CLASSIFICATION OF MINESOILS: SOME RADICAL PROPOSALS[1]

by

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Abstract. In spite of the best efforts, classification of minesoils in the American soil taxonomic system is not resolved. Placement of these soils in Entisols (Arents or Orthents) or Inceptisols is not satisfactory since it does not recognize the anthropogenic origin of these soils. Anthrosols are recognized internationally in the World Reference Base for Soil Resources (WRB), but these are meant to include only anthropogenic soils in the strict sense. A fundamental distinction between anthropedogenesis and anthropogeomorphology suggests it might be more appropriate to recognize a new order of Noosols where anthropogeomorphic processes predominate. Classification of minesoils as Noosols would not require distinguishing these soils from "natural" soils, but it would be necessary to separate these soils from other soils in the same order. Standard geomorphic descriptions of minesoils could be used although it would require new terminology. Suggestions for incorporating anthropedogenic factors in the fundamental soil-forming equation are also made.

Additional key words: American soil taxonomic system, World Reference Base for Soil Resources (WRB), anthropedogenesis, anthropogeomorphology, Anthrosols, Noosols.

Introduction

Current classification of minesoils in the American soil taxonomic system fails to take account of the unique nature of these soils, commonly placing them in Entisols (Arents or Orthents) or Inceptisols (Soil Survey Staff 1999). Proposals to establish a separate suborder of Spolents to accommodate these soils have not found universal acceptance, partly because of difficulties in separating these soils unambiguously from "natural" soils (Sencindiver and Ammons 2000). While this may be dismissed as an academic exercise, it has important implications for defining soil series and as an aid in soil management. Problems in separating minesoils from other soils developed in anthropogenic soil materials need also to be examined as this may prove equally difficult.

Attempts to develop rigorous morphometric critera to distinguish Spolents in the American soil taxonomic system have been unsuccessful, although of limited regional applicability in the United States (Sencindiver and Ammons 2000). Use of subgroup modifiers based on the presence of major rock types appears premature, considering the rejection of earlier proposals for recognizing a separate suborder for Spolents (Ammons and Sencindiver 1990). While this has the utility of distinguishing important management classes, it would be more consistent in the American system to recognize dominant lithology at the family level (Soil Survey Staff 1999).

Several minesoil series have been established in the United States, mostly in eastern states and the Midwest, but it is unclear what criteria were used in their definition or if these were applied consistently (Sencindiver and Ammons 2000). Resolution of taxonomic problems in placement of these soils in the American system seems essential for future progress. How to rectify this situation is not entirely clear, given the strong emphasis that soil differentiae have on the American soil taxonomic system. It would, of course, be inappropriate to disregard the fundamental logic of the system, which has resulted in considerable advances in soil classification. Nonetheless, the basic conception of the soil orders, which are held to reflect differences in soil genesis (or its lack), may provide a means for resolving some of the difficulties encountered in classification.

Separate Order of Anthrosols

Previous attempts to propose a separate order of

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Anthrosols were presented at several American Society of Agronomy Meetings, including an earlier presentation dealing explicitly with the classification of minesoils (Kosse 1980, 1982). In part, this was intended to accommodate or expand earlier suggestions by Fanning, Stein and Patterson (1978) to treat "highly man-influenced soils" as subgroups in Entisols (see Fanning and Fanning 1989 for discussion of the topic). Placement of these soils in a separate order of Anthrosols (Table 1) preserves taxonomic efficiency (allowing for subgroup development), while emphasizing their anthropogenic origin. An alternative proposal to recognize "man-influenced soils" as a possible new suborder (Anthropents) has some appeal (Table 2) although this again limits subgroup development.

Subsequent proposals to establish a separate order of Anthrosols were different in scope and depended on a fundamental distinction between "anthropedogenesis" and anthropogeomorphology (Kosse 1986, 1990). According to these more recent proposals, Anthrosols are limited to anthropogenic soils (*sensu strictu*) as this term is commonly applied in other countries and are seen as the product of unique pedogenic processes (anthropedogenesis). It would seem this is consistent with the logic of the American system since Anthrosols are seen to reflect a distinct set of anthropedogenic processes. Several subgroups were recognized, including Plaggans, Terrans, Hortans, Irrigans, and Aquans and are defined by diagnostic horizons of sufficient depth or intensity of expression (Kosse 1990). It seems necessary to add that archaeological sites were explicitly excluded, both because of their complex nature and difficulties in separating them from anthropogenic soils.

Anthrosols soils are recognized internationally in the World Reference Base for Soil Resources (WRB) to include a wide range of anthropogenic soils and are seen as the product of distinct anthropedogenic processes (FAO 1998). Several diagnostic horizons are recognized consistent with earlier proposals, which form the basis for recognizing secondary groupings in Anthrosols (Table 3). Aside from terminological differences, classification of anthropogenic soils follow essentially the same basic concepts elaborated in proposals for creating a separate order of Anthrosols in the American system (Kosse 1990, 1994). It is gratifying to know that most anthropedogenic horizons recognized in WRB will be retained although problems in definition are not fully resolved (FAO 1998:22-26). Soils where anthropogeomorphic processes predominate are *not* included in Anthrosols, but are accommodated mainly in Regosols, depending on the kind and degree of pedogenic expression. Preliminary efforts to define a range of anthropogenic soil materials in WRB depend heavily on the framework developed by Fanning and Fanning (1989) with some exceptions.

Conceptual Model

The distinction between anthropedology and anthropogeomorphology is probably best grasped in diagram form (Fig. 1), which includes both the "natural" and "artificial" realms. Pedology and geomorphology are counterparts in the "natural" realm although there is obviously overlap between the various domains. Anthropogeomorphology is, of course, an established subdiscipline of geomorphology (Golomb and Eder 1964, Brown 1970), but the term "anthropedogenesis" is new (Kosse 1986). Recognition of a distinct set of pedogenic processes associated with man seems long overdue, and these could be expected to differ both in rate and kind from the set of anthropogeomorphic processes (Kosse 1994).

Several distinct anthropedogenic processes may be recognized (Table 4), including deep working, intensive fertilization, additions of extraneous materials, irrigation with sediment-rich waters, and wet cultivation. While the list is not intended to be exhaustive, emphasis is on long-term, continuous processes taking place in the soil. It is, of course, not meant to imply that any one anthropedogenic process is dominant, and more than not they act in concert. Obviously, the basic concept has wider implications, and the list could be expanded to include other anthropedogenic processes, depending on research needs or interests.

Yaalon and Yaron (1966) in a classic paper developed the concept of metapedogenesis to encompass man-made soil changes, represented by the following factorial statement:

$$S_2 = f(S_1, m_1, m_2, m_3, \ldots) \quad (1)$$

where "S_2" is the new soil and "m_1, m_2, m_3, ..." represent metapedogenic factors. While this represents a considerable advance in considering the original soil (S_1) as parent material, the authors do not adequately distinguish anthropedogenic from anthropogeomorphic factors. This may be indicated by a simple change in terminology, where "a_1, a_2, a_3, ..." represent anthropedogenic factors as in the following equation:

$$S_2 = f(S_1, a_1, a_2, a, \ldots) \quad (2)$$

It does not seem this has particular relevance to drastically disturbed soils or minesoils, but where anthropogeomorphic soil materials are present this can

Table 1. Classification of human-influenced soils as Anthrosols.

Classification proposed by Fanning, Stein and Patterson (1978)	Classification as separate order
Scalpic Udortents	Udorthents (not included in Anthrosols)
Urbic Garbic Udorthents	Urbic Udisanitans
Spolic Garbic Udorthents	Typic Udisanitans
Urbic Udorthents	Typic Udiurbans
Urbic Eutrochrepts	Inceptic Udiurbans
Spolic Udorthents	Typic Udispolans

Table 2. Classification of human-influenced soils as Anthropents.

Classification proposed by Fanning, Stein and Patterson (1978)	Classification as separate suborder
Scalpic Udorthens	Udorthents (not included in Anthropents)
Urbic Garbic Udorthents	Urbic Garbic Udanthropents
Spolic Garbic Udorthents	Spolic Garbic Udanthropents
Urbic Udorthents	Urbic Udanthropents
Urbic Eutrochrepts	Inceptic Urbic Udanthropents
Spolic Udorthents	Spolic Udanthropents

Table 3. Anthrosols soil units in WRB (FAO 1998).

Anthrosol soil units	Diagnostic horizons
Hydragric Anthrosols	Anthrosols developed under wet cultivation with hydragric horizon; usually underlies anthrolydric horizon
Irragric Anthrosols	Anthrosols having irragric horizon > 50cm
Terric Anthrosols	Anthrosols having terric horizon > 50cm
Plaggic Anthrsosls	Anthrosols having plaggic horizon > 50cm
Hortic Anthrosols	Anthrosols having hortic horizon > 50cm

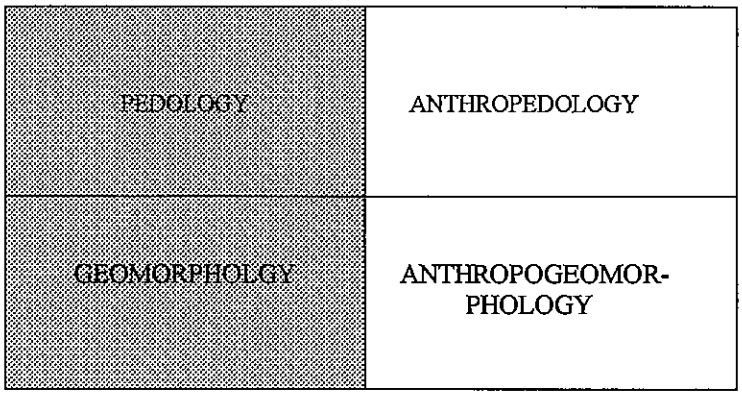

Fig. 1. Diagram showing relationship of anthropedology and anthropogeomorphology.

Table 4. Anthropedogenic processes

Deep working	Mechanical operations (*continuous*) extending beyond normal Depth of field operations
Intensive fertiliazation	Continuous applications of organic/inorganic fertilizers *without* substantial additions of mineral matter (e.g., manures, kitchen refuse, compost, etc.)
Additions of extraneous materials	Continuous applications of earthy materials involving substantial additions of mineral matter (e.g., sods, beach sand, earthy manures, etc.)
Additions of irrigation water with sediments	Continuous applications of irrigation water *with* substantial amounts of sediments (may also include fertilizers, soluble salts, organic matter, etc.)
Wet cultivation	Processes associated with submergence during cultivation; puddling of cultivation layer; additions of organic manures and fertilizers; usually involving changes in aquic conditions. Diagnostic subsoil features may develop under wet cultivation, depending on depth of water table, texture, presence of organic matter, etc.

Table 5. Classification of human-influenced soils as Noosols.

Classification proposed by Fanning, Stein and Patterson (1978)	Classification as separate order
Scalpic Udorthents	Udorthents (not included in Noosols)
Urbic Garbic Udorthents	Urbic Udisanos
Spolic Garbic Udorthents	Typic Udisanos
Urbic Udorthents	Typic Udiurbanos
Urbic Eutrochrepts	Inceptic Udiurbanos
Spolic Udorthents	Typic Udispolnos

be indicated by substituting "p_a" for "S_1" according to the following equation:

$$S = f(p_a, a_1, a_2, a_3, \ldots) \quad (3)$$

Yaalon and Yaron (1966) stress the point that the metapedogenic factors in a sense override the classical soil-forming factors and do not include these in their factorial statement (regarding them as essentially ineffective). I have followed suite, but obviously where anthropedogenic factors (management and cultivation) cease to operate "natural" conditions remain effective, according to the following equation:

$$S = f(p_a, cl, o, r, p, t) \quad (4)$$

Noosols as New Soil Order

Soils where anthropogeomorphic processes predominate are not included as Anthrosols in the recent publication of the World Reference Base for Soil Resources (WRB), but are classified as Anthropic (Anthric) Regosols in this latest version (FAO 1998). Similarly, in the American system proposals have been made to include certain of these soils in Entisols where peodgenic expression is limited (Fanning and Fanning 1989). Attempts to set up a separate suborder of Spolents have not found ready acceptance, primarily because of difficulties in defining suitable morphometric criteria (Sencindiver and Ammons 2000), and it may be that a more radical approach is required.

In any case, it seems desirable to distinguish these soils from Anthrosols since for the most part insufficient time has elapsed for pedogenic expression. While the creation of a new soil order may be accepted on methodological grounds, suitable terminology is a persistent problem in the American soil taxonomic system. Use of the term noosphere to refer to the realm of the human mind was seen by Vernadsky (1945) to initiate a new era in geological history, while essentially an extension of the biosphere. Its acceptance by earth scientists as a technical term is gaining currency (Westerbroek 1991), and the recent (1997) publication in English of Vernadsky's seminal work on the biosphere should make his views accessible to a wider audience. It would be appropriate to honor Vernadsky by recognizing a new order of Noosols since he is considered one of the foremost geochemists of the twentieth century. I am aware that competing terms, such as Neosols, may seem equally suitable, but they do not necessarily carry the implication of human agency.

Problems in separating these soils from Entisols or Inceptisols would be resolved at the onset once a separate domain of anthropogeomorphology is recognized. It may seem extravagant to argue for the creation of a new soil order when the acceptance of Anthrosols as a separate order is hardly assured. It would no longer be necessary, however, to engage in sterile attempts to separate these soils from either Entisols or Inceptisols (or other orders) since reliance need not be placed *solely on* morphometric criteria, although internal consistency would be required. Something of the same concept adheres to the definition of "relational" properties as used by Evans et al. (2000), but it is important to understand that the decision to place certain human-influenced soils in Noosols is made beforehand, making unashamed use of whatever documentary sources are available (these are not considered soil properties). Similarly, it should now be possible to describe these soils in the field, using descriptive terminology develop by geomorphologists (Demek 1972). Physical and chemical studies of anthropogenic soil materials or overburden should, of course, be undertaken, but these need not have immediate taxonomic implications.

Application of the concept is shown in Table 5, where human-influenced soils are classified as Noosols. Although seemingly only a logical exercise, it nonetheless serves to distinguish these soils terminologically from Anthrosols. In time, if this terminology is accepted it will become routine. Part of the reason for establishing a separate order of Noosols

Table 6. Spolent subgroups and Noosols counterparts; compiled from Smith and Sobek (1978). It is not entirely clear whether some of these families are loamy-skeletal or not. Calcareous or reaction classes may be used as for Entisols, Aquands or Aquepts (although this may require specific instructions for Noosols).

Udispolents subgroups	Udispolnos families
Fissile Udispolents	loamy-skeletal, mixed (tegulithic), mesic Typic Udispolnos
Plattic Udispolents	loamy-skeletal, mixed (psammolithic), mesic Typic Udispolnos
Carbolithic Udispolents	loamy-skeletal, mixed (carbolithic), mesic Typic Udispolnos
Schlickig Udispolents*	fine-loamy, mixed, mesic Typic Udispolnos
Typic Udispolents	loamy-skeletal, mixed, mesic Typic Udispolnos
Kalkig Udispolents	loamy-skeletal, mixed (calcolithic), mesic Typic Udispolnos
Matric Udispolents	fine-loamy, mixed, mesic Typic Udispolnos
Pyrolithic Udispolents	fine-loamy, mixed (pyrolithic), mesic Typic Udispolnos
Lithic Udispolents	loamy, mixed, mesic Lithic Udispolnos

*Recognized at series level.

is to preserve the taxonomic efficiency of the system since if placed in Anthrosols further defintion would be required at the suborder level to distinguish these soils from anthropogenic soils (*sensu strictu*).

Tentative family designations for Udispolnos (Table 6) follow essentially the list presented in Smith and Sobek (1978) although I would favor recognition of lithological (mineralogical) distinctions at the family level, using somewhat different terminology. If calcareous and reaction classes are to be retained, rock types could be listed after particle-size classes in parentheses (although this would require rewriting rules for naming families). Once the notion of a new soil order of Noosols is adopted more rigorous definitions are possible, and Table 5 is intended only as an illustration of the approach. Of course, adoption of Noosols as a new soil order would allow development of specific criteria for distinguishing mine soils from other soils in the same order. It would not be necessary in this case to separate minesoils from "natural" soils, but proposed criteria should aim for internal consistency.

Summary

Proposals for classifying minesoils in the American soil taxonomic system (Spolents or Arents) have not found ready acceptance, primarily because of difficulties in separating these soils from "natural" soils. Anthrosols as defined in the World Reference Base for Soil Resources (WRB) are the product of unique pedogenic processes (anthropedogenesis). Included are soils developed in areas of old cultivation under traditional agricultural practices. Proposals to establish a new soil order of Noosols in the American soil taxonomic system are meant to accommodate soils which are predominantly the product of anthropogeomorphic processes. Definition of these soils would not require distinguishing them from "natural" soils once the decision is made to include them in Noosols. Proposals to classify minesoils in Noosols (Spolnos) are advanced, which would conform more closely to differentiae used at the family level in the American soil taxonomic system. Additionally, suggestions are made for incorporating anthropedogenic factors in the fundamental soil-forming equation.

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