POSTMINE SOILS — A LEGACY OF SURFACE MINING RECLAMATION[1]

by

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Abstract. Long after surface mining operations have ceased within a given area, the postmine soils will remain as a legacy of reclamation planning and implementation. Many of the native soils in east Texas are highly weathered and have excessive sands within surface horizons or excessive clays within subsoil horizons. The paper discusses limitations of such soils and how studies have shown that the use of selected overburden to replace these layers has resulted in long time favorable impacts due to improved soil quality. Examples are given where such improvements have taken place. The use of computers has enhanced the characterization of overburden strata and evaluation of these materials as a substitute for native soils. A brief discussion is given on postmine soil adaptability to economically-enhanced cropping systems within areas of East Texas. Suggestions are made for quantifying methods of monitoring postmine soil quality to better predict the longtime impacts of the postmine soils. Soil reconstruction standards should not be based on individual geochemical parameters taken in isolation, but on the interaction of all significant properties including vegetative response.

Introduction

Long-term impacts of surface coal mining depend in large part on the quality of minesoils left after reclamation is completed. Good, bad or otherwise, minesoils provide a legacy that will be dealt with by future generations. Historically, reclamation efforts--or the lack of them--have created negative impacts in some areas requiring remedial actions with considerable effort and expense. These instances, though few when compared to the total picture, are part of the environmental concerns responsible for the creation of Federal and State controls on coal mining and are what frequently comes to mind by the public when thinking of surface mining. A major requirement of reclamation regulations is to salvage native soils or provide minesoils as good as, or better than, native soils in the area using substitute materials.

Permitting requirements call for the assembly of large amounts of baseline environmental information, including soils and geology.

The volume of data makes computer enhancement almost a necessity in sorting the information into correlated classes about which interpretations can be made for a given purpose. The final analysis of minesoil quality, however, lies in the ability of reclamation special- ists to make intelligent decisions during premine planning and in the expertise of operators in executing these decisions.

The purpose of this paper is to relate some of the pre-planning and operational procedures that seem to insure high-quality minesoils. Most of them have created minesoils that more than meet the requirements of regulatory agencies. Our experience is based primarily on lignite surface mining in East Texas, but there is reason to believe that the principles involved are applicable to other areas. The basic approach is to (1) characterize native soil and overburden into classes within the permit area; (2) through relevant inter- pretations, select the most desirable materials for postmine soils, whether native soil or overburden; and (3) use reclamation procedures that preclude the development of adverse conditions such as compaction, steep slopes, and other undesirable features.

Overburden and Native Soils

Figure 1 represents a pit highwall in East Texas that has simple overburden relationships. The surface layer is the native soil profile, a thin zone of pedogenic (soil-forming) activities. It includes soil horizons that differ from underlying material as a result of chemical and physical interventions caused by climate, living organisms, parent material, and relief over a period of time

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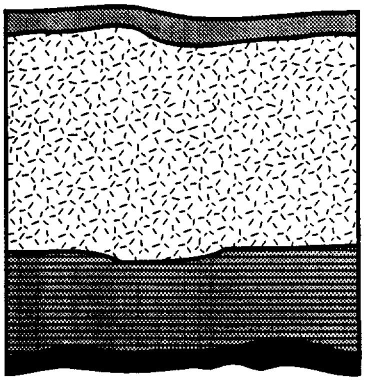

Figure 1. Schematic diagram showing overburden zones.

(Soil Survey Staff, 1975). For the most part, this zone is highly oxidized. It seldom contains acid-forming or toxic-forming materials, although low pH accompanied by high exchangeable acidity is common in much of the area. An accumulation of organic matter is present in the surface layer (A horizon), although not to the extent found in midwestern prairie soils. In sandy overburden, the A horizon may range from one-half to more than a meter thick, with sand content often greater than 80 per- cent. In clayey overburden materials, the profile is thin- ner, the surface layer is loamy, and clay content within the subsoil (B horizon) is excessively high, forming clay- pans in many of the soils. These limiting factors support conclusions by Borlaug (1976) that "nature's way is not always best."

Beneath the pedogenic zone lies an oxidized zone in which chemical and physical changes have been less intensive. For the most part, acid-forming materials are absent, although they have been noted in places, apparently stemming from marine-deposited sediments.

In Figure 1, the reduced zone has experienced little alteration through chemical and physical reactions. Although data show that much of this zone in the Wilcox Group of East Texas is suitable for use as substitute material (DeMent et al, 1992), care must be taken to avoid strata high in acid-forming materials or other characteristics that would prohibit plant growth.

The challenge facing reclamationists is to recognize which materials within the overburden are best suited for use as postmine soils.

Searching for Best Suitable Materials

Previous workers (Smith and Sobek, 1978) have pointed out the need for soils and overburden data during advance planning for mining operations. Soil sampling, mapping, classification, and adequate interpretations satisfy these requirements for native soils, but methods for gathering comparable information on overburden are less well established.

One procedure for overburden characterization used in East Texas (Hall Southwest, 1986) is the correlation of stratigraphic units. These are defined as bodies of strata within the overburden that have a characteristic textural composition range, a reasonably constant and predictable stratigraphic relationship with mineable lignite seams, a recognizable geophysical log pattern and a mappable thickness and geographical extent. These relationships are developed by combining chemical and textural data from cored sediments with associated geophysical log signatures to identify the different units. Once stratigraphic units are identified, chemical and physical values can be determined for a given unit by relating its depths to comparable depths within continuous cores.

The data compiled for individual stratigraphic units can be compared to baseline values of native soils to predict which materials have the best potential for postmine soils use. This is illustrated in Table 1, where a few of the soils and stratigraphic units within the Martin Lake Mine Permit 4G Area are used as examples of overburden evaluation.

This mine, operated by Texas Utilities Mining Company (TUMCO), is located in Panola County, Texas about 12 miles northwest of Carthage. The Bowie soils (fine-loamy, siliceous, ther- mic Plinthic Paleudults) are among the best agricultural soils in the permit area. These soils have moderately thick, loamy surface horizons that grade into loamy sub- soils. Sacul soils (clayey, mixed, thermic Aquic Paleu- dults) have thin sandy surfaces resting abruptly on clayey subsoils, and Troup soils (loamy, siliceous, thermic Grossarenic Paleudults) have very thick sandy surfaces that grade into loamy subsoils. The data show that even the Bowie soils have a negative acid-base account (ABA) which is basically a rough indicator of lime requirement (Smith and Sobek, 1978). The subsoil of Sacul has a negative ABA as well as excessive clay content which limits water movement, aeration and root extension. Troup soils are excessively sandy, causing them to suffer moisture stress during parts of most years.

The overburden stratigraphic units such as the examples in Table 1 can be evaluated against the native soils. Unit KL2 is a clayey zone above a lignite seam. In addition to a negative ABA and high clay content, the data (not listed in Table 1) show that selenium exceeds desirable limits. Unit RS, a rider seam also high in selenium, has a negative ABA. In the permit application, these units were rated unsuited for use as postmine soil material. On the other hand, Unit OBUd (an extensive silty unit) was recommended as a desirable substitute for use within the top four feet of graded spoil.

Table 1. Example for evaluating overburden against native soils for postmine use- Martin Lake Mine, Texas

MATERIALS	DEPTH (CM)	ABA (T/KT)	SAND (%)	CLAY (%)
A. Native Soils				
Bowie Series	0-30	0	61	16
	30-120	-2	43	35
Sacul Series	0-30	-1	46	30
	30-120	-5	23	46
Troup Series	0-30	0	86	8
	30-120	0	83	11
B. Overburden Units				
KL2	—	-2	13	43
OBUd	—	7	33	22
RS	—	-19	44	25

Indicates Undesirable for postmine soils.

— Indicates Not applicable.

Figure 2 illustrates how the Sacul soil series is much more limiting to plant growth than overburden unit OBUd. The overburden unit, if substituted, would have a loam texture throughout, much better ABA relationships and (according to data not shown) no other limiting factors when compared to the Sacul soil. In the evaluation, Unit OBUd was recommended as substitute material within the Martin Lake Mine Area. Indeed, at other TUMCO mines, this is one of the substitute units in which postmine soils have qualified as prime farmland (DeMent et al, 1992).

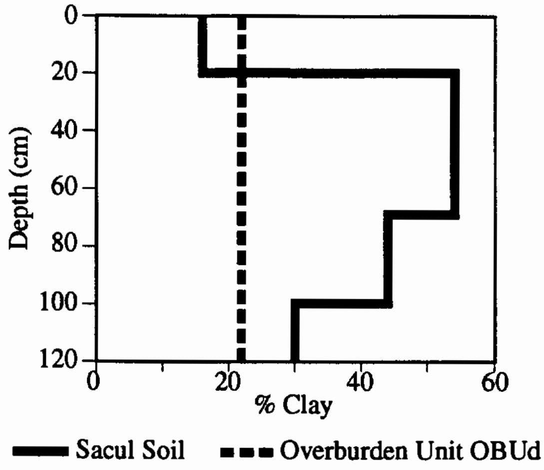

Figure 2. Clay Distribution in Native Sacul Soils Versus Overburden Unit OBUd

Other procedures for evaluating overburden quality have been used, but, regardless of procedure, the key to evaluating overburden as substitute material lies in identifying suitable, correlatable units of sufficient thickness and geographical extent to use in postmine soils.

Postmine Soil Evaluation

Assessment Procedures

Pre-planning allows predictions as to the quality of minesoils; postmine monitoring is necessary to confirm these predictions. In essence, data such as chemical and physical parameters, yields, etc., can be statistically com- pared to baseline data of native soils for quality assessment.

But do statistical comparisons provide the best assessment of minesoil quality? By using mean values, standard deviation, number of samples, and frequency distributions, one can determine if a given parameter is statistically different from another. But are statistical differences important to a plant's roots and performance? The difference between a pH of 4.9 and 5.1 might be statistically important, but loblolly pine growth might be as good with one value as with the other, especially if desirable changes were made in other parameters.

Statistical evaluations based on comparisons of single geochemical parameters fail to consider that soils are dynamic systems in which may factors interact to form a given set of characteristics. For example, the elimination of claypans in native soils during mining operations can more than compensate for minor adverse changes in acidity relationships. Regardless of mining procedures, postmine soils are never clones of native soils within a given area. Thus, minesoil evaluation must take a holistic approach, weighing all changes and their interactions within the whole system. Although computer enhance- ment can organize data for comparative purposes, earth scientists must make the final judgement on soil quality. A major consideration should be plant response to the new environment. Changes in land use potential with related changes in economic and aesthetic values might also be a part of quality comparisons. Some thoughts to these matters are given in following sections.

Soil Mapping

Some workers feel that selectively focusing on statistical procedures instead of a broad spectral evaluation by soil scientists and agronomists does not fully satisfy reclamation requirements. Some (Indorante et al, 1992) have pointed out the desirability of an Order 2 (detailed) soil map of postmine soils with appropriate interpretations for relevant land uses. The Office of Surface Mining regulations require native soil (premine) mapping, but there are no requirements for postmine soil mapping. Thus, monitoring for reclamation success reverts primarily to comparisons of premine and postmine data without recognizing that a mapping and classification program delineates bodies that are subject to more accurate interpretive statements and more direct comparisons of soil quality.

Currently there are more than 25 proposed or established minesoil series, primarily in Ohio, Illinois, West Virginia, and Texas, even though there is general agreement that additional work on the description, classification and interpretations of such soils is needed. They are now classified in the suborder Orthents (Soil Survey Staff, 1975) or in cases where diagnostic soil horizons are present, in Arents (DeMent & Associates, 1985). There are suggestions (Smith and Sobek, 1978; Indorante et al, 1992) that the current system of classification needs modifications to fit criteria more relevant to minesoils.

Soil Potentials

Some workers (e.g., Barnhisel et al, 1992; Hammer, 1992) have proposed soil productivity indices as measures of soil quality. Too lengthy for discussion here, most of these use chemical and physical data to develop models for predicting soil productivity. Mostly in developmental stages, these procedures might work toward a broader spectrum of soil potential and its economic and environmental impacts on a given community. Consider the fact that postmine prime farmland has been produced in East Texas where little prime farmland existed prior to mining (DeMent, 1985). Consider also the philosophy of Schwarzkoph (1993) and others of "economically mining and reclaiming land to an environmentally sound condition with an understanding that changes may occur." Such changes involve land use which can, among other things, improve wildlife habitat or develop postmine soils with greater economic potential than existed prior to mining.

Postmine studies at the Monticello-Winfield Mine, operated by TUMCO near Mt. Pleasant in Northeast Texas, have shown such potentials. Developing in overburden similar to Unit OBUd in Table 1, the Grayrock soils (fine-silty, mixed, nonacid, thermic Typic Udorthents) have no resemblance to native soils in the area. They meet or exceed reclamation standards but more interesting is their potential impact within the area. They show high potential for the production of alfalfa (Medicago sativa L), winter wheat (Triticum aestivum L), grain sorghum (Sorghum bicolor [L] Moehch) and corn (Zea mays L) in an area where most native soils are undeveloped or adapted to more or less marginal uses. Providing high quality hay and grain to a nearby milkshed serving Dallas and Fort Worth, would create long-term favorable impacts even outside the mine area. The alfalfa grown on minesoils at the Monticello Mine occur in a part of Texas where native soils do not support that crop.

TUMCO has planted habitat areas on reclaimed soils for many years. The species composition has gradually changed to more mast-producing trees and commercial forest land, both hardwood and pine. More than ten million trees have been planted through the 1997 planting season. The potential for producing commercial forests is greatly enhanced on the minesoils because of more uniform textures throughout the soil profile.

Summary

Since the inception of coal mining regulations in Texas in the mid 1970s, reclamation practices continue to improve. Input from educational institutions, Federal and State Regulatory personnel, and the industry, have developed means whereby postmine soils show, in places, great improvement over native soils. Procedures that broaden past efforts at reclamation are needed for continued improvement. The goal of decision making authorities should be to attain the greatest potential quality of minesoils and to encourage more efficient measures for assessing reclamation success.

Statistical assessment of single geochemical parameters for comparing soil quality can be misleading.

Soils are dynamic systems in which multiple factors interact to determine soil characteristics. Single parameters that are statistically significant may not adversely affect plant growth, particularly where improvements have been made in other parameters of the system.

Reclamation done incorrectly can lead to many years of remediation efforts and contention with local land owners. But reclamation which is well planned and has the advantage of good overburden materials should lead to very productive minesoils which will benefit present and future land owners both economically and aesthetically. Past measures were rather simple, as illustrated by a prominent industrial environmentalist who, in a moment of frustration asked, "If the grass is green and the cattle are fat, what's wrong with the soils?" Whatever changes take place in reclamation efforts, perhaps the ultimate goal of green grass and fat cattle should serve as a legacy for future generations.

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