PROPOSED CHANGES TO SOIL TAXONOMY THAT MAY AFFECT MINE SOIL CLASSIFICATION[1]

J.M. Galbraith[2]

Abstract: Mine soils begin developing horizons from natural processes after mining excavation and transportation of spoil ceases. Spoil deposits and altered landforms are easily recognized from a distance but the soils in those landforms seldom contain proof of their origin. *Soil Taxonomy* provides a few diagnostic horizons and materials and classes for mine soils. Most excavated or transported mine soils are identified in one of two suborders (*Arents* or *Orthents*) because they have no currently accepted diagnostic features other than remnant fragments of soil material. Mine soils (excavated and dredged) with *sulfuric horizons* are classified in "Sulf" Great Groups, although dredged deposits without *sulfidic materials* may classify in the *Fluvents* or *Psamments* suborders. There are no provisions in *Soil Taxonomy* to identify human transported material (HTM), human-manufactured or -modified materials, or to identify mine soils that contain those materials separately from natural soils such as in landslides. New designations and diagnostic layers and horizons are needed to establish new classes in *Soil Taxonomy* for HTM such as mine soils. The International Committee for Anthropogenic Soils (ICOMANTH) circulated letters requesting input for changes to describe, map, and manage mine soils. Most respondents would like to identify human-transported material with a special horizon prefix where evidence of mechanical transportation is left behind. Spoils left on the surface after surface mining or dredging presently have little variation in classification above the soil series level. Approximately two dozen soil series are available for identifying mine soils, although some of the series have overlapping properties. Many mine soils deposited following passage of the Surface Mining Control and Reclamation Act of 1977 contain *densic materials* due to compaction during reclamation, although none of the existing series recognize the *densic contact* that is the dominant factor in interpreting their use and management. Proposals to revise Soil Taxonomy will be submitted following recommendations from ICOMANTH with the goal of providing classes for mine soils with unique properties.

Additional Key Words: Spoil, Artifacts, *Densic Contact*, *Densic Materials*, *Sulfidic Materials*, Anthropogenic Soils, Human-altered soils.

---

[1] Paper was presented at the 2004 National Meeting of the American Society of Mining and Reclamation and The 25th West Virginia Surface Mine Drainage Task Force, April 18-24, 2004. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502

[2] John M. Galbraith is an Assistant Professor of Soil Science at Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0404.

Proceedings America Society of Mining and Reclamation, 2004 pp 706-
DOI: 10.21000/JASMR04010706
https://doi.org/10.21000/JASMR04010706

Introduction

Mine soils are soils that form in organic matter, mineral soil materials, sediments, and rocks redistributed by humans during or after mining processes. These processes may include surface and subsurface excavation with a directed purpose of collecting specific materials that are being mined and dredging to deepen or widen channels. Since the desired material is rarely found in pure form at the surface, there are usually spoil materials and exposed soil and geologic material left after mining ceases. When mining or dredging operations cease, soil horizons begin to develop in the transported or exposed soil materials (Roberts et al., 1988a; Roberts et al., 1988b; Indorante et al., 1992; Sencindiver and Ammons, 2000).

In most land-based mining processes, heavy machinery is used to excavate, transport and deposit spoil, leaving a landscape of pits, vertical bedrock high-walls, and mounds. Soils that form in mine and dredge spoils have similar characteristics to natural soils that form in recently transported materials. Most of these soils do not have well-developed topsoils rich in organic matter, distinct horizonation, or significant structural development compared to older, unaltered natural soils or truncated natural soils. Most land-based transported mine soils resemble soils forming in recent landslide deposits, except those that contain reorganized subsoil fragments or have developed Sulfuric horizons (Fanning and Fanning, 1989; Galbraith et al., 2002, Ch. 20). Mine soils in HTM may have an irregular distribution of organic carbon with depth, unlike older, unaltered upland soils. Mine soils in HTM also differ from older, unaltered soils (Sencindiver and Ammons, 2000) in that they are:

a) higher in bulk density and lower in porosity,
b) lower in saturated hydraulic conductivity,
c) lower in soil carbon and organic matter,
d) higher in unweathered rock fragments,
e) higher or much lower in reaction (pH),
f) lower in cation exchange capacity and exchange acidity,
g) higher in percentage of rock fragments, and are
g) located on human-created landforms.

In dredge mining, the spoil is often redeposited by truck or pumped in aqueous slurry into a pit or body of water. Unlike mine soils, soils that form in dredged materials have lower than normal bulk densities, higher than normal porosity, and higher *n*-value (Soil Survey Staff, 1999) than most older, unaltered upland soils. They differ from older floodplain soils that have had time to develop buried diagnostic horizons, although both soils on floodplains and in dredged materials often contain an irregular distribution of organic carbon with depth. Dredged materials high in *sulfidic materials* (Soil Survey Staff, 1999) quickly form diagnostic *sulfuric horizons* and do not resemble recent deposits in frequently flooded areas or active deltas that do not contain *sulfidic materials* (Galbraith et al., 2002, Ch. 15-16).

Human-constructed or excavated landforms are often easily identified on aerial photos, satellite images, topographic maps, or by field observation. Dredge-based mine soils are often deposited in pits or tailing-ponds with polygon-shaped berms that are easily located and identified.

Haering et al. (2004a; 2004b) reported that in their study area in Cumberland Plateau of the Eastern US, post-SMCRA mine soils often have distinct differences in soil properties and classification than unaltered natural soils and mine soils deposited before that Act. Most pre-SMCRA mine soils are finer-textured (have less sand and more clay) and are lower in pH than most post-SMCRA mine soils because the pre-SMCRA soils were more likely to come from contour-mining of oxidized, pre-weathered overburden extracted from near the original land surface. The oxidized overburden is pre-weathered and breaks down into finer soil components more easily than the more highly-cemented rock material extracted from deeper, less-oxidized zones. Soil horizon formation is evident a few years after mine soils are placed and left undisturbed (Haering et al., 1993). The pre-SMCRA spoils are older and have had more time to be leached and acidify after placement. Unless the oxidized overburden was stockpiled and used as a topsoil substitute, the post-SMCRA soils are more likely to form in less-oxidized material mined from deeper underground (Haering et al., 2004a; Haering et al., 2004b).

Some older pre-SMCRA mine soils, located in warm or moist climates, that had been pushed loosely off a bench during contour-mining possess favorable growth properties and have become largely reforested (Rodrigue and Burger, 2002). These soils may be hard to identify from under a forest canopy at ground level but many can still be identified from historical documents, aerial photos, and imagery. Compacted mine soils left in unseeded spoil piles, those containing or exposing *sulfidic materials* (Soil Survey Staff, 1999), or deposited in cold or dry climates are still easily identified on-site because most have not revegetated to their pre-mined vegetation conditions. Mine soils or excavations containing *sulfidic materials* that are exposed to oxidation form *sulfuric horizons* and the resulting low pH prevents revegetation to a large degree (Fanning and Fanning, 1989). Post-SMCRA soil boundaries are easily identified in the field because they are younger, often featureless soils that are mostly seeded to grass-legume mixtures and converted to grasslands (Daniels and Zipper, 1988). Exceptions occur in states such as Illinois where post-SMCRA excavation sites conducted under active farmlands are restored to farmland use after mining (Wiesbrook and Darmody, 1989; Indorante et al., 1992).

Identification of the boundary between mined and un-mined areas is simpler than the identification of the composition of the soils within a mined area. After mining ceases, the revegetation and management of post-SMCRA mine soils is almost always different from that of un-mined soils. Therefore, post-SMCRA mine soils are identified, mapped, and classified differently than un-mined soils.

Soil Taxonomy (Soil Survey Staff, 1999) classifies soils by properties found within the soil body or landscape unit. The system does not allow historical evidence, artificial landform identification, or relative comparison to other soils as diagnostic evidence for identifying the soil class. While landforms containing mined soils can be identified using many tools and records, most of the soils themselves are indistinct and contain little evidence of their history. Recent mine soils are difficult to distinguish from natural soils in recently deposited materials because many properties commonly found in mine soils (Indurante et al., 1992; Sencindiver and Ammons, 2000) are commonly found in recent floodplain or landslide deposits. Soil scientists have found that they can positively identified mine soils from within pits in cases where artifacts, proving human-influence, are left behind or where diagnostic horizons have formed (Galbraith et al., 2002, Ch. 5-18).

The objectives of this paper are to review the diagnostic horizons and materials that apply to identification and description of mine soils, the current classification of mine soils, and potential changes to *Soil Taxonomy* to improve mine soil description, classification, mapping, and management.

Existing Diagnostic Materials/Horizons/Epipedons and Soil Classification

According to the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) Soil Taxonomy Staff, the original authors of Soil Taxonomy wanted to keep undisturbed soils and the cultivated or otherwise human-modified equivalents in the same classes insofar as possible (Galbraith et al., 2002, Ch. 2). Topsoil placed over mine soils has little similarity to the original surface soil, which can drastically change the classification. Exceptions may occur where mining regulations require original soil material replacement.

Early efforts have been made to propose new horizons, materials, and classes for Soil Taxonomy to deal with mine soils (Fanning and Fanning, 1989; Ammons and Sencindiver, 1990; Sencindiver and Ammons, 2000). Several soil series have been proposed or established for mine soils and other soils formed in HTM (Wiesbrook and Darmody, 1990). Mine soils may be identified at the order level by the diagnostic *mollic epipedon*, the *cambic* or *sulfuric horizon*, or the absence of all diagnostic horizons, layers, and materials. Mine soils may be identified at the great group level by the *sulfuric horizon* or recognizable fragments of displaced soil materials. *Densic materials* within the subsoil can be used to differentiate soil series (Soil Survey Staff, 1999).

In older mine soils, a *cambic horizon* may develop and those soils are classified as *Inceptisols*. Mine soils with *sulfuric horizons* are also Inceptisols. Some recently reclaimed mine soils contain rearranged fragments of diagnostic horizons, and those are identified as *Arents* if there are no other diagnostic horizons. In the Midwest, mine soils that were carefully reclaimed may have a dark (m*ollic*) surface horizon (*epipedon*) and those classify as *Mollisols*. Soils that form in non-sulfidic sandy dredged materials are classified as *Psamments*, soils that have no diagnostic features and are very sandy throughout. Most finer-textured mine spoils contain no diagnostic soil horizons, layers, or materials and are identified as *Orthents*, a class of featureless soils.

The *mollic epipedon* is a relatively thick, dark colored, humus-rich surface to subsurface horizon in which cations such as Ca and Mg are dominantly available and the soil structure is not massive. These properties are common in the soils of the steppes in the Americas, Europe, and Asia. A *mollic epipedon* does not form in mine soils rapidly, but it may be found where the original top soil of a *Mollisol* has been replaced.

A *cambic horizon* forms as the result of physical alterations, chemical transformations, and chemical removals from the upper subsoil. In mine soils, common physical alterations include the movement of soil particles by freezing and thawing, shrinking and swelling, root proliferation, wetting and drying, or animal activities to form aggregations of the soil particles. Chemical transformations in mine soils that form a cambic horizon are the result of hydrolysis of primary minerals to form iron (hydr)oxides and other minerals, dissolution and redistribution or removal of carbonates or gypsum, reduction and segregation or removal of iron, or a combination of these processes. The subsoil accumulation of silicate clay, sesquioxides, or organic matter or by the removal of calcium carbonate or gypsum can also produce a cambic horizon.

A *sulfuric horizon* can form in areas where sulfidic materials have been exposed as a result of surface mining, dredging, or other earth-moving operations. Brackish water sediments and rocks that form from those sediments frequently contain pyrite, an iron sulfide. When exposed to oxygen, the pyrite oxidizes and produces iron (hydr)oxides, jarosite (hydrous potassium iron sulphate), and sulfuric acid, resulting in very low (< 3.5) pH values unless there is sufficient $CaCO_3$ to neutralize the acid. The low pH associated with *sulfuric horizons* is detrimental to the survival of most plants and microbes. Some *sulfuric horizons* can be identified by a straw-yellow colored jarosite precipitate along pores or ped surfaces in the soil in combination with a pH less than or equal to 3.5.

Densic materials are noncemented but the bulk density or the organization of particles is such that roots cannot enter, except in cracks. *Densic materials* and *densic contacts* often occur in mine spoils in areas of heavy vehicle traffic and where heavy machinery was used to deposit and intentionally compact the mine spoil. *Densic materials* have, at their upper boundary, a *densic contact* if they have no cracks, or if the spacing of cracks where roots can enter is 10 cm or more.

Mine soils may be classified by using one or more of several existing diagnostic horizons and materials, but the variety of placement is narrow. Table 1 shows the current classification of the mine soils used in areas of the United States where mine soil series have been proposed or established. Although the mine soils are found in a wide variety of locations and conditions, most of the mine soil series that have been proposed or established are classified as *Typic Udorthents* or *Alfic Udarents* subgroups and must be separated by properties at the family or series level. Ammons and Sencindiver have proposed recognition of mine soils at the family level (Ammons and Sencindiver, 1990).

Table 1. Soil Taxonomy classification of existing and tentative mine soils through 2002.

Soil Series	Family Class	Subgroup Class
Marklake	Fine-loamy, siliceous, active, acid, thermic	Alfic Udarents
Kanima	Loamy-skeletal, mixed, active, nonacid, thermic	Alfic Udarents
Schuline	Fine-loamy, mixed, superactive, calcareous, mesic	Alfic Udarents
Swanwick	Fine-silty, mixed, active, nonacid, mesic	Alfic Udarents
Lenzburg	Fine-loamy, mixed, active, calcareous, mesic	Haplic Udarents
Brazilton	Fine, mixed, nonacid, thermic	Mollic Udarents
Rapatee	Fine-silty, mixed, superactive, nonacid, mesic	Mollic Udarents
Pirkey	Fine-loamy, siliceous, semiactive, acid, thermic	Ultic Udarents
Levelland	Coarse-loamy, mixed, superactive, nonacid, thermic	Aridic Ustifluvents
Pinegrove	Mixed, mesic	Typic Udipsamments
Tihonet*	Mixed, mesic	Typic Psammaquents
Barkcamp	Loamy-skeletal, siliceous, acid, mesic	Typic Udorthents
Bethesda	Loamy-skeletal, mixed, active, acid, mesic	Typic Udorthents
Briery	Loamy-skeletal, mixed, active, nonacid, frigid	Typic Udorthents
Brilliant	Loamy-skeletal, mixed, nonacid, thermic	Typic Udorthents
Cedar Creek	Loamy-skeletal, mixed, active, acid, mesic	Typic Udorthents
Enoch	Loamy-skeletal, siliceous, acid, mesic	Typic Udorthents
Fairpoint	Loamy-skeletal, mixed, active, nonacid, mesic	Typic Udorthents
Farmerstown	Fine-loamy, mixed, acid, mesic	Typic Udorthents
Fiveblock	Loamy-skeletal, mixed, semiactive, nonacid, mesic	Typic Udorthents
Grayrock	Fine-silty, mixed, active, nonacid, thermic	Typic Udorthents
Itmann	Loamy-skeletal, mixed, semiactive, acid, mesic	Typic Udorthents
Janelew	Loamy-skeletal, mixed, calcareous, mesic	Typic Udorthents
Kaymine	Loamy-skeletal, mixed, active, nonacid, mesic	Typic Udorthents
Marclay	Fine, mixed, nonacid, thermic	Typic Udorthents
Morristown	Loamy-skeletal, mixed, active, calcareous, mesic	Typic Udorthents
Myra	Loamy-skeletal, mixed, calcareous, mesic	Typic Udorthents
Palmerdale	Loamy-skeletal, mixed, acid, thermic	Typic Udorthents

Soil Series	Family Class	Subgroup Class
Putco	Fine, mixed, superactive, calcareous, mesic	Typic Udorthents
Sewell	Loamy-skeletal, mixed, semiactive, acid, mesic	Typic Udorthents
Verazano*	Coarse-loamy over sandy or sandy-skeletal, mixed, active, nonacid, mesic	Typic Udorthents
Bigbrown	Fine-silty, mixed, nonacid, thermic	Typic Ustorthents
Gibbonscreek	Fine-loamy, mixed, nonacid, thermic	Typic Ustorthents
Sinepuxent*	Coarse-loamy, siliceous, subactive, nonacid, mesic	Typic Sulfaquents
Centralpark*	Loamy-skeletal, mixed, active, mesic	Typic Dystrudepts
Greenbelt*	Coarse-loamy, mixed, active, mesic	Typic Dystrudepts
Weaver	Fine-loamy, mixed, active, mesic	Fluvaquentic Eutrudepts
Conquista	Fine-loamy, mixed, superactive, hyperthermic	Entic Haplustolls

* tentative series, not fully established.

The presence of a *densic contact* within 50 cm of the surface defines soils in shallow families (Soil Survey Staff, 1996). The presence of a dense, root-limiting layer in mine soils has a major influence on how easily and economically the site can be forested and how much internal water movement and runoff can occur. Mine soils created since 1977 or that were the former site of haul roads or soils on fairly level benches are likely to contain *densic contacts* within 50 cm of the surface. The official soil series descriptions of a few mine soils include very dense horizons with root-restrictive properties, but *densic soil materials* are not recognized in those soil series and their depth class does not reflect the described depth to a root-limiting contact. However, since *densic materials* were not defined or added to *Soil Taxonomy* until after many mine soil series were established (Haering et al., 2004b), a redefinition of some mine soil series and a creation of new series for mine soils with *densic contacts* and *densic soil materials* is needed, as proposed by Wiesbrook and Darmody for soils in Illinois (1998).

The properties most often used to distinguish mine soils series from each other are taxonomic class, rock type and composition, pH, control section clay content, and drainage class (Haering, et. al., 2004b), since many mine soils fall into similar taxa above the family level (Table 1). However, the set of existing mine soils does not cover all of the combinations rock type and composition, pH, control section clay content, and drainage class. For example, at the Powell

River project in Southwest Virginia, mine soils were commonly found that did not fit into the range of any existing mine soil but did fit into all of the distinguishing properties of the existing Kaymine soil series except for the clay content. In addition, few of the existing mine soil series are described as being other than excessively or well drained. Further review is needed to compare the distinguishing property ranges of existing series, revise official soil series descriptions where needed, and set up a key for soils scientists to use in mapping mine soils.

Potential Changes to Soil Taxonomy

ICOMANTH was formed in 1995 with a mission to define appropriate classes in Soil Taxonomy for soils that have their major properties derived from human activities (http://clic.cses.vt.edu/icomanth/). New diagnostic horizons, layers, or materials will be proposed by ICOMANTH through the procedures outlined in National Soil Survey Handbook Section 614.05 (USDA-NRCS, 2002) to allow finer division of mine soils.

Since 1997, ICOMANTH has distributed circular letters to solicit ideas from the soil science community about classifying human-altered soils. In 1998, the USDA-NRCS, ICOMANTH, and the Professional Soil Scientists Association of California sponsored a tour of mine soils in Nevada and California (Kimble et al., 1999). Scientists from many nations attended. A number of examples of mine soils were sampled and analyzed before the tour. Information from the tour is found on the Internet at URL (http://clic.cses.vt.edu/icomanth/04-AS_CA_Tour_98.pdf). In January 2003, Circular Letter #4 was distributed to solicit ideas about naming horizons of human-altered or -transported soil materials URL (http://clic.cses.vt.edu/icomanth/circlet4.pdf). In 2002, ICOMANTH compiled Anthropogenic Soils (CD) Report 1 with references, pictures, posters, and lab data concerning mine soils (Galbraith et al., 2002, Ch. 3-4). The following amendments to *Soil Taxonomy* are among those being considered for proposal by ICOMANTH based on the soils tour in 1998, the data contained in Anthropogenic Soils (CD) Report 1, and responses from the Circular Letters. Some of these proposals have been reviewed and tested by the USDA-NRCS Staff (Galbraith et al., 2003).

Human-modified or -manufactured materials found in the soil will be called artifacts. Artifacts range from durable to easily degradable and may include physical and chemical materials or objects such as coal ash, steel, concrete, bricks, plastic, diesel fuel, or asphalt. Soil layers and horizons composed of human-transported materials will be identified if they contain artifacts or other evidence of being moved by humans and their machines. Scars or scrape marks from mechanical tools during excavation or deposition events are further proof of human transportation and are considered to be artifacts by some soil scientists (Delvin Fanning, personal communication).

Several new diagnostic horizons or layers may be proposed in order to allow easier identification of mine soils based on internal soil properties. *Densic materials* described as containing artifacts or other evidence of being HTM may be identified as a new diagnostic horizon, such as a compressic layer (from Latin *compressare* to press hard). A spolic (from Latin *spoliare*, earth and rock waste materials) material may be proposed that contains sufficient evidence of being HTM (Sencindiver and Ammons, 2000), but containing very few artifacts. Dredged HTM that contains evidence of being deposited in aqueous manner or environment by humans may be called an aquadepic (from Latin *aqua* water and *depositus* to place) material. Any of these diagnostic materials or layers, if accepted by the USDA-NRCS and National Cooperative Soil Survey (NCSS), could be used to identify mine soils separately from other soils. Erratic vertical and internal distribution of parent materials, buried soil horizons, and lack of distinct horizon development on non-flooded areas on top of isolated landforms may also be used by field soil scientists to rule out natural deposition from a higher area. Soil or geologic material that can be identified as having come only from an outside source and is a mismatch with known regional materials could be considered human-transported. The addition of these two new materials and the new horizon will allow soil scientists to more easily identify mine and dredged soils, although the level of the classification of those soils has not been determined.

Most soil scientists that responded to the ICOMANTH Circular Letters would like to identify layers of HTM with a special prefix (such as a “prime”) in soils where evidence of mechanical transportation of HTM exists. Respondents to the Circular Letters also indicated a need to identify layers that contain a significant amount of artifacts with special suffix symbols, such as the “plus” symbol or the lowercase letter u. Table 2 contains an example mine soil description that uses new horizon symbology and descriptive terms than currently found in USDA-NRCS technical manuals (Soil Survey Staff, 1999; USDA-NRCS, 2002). The HTM occurs to 117 cm, the spolic material occurs above 79 cm, and the top of the compressic layer occurs at 20 cm. These changes should allow readers of soil descriptions and the users of soil databases to identify the depth of HTM and thus interpret and manage the soils. Taking this example one step further, if the base saturation was high and the soil temperature regime was thermic and the soil moisture regime was ustic, then this pedon would classify as a Loamy-skeletal, mixed, thermic, active, calcareous, shallow family of Typic Ustorthents. The challenge for ICOMANTH will be to recognize new classes in Soil Taxonomy that would allow recognition of the example soil series as being different than other Typic Ustorthents in the same family.

Table 2. Example description of a deposited mine soil using new horizon symbology and descriptive terms.

‘A	0 to 6 cm; dark brown (7.5YR 3/4) gravelly sandy loam; few, medium distinct gray (2.5Y 5/1) lithochromic colors from weathered rock fragments; weak, coarse, subangular blocky and thick platy structure; friable; 20% by vol. light gray siltstone and 5% by vol. pinkish gray sandstone gravel; 5% by vol. light brown sandstone cobbles; common fine and medium plus few coarse roots; no pores; slightly alkaline (pH 7.4); slightly calcareous; clear wavy boundary.
‘C	6 to 20 cm; grayish brown (10YR 5/2) very cobbly coarse sandy loam; structureless, massive; firm; common fine and medium plus few coarse roots; no pores; 10% by vol. light gray siltstone and 15% by vol. pinkish gray sandstone gravel; 25% by vol. light brown sandstone cobbles; slightly alkaline (pH 7.5); slightly calcareous; clear wavy boundary.
‘Cd	20 to 79 cm; gray (10YR 5/1) extremely stony coarse sandy loam; structureless, massive; extremely firm; very few fine roots in upper part; no pores; 10% by vol. light gray siltstone and 15% by vol. pinkish gray sandstone gravel; 20% by vol. light brown sandstone cobbles; 20% by vol. light gray sandstone flagstones; slightly alkaline (pH 7.6); slightly calcareous; clear wavy boundary.
‘Cdu	79 to 117 cm; dark gray (10YR 4/1) extremely stony coarse sandy loam; structureless, massive; extremely firm; no roots; no pores; 15% by vol. light gray siltstone and 15% by vol. pinkish gray sandstone gravel; 15% by vol. light brown sandstone cobbles; 35 by vol. light gray sandstone flagstones; 5% by vol. boulders of light gray sandstone; 5% by vol. iron rod fragments (construction debris); slightly alkaline (pH 7.6); slightly calcareous; abrupt wavy boundary.
2R	117 to 200 cm; strongly-cemented light gray, mildly alkaline siltstone bedrock.

Conclusion

Mine soils are difficult to identify based solely on internal properties, even though the landforms where they reside are often obvious and easily defined. Several existing diagnostic horizons and materials in *Soil Taxonomy* and many soil series apply and can be used to classify mine soils. However, most mine soils in the Eastern US are classified in only a few taxa and are difficult to distinguish from each other above the soil series level. Although it is beyond the scope of this paper, changes to Soil Taxonomy will be proposed by ICOMANTH to allow easier description, classification, mapping, and management of mine soils in the future. The level that mine soils may enter the USDA-NRCS system is still undetermined, but will probably occur at several levels based on the variety of materials found in established and tentative soil series.

Acknowledgements

The author would like to thank Delvin S. Fanning for his contributions to this paper and Sue Brown of Virginia Polytechnic Institute and State University for her assistance in preparing this paper.

Literature Cited

Ammons, J.T. and J.C. Sencindiver. 1990. Minesoil mapping at the family level using a proposed classification system. J. Soil and Water Cons. 45:567-571.

Fanning, D.S. and M.C.B. Fanning. 1989. Soil -- Morphology, genesis, and classification. John Wiley and Sons, New York, NY, USA.

Galbraith, J.M., H.R. Mount and J.M. Scheyer. 2002. Anthropogenic Soils. ICOMANTH Report No. 1. CD-ROM. USDA-NRCS. Lincoln, NE. Available from URL http://clic.cses.vt.edu/icomanth/ (last verified 1/2004).

Galbraith, J.M., D.S. Fanning and J.C. Sencindiver. 2003. ICOMANTH Circular Letter #4. Nat. Coop. Soil Survey Conf. Proceedings. 2003 Meeting, Plymouth, MA.

Haering, K.C., W.L. Daniels and J.M. Galbraith. 2004a. The influence of overburden weathering and mining method on Appalachian mine soil morphology and properties. Soil Sci. Soc. Am. J. Accepted June 10, 2003. https://doi.org/10.2136/sssaj2004.1315

Haering, K.C., W.L. Daniels and J.M. Galbraith. 2004b. Mapping and classification of Southwest Virginia mine soils. Soil Sci. Soc. Am. J. https://doi.org/10.2136/sssaj2005.0463

Haering, K.C., W.L. Daniels and J.A. Roberts. 1993. Changes in mine soil properties resulting from overburden weathering. J. Environ. Qual. 22:194-200. http://dx.doi.org/10.2134/jeq1993.00472425002200010026x http://dx.doi.org/10.2134/jeq1993.221194x.

Indorante S.J., D.R. Grantham, R.E. Dunker and R.G. Darmody. 1992. Mapping and classification of minesoils: Past, present, and future. *In* Dunker, R.E., R.I. Barnhisel, and R.G. Darmody (Eds.) Proc. of the 1992 Nat. Symp. on Prime Farmland Reclamat. Univ. of Illinois, Urbana, IL 61801.

Kimble, J.M, R.J. Ahrens and R.B. Bryant. 1999. Classification, correlation, and management of anthropogenic soils. Proceedings-Nevada and California, 21 September - 2 October, 1998. USDA-NRCS, National Soil Survey Center, Lincoln, Nebraska, USA.

Roberts, J.A., W.L. Daniels, J.C. Bell and J.A. Burger. 1988a. Early stages of mine soil genesis in a southwest Virginia spoil lithosequence. Soil Sci. Soc. Amer. J. 52:716-723. http://dx.doi.org/10.2136/sssaj1988.03615995005200030023x.

Roberts, J.A., W.L. Daniels, J.C. Bell and J.A. Burger. 1988b. Early stages of mine soil genesis as affected by topsoiling and organic amendments. Soil Sci. Soc. Amer. J. 52:730-738. http://dx.doi.org/10.2136/sssaj1988.03615995005200030025x.

Rodrigue, J.A., J.A. Burger and R.G. Oderwald. 2002. Forest productivity and commercial value of mined land reclaimed prior to enactment of federal reclamation law. North. J. Appl. For. 19(3):106-114.

Sencindiver, J.C. and J.T. Ammons. 2000. Minesoil Genesis and Classification. Ch. 23. *In:* R.I. Barnhisel, R.G. Darmody, and W.L. Daniels (Eds.) Reclamation of drastically disturbed lands. Agronomy Series #41. American Society of Agronomy, Madison, Wisconsin, USA.

Soil Survey Staff. 1996. Keys to Soil Taxonomy. Seventh edition. U.S. Govt. Printing Office, Washington, DC.

Soil Survey Staff. 1999. Soil Taxonomy Second Ed: A basic system of soil classification for making and interpreting soil surveys. USDA-NRCS Agriculture Handbook No. 436.

USDA-NRCS. 2002. National Soil Survey Handbook, title 430-VI. [Online] Available: http://soils.usda.gov/technical/handbook/

Wiesbrook, S.M. and R.G. Darmody. 1998. Mine soil mapping, classification, and characterization in Illinois. Session 3. Proc. of Prime, Farmland Interactive Forum, Univ. So. Indiana at Evansville, IN. 3 and 4 March, 1998.