PROPERTIES AND GENESIS OF MINESOILS ON SITES MINED FOR BAKERSTOWN AND UPPER FREEPORT COALS[1]

Jennifer R. Jones and John C. Sencindiver[2]

Abstract: Appalachian Corridor H will pass through Beaver Creek watershed in Tucker County, West Virginia. This is a sensitive area because numerous wetlands and reclaimed mined lands are located in the vicinity of the proposed highway. The West Virginia Division of Highways funded a project to assess the effects of the highway on the watershed. The two major coal beds in the watershed were Bakerstown, a member of the Conemaugh Formation, and Upper Freeport, a member of the Allegheny Formation. Bakerstown was mined and reclaimed in the 1970s, and Upper Freeport was mined and reclaimed in the 1960s. The dominant vegetation on the Bakerstown sites was grasses and legumes with scattered trees, while Upper Freeport sites were uniformly covered with red pine (*Pinus resinosa* Ait.). In order to document the existing conditions prior to the construction of the highway, a study was initiated to evaluate the properties and genesis of minesoils in the watershed. Six minesoil sampling points were located on Bakerstown sites and six were located on Upper Freeport sites. In addition, six sampling points were located on contiguous native soils. Soil profiles were described and horizons were sampled for laboratory physical and chemical analyses. The native soils were well drained to very poorly drained Inceptisols or Ultisols developed in alluvium or colluvium. Three of the six sampling points had fragipans. Minesoils developing on the Bakerstown sites had A horizons ranging from 3 to 16 cm thick. Sola of these soils ranged in thickness from 15 to 49 cm. Five of the six points had sola ranging from 15 to 33 cm thick. Minesoils on the Upper Freeport sites had A horizons that were 4 to 11 cm thick. Five of the six sampling points had sola ranging from 9 to 35 cm thick. One point had an uncommonly thick solum with Bw horizons described to 99 cm. Minesoils on both sites were classified as Entisols and Inceptisols. Although the depth of minesoil sola forming on the Upper Freeport and the Bakerstown sites was similar, fewer horizons were described per profile in Bakerstown minesoils. We attributed this horizonation difference to differences in parent materials. The rock fragments in Bakerstown minesoils were predominantly sandstones, whereas rock fragments in the Upper Freeport minesoils were a mixture of shale and sandstone.

Additional Key Words: Reclamation, soil development, *Soil Taxonomy*.

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[2] Jennifer R. Jones is a graduate research assistant and John C. Sencindiver is a professor in the Division of Plant and Soil Sciences, West Virginia University, P.O. Box 6108, Morgantown, WV 26506-6108.

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Introduction

A portion of Appalachian Corridor H has been planned by the West Virginia Division of Highways (WVDOH) to pass through the Beaver Creek watershed near Davis in Tucker County, West Virginia. Construction of the highway will disturb native soils, reclaimed mined areas, and wetlands. Some of the mined sites in this watershed are currently producing acid mine drainage (AMD), and highway construction has the potential to increase the production of AMD (Jones et al., 2003; Stephens et al., 2003). Therefore, the sensitive nature of this watershed has raised concerns about the environmental impact of the highway, especially effects on water quality. The West Virginia Division of Highways is aware of these concerns and intends to minimize/prevent any negative environmental impacts. In order to assess the effects of the highway on the watershed, WVDOH funded a multifaceted project to evaluate pre-highway construction conditions in the watershed. Some parts of the study, including characterization and assessment of wetland soils in the area (Stephens et al., 2003) and the potential of soils and overburden materials to produce additional AMD (Jones et al., 2003) have been completed.

The objective of this study was to document existing minesoils and to compare them to native soils of the Beaver Creek watershed prior to road construction. Therefore, the properties and genesis of the undisturbed soils and minesoils forming on areas mined for the Bakerstown and Upper Freeport coal beds were evaluated.

Methods and Materials

The research area is located in Tucker County, West Virginia, 5 km northeast of the town of Davis where Beaver Creek parallels State Route 93 in a southwest-northeast direction. Beaver Creek enters the Blackwater River near Davis. The elevation of the soil sampling sites is approximately 975 m. Mean annual air temperature at Canaan Valley is $8^{o}C$, and average annual precipitation is 136 cm (Losche and Beverage, 1967). The weather station at Canaan Valley is at the same elevation as the sampling sites and is approximately 16 km south of the research area. According to research conducted by Carter and Ciolkosz (1980), the mean annual soil temperature (MAST) at the research area is border-line between the frigid ($<8^{o}C$) and mesic (8 - $15^{o}C$) soil temperature regimes. Their research shows the frigid-mesic soil temperature boundary to be at an elevation of 1088 $\pm$ 26 m at Davis.

Bakerstown coal, a member of the Conemaugh Formation, was mined in the 1970s on the northwestern side of Beaver Creek. Sandstone was the predominant rock type of the overburden. The site was mined by contour methods, and reclaimed to gently rolling topography with relatively short outslopes. The part of the mine that was sampled covered a straight-line distance of approximately 4.2 km. Reclamation included partial highwall elimination. In some areas, part of the highwall was still visible at the time of sampling, but in other areas, none of the highwall was visible.

Upper Freeport coal, a member of the Allegheny Formation, was mined in the 1960s on the southeastern side of Beaver Creek. Overburden of Upper Freeport consisted of shale and sandstone. The sampling area actually consisted of three separate spoil areas with undisturbed soils between them. They cover a straight-line distance of approximately 3.0 km. Each of these three sites was mined by modified area mining methods, following the dip of the coal. Spoil was stockpiled behind or to the side of the mining equipment, resulting in piles of spoil with variable slopes. At the time of sampling, it appeared that very little land-leveling had been done prior to revegetation of the site.

Predominant vegetative species on the Bakerstown sites were grasses and forbs, while red pine (*Pinus resinosa* Ait.) dominated the Upper Freeport sites. Ground cover under the pine was generally sparse, but consisted of various grasses, forbs, and shrubs. Vegetation on the undisturbed sites varied from one site that had predominantly wetland species consisting of grasses, rushes, and sedges to forested sites consisting of predominantly black cherry (*Prunus serotina* Ehrh.).

Eighteen soil pits were dug, described and sampled in 2001 and 2002: six on Bakerstown minesoils, six on Upper Freeport minesoils, and six on undisturbed soils. These pits were located to represent the variability in slope and landscape position of the study area. Each of the soil pits was excavated to at least 100 cm and described according to standard soil survey techniques (Soil Survey Division Staff, 1993). Each profile was tentatively classified based on field data using Keys to Soil Taxonomy (Soil Survey Staff, 1998). Bulk samples were collected from each described horizon and were taken to laboratories in the Division of Plant and Soil Sciences at West Virginia University for chemical and physical analyses. Discussion and conclusions in this paper are primarily based on field data. The only laboratory data presented are soil pH values. Some of the chemical data for the Upper Freeport minesoils and the undisturbed soils have been reported elsewhere (Jones et al., 2003).

Results and Discussion

Properties of Undisturbed Soils

Three of the soil profiles had organic (O) layers at the surface (Table 1). Two of the O layers were 4 cm thick, and the third was 10 cm thick. One of the sites with an organic layer had E horizons immediately below the O, but the others had A horizons. The other three undisturbed soils had A horizons at the surface. An Ap was described in the profile on a terrace, indicating that this site had been farmed at one time. All profiles had B horizons. The terrace soil had an argillic (Bt) horizon indicated by a distinct increase in clay and the presence of clay films on ped surfaces. All other profiles had cambic (Bw) horizons. Three of the profiles, including the terrace soil, had fragipans (Bx). The solum, including all O, A, B and transition horizons, ranged from 75 to 100+ cm in thickness (Table 1).

Colors described in the A horizons exhibited hues of 2.5Y, 10YR, or 7.5YR (data not shown). Values were 2, 2.5, or 3, and chromas were 1 or 2. The B horizons contained hues of 2.5Y, 10YR, 7.5YR, or 5YR, values of 4 or 5, and chromas of 1 to 8. In the C horizons, hues were 2.5Y, 10YR, or 7.5YR, values were 3 to 5, and chromas were 1 to 6. Some of the B and C horizons were gleyed. Drainage class of these soils varied from well drained to very poorly drained. Therefore, redoximorphic depletions and concentrations were commonly found in the B and/or C horizons.

Field textures of the A horizons were silt loam or loam (Table 1). Textures of the B horizons were variable, with seven different textures being described. C horizon textures were sandy loam, loam, or clay loam. Rock fragment contents ranged from 0 to 5% in the A horizons, and up to 35% in B horizons and 50% in C horizons (Table 1.) The terrace soil had no rock fragments in any horizon, and two other profiles had 10% or fewer rock fragments in any one horizon. Because most of these soils formed in colluvium, the rock fragment content did not increase consistently with depth. Some lower horizons had fewer rock fragments than some of the upper horizons. Structure was granular in A horizons and subangular blocky or prismatic in B horizons.

Table 1. Properties of the undisturbed soils, Upper Freeport minesoils, and Bakerstown minesoils in the Beaver Creek Watershed[1].

Property		Undisturbed		Upper Freeport		Bakerstown	
Horizon Thickness (cm)		Range	Ave.	Range	Ave.	Range	Ave.
	O	0-10	3.0	0-3	0.7	0-4	0.8
	A	0-23	10.6	4-8	5.7	3-16	6.5
	Solum[2]	75-100+	83	9-99	40	15-49	27
pH	A	3.5-5.0		3.4-4.5		3.5-5.8	
	B	4.0-4.6		3.3-4.9		5.3-6.1	
	C	4.2-4.6		3.0-4.7		2.9-4.6	
Structure[3]	A	wk & mo gr		wk & mo gr, wk sbk		wk & mo gr, wk sbk	
	B	wk & mo sbk wk & mo pr		wk & mo sbk		wk & mo sbk	
	C	massive		massive		massive	
Texture[4] (field)	A	sil, l		sil, l, cl, sicl		sil, l, cl, sicl	
	B	sl, l, scl, cl, sicl, sc, sic		sil, cl, sicl		sl, l, cl	
	C	sl, l, cl		sl, cl, sicl, c		sl, cl, sicl	
Roots (Abundance)	A	Common or many		Common or many		Common or many	
	B	Few, common, or many		Few, common, or many		Few, common, or many	
	C	None, very few, or few		None, very few, few, or common		None, very few, few, or common	
Rock Fragments (vol. %)	A	0-5		5-30		10-60	
	B	0-35		20-50		25-50	
	C	0-50		20-80		40-75	
Slope (%)		2-36		7-28		8-31	

[1] Ranges and averages of data are presented for six pedons of each of the three soil types, i.e., undisturbed, Upper Freeport and Bakerstown.
[2] Solum = O horizons + all mineral horizons with structure development.
[3] Structure: wk = weak, mo = moderate, gr = granular, sbk = subangular blocky, pr = prismatic.
[4] Texture: sil = silt loam, l = loam, sl = sandy loam, scl = sandy clay loam, cl = clay loam, sicl = silty clay loam, sc = sandy clay, sic = silty clay.

Roots were found throughout the soil profiles, but abundance decreased with depth. Roots were not observed in some C horizons. All pH values were 5.0 or below.

Properties of Upper Freeport Minesoils

All of the Upper Freeport minesoils sampled exhibited some degree of pedogenesis and horizonation. Two of these soils had O (organic) horizons at the surface with A horizons below the O horizons, and Bw (weakly developed B) horizons under the A horizons. The other four minesoils had A horizons at the surface. Three of these profiles had A-Bw-C horizonation, and the fourth profile had A-AC-C horizonation. Solum thickness ranged from 9 to 99 cm (Table 1). Five of six sites had sola ranging from 9 to 35 cm thick, while one site had a solum thickness of 99 cm. This thick solum is uncommon in minesoils.

Colors of A horizons exhibited hues of 2.5Y or 10YR, with values of 4 or 5, and chromas of 1, 2, or 3. In the major B horizons, hues were 2.5Y, 10YR, or 7.5YR, with values of 3, 4 or 5, and chromas of 1, 2, or 3 in most subhorizons. However, one Bw horizon contained a chroma of 8. The C horizons exhibited predominantly 10YR hues, but neutral hues as well as 5Y, 2.5Y, or 7.5YR were present. Color values in C horizons were predominantly 4 or 5 with chromas of 1, 2, 4, or 8. Some horizons contained neutral black colors of 2.5/0 due to the presence of carbolithic materials. All sites contained some lithochromic colors that were low chroma. Three of the sampling sites were well drained, two were moderately well drained and one was somewhat poorly drained. The moderately well drained and somewhat poorly drained sites exhibited redoximorphic depletions and concentrations in subsoil horizons.

Similar textures were described in A, B, and C horizons (Table 1). Rock fragments consisted of approximately 50% sandstone and 50% shale, mudstone and siltstone throughout the profiles at all sites. In general, the rock fragment content increased with depth. A, AB and AC horizons contained 5 to 30% rock fragments. One Bw horizon contained 50% rock horizons, while all other Bw and BC horizons contained 20-30%. Rock fragments in C horizons varied widely, with 20% in one C horizon at one site and 80% in one C horizon at another site. Only three of the sites exhibited 50% or more rock fragments in C horizons. Structure was granular or subangular blocky in the A horizons and subangular blocky in the B horizons. Roots were described in all A and B horizons, but were absent in some C horizons. The pH values ranged from 3.0 to 4.9 (Table 1).

Properties of Bakerstown Soils

All Bakerstown minesoils also showed horizonation. However, horizonation was not as complex as in either the Upper Freeport or the undisturbed soils. In general, fewer horizons were described per profile. Three profiles had A horizons at the surface and exhibited either A-Bw-C or A-AC-C horizonation. Two profiles had O horizons at the surface and exhibited either O-A-C or O-A-Bw-C horizonation. Finally, one profile had an O/A horizon at the surface and had O/A-Bw-C horizonation. Solum thickness ranged from 15 to 49 cm.

Five of six profiles exhibited color hues of 10YR in A horizons, with the sixth profile having a 2.5Y hue. Values of five profiles were 2, 3, or 4, and chromas were 1, 2, or 3. One surface horizon, described as an Ap, contained a 10YR 5/6 color. This color resulted from subsoil of the original undisturbed soil being placed on the surface of the minesoil. In the B horizons, hues were 2.5Y, 10YR, or 7.5YR. Values were 3 to 5, and chromas were 3 to 6. Hues in C horizons ranged from 5Y to 7.5YR, with values of normally 3 to 6 and chromas of 1 to 8. Color of most horizons was uniform with only one or two colors described. However, four of the six sites exhibited mixed colors in at least one horizon, including black (N 2.5/0) and other lithochromic high and low chroma colors. The black colors were weathered carbolithic materials.

The range of described textures within all horizons was similar (Table 1). Rock fragment content increased with depth in four of the six sites. However, 40% rock fragments were described in all horizons at one site, and another site contained 60% in the A horizon, 50% in Bw and C1 horizons, and 70 and 75% in 2C2 and 2C3 horizons. The A horizons of the four sites in which rock fragment content decreased with depth contained 10 to 25% rock fragments. AC horizons, described at three sites, contained 35-50% rock fragment, and Bw horizons described at the other three sites exhibited 25 to 50% rock fragments. C horizons exhibited 40 to 75% rock fragments. In five of the six profiles, rock fragments were predominantly sandstone with typically 10% or less shale, siltstone, mudstone, and carbolithic materials in any one horizon. The sixth profile contained a more even mixture of rock fragments, but this profile still contained more sandstone than any other type of rock fragment. Structure was granular or subangular blocky in the A horizons and subangular blocky in B horizons. Roots were described in all A and B horizons, but were not observed in all C horizons (Table 1). Soil pH ranged from 2.9 to 6.1 (Table 1).

Soil Genesis

Morphology and slope for the undisturbed, Upper Freeport, and Bakerstown soils were similar (Tables 1 and 2). All minesoil sites were located on fill slopes, but landscape positions varied for the undisturbed soils. Two were located on sideslopes, two on toeslopes, one on a footslope, and one on a terrace. All Bakerstown profiles were well drained. Drainage classes ranged from well to somewhat poorly drained for Upper Freeport minesoils, and from well to very poorly drained for the undisturbed soils.

Depth of soil development was greater for the undisturbed soils than for the minesoils, but soil development was similar for the two types of minesoils (Tables 1 and 3). The average solum thickness of the Upper Freeport minesoils (40 cm) appears to be thicker than the Bakerstown minesoils (27 cm) (Table 1). However, as stated above, one of the Upper Freeport profiles had structure developed to 99 cm. This is an anomaly. If this profile is excluded, the average solum thickness of Upper Freeport is 28 cm, which is similar to the Bakerstown solum. In terms of actual number of years, the minesoils are much younger than the undisturbed soils. However, Bw horizons were observed in eight of the 12 minesoil profiles, five in the Upper Freeport minesoils and three in the Bakerstown minesoils. The presence of the Bw horizons indicates a rather rapid rate of soil development that has also been observed in other studies (Ciolkosz et al., 1985; Haering et al., 1993; Sencindiver and Ammons, 2000; Thomas et al., 2000).

Differences in parent material of the minesoils may have affected horizon development. Upper Freeport minesoils had more mudstones and shales than the Bakerstown minesoils. Haering et al. (1993) observed Bw horizons in minesoils constructed from coal overburden strata consisting of siltstone, but in material containing more than 25% sandstone, only A, AC and C horizons were evident. Although we observed Bw horizons in minesoils with considerable sandstone, these Bw horizons were not as strongly developed as those in the minesoils with significant proportions of mudstone and shale.

If the 99-cm solum is omitted from consideration, the average solum thickness is related to the average rooting depth (Table 3). In both the Upper Freeport and the Bakerstown minesoils, the average solum depth is closely related to the average depth to which many or common roots were described. However, solum depth in the undisturbed soils is more closely related to the depth to which all roots, including few and very few roots, were described. So, time is apparently a major factor related to the formation of these soils.

Table 2. Landscape position and classification of the undisturbed soils, Upper Freeport minesoils, and Bakerstown minesoils in the Beaver Creek Watershed.

Site/Soil	Landscape Position	Drainage Class	Subgroup	Particle-Size Class
Undisturbed				
1	Terrace-Alluvium	Very poorly drained	Umbric Fragiaquults	Fine-loamy
2	Sideslope-Colluvium	Moderately well drained	Typic Fragiudepts	Fine-loamy
3	Sideslope-Colluvium	Somewhat poorly drained	Aquic Dystrudepts	Fine-loamy
4	Toeslope-Colluvium	Very poorly drained	Typic Endoaquepts	Coarse-loamy
5	Toeslope-Colluvium	Poorly drained	Aquic Fragiudepts	Coarse-loamy
6	Footslope-Colluvium	Well drained	Typic Dystrudepts	Coarse-loamy
Upper Freeport				
1	Fill slope	Well drained	Typic Dystrudepts	Loamy-skeletal
2	Fill slope	Well drained	Typic Dystrudepts	Loamy-skeletal
3	Fill slope	Well drained	Typic Udorthents	Fine-loamy
4	Fill slope	Moderately well drained	Oxyaquic Dystrudepts	Loamy-skeletal
5	Fill slope	Moderately well drained	Aquic Udorthents	Fine-loamy
6	Fill slope	Somewhat poorly drained	Aquic Dystrudepts	Fine
Bakerstown				
1	Fill slope	Well drained	Typic Udorthents	Loamy-skeletal
2	Fill slope	Well drained	Typic Udorthents	Loamy-skeletal
3	Fill slope	Well drained	Typic Dystrudepts	Loamy-skeletal
4	Fill slope	Well drained	Typic Udorthents	Loamy-skeletal
5	Fill slope	Well drained	Typic Udorthents	Loamy-skeletal
6	Fill slope	Well drained	Typic Udorthents	Loamy-skeletal

Table 3. Relationship of solum depth to rooting depth of the Upper Freeport, Bakerstown, and Undisturbed soils in the Beaver Creek Watershed[1].

Profile No.	Upper Freeport			Bakerstown			Undisturbed		
	Sol. Depth	Root Depth		Sol. Depth	Root Depth		Sol. Depth	Root Depth	
		M-C	F-VF		M-C	F-VF		M-C	F-VF
1	35	35	190	33	33	100	79	34	79
2	99 [2]	206[2]	206[2]	21	14	32	82	48	64
3	12	38	109	49	49	83	81	81	81
4	49	16	61	24	8	24	83	19	68
5	9	9	65	19	19	88	100	39	74
6	34	11	51	15	33	86	75	61	120
Ave.	28	22	95	27	26	69	83	47	86

[1] All depths = cm. M = many, C = common, F = few, VF = very few roots.
[2] This profile was omitted from the average calculations for Upper Freeport minesoils.

Although the sola of minesoils are thinner than the sola of undisturbed soils, structure of A and B horizons are similar for all three types of soils (Table 1). Textures of the various horizons of the three types of soils also appear to be similar (Table 1). However, some A horizons of the minesoils had clay loam or silty clay loam textures, whereas all undisturbed soils had loam or silt loam textures in A horizons. More clay in the A horizons of some of the minesoils is the result of replacing soil materials during reclamation of the mined lands. Rock fragment contents also are higher in the minesoils than in the undisturbed soils as a result of placement of materials in the minesoils during reclamation, and longer weathering times for the undisturbed soils.

Soil pH of A and C horizons for all three types of soils and of B horizons for the undisturbed and Upper Freeport soils were similar (Table 1). Bakerstown B horizons had higher pH values than either the undisturbed or the Upper Freeport soils. This difference is probably related to the geologic materials from which the soils are developing.

Soil Classification

Four of the five undisturbed soils had cambic horizons and were classified as Inceptisols (Table 2). The remaining undisturbed soil had an argillic horizon and was classified as an Ultisol. Three of the sites had a coarse-loamy particle-size class and three had a fine-loamy particle-size class.

All minesoils were classified as Entisols or Inceptisols (Table 2). Two of the Upper Freeport minesoils (sites 3 and 5) did not have B horizons that qualified for cambic, so they were classified as Udorthents. Upper Freeport site 3 had a Bw horizon described, but it was not thick enough to fit the cambic definition. Site 5 had an A-AC-C profile. The other four sites did have cambic horizons and were classified as Dystrudepts. Three of these minesoils had >35% rock fragments in the control section (25-100 cm depth), so they had a loamy-skeletal particle-size class. The other three had <35% rock fragments in the control section, so they had fine-loamy or fine particle-size classes. These minesoils had low rock fragment contents because original materials placed during reclamation had low rock fragment contents. The soil with the fine particle-size class had clay textures in two subsoil horizons, one of which was gleyed. These horizons also contained pockets of carbolithic materials. Therefore, the materials in these horizons may have come from the underclay commonly found below the coal bed.

All Bakerstown minesoils contained >35% rock fragments in their control sections, so they were classified in the loamy-skeletal particle-size class. Only one of these minesoils (#3) contained B horizons that fit the color and depth requirements to be a cambic horizon. This soil was classified as a Dystrudept (Table 2). All of the other five Bakerstown minesoils had AC or Bw horizons described, but these did not meet either the color or the depth requirement of cambic horizons. So they were classified as Udorthents.

Current classification (Soil Survey Staff, 1993) of the 12 minesoil profiles was compared to two proposed classification systems (Fanning and Fanning, 1989; Sencindiver and Ammons, 2000) (Table 4). Five subgroups were identified in the current system, eight subgroups were identified in the proposed system of Sencindiver and Ammons (2000), and five subgroups were

Table 4. Current classification and proposed classification of Upper Freeport and Bakerstown Minesoils.

Minesoil	Current Classification[1]	Proposed Classification[2]	Proposed Classification[3]
Upper Freeport			
1	Typic Dystrudepts	Schlickig Spoludepts	Spolic Dystrudepts
2	Typic Dystrudepts	Typic Spoludepts	Spolic Dystrudepts
3	Typic Udorthents	Schlickig Udispolents	Spolic Udorthents
4	Oxyaquic Dystrudepts	Oxyaquic Spoludepts	Oxyaquic Dystrudepts
5	Aquic Udorthents	Aquic (Carbolithic) Udispolents	Aquic Udorthents
6	Aquic Dystrudepts	Aquic (Plattic) Spoludepts	Aquic Dystrudepts
Bakerstown			
1	Typic Udorthents	Plattic Udispolents	Spolic Udorthents
2	Typic Udorthents	Plattic Udispolents	Spolic Udorthents
3	Typic Dystrudepts	Plattic Spoludepts	Spolic Dystrudepts
4	Typic Udorthents	Plattic Udispolents	Spolic Udorthents
5	Typic Udorthents	Plattic Udispolents	Spolic Udorthents
6	Typic Udorthents	Plattic Udispolents	Spolic Udorthents

[1] Current classification according to Soil Survey Staff (1998).
[2] Proposed classification according to Sencindiver and Ammons (2000).
[3] Proposed classification according to Fanning and Fanning (1989).

identified in the system proposed by Fanning and Fanning (1989). Oxyaquic and aquic subgroups of the current system would remain the same in the Fanning and Fanning (1989) proposed system. The subgroup modifier also would be the same in the Sencindiver and Ammons (2000) system, although the great group name would change.

All minesoils in this study that classified as Entisols had some soil development within the last 30 to 40 years. Although they may not have had the properties required of a cambic horizon for classification as Inceptisols, they were intergrading toward Inceptisols. However, Soil Taxonomy currently does not identify an intergrade between Udorthents and Inceptisols that would document this weak development. Other great groups of Entisols have intergrades identified. Some examples are Vertic Udifluvents, Spodic Udipsamments, and Mollic Endoaquents. Therefore, one could infer more about minesoils classified as Typic Udorthents in this study if they were classified as Inceptic Udorthents or Dystrudeptic Udorthents.

Summary and Conclusions

The undisturbed soils had the thickest sola and exhibited more pedogenic development than the minesoils in this study. This difference was expected because the undisturbed soils have not experienced any major disturbance that affected the factors of soil formation. However, the undisturbed soils had relatively young profiles, because most had cambic rather than argillic horizons, indicating relatively little illuviation of clay. This lack of soil development is the result of the cooler climate in this area compared to other parts of West Virginia and the region at lower elevations, the coarse texture of the parent materials from which most of the soils developed, and the relatively young age of the colluvial and alluvial parent materials.

Although these minesoils are very young, cambic horizons have developed in five of the twelve profiles, and thin Bw horizons that almost fit cambic have developed in four others. So, the classification of the minesoils that have cambic horizons is very similar to the classification of the undisturbed soils.

Although the Upper Freeport minesoils were approximately 10 years older than the Bakerstown minesoils, the average depth of solum development was similar for the two types of minesoils (except for one Upper Freeport profile). It is apparent from this comparison that the Bakerstown minesoils have developed horizons with at least weak structure at a more rapid rate than the Upper Freeport minesoils. However, the Upper Freeport horizons are more strongly developed in terms of color and structure because more cambic horizons were observed in Upper Freeport than in Bakerstown. We conclude that the differences in parent material affected the development of the minesoils. Since the parent material of the Upper Freeport minesoils had more shales and mudstones than the Bakerstown minesoils, color and structure development was stronger. At this current rate of development, the Bakerstown minesoils may show stronger structure development in another 10 years and be more similar to the Upper Freeport minesoils.

In conclusion, we expect that the minesoils will develop into soils similar to those of the undisturbed soils, given enough time and continuation of the current environmental conditions.

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