RECOGNITION OF NOOGENIC SOIL MATERIALS IN CLASSIFYING MINE SOILS[1]

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Abstract. Proposals for a separate order of Noosols have been advanced to include soils where anthropogeomorphic processes predominate. Although a number of soil series for mine soils are established in the United States, these soils have not been fully incorporated in the U.S.D.A. taxonomic system. Problems in separating mine soils from "natural" soils remain, and these soils are inevitably placed in Entisols (Orthents or Arents). Proposals for recognizing a separate suborder of Spolents have not been approved, while attempts to distinguish mine soils at the subgroup level (using dominant lithology) seem inconsistent with family criteria. Recognition of a separate suborder (Spolnos) in Noosols to accommodate mine soils is discussed, and proposals to define noogenic materials using field criteria are presented as a basis for distinguishing other suborders. Provisional classes for spolic materials based on dominant lithology are proposed for loamy- skeletal families in Spolnos. Use is made of the so-called clastic ratio in distinguishing relative abundance of rock types as an aid in reclamation and management. Additional characterization of spolic materials will be required to recognize other types of spolic materials, and eventually it may be necessary to introduce unique families to accommodate mine soils.

Additional Key Words: Noosols, Spolnos, Spolents, anthropogeomorphology

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[1] Paper 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.

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Proceedings America Society of Mining and Reclamation, 2004 pp 1147-1156
DOI: 10.21000/JASMR04011147

https://doi.org/10.21000/JASMR04011147

Introduction

Current proposals to classify mine soils as Spolents in the U.S.D.A. system have not been formally approved (Sencindiver and Ammons, 2000). Although a number of mine soil series have been established in the United States, these have not been fully incorporated in the U.S.D.A. taxonomy and are included in Entisols (Orthents or Arents). Problems in separating these soils from other Entisols remain unresolved, and it has proven difficult, if not impossible, to derive unambiguous criteria, using a rigorous morphometric approach. Current proposals by the ICOMANTH Committee (Circular Letter No. 4) to distinguish spolic materials as the basis for recognizing these soils inevitably introduce genetic concepts in their definition. It is unacceptable to define certain criteria as anthropogenic and then treat these as purely morphometric criteria.

It has been suggested that these methodological problems may be more easily overcome by establishing a new soil order (Noosols) to accommodate soils where anthopogeomorphic processes predominate. Problems in separating these soils from other Entisols (Arents or Orthents) would be resolved at the onset once a separate domain of anthropogeomorphology is recognized (Kosse, 2001). While this may seem a radical departure, it would be consistent with the logic of the U.S.D.A. soil taxonomy since orders are held to reflect dominant pedogenic processes (or their lack). Recognition of the wide range of noogenic soil materials provides a means for distinguishing suborders in Noosols. Mine soils would be classified as Spolnos based on the presence of spolic materials although this suborder is not intended to be exclusive.

Using a list of established mine soil series, I attempted in an earlier paper to classify these soils in Spolnos to illustrate the utility of the approach (Kosse, 2003). Placing all or most mine soils in a single suborder seems justified, given the common origin of most of these soils. Subgroup categories were developed to differentiate important mine soils, including those where topsoil was stockpiled and replaced. In most cases, family differentiae were retained, and it did not require changes in or recognition of new series. It seemed to me, however, that while lithology could better be introduced as family criteria a more general approach was required. Family differentiae have become increasing cumbersome, and by recognizing appropriate categories of spolic materials characteristics of mine soils important to management and reclamation can be indicated.

Noogenic Soil Materials

Noogenic soil materials are defined as the product of anthropogeomorphic processes and in most cases have not been extensively influenced by pedogenic processes. Although a wide range of noogenic soil materials may occur, it is expedient to exclude indirect anthropogeomorphic processes, such as soil erosion or subsidence, and in general direct manipulation of the soil is involved. Several types of noogenic soil materials are shown in Table 1, following the lead of Fanning and Fanning (1989). A similar list was developed for the World Reference Base for Soil Resources (WRB) to accommodate a range of anthropogeomorphic materials, and I have added dredgic and technogenic to meet additional needs (FAO, 1998). Undoubtedly the list could be expanded if desired, but the aim is to allow for ready identification in the field, and criteria have been chosen with this in mind. If these are recognized as noogenic soil materials at the onset, it is a simple matter to arrange them as a key although the precise order does not seem to matter much. Spolic materials would logically fall out at the end of the sequence since other noogenic materials are easily recognizable.

Table 1. Noogenic soil materials.

Garbic	Organic waste materials; land fill containing dominantly organic waste products
Urbic	Soil materials containing cultural debris and artifacts (> 35 percent by volume)
Dredgic	Subaqueous materials removed by mechanical means; these are characterized by high n-values (>0.7) and low bulk densities before ripening
Spolic	Soil materials resulting from earth-moving activities; these do not meet the requirements for garbic or urbic materials
Aric	Soil materials mixed *in situ* (>50 cm) containing recognizable fragments of diagnostic horizons
Technogenic	Soil materials containing artificial materials (> 60 percent by volume) produced by industrial processes, usually as slag or waste

Urbic materials are distinguished by the presence of artifacts and cultural debris if > 35% by volume. Similarly, garbic materials are dominated by organic remains although other cultural debris may also occur. The distinction between spolic and aric materials may appear problematic, but in the case of aric materials drastic disturbance remains local and soil materials are not transported or stockpiled. Dredgic materials are easily distinguished from spolic materials before ripening by their n-values and low bulk densities. Otherwise, they may be included as spolic materials unless meeting criteria for other noogenic soil materials. Technogenic materials have been added to the list to include artificial noogenic materials and are usually linked to distinct industrial processes, such as iron production or smelting.

Spolic Materials

Criteria used to separate noogenic soil materials make use of gross morphology to allow for easy recognition in the field. It is important to realize that these definitions do not necessarily carry genetic implications, and this has lead to some confusion. So, for example, not all urbic materials will be found in urban context, and it may be that a more suitable term than "urbic" should be found. Similarly, not all spolic materials necessarily refer to mine spoil, and spolic materials may occur in urban context or elsewhere, including other kinds of fill materials. If a broader concept of spolic materials is accepted, many of the taxonomic problems associated with earlier efforts to restrict the definition to mine soils disappear or may be relegated to a lower taxonomic level. It seems relatively easy to separate spolic from dredgic materials, but in some cases recent mine tailings or settling ponds may meet the requirements for dredgic materials. Differentiation of spolic and aric materials may be difficult to apply in practice but knowledge of reclamation practices may be employed in making a final decision.

Characterization of spolic materials should make use of standard soil descriptions, but special terminology may be required to record special anthropogenic soil features. Horizon boundaries especially may be revealing as to process, and if necessary may be recorded in section drawings. Other soil features relating to emplacement or mechanical mixing should be recorded, and technical terms used to describe these features. Emphasis should be placed on recording obvious features in the field, ultimately leading to the development of standard descriptive terminology. Rock types should be recorded as to percentages by volume and their orientation noted.

Chemical or physical studies may be necessary to further distinguish spolic materials, and laboratory methods used to characterize overburden may be usefully employed to refine classification (Smith and Sobek, 1978; Sobek et al., 2000).

Rock Fragments

Rock fragments are important in determining water holding capacity of the soil, infiltration rates and runoff, and may have an important effect on nutrient status (Munn et al., 1987). Lithology of rock fragments is important in assessing rock stability and potential for weathering. Important differences in reclamation potential are related to rock type and form the basis for defining great groups in Spolents (Smith and Sobek, 1978). While these proposals must await final resolution of taxonomic problems, they provide a framework for classification of spolic materials based on dominant rock types and associated properties. Suitability criteria in evaluating rock types should include both percentages of rock types and important differences in lithology. It is probably not sufficient to simply indicate dominant lithology, and definitions of spolic materials containing rock fragments should also include their relative abundance.

Krumbein and Sloss (1963) have advanced the notion of using ratios to characterize lithologic components in constructing lithofacies maps to show the relative contribution of various rock types. While this mainly concerns geological strata and their correlation in geological mapping, similar concepts could be used to characterize lithologic content of spolic materials. Their use of the clastic ratio, for example, could be used as an estimate of the relative contribution of clastic components (sandstone, shale) vs. nonclastic components (such as limestone, coal, carboliths). Similarly, their use of the sandstone-shale ratio provides an easily understood parameter for determining weatherability of rock types. Other ratios suggest themselves, such as a carbolith-sandstone ratio, while ratios of other rock types with significance for reclamation and management may also be usefully employed. Actual amounts of rock fragments, of course, must be considered, and suitability criteria tend to follow guidelines developed in soil survey for recording percentages of rock fragments (Munn et al., 1987).

Family Criteria in Spolnos

Dominant lithology was used to define subgroups in Spolents in previous proposals to classify mine soils (Smith and Sobek, 1978). While this highlights the profound influence rock types may exert, other properties of mine soils important in determining suitability are relegated to the family level. It would seem to me more consistent to introduce dominant lithology at the family level although this would require recognition of a wide range of spolic materials. Presumably this would also encourage further studies of spolic materials, and progress in classification of mine soils must await these results. Once taxonomic problems are resolved, special categories for mine soils could be established, reflecting more properly suitability criteria for management and reclamation.

To illustrate the approach I have defined tentative classes of spolic materials for select loamy-skeletal families in Spolnos, based primarily on type and occurrence of rock types (Table 2). Other physical and chemical properties could perhaps be added but little additional information is available. The clastic ratio of Krumbein and Schloss (1963) proved useful in differentiating spolic materials, and other ratios were introduced to define classes of spolic materials. It is unclear to me how useful this will eventually prove, but I think an attempt to provide quantitative estimates of rock types other than percentages is worth pursuing. Actual limits for rock fragments are based on criteria for particle-size classes, and there seems to be some consistency in using these criteria for suitability classes. It may well be that the limits for suitability criteria based on rock fragments will have to be modified to create more useful classes for spolic materials.

Spolic Materials as Differentiae in Families

Previously I suggested that dominant lithology might be introduced in parentheses after particle-size class in loamy-skeletal families of Spolnos (Kosse, 2003), but this does not seem entirely satisfactory. Family differentiae have become increasingly cumbersome, and defining a class of spolic materials to include a number of associated properties would be considerably more efficient. Connotative terminology for spolic materials using rock types presents problems, but use of “lithic” as a formative element would avoid any confusion with mineralogy classes.

How constraining family criteria will prove is difficult to predict, but careful definitions for spolic materials to include other family criteria may reduce redundancy. Of course, different kinds of spolic materials (without significant rock fragments) would require different terminology when introduced as family criteria. Other soil properties not related to rock type could be introduced, and any constraints, such as salinity or toxic metals, indicated.

It might be useful to present a list of loamy-skeletal families in Spolnos (Table 3) to illustrate how classes of spolic materials could be developed. Use of spolic matrials as family differentiae may seem a radical step, but it at least allows limits to be specified for rock fragments, if these differ from particle-size classes. Other characteristics of spolic materials other than rock fragments could be included in definitions for spolic materials and would perhaps eliminate the

Table 2. Loamy-skeletal spolic materials in Spolnos. (Representative established series are shown in parentheses.)

Arenolithic* materials (Barkcamp, Sewell): Rock fragments > 35 percent, dominantly medium and coarse-grained sandstone; small amounts of siltston, shale and coal. Mixed mineralogy. Clastic ratio > 8. Sandstone-shale ratio > 8.

Calcolithic materials** (Morristown): Rock fragments > 35 percent, mostly limestone and shale; some medium grained sandstone and siltstone. Mixed mineralogy. Clastic ratio 0.25 -1. Sandstone-shale ratio < 1.

Carbolithic* materials** (Itmann): Rock fragments > 35 percent, mostly carboliths with smaller amounts of siltstone, sandstone and shale. Mixed mineralogy. Clastic ratio 0.25 – 1. Carbolith-siltstone ratio > 1.

Limolithic materials† (Enoch): Rock fragments > 35 percent, mostly shales, medium and coarse grained sandstone with small amounts of fine grained sandston, siltstone and coal. Mixed mineralogy. Clastic ratio > 8. Sandstone-shale ratio > 1.

Tegulithic materials‡ (Briery, Palmerdale): Rock fragments > 35 percent, mostly siltstone and (fissile) shale with small amounts of sandstone and coal. Mixed mineralogy. Clastic ratio > 8. Sandstone-shale ratio < 1.

* arenolithic: Dominantly sandstone; from *arena* L., sand
** calcolithic: Dominantly calcareous rock (limestone); from *calx* L., chalk, limestone
***carbolithic: Dominantly carbonaceous rock or coal; from *carbo* L., coal
†limolithic: Dominantly mudstone; from *limosus* L., muddy
‡tegulithic: Dominantly thin-bedded shale (fissle); from *tegula* L., tile

need for additional family modifiers. It may be that other family criteria could be developed specifically for Spolnos to enhance usefulness of family groupings.

Conclusions

Attempts to create a separate suborder (Spolents) to accommodate mine soils have been unsuccessful as it is difficult to separate these soils from other Entisols. If a separate domain of anthropogeomorphology is accepted, paralleling the natural system, a new order (Noosols) could be recognized for these kinds of drastically disturbed soils. Several kinds of noogenic soil materials could be recognized, forming the basis for defining suborders. Spolnos is created to accommodate mine soils but other soils might be included in the suborder. Differentiation would be based on contrasting spolic materials, using criteria recognizable in the field. Suggestions for

Table 3. Selected mine soil series (loamy-skeletal) and proposed classification in Spolnos.

Barkcamp	loamy-skeletal, siliceous, acid, mesic Typic Udorthents arenolithic, acid, mesic Typic Udisponos
Briery	loamy-skeletal, mixed, active, nonacid, frigid Typic Udorthents tegulithic, active, nonacid, frigid Typic Udispolans
Enoch	loamy-skeletal, siliceous, acid, mesic Typic Udorthents limolithic, active, nonacid, frigid Typic Udispolnos
Itmann	loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents carbolithic, semiactive, acid, mesic Typic Udispolnos
Morristown	loamy-skeletal, mixed, active, calcareous, mesic Typic Udorthents calcolithic, active, calcareous, mesic Typic Udispolnos
Palmerdale	loamy-skeletal, mixed, acid, thermic Typic Udorthents tegulithic, acid, thermic Typic Udorthents
Sewell	loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents arenolithic, semiactive, acid, mesic Typic Udispolnos

using spolic materials as family differentiae show promise, and remove the burden of elaborating family criteria. Classes of spolic materials for Spolnos could be developed to meet management and reclamation needs. Examples were given for loamy-skeletal families in Spolnos, but other types of spolic materials could be recognized. Clastic ratios show some promise in differentiating spolic materials where rock types are significant. Other physical and chemical properties may be equally important and can be examined using routine methods similar to overburden analysis.

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