be made before the area is disturbed.

Evaluation of a new operation by core-drilling is especially important and perhaps should be required in areas that are considered highly sensitive to environmental damage and on coal seams known to have produced acid spoil in the past. In many instances, coal properties are evaluated by core-drilling, and overburden sampling could be done at the same time.

Another method of obtaining overburden samples is to collect the rock chips produced during drilling of blast holes. This will enable the operator to check on overburden characteristics somewhat in advance of mining. This, of course, depends on the availability of rapid analytical services. The main drawback to this method is the care required to insure adequate sampling control so that the data can be correlated with the sequence of strata being drilled.

FIELD TESTS

Field tests are not as reliable as laboratory tests, but they can give some indication of strata that may produce acid spoil. Three helpful criteria that can be used in the field are: color, pyrite content, and pH.

Color

Color can be a reliable guide to recognizing "safe" strata — if used with caution. This has been demonstrated in West Virginia where Grube et al. *(1973)* have accomplished much to correlate color of rock strata and acid-producing potential. Sandstones exhibiting shades of brown, yellow, or red can be considered safe; but care must be taken to be sure that these colors extend throughout the rock and are not present merely as surface staining or fracture coatings.

These colors, characteristic of the zone of intense weathering, occur in the upper part of the highwall. Gray material is ambiguous and can be either safe or acid. Black material is always suspect, but sometimes is safe. Gray and black strata should always be checked by one or both of the following criteria.

Pyrite

Oxidation of pyrite contained in strata that have been exposed to weathering is the predominant source of acid spoil. Therefore, if pyrite is present, the material is usually acid-producing.

Pyrite can be recognized by its metallic appearance, brassy color, and hardness (it cannot be scratched with a knife). Care should be taken not to confuse pyrite with mica, which is very abundant in some strata. Mica can be recognized by its occurrence as very thin plates, its glassy rather than metallic luster, and its extreme softness. Also, mica is usually concentrated along bedding planes of the strata, while pyrite occurs as grains and streaks distributed throughout the rock. Additional information on mineral identification can be obtained from standard mineralogy texts, such as that by Hurlbut *(1952)*.

If pyrite can be seen in overburden strata, such material should definitely be considered potentially acid-producing. However, inability to see pyrite does not mean that it is not present. In many rocks, especially black shales, pyrite may be present in a highly dispersed, very fine-grained form that is visible only under a microscope. If present in sufficient amounts, this form of pyrite is actually more harmful than the visible type, for at least two reason: (1) pyrite that occurs as grains large enough to be recognizable by eye sometimes possesses a crystal structure that is relatively inert to oxidation; and (2) the very fine-grained pyrite is usually of a form that is susceptible to oxidation and also has a very large surface area. Therefore, it is essential that all fine-grained strata such as shales and claystones be checked carefully for pyrite.

pH

The pH of a rock that has been exposed to weathering, even for a short time, can be used as a guide to its acid-producing potential. Rock pH can be determined by making a slurry of equal volumes of ground rock and distilled water and then by measuring the slurry with a pH meter.

Determining the pH of a rock slurry by using chemical indicators is unreliable and should not be attempted. If the pH of such a slurry is above 5.5, the rock can be considered safe. If the pH is lower, the material should be considered suspect; and samples should be submitted to a laboratory for further tests.

A pH test is useful only for weathered or partially weathered rock. The pyrite in fresh rock, such as that obtained from drill cores or freshly exposed highwalls, may not have been oxidized to form acid and can be evaluated only by laboratory tests.

LABORATORY TESTS

Field methods for evaluating rock strata are tentative. The only truly reliable method for evaluating overburden strata is to collect representative samples from either highwalls or drill cores and submit them to a laboratory for testing. Such tests should be evaluated by someone who has a background in geology and can interpret their meaning. At present, microscopic identification of pyrite in rock samples and determination of total acidity after all pyrite present in the sample has been chemically oxidized seems to be the most reliable way of testing overburden strata for acid-producing potential.

Total Acidity

Although pH can be used as a field guide, final evaluation of a sequence of strata must be based on total acidity. The pH of a material is a measure only of the acidity caused by the concentration of hydrogen ions present.

Most of the hydrogen ions in acid spoil are derived from the sulfuric acid produced by the oxidation of pyrite and, to a lesser extent, from ion exchange reactions of clay minerals. Total acidity can be used to measure, in addition to hydrogen ions, any material present that will react with a basic material such as lime.

This additional acidity mostly involves reactions of the basic material with iron and aluminum and usually is much greater than the hydrogen-ion acidity. In other words, the amount of lime required to raise the pH of a spoil material to any given pH value depends on the amount of hydrogen ions, iron, and aluminum present; and it is this quantity that is measured by the determination of total acidity. More extensive discussions of pH and total acidity can be found in publications by Bear *(1964)* and Peech *(1965)*.

Total Potential Acidity

In testing overburden strata or spoil that is only partially weathered or not weathered at all, a further complication arises in determining the acid-producing potential and lime requirements. The usual determination of total acidity measures only the acidity that has already formed in the material being tested. As this material continues to weather, any remaining pyrite may oxidize, producing additional acidity. Over a period of time, acid spoil that had been neutralized with lime could again become acid.

The additional acidity that may be produced by continued weathering can be called the total potential acidity, which can be determined by measuring the acidity after all the pyrite in the sample has been chemically oxidized. There is no way of determining the rate at which this additional acidity will form or even if it will form at all. However, by knowing that such a possibility exists, one can check spoil pH periodically to determine when additional lime is needed. Also, situations may arise where the indicated amounts of lime required will make reclamation impractical. By proper sampling and testing, such situations can be recognized and avoided.

SUMMARY

The main objective of strip-mine reclamation is to restore the land to a condition that will prevent environmental damage. It is becoming more and more important that such areas be restored to a useful and aesthetic condition. If a strip-mined area is to be developed for a useful purpose, an effective reclamation program must be formulated and followed through to completion. A plan must be devised *before* mining is begun.

Thus, as much knowledge as possible must be obtained about the material to be disturbed. The best way to evaluate the overburden material adequately is to sample the area to be disturbed by core-drilling and then to test the recovered samples in the laboratory. In this way, the location of toxic strata in the overburden can be ascertained; and a mining plan can be devised that will insure burial of such material. Constant checking of the highwall as mining progresses will also help avoid the creation of problem spoil.

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