FAMILY DIFFERENTIAE IN SPOLNOS[1]

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Abstract. Proposals for a new order of Noosols have been advanced to include soils resulting from direct anthropogeomorphic processes. Although a number of soil series for mine soils have been established in the United States, problems remain in distinguishing these soils from "natural" soils, and they are inevitably consigned to Orthents or Arents in the American system. Recognition of a separate suborder (Spolnos) in the new order to accommodate mine soils is discussed and proposals to define spolic materials using field criteria presented. It is suggested that family criteria be developed specifically to accommodate mine soils as an aid in series recognition and soil interpretation. It is not entirely clear that the particle-size control section should be retained and if modified probably should include surface layers similar to the series control section. Family criteria have become increasingly cumbersome over the years, and defining separate classes of spolic materials would preserve the utility of the system.

Additional Key Words: Noosols, anthropogeomorphic, noogenic soil materials, spolic soil materials

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Introduction

Proposals to classify mine soils in the American soil taxonomy as a distinct suborder of Entisols (Spolents) have not been formally approved although subgroup categories have been devised (Ammons and Sencindiver, 1990). At present, most mine soils are classified as Orthents or Arents, and problems in separating mine soils from "natural" soils remain. While the current classification should be considered provisional, it does not seem possible at present state of knowledge to arrive at unambiguous criteria separating these soils from other Entisols. Partly, of course, this reflects the morphometric bias of the American system and illustrates the difficulties inherent in any soil taxonomy not founded on genetic principles.

Several soil series have been established for mine soils, but the present taxonomic system does not adequately reflect the genesis of these soils (Sencindiver and Ammons 2000). The unique nature of mine soils is not fully incorporated in the system, and efforts to highlight this with special subgroup categories are at best only temporary solutions. Until these classification problems are fully resolved, progress in developing family criteria for soil interpretation and management will remain an elusive objective. Once concerns about classification have been laid aside, family criteria could then be developed following normal protocol although changes in terminology may be required.

Concept of Noosols

Use of the term noosphere as the realm of the human mind was introduced by Vernadsky (1945) to mark a new epoch in earth's geological history. As a technical term, it is gaining currency among earth scientists dealing with man as a geological agent, and it is in this restrictive sense that the term is used here (Westerbroek, 1991, Smil, 2002). Use of the term Noosols to refer to the more drastic (direct) effects of man as a geological agent seems appropriate and furnishes a ready formative element in the American taxonomic system. Other terms, such as Anthrosols or Technosols, have been suggested but are often more narrowly applied. Recognition of a separate domain of anthropogeomorphology may seem a radical step, but it is an established subdiscipline of geomorphology (Brown, 1970, Demek, 1973). In any case, the distinction seems a fundamental one, and recognition of separate anthropogenic domains for geomorphology and pedogenesis in the "artificial" realm seems justified on methodological grounds (Kosse, 2001).

Noogenic Soil Materials

Several commonly occurring noogenic soil materials are shown in Table 1, following the lead of Fanning and Fanning (1989). While this list is not meant to be exhaustive, it does provide for ready identification of noogenic soil materials likely to be encountered in the field. Diagnostic criteria have been chosen with this in mind, and once identification is made these can be arranged in a key, forming the basis for recogntion of Noosols suborders (Kosse 2004). The precise order does not seem to matter much, but for our purposes spolic materials might be placed at the bottom of the key since most noogenic soil materials are easily recognizable. It is not necessary to discuss in detail the other noogenic soil materials, but they differ markedly amongst themselves, making field identification easy. Undoubtedly the list could be expanded as need arises, but this will have to await further documentation and fieldwork.

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)
Technogenic	Soil materials containing artificial materials (> 60 percent by volume) produced by indus- trial or technical processes
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, urbic or technogenic materials

Noosols Suborders

Proposed Noosols suborders are shown in Table 2, following logically the abbreviated key for noogenic soil materials. Obviously the list could be expanded as need arises, but the intention is to restrict these to recognized suborders since the scheme is not intended as a theoretical exercise. The system itself need only aim for internal consistency since Noosols once identified remain aloof from other soil orders. Spolnos include those soils consisting dominantly of spolic materials, but the concept is not limited solely to mine soils and may include other similar soils. (I have decided to abandon the original distinction I made involving local disturbance in the case of aric soil materials (Kosse 2004) because of difficulties in applying this in the field. If necessity dictates, this could be introduced at the subgroup level in Spolnos, and provision made for this with extra subgroup modifiers.) Noosols have not had sufficient time for diagnostic horizons to develop except possibly ochric or umbric epipedons. Subsequent pedogenesis may require placing them in other soil orders, such as Inceptisols or Alfisols, depending on the presence or absence of certain diagnostic horizons. It is unclear whether or not to retain these soils in Noosols, and much will depend on the nature of noogenic soil materials.

Table 2. Noosols suborders.

Garbinos	Soils developed in garbic soil materials
Urbinos	Soils developed in urbic soil materials
Fabrinos	Soils developed in technogenic soil materials
Subaquinos	Soils develop in dredgic soil materials
Spolnos	Soils developed in spolic soil materials

Current Mine Soil Series

At present, some forty-two (42) mine soil series have been established (Table 3), mostly concentrated in the eastern United States. With the possible exception of Texas, only a few mine soil series are found in the western part of the country. Most mine soil series are classified as Entisols, either as Udorthents or Udarents, in recognized subgroups (Table 4). While difficult to document, there seems to be a growing tendency to place mine soil series in Arents, which perhaps reflects dissatisfaction with original placement of these soils. The Conquista series is classified as Entic Haplustolls but might more properly be classified as Mollic Ustarents along with the Brazilton series. Soils in the Rapatee series are classified as Mollic Udarents. The large number of Alfic Udarents probably only reflects local efforts, and it is unclear if these should be considered dominant. Similarly, the large number of Typic Udorthents is difficult to interpret since the subgroup is relatively heterogeneous. It is interesting to note that no established mine soil series are included in Inceptisols although cambic horizons have been recorded, particularly in older mine spoil (Ciokosz et al., 1985).

Table 3. Established mine soil series in the United States and family designations.[a]

Barkcamp	loamy-skeletal, siliceous, acid, mesic Typic Udorthents	OH (1978)
Bethesda	loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	OH (1978)
Blocker	loamy mixed, nonacid, thermic, shallow Alfic Udarents	OK (1989)
Bigbrown	fine-silty, mixed, nonacid, thermic Typic Udispolnos	TX (1986)
Brazilton	fine, mixed, nonacid, thermic Mollic Udarents	KS (1983)
Briery	loamy-skeletal, mixed, active, nonacid, frigid Typic Udorthents	WV (1986)
Brilliant	loamy-skeletal, mixed, nonacid, thermic Typic Udorthents	AL (1977)
Cartersville	loamy, mixed, nonacid, thermic, shallow Alfic Udarents	OK (1989)
Cedarcreek	loamy-skeletal, mixed, active, acid, mesic Typic Udorthents	WV (1984)
Coalgate	fine-silty, mixed, nonacid, thermic Alfic Udarents	OK (1989)
Conquista	fine-loamy, mixed, superactive, hyperthermic Entic Haplustolls	TX (1989)
Emachaya	fine, mixed, nonacid, thermic Alfic Udarents	OK (1989)

Table 3. Continued.

Enoch	loamy-skeletal, siliceous, acid, mesic Typic Udorthents	OH (1984)
Fairpont	loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	OH (1978)
Farmerstown	fine-loamy, mixed, acid, mesic Typic Udorthents	OH (1987)
Fiveblock	loamy-skeletal, mixed, semiactive, nonacid, mesic TypicUdorthents	WV (1984)
Gibbonscreek	fine-loamy, mixed, nonacid, thermic Typic Ustorthents	TX (1988)
Grayrock	fine-silty, mixed, active, nonacid, thermic Typic Udorthents	TX (1984)
Hollybrook	fine-loamy, mixed, active, nonacid, mesic Alfic Udarents	IN (1996)
Ironbridge	fine, mixed, activ, nonacid, thermic Alfic Udarents	OK (1989)
Itmann	loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	WV (1984)
Janelew	loamy-skeletal, mixed, calcareous, mesic Typic Udorthents	WV (1988)
Kanima	loamy-skeletal, mixed, active, nonacid, thermic Alfic Udarents	OK (1972)
Kaymine	loamy-skeletal, mixed, active, nonacid, mesic Typic Udorthents	WV (1984)
Latimer	fine, mixed, nonacid, thermic Alfic Udarents	OK (1989)
Lenzburg	fine-loamy, mixed, active, calcareous, mesic Haplic Udarents	IL (1981)
Lenzwheel	fine-loamy, mixed, active, calcareous, mesic Alfic Udarents	IL (1995)
Lequire	loamy, mixed, nonacid, thermic shallow Alfic Udarents	OK (1989)
Marclay	fine, mixed, nonacid, thermic Typic Udorthents	TX (1985)
Marklake	fine-loamy, siliceous, active, acid, thermic Alfic Udarents	TX (1987)
Minnehaha	fine-loamy, mixed, active, nonacid, mesic Alfic Udarents	IN (1996)
Morristown	loamy-skeletal, mixed, active, calcareous, mesic Typic Udorthents	OH (1978)
Myra	loamy-skeletal, mixed, calcareous, mesic Typic Udorthents	KY (1985)
Palmerdale	loamy-skeletal, mixed, acid, thermic Typic Udorthents	AL (1974)
Pinegrove	mixed, mesic Typic Udipsamments	OH(1988)
Pirkey	fine-loamy, siliceous, semiactive, acid, thermic Utlic Udarents	TX (1989)
Putco	fine, mixed, superactive, calcareous, mesic Typic Udorthents	MO (1989)
Rapatee	fine-silty, mixed, superactive, nonacid, mesic Mollic Udarents	IL (1983)
Schuline	fine-loamy, mixed, superactive, calcareous, mesic Alfic Udarents	IL (1983)
Sewell	loamy-skeletal, mixed, semiactive, acid, mesic Typic Udorthents	WV (1984)
Swanwick	fine-silty, mixed, active, nonacid, mesic Alfic Udarents	IL (1983)
Whitefield	fine, mixed, nonacid, thermic Alfic Udarents	OK(1989)

[a] Official series descriptions furnished courtesy of Henry R. Mount, Soil Scientist, National Soil Survey (Lincoln)

Table 4. Subgroups in established mine soil series

Typic Ustorthents	2
Typic Udorthents	19
Typic Udipsamments	1
Alfic Udarents	15
Ultic Udarents	1
Mollic Udarents	2
Haplic Udarents	1
Entic Haplustolls	1

Spolnos Subgroups

Placement of mine soils in a separate suborder of Noosols reflects the anthropogenic origin of these soils and allows for the development of subgroups in the system. Proposed subgroup categories for Spolnos are summarized in Table 5 along with brief definitions. On superficial examination this does not seem markedly different from current subgroups, but it would be a mistake not to recognize the radical nature of these proposals. While Alfic and Ultic subgroups are currently recognized in Udarents, I have devised a separate subgroup (Aric) for Spolnos where fragments of other diagnostic horizons are present. Subsequent pedogenesis may result in the development of mollic epipedons, but use of the term pseudo-mollic is designed to accommodate mine soils (Mollic Udispolnos) where reclamation requires replacement of the original dark colored surface layer.

Using the proposed subgroup categories for Spolnos, the number of mine soils in each subgroup is listed in Table 6. It is worth noting that the largest subgroup for mine soils (Typic Udorthents) is retained in the new system, but it is unclear if these should be considered typical. Likewise Alfic Udispolnos are meant to replace a major subgroup in Spolents although perhaps not entirely equivalent. No examples of Lithic subgroups are presently recognized, and this subgroup is included only for the sake of completeness. Included as mollic subgroups are series, such as Brazilton, Conquista and Rapatee, where the mollic epipedon has been stockpiled and subsequently replaced. While similarities between subgroup categories in both systems are obvioust, recognition of a separate suborder of Spolnos to accommodate mine soils represents a radical departure (Kosse, 2001). The fact that it does not generally disrupt the relative frequency of soil series is perhaps another reason for recommending its adoption.

Table 5. Proposed subgroups for Udispolnos.

Lithic Udispolnos	Lithic contact < 50cm
Psammentic Udispolnos	Loamy fine sand or coarser (particle-size control section)
Mollic Udispolnos	Pseudo-mollic epipedon
Alfic Udispolnos	Fragments of argillic (bases > 35 percent)
Ultic Udispolnos	Fragments of argillic
Aric Udispolnos	Fragments of diagnostic hori-zons other than alfic or ultic
Typic Udispolnos	Other Spolnos (udic)

Table 6. Mine soil series subgroups in Spolnos.

Lithic Udispolnos	0
Psammentic Udispolnos	1
Mollic Udispolnos	3
Alfic Udispolnos	15
Ultic Udispolnos	1
Aric Udispolnos	1
Typic Udispolnos	19
Typic Ustispolnos	2

Family Differentiae

Whether or not the family should be regarded as an integral part of the taxonomic system is a matter of dispute, but there seems to be a perceptible gap between family and the higher taxonomic units. Originally, the intention was to create a technical classification for soil interpretation, mainly for agronomic purposes, although other uses were contemplated (Riecken, 1962). The soil series itself, although regarded as the lowest taxonomic unit, has an earlier history going back to the origins of soil survey. The function of both series and family is essentially pragmatic, and while the family is meant to include series with similar soil interpretations it has not been used to the extent originally envisaged. Partly this reflects uncertainty as to how the family is to be integrated in the system, but it also could be argued that the concept has not been as fully developed as it might. Aside from its practical application, the family often serves as a useful template in developing new series in areas where soil survey has failed to make its full impact.

Particle-size control section

Presently particle-size classes or their substitutes are used to differentiate family groupings and are defined in terms of the particle-size control section (Soil Survey Staff, 1999). Aside from substitute materials, particle-size classes include both the fine earth fraction (< 2 mm fraction) and rock or pararock fragments up to the size of the pedon. It is probably not necessary to examine in detail definitions of the particle-size control section, but in the case of most mine soils the surface 25 cm (or the plow zone) would be excluded except where a shallow root-limiting layer occurs. Recent redefinition of the series control section to include surface layers (formerly designated as soil type) suggests a similar expedient might be requisite for the particle-size control section, if only to bring it in conformity with the series control section (Soil Survey Staff, 1999). Some minor differences in the definition of the series control section need not concern us here, but it should be obvious that redefinition of the particle-size control section would enhance the interpretive potential of family groupings.

Contrasting particle-size classes

It is not entirely clear to me what the precise implications would be in the case of current series, but a quick appraisal of established mine soil series suggests that in only a few cases would contrasting particle-size classes be required (Table 7). Although only a small number of series are involved, most of these are in thermic temperature regimes, suggesting the possible role of aeolian deposition. Nonetheless, it is precisely in thermic (or hyperthermic) temperature regimes with limited rainfall that vegetative restoration depends most critically on the nature of the surface horizon. It may well be, of course, as more mine soil series are described that inclusion of surface horizons would result in the need for additional series. Additionally, where reclamation procedures have resulted in important modification of the surface texture it might be useful to recognize this at the family level. The use of fly ash, for example, as a soil amendment could be recognized as contrasting particle-size, if of sufficient depth (Thurman and Sencindiver, 1986). Some reclamation procedures, particularly in arid or semi-arid regions, might actually mandate emplacement of coarse-textured surface horizons to maximize infiltration. Recognition of this at the family level would aid in soil interpretation and allow for the establishment of meaningful family groupings in mine soils.

Table 7. Series with contrasting particle-sizes in Spolnos.

Colgate	coarse-loamy over clayey, mixed, nonacid, thermic Alfic Udispolnos
Conquista	clayey over loamy, mixed, superative, hyperthermic Mollic Udispolnos
Emachaya	fine-silty over clayey, mixed, nonacid, thermic Alfic Uidspolnos
Ironbridge	coarse-loamy over clayey, active, nonacid, thermic Alfic Udispolnos
Lenzburg	fine-silty over clayey, mixed, active, calcareous, mesic Aric Udispolnos

Rock type lithology

Previous proposals to classify mine soils in a new suborder (Spolents), have not found universal acceptance (Smith and Sobek, 1978, Sencindiver and Ammons, 2000). Subgroup categories are largely based on rock type lithology, and while a useful expedient, recognition of subgroup categories might more properly be handled at the family level. Suggested subgroup categories for Spolents were intended primarily to meet circumstances in coal mining regions (Table 8), but there is no reason to disregard these in establishing family classes. Most of the mine soils included in earlier studies were dominantly loamy-skeletal, and with some changes in terminology particle-size classes can be developed for these families similar to proposed subgroups in Spolents (Smith and Sobek, 1978).

Table 8. Proposed mine soils subgroups for Udispolents (Sencindiver and Ammons, 2000).

Carbolithic	Black, high carbon rock
Fissile	Thin-bedded shale
Kalkig	Limestone or calcareous mudstone
Matric	< 10 percent rock fragments
Plattic	Sandstone, predominantly low chroma (gray)
Pyrolithic	Burnt carbolithic material
Regolithic Plattic	Sandstone, predominantly high chroma (brown)
Schlickig	Nonfissile mudstone
Typic	Mixture of rock types

A list of loamy-skeletal mine soil series and substitute classes for spolic materials are presented in Table 9. Previous attempts to characterize spolic materials as substitutes for particle-size classes were intended only as exercises in method, and with some exceptions field descriptions and laboratory data are inadequate for the task (Kosse, 2004). It is perhaps revealing that most mine soil series are found in arenolithic or limolithic families in equal numbers, suggesting a broad uniformity of approach. Recognition of spolic soil materials need not be restricted to loamy-skeletal families and could readily be expanded to include other particle-size classes. Where rock fragments are not indicated, alternate terminology could be developed, which would then depend on the creation of new substitute classes. Development of a class of substitute materials specific to Spolnos families seems useful and would allow for meaningful grouping of mine soil families.

Table 9. Loamy-skeletal series and substitute classes for Udispolnos.

Barkcamp	arenolithic†, acid, mesic Typic Udispolnos
Cedarcreek	arenolithic, mixed, active, acid, mesic Typic Udispolnos
Fairpoint	arenolithic, mixed, active, nonacid, mesic Typic Udispolnos
Fiveblock	arenolithic, mixed, semiactive, nonacid, mesic Typic Udispolnos
Sewell	arenolithic, mixed, semiactive, acid, mesic Typic Udispolnos
Morristown	calcolithic‡, mixed, active, mesic Typic Udispolnos
Itmann	carbolithic*, mixed, semiactive, acid, mesic Typic Udispolnos
Brilliant	limolithic**, mixed, nonacid, thermic Typic Udispolnos
Enoch	limolithic, acid, mesic Typic Udispolnos
Janelew	limolithic, mixed, calcareous, mesic Typic Udispolnos
Kaymine	limolithic, mixed, active, nonacid, mesic Typic Udispolnos
Bethesda	tegulithic***, mixed, active, acid, mesic Typic Udispolnos
Briery	tegulithic, mixed, calcareous, mesic Typic Udispolnos

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

Summary and Conclusions

Proposals to establish a separate order of Noosols have been advanced to accommodate soil where anthropogeomorphic processes predominate. Recognition of a separate domain of anthropogenic geomorphology would allow these soils to remain consistent with the logic of the American taxonomic system since orders are taken to reflect dominant pedogenic processes (or their lack). Several suborders are proposed based on the recognition of distinct noogenic soil materials. Emphasis throughout is on direct anthropogeomorphic processes, and indirect geomorphic processes, such as soil erosion or subsidence, are necessarily excluded. Diagnostic criteria for suborders need only aim for internal consistency and a simple key can be constructed featuring the salient features of each suborder.

Mine soils are relegated to the Spolnos suborder although this is not intended to be exclusive. Recognition of a separate suborder of Spolnos to accommodate mine soils seems fundamental in resolving placement of these soils in the American taxonomic system. Once this is accomplished efforts can be directed to developing family criteria to adequately characterize this important group of soils. It is suggested that the particle-size control section could be expanded to include surface horizons, bringing it into conformity with the series control section. Proposed family differentiae for mine soils emphasize rock type lithology as substitute classes for particle-size classes. Classes for loamy-skeletal families are proposed and a terminology introduced for distinguishing dominant lithology and rock type. Such groupings provide a ready basis for management decisions, and the approach could be expanded to include other mine soils not included in loamy-skeletal families. Family differentiae in general have become increasingly cumbersome, and use of substitute materials for mine soils in particle-size classes would make for greater efficiency and facilitate soil interpretation.

Literature Cited

Brown, E.H. 1970. Man shapes the earth. Geogr. J. 136:74-85. http://dx.doi.org/10.2307/1795683

Ciokosz, E.J., R.I. Cunningham, G.W. Petersen, and R.C. Cronce. 1983. Characteristics, interpretation and uses of Pennsylvania minesoils. Penn. Agric. Exp. Stn. Progress Rep. 381.

Demek, J. 1973. Quaternary relief development and man. Geoforum 15:68-71. http://dx.doi.org/10.1016/0016-7185(73)90054-7.

Fanning, D.S. and M.C.B. Fanning. 1989. Soil morphology, genesis and classification. John Wiley & Sons, New York.

Kosse, A. 2001. Classification of minesoils: some radical proposals. Proceedings 18th Annual National Meeting of the American Society for Surface Mining and Reclamation, p. 418-424. https://doi.org/10.21000/JASMR01010418

Kosse, A. 2004, Recognition of noogenic soil materials in classifying mine soils. Proceedings America Society of Mining and Reclamation, 2004 pp. 1147-1156. http://dx.doi.org/10.21000/JASMR04011147.

Riecken, F.F. 1962. Some aspects of soil classification in farming. Soil Sci. 96:49-61. http://dx.doi.org/10.1097/00010694-196307000-00009.

Sencindiver, J.C. and J.T. Ammons. 2000. Minesoil genesis and classification, p. 595-613. *In* R.I. Barnhisel, R.G.Darmody, and W.I. Daniels (ed.) Reclamation drastically disturbed land. ASA, CSSA, and SSSA, Madison, WI.

Smil, V. 2002. The earth's biosphere. Evolution, dynamics, and change. MIT Press, Cambridge, MA.

Smith, R.M. and A.A. Sobek. 1978. Physical and chemical properties of overburdens, spoils, wastes, and new soils. *In* F.W.Schaller and P. Sutton (ed.) Reclamation of drastically disturbed lands. ASA, Madison.

Soil Survey Staff. 1999. Soil taxonomy. USDA, NRCS Agric. Handbk. No. 436. US Gov. Printing Office, Washington, DC.

Thurman, N.C. and J.C. Sencindiver. 1986. Properties, classification, and interpretations of minesoils at two sites in West Virginia. Soil Sci. Soc. Amer. J. 50:181-185. http://dx.doi.org/10.2136/sssaj1986.03615995005000010034x.

Vernadsky, W.I. 1945. The biosphere and the noösphere. Amer. Sci. 33:1-12.

Westerbroek, P. 1991. Life as a geological force. W.W. Norton @ Co., New York.