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Total Elemental Analysis of Pennsylvania Soils

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Edward J. Ciolkosz,
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and
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Contents

Introduction

Total elemental analysis was one of the earliest chemical analysis methods used to characterize the composition of soil material. With the advent of x-ray analysis emphasis shifted from total analysis to mineralogical analysis and the use of various extracting solutions to determine discreet components of the soil. Examples of this include the use of citrate-bicarbonate-dithionite to extract "free iron oxides" and KCl to extract monomeric aluminum. These shifts occurred in the 1930's and 40's. Although this shift has occurred, significant value still exists in knowing the total elemental analysis of Pennsylvania soil samples. For example, the ratio of free iron oxides to total iron can be used as an index of soil development (Ciolkosz et al., 1993; Alexander and Holowaychuk, 1983; Alexander, 1985). No concerted effort has been made in the past or is currently underway to inventory these type of data for Pennsylvania soils. Although this is the case, some data are available in obscure places. Thus, the objective of this publication is to make these obscure data available to whomever may need it. In the future, if more data are uncovered or obtained by analysis, an update of this publication will be presented. In addition to this report, the data will be available in digital form as a part of the Penn State Soil Characterization Laboratory Database (Ciolkosz and Thurman, 1993).

Materials and Methods

Four sets of total elemental analysis data are presented. Table 1 gives data that were generated by a joint Penn State-United States Geological Survey (USGS) sampling project in southwestern Pennsylvania. The soils were sampled horizon by horizon for complete soil characterization analysis, and these data are presented in Cunningham et al. (1977) and Ciolkosz et al. (1976). In addition, the

characterization data are also available in Ciolkosz and Thurman (1993). Selected horizons of these soils (B and R) were sampled by Peter Briggs of the USGS and sent to the USGS Rapid Rock Analysis Laboratory for total elemental analysis. Both major as well as trace elements were determined on the USGS samples. Only the major element data are presented here. Copies of the trace element data are available from E. Ciolkosz at the Penn State University Agronomy Department. The method of analysis used by the USGS laboratory is described by Shapiro and Brannock (1962) and Shapiro (1967).

Table 2 gives the second set of total elemental analysis data. The samples for these data were obtained in a soil radon study (Washington, 1991; Greeman, 1992). Total analysis on these samples was determined in the Penn State Mineral Characterization laboratory by plasma spectrometry after fusion in $LiBO_3$ (Suhr and Gong, 1983). Selected soil horizons were also analyzed for radium, thorium, and uranium. These data are available in Greeman (1992). Complete soil characterization data for these samples are also available (Ciolkosz and Thurman, 1993).

The third set of data (Table 3) was a part of an iron and aluminum study of Pennsylvania and New York soils (Ciolkosz et al., 1993). The total analysis of these samples was done by the Cornell University College of Agricultural and Life Sciences (CALS) analytical laboratory. They used the HF dissolution method of Lim and Jackson (1982) and the elements were determined by inductive coupled plasma (ICP) spectrometry (McClenahan and Ferguson, 1989). Complete soil characterization data for the Pennsylvania samples are available in Ciolkosz and Thurman (1993). The New York total analysis data are not presented here, but some of these data are presented by Ciolkosz et al. (1993). The New York data include the following pedons: Lackawanna, Wellsboro, Morris, Norwich, Mardin, Volusia, and Chippewa.

The last total element data set (Table 4) was a part of a limestone soils study done in the 1930's (Alexander et al., 1939) and is included because a Hagerstown soil in the study was sampled on the campus of Penn State University. In the publication of Alexander et al. (1939) particle size, chemical, and morphological data are also given. Some additional Pennsylvania soil total element analysis data are also available, but they are on the clay size (< 2 μm) material only and not the total fine earth (< 2 mm) basis. These data are presented by Johnson and Chu (1983), and are not reproduced in this publication.

Results

The results of this publication are listed in Tables 1, 2, 3, and 4. An examination of the data shows, with some exceptions, the following trends:

1. The content of major elements follows the order silicon > aluminum > iron.
2. The content of secondary elements in acid soils is in the order K > Mg > Ca > Na. In calcareous horizons calcium may be higher in concentration than the other elements.
3. Silicon content shows no distinctive trend with depth.
4. Iron and aluminum contents are generally lower in the upper few horizons than in lower horizons.
5. Titanium content is greater than that of manganese; the manganese content is approximately equal to that of phosphorous.
6. No distinctive trends with depth were noted in titanium, manganese, and phosphorus contents.

References

Alexander, E. B. and N. Holowaychuk. 1983. Soils on terraces along the Cauca River, Columbia: I. Chronosequence Characteristics. Soil Sci. Soc. Am. J. 47:715-721.

Alexander, E. B. 1985. Estimating relative ages from iron-oxide/total-iron ratios of soils in the western Po Valley, Italy: A discussion. Geoderma 35:257-259.

Alexander, L. T., H. G. Byers, and G. Edginton. 1939. A chemical study of some soils derived from limestone. USDA Tech. Bull. 678. 27 pp.

Ciolkosz, E. J., R. L. Cunningham, G. W. Petersen, R. P. Matelski, and R. Pennock, Jr. 1976. Characteristics, interpretations, and uses of Pennsylvania soils developed from redbeds and calcareous materials. Pennsylvania State University Agri. Expt. Station Progress Rept. 355. University Park, PA. 36 pp.

Ciolkosz, E. J. and N. C. Thurman. 1993. Pennsylvania State University Soil Characterization Laboratory database. Agronomy Dept., Penn State University.

Ciolkosz, E. J., W. J. Waltman, and N. C. Thurman. 1993. Iron and aluminum in Pennsylvania soils. Pennsylvania State University Agronomy Series (In press).

Cunningham, R. L., E. J. Ciolkosz, R. P. Matelski, G. W. Petersen, and R. Pennock, Jr. 1977. Characteristics, interpretations, and uses of Pennsylvania soils developed from acid shale. Pennsylvania State University Agr. Expt. Station Progress Report 362. University Park, PA. 81 pp.

Greeman, D. J. 1992. The geochemistry of uranium, thorium, and radium in soils of the eastern United States. Ph.D. Thesis, Pennsylvania State University, University Park, PA. 231 pp.

Johnson, L. J. and C. H. Chu. 1983. Mineralogical characterization of selected soils from Northeastern United States. Pennsylvania State University Agricultural Experiment Station Bull. 847. 32 pp.

Lim, C. H. and M. L. Jackson. 1982. Dissolution for total elemental anlaysis. In A. L. Page, R. H. Miller, and D. R. Keeney (ed.). Methods of Soil Analysis. Part 2. (2nd edition). Agronomy 9:1-12.

McClenahn, M. G. and G. A. Ferguson. 1989. Methods for soil fertility analysis. Cornell University Nutrient Analysis Laboratory. Ithaca, NY. 49 pp.

Shacklette, H. T. and J. G. Boerngen. 1984. (reprinted 1992). Elemental concentration in soils and other surficial materials of the conterminous United States. U.S. Geol. Sur. Prof. Paper 1270. 105 pp.

Shapiro, L. and W. W. Brannock. 1962. Rapid analysis of silicate, carbonate, and phosphate rocks. US Geol. Sur. Bull. 1144-A. 56 pp.

Shapiro, L. 1967. Rapid analysis of rocks and minerals by a single solution method. US Geol. Sur. Prof. Paper 575B:187-191.

Suhr, N. H. and H. Gong. 1983. Some procedures for the chemical and mineralogical analysis of coals. In A data base for the analysis of compositional characteristics of coal seams and macerals. Final Rept. Part 3, DOE-30013-F3, p. 16-25.

Washington, J. W. 1991. Radon generation and transport in soils. Ph.D. Thesis. Pennsylvania State University, University Park, PA. 208 pp.

Table 1. Total elemental composition of selected soil and rock horizons from soils of southwestern Pennsylvania. See Ciolkosz et al. (1976) and Cunningham et al. (1977) for soil descriptions and additional laboratory physical and chemical data for these soils. The physical and chemical data are also given in the Penn State Soil Characterization Database (Ciolkosz and Thurman, 1993). H_2O^- is water loss at 105°C (adsorbed H_2O) and H_2O^+ is water loss above 105°C (crystalline H_2O).

Series Drainage	Soil Number	Horizon	Percent SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	CO_2	S	H_2O^+	H_2O^-	Sum
								Red Calcareous Shales										
Upshur WD**	02-20-03 (GP7)*	Bt2	55.0	18.6	7.2	0.88	1.60	1.10	0.18	3.2	0.87	0.12	0.09	0.25	0.00	7.0	3.8	100
	02-20-07 (GP6)	C3	37.9	13.7	5.4	0.56	1.20	17.90	0.14	2.2	0.63	0.13	0.31	13.60	0.01	4.4	1.8	100
	02-20-08 (GP5)	2C4	37.5	13.8	2.2	0.88	1.70	19.80	0.23	1.9	0.61	0.11	0.04	15.70	0.00	4.3	1.2	100
Upshur WD	02-23-03 (GP2)	Bt2	55.5	19.3	7.1	0.40	1.20	0.33	0.14	2.2	0.92	0.17	0.04	<0.05	0.01	8.1	4.6	100
	02-23-08 (GP1)	C2	57.6	20.0	6.0	0.64	1.30	0.61	0.28	3.1	1.00	0.21	0.05	<0.05	0.01	6.6	2.6	100
Upshur WD	10-40-03 (GP53)	Bt2	56.0	19.6	7.3	0.44	1.50	0.59	0.22	2.3	0.87	0.07	0.02	0.01	0.00	5.7	6.2	101
	10-40-10 (GP52)	R	59.2	19.7	5.7	0.36	1.20	0.65	0.17	2.3	1.00	0.11	0.00	0.02	0.00	5.0	4.8	100
Vandergrift MWD	02-21-04 (GP4)	Bt3	52.4	20.6	8.7	0.56	1.40	0.25	0.20	2.7	0.95	0.07	0.11	<0.05	0.01	8.3	3.8	100
	02-21-09 (GP3)	2R	77.2	9.7	3.1	2.00	0.76	0.40	1.00	1.1	0.80	0.06	0.11	<0.05	0.01	3.3	0.5	100
Vandergrift MWD	04-01-04 (GP9)	Bt3	50.2	22.8	8.6	0.56	1.10	0.36	0.23	2.9	0.93	0.17	0.04	<0.05	0.02	8.9	3.2	100
	04-01-11 (GP8)	R	59.0	21.4	3.6	0.60	1.30	0.43	0.24	3.1	1.10	0.06	0.04	<0.05	0.01	7.1	2.1	100
								Gray and Brown Neutral to Calcareous Shales										
Westmoreland WD	63-43-03 (GP11)	Bt1	64.6	15.0	6.8	0.68	0.98	0.28	0.63	2.2	0.97	0.11	0.14	<0.05	0.02	5.6	2.1	100
	63-43-08 (GP10)	R	71.6	12.3	4.8	0.92	0.94	0.38	1.20	1.7	0.90	0.10	0.06	<0.05	0.01	3.7	1.2	100
Library SWPD	63-44-03 (GP13)	Btg1	52.5	19.2	9.8	1.70	0.97	0.35	0.18	2.7	0.84	0.10	0.06	<0.05	0.04	8.7	2.8	100
	63-44-10 (GP12)	5C4g	57.3	22.6	2.4	0.80	0.82	1.50	0.25	2.6	1.10	0.06	0.04	0.60	0.02	7.4	2.3	100
Library SWPD	63-45-03 (GP15)	Bt2	64.9	14.2	7.0	0.40	0.84	0.47	0.50	2.1	0.93	0.08	0.18	<0.05	0.02	5.9	2.4	100
	63-45-09 (GP14)	C2	73.9	11.5	3.7	1.00	1.10	0.30	1.00	1.7	0.76	0.06	0.07	<0.05	0.01	4.1	0.8	100

* US Geological Survey Field Number.

** Drainage Class: WD = well drained, MWD = moderately well drained, SWPD = somewhat poorly drained.

Table 1. Cont. Total elemental composition of selected soil and rock horizons from soils of southwestern Pennsylvania. See Ciolkosz et al. (1976) and Cunningham et al. (1977) for soil descriptions and additional laboratory physical and chemical data for these soils. The physical and chemical data are also given in the Penn State Soil Characterization Database (Ciolkosz and Thurman, 1993). H_2O^- is water loss at 105°C (adsorbed H_2O) and H_2O^+ is water loss above 105°C (crystalline H_2O).

Series Drainage	Soil Number	Horizon	Percent SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	CO_2	S	H_2O^+	H_2O^-	Sum
								Gray and Brown Acid Shales										
Gilpin WD	65-21-04 (GP20)*	R	75.4	13.6	2.4	0.44	0.63	0.09	0.08	1.6	0.87	0.04	0.06	<0.05	0.02	4.5	0.4	100
Rayne WD	63-46-03 (GP17)	Bt1	70.7	12.0	5.5	0.48	0.74	0.38	0.59	2.0	0.80	0.06	0.14	<0.05	0.03	4.8	1.8	100
	63-46-09 (GP16)	2R	80.9	10.3	1.3	0.52	0.57	0.23	1.40	1.3	0.22	0.11	0.06	<0.05	0.00	2.7	0.4	100
Wharton MWD	65-20-03 (GP19)	Bt2	53.0	19.4	11.7	0.36	0.84	0.15	0.27	2.8	0.95	0.17	0.10	<0.05	0.05	8.1	2.1	100
	65-20-07 (GP18)	R	58.4	22.2	4.2	0.60	1.80	0.31	0.24	3.5	0.15	0.04	0.06	<0.05	0.01	6.8	1.7	100
Cavode SWPD	10-37-05 (GP59)	Btg4	53.1	27.7	3.0	0.44	0.93	0.00	0.40	3.3	1.10	0.04	0.00	0.01	0.00	7.0	3.1	100
	10-37-11 (GP58)	3R	61.0	23.8	1.5	0.64	0.73	0.00	0.31	2.0	1.50	0.04	0.00	0.01	0.00	6.9	2.0	100
Cavode SWPD	10-38-05 (GP57)+	Btg4	58.0	23.5	3.7	0.80	1.30	0.00	0.32	3.3	1.10	0.10	0.00	0.01	0.00	5.8	2.5	100
	10-38-06 (GP57)	Btg5																
	10-38-09 (GP56)	2R	65.4	17.7	4.1	0.88	1.20	0.00	0.25	2.8	1.20	0.06	0.00	0.01	0.00	4.6	1.6	100
Cavode SWPD	10-39-02 (GP55)#	Bt1	64.3	16.8	6.3	0.28	0.69	0.00	0.25	2.0	1.00	0.08	0.00	0.01	0.04	5.0	2.4	99
	10-39-03 (GP55)	Btg1																
	10-39-10 (GP54)	2C	65.5	15.5	6.4	0.24	1.00	0.00	0.24	2.3	1.00	0.17	0.04	0.01	0.02	4.3	3.1	100

* US Geological Survey Field Number.
\+ Horizons 5 and 6 were combined for analysis.
\# Horizons 2 and 3 were combined for analysis.

Table 2. Total elemental composition of soil samples from an array of Pennsylvania parent materials. See Ciolkosz and Thurman (1993) for soil descriptions and additional laboratory physical and chemical data. These sites were a part of a soil radon study. See Washington (1991) and Greeman (1992) for information on the radon study.

Soil			Percent											
Series Drainage	Number	Horizon	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	SO_3	LOI*	Sum
							Limestone								
Hagerstown	14-80-01	A	67.2	6.87	3.04	0.49	0.56	0.24	1.58	0.85	0.23	0.44		18.70	
Well	14-80-02	E	80.1	8.24	3.53	0.63	0.15	0.27	2.28	1.04	0.11	0.12		3.37	
drained	14-80-03	BE	75.2	11.10	4.44	0.94	0.11	0.23	2.84	0.96	0.07	0.06		4.33	
	14-80-04	Bt1	65.2	16.50	5.81	1.62	0.14	0.13	3.89	0.82	0.08	0.05		6.39	
	14-80-05	Bt2	55.3	21.50	7.05	1.91	0.16	0.07	4.23	0.66	0.11	0.07		8.22	
	14-80-06	Bt3	56.4	20.50	6.85	1.93	0.13	0.06	4.20	0.63	0.08	0.08		8.29	
	14-80-07	Bt4	58.6	20.40	6.50	1.86	0.15	0.05	3.64	0.57	0.09	0.08		8.30	
	14-80-08	Bt5	54.9	21.50	7.22	2.09	0.13	0.06	4.00	0.70	0.14	0.10		9.03	
	14-80-09	BC	59.2	18.90	5.64	2.40	0.11	0.06	6.07	0.61	0.10	0.06		5.85	
Clarksburg	14-81-01	A	68.6	8.70	2.87	0.69	0.47	0.49	1.77	0.81	0.21	0.60		14.90	
Moderately	14-81-02	E	78.8	9.13	3.08	0.61	0.17	0.57	2.10	0.91	0.11	0.17		3.69	
well	14-81-03	BE	76.5	10.10	3.59	0.71	0.15	0.55	2.24	0.90	0.09	0.08		3.71	
drained	14-81-04	Bt	73.6	11.60	4.74	0.92	0.15	0.53	2.48	0.84	0.09	0.06		4.38	
	14-81-05	Bx1	75.2	10.70	4.58	0.91	0.23	0.64	2.48	0.84	0.08	0.07		3.86	
	14-81-06	Bx2	76.8	10.40	4.27	0.95	0.32	0.74	2.58	0.80	0.07	0.08		3.52	
	14-81-07	BC	76.0	10.50	5.67	1.06	0.17	0.18	2.67	0.53	0.07	0.06		3.99	
	14-81-08	2C1	76.2	10.70	3.37	1.02	0.16	0.17	3.14	0.72	0.06	0.07		3.50	
	14-81-09	2C2	74.3	11.50	3.63	1.13	0.14	0.13	3.05	0.76	0.06	0.04		4.47	
	14-81-10	2C3	73.9	11.30	4.19	1.18	0.13	0.10	2.95	0.69	0.07	0.08		4.66	

* Loss on Ignition (750°C).

Table 2. Cont. Total elemental composition of soil samples from an array of Pennsylvania parent materials. See Ciolkosz and Thurman (1993) for soil descriptions and additional laboratory physical and chemical data. These sites were a part of a soil radon study. See Washington (1991) and Greeman (1992) for information on the radon study.

Soil			Percent											
Series Drainage	Number	Horizon	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	SO_3	LOI*	Sum
							Sandstone								
Clymer	14-83-03	E	89.9	3.75	0.83	0.16	0.04	0.14	0.73	0.80	0.03	0.01		2.50	
Well	14-83-04	Bhs	78.8	8.40	2.61	0.33	0.06	0.24	1.30	0.75	0.08	0.01		6.65	
drained	14-83-05	Bs	76.8	10.90	2.70	0.49	0.07	0.28	1.60	0.74	0.09	0.02		5.91	
	14-83-06	Bw1	80.3	9.88	2.90	0.46	0.06	0.22	1.69	0.53	0.04	0.02		3.94	
	14-83-07	Bw2	78.0	11.10	3.01	0.45	0.04	0.22	1.97	0.71	0.04	0.02		3.62	
	14-83-08	Bt1	70.6	15.10	4.80	0.45	0.02	0.13	2.63	0.69	0.06	0.04		4.45	
	14-83-09	Bt2	75.9	13.00	4.61	0.36	0.02	0.11	2.20	0.59	0.06	0.05		3.94	
	14-83-10	BC	74.6	13.60	2.87	0.42	0.03	0.11	2.70	0.73	0.03	0.03		3.77	
	14-83-11	C1	76.0	13.40	2.87	0.39	0.03	0.12	2.87	0.78	0.05	0.02		3.24	
	14-83-12	C2	74.2	13.80	3.11	0.45	0.03	0.15	2.93	0.79	0.05	0.04		3.69	
Cookport	14-82-01	A	71.2	5.27	1.37	0.22	0.09	0.20	0.88	0.72	0.09	0.05		18.70	
Somewhat	14-82-02	E	79.3	9.70	2.01	0.37	0.06	0.26	1.53	0.79	0.05	0.02		4.91	
poorly	14-82-03	Bw1	76.3	11.80	2.79	0.53	0.08	0.29	1.93	0.80	0.06	0.02		4.57	
drained	14-82-04	Bw2	75.7	12.50	3.64	0.58	0.07	0.33	2.15	0.79	0.04	0.02		4.33	
	14-82-05	Bx1	78.6	11.00	3.35	0.48	0.06	0.26	1.97	0.70	0.05	0.02		3.89	
	14-82-06	Bx2	83.3	8.72	2.33	0.30	0.07	0.20	1.63	0.62	0.05	0.03		2.59	
	14-82-07	Bx3	74.4	13.00	4.44	0.35	0.05	0.17	2.39	0.71	0.06	0.04		4.46	
	14-82-08	Bx4	69.8	14.20	6.43	0.47	0.08	0.15	2.46	0.72	0.07	0.08		5.29	
	14-82-09	Bx5	75.7	11.60	3.57	0.53	0.12	0.34	2.26	0.78	0.08	0.04		4.18	
	14-82-10	Bx6	76.8	12.00	3.87	0.48	0.08	0.26	2.31	0.69	0.07	0.04		4.13	
	14-82-11	2C	78.3	10.90	3.91	0.42	0.05	0.12	2.02	0.51	0.07	0.05		3.95	

* Loss on Ignition (750°C).

Table 2. Cont. Total elemental composition of soil samples from an array of Pennsylvania parent materials. See Ciolkosz and Thurman (1993) for soil descriptions and additional laboratory physical and chemical data. These sites were a part of a soil radon study. See Washington (1991) and Greeman (1992) for information on the radon study.

Soil			Percent											
Series Drainage	Number	Horizon	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	SO_3	LOI*	Sum
							Gray and Brown Acid Shale								
Bedington	06-12-02	A	63.5	9.90	3.50	0.65	0.19	0.27	1.27	0.81	<0.05	0.28	<0.05	18.50	98.9
Well	06-12-03	E	72.9	12.60	3.97	0.82	0.20	0.25	1.85	1.04	0.11	0.12	<0.05	6.73	100.6
drained	06-12-04	Bt1	71.0	14.10	4.78	1.00	0.25	0.24	2.55	0.95	0.12	0.04	<0.05	5.59	100.6
	06-12-05	Bt2	64.8	16.90	6.15	1.29	0.15	0.20	3.44	0.97	<0.05	0.05	<0.05	5.74	99.7
	06-12-06	Bt3	57.8	20.40	7.30	1.34	0.32	0.05	4.72	0.97	0.14	0.05	<0.05	6.02	99.1
	06-12-07	Bt4	57.1	20.80	7.97	1.59	0.27	0.07	4.49	0.89	<0.05	0.13	<0.05	6.75	100.1
	06-12-08	Bt5	57.6	19.90	7.84	1.41	0.07	0.15	4.57	0.80	0.12	0.13	<0.05	6.76	99.4
	06-12-09	BCt	56.0	20.20	8.04	1.66	0.24	0.05	4.29	0.98	0.13	0.17	<0.05	6.46	98.2
							Brown Acid Floodplain								
Pope	14-84-01	A	75.8	8.84	3.65	0.57	0.19	0.43	1.59	0.82	0.13	0.09	<0.05	7.12	99.2
Well	14-84-02	Ab	77.3	10.30	4.03	0.65	0.32	0.45	1.76	0.87	0.10	0.10	<0.05	4.22	100.1
drained	14-84-03	Bw1	76.8	11.00	4.36	0.75	0.16	0.46	1.91	0.80	0.08	0.08	<0.05	4.31	100.7
	14-84-04	Bw2	75.5	10.90	4.61	0.77	0.21	0.45	1.95	0.84	0.10	0.08	<0.05	3.83	99.2
	14-84-05	Bw3	76.0	11.40	4.57	0.73	0.09	0.43	1.97	0.80	0.08	0.07	<0.05	4.07	100.2
	14-84-06	Bw4	76.9	10.30	4.70	0.75	0.22	0.47	1.76	0.84	0.11	0.08	<0.05	3.71	99.8
	14-84-07	BC	81.6	8.29	3.32	0.53	0.13	0.39	1.46	0.72	0.09	0.01	<0.05	3.12	99.7
	14-84-08	2C1	77.3	10.10	5.44	0.63	0.12	0.35	1.84	0.59	0.14	0.07	<0.05	4.03	100.6
	14-84-09	2C2	73.0	10.50	7.17	0.76	0.23	0.36	1.99	0.63	0.21	0.07	<0.05	4.29	99.2

* Loss on Ignition (750°C).

Table 2. Cont. Total elemental composition of soil samples from an array of Pennsylvania parent materials. See Ciolkosz and Thurman (1993) for soil descriptions and additional laboratory physical and chemical data. These sites were a part of a soil radon study. See Washington (1991) and Greeman (1992) for information on the radon study.

Soil			Percent											
Series Drainage	Number	Horizon	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	SO_3	LOI*	Sum
							Granite and Gneiss								
Glenelg	06-11-02	A	56.5	16.8	4.89	0.33	0.33	0.35	4.22	0.58	0.18	0.21	<0.05	14.60	99.0
Well	06-11-03	AB	61.5	17.9	4.35	0.31	0.19	0.41	4.60	0.52	0.11	0.17	<0.05	9.23	99.3
drained	06-11-04	Bt1	64.6	17.3	4.81	0.34	0.29	0.33	4.51	0.51	0.13	0.06	<0.05	6.32	99.2
	06-11-05	Bt2	61.0	20.0	5.25	0.33	0.21	0.29	4.61	0.45	<0.05	0.05	<0.05	6.80	99.0
	06-11-06	Bt3	58.8	21.7	4.49	0.21	0.22	0.31	5.44	0.44	0.07	0.05	<0.05	7.57	99.3
	06-11-07	BC	57.3	21.9	5.53	0.15	0.32	0.27	5.62	0.35	0.09	0.08	<0.05	6.93	98.5
	06-11-08	C1	59.0	21.9	4.70	0.14	0.27	0.25	6.19	0.27	<0.05	0.06	<0.05	6.73	99.5
	06-11-09	C2	59.7	20.8	4.90	0.31	0.23	0.30	6.23	0.33	0.07	0.08	<0.05	7.05	100.0
	06-11-10	C3	59.9	21.1	4.86	0.21	0.16	0.31	5.82	0.30	0.05	0.06	<0.05	6.90	99.7
	06-11-11	C4	57.2	21.2	5.91	0.38	0.28	0.22	5.33	0.48	0.07	0.10	<0.05	7.89	99.1
							Gray and Brown Wisconsinan Glacial Till								
Bath	08-99-02	A	82.4	8.93	3.51	0.56	0.30	0.77	1.49	0.85	0.15	0.09	<0.1	11.90	99.1
Well	08-99-03	E	83.1	8.01	3.04	0.54	0.27	0.74	1.43	0.74	0.10	0.08	<0.1	4.65	98.1
drained	08-99-05	Bw1	77.1	12.7	5.29	1.05	0.12	0.77	2.59	0.97	0.13	0.05	<0.1	3.97	100.8
	08-99-07	Bx2	69.2	16.6	6.34	1.28	0.13	0.81	3.52	0.96	0.15	0.09	<0.1	4.65	99.1
	08-99-09	Bx4	71.9	15.0	5.97	1.18	0.26	0.93	3.12	0.94	0.17	0.11	<0.1	3.91	99.6
	08-99-12	Bx7	70.1	15.5	6.02	1.29	0.18	0.90	3.33	1.01	0.11	0.09	<0.1	4.46	98.6

* Loss on Ignition (750°C).

Table 3. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
Late Wisconsinan Brown Glacial Till																			
Bath	45-79-01	Ap	5.70	3.68				0.98	0.24	0.03									
Well	45-79-02	Bw1	6.15	3.87	0.71	0.09	0.07	1.10	0.23	0.02	457	59.02	<0.01	17.21	27.08	50.60	14.61	76.51	74.29
drained	45-79-03	Bw2	5.59	3.82	0.74	0.06	0.06	1.10	0.21	0.03	229	23.28	<0.01	23.10	30.54	43.07	18.43	72.15	72.56
	45-79-04	Bx1	7.51	5.28				1.95	0.16	0.08									
	45-79-05	Bx2	6.90	4.53	0.90	0.03	0.06	1.61	0.24	0.06	454	22.36	<0.01	20.14	37.19	58.70	26.18	91.26	91.52
	45-79-06	Bx3	9.09	5.55	1.21	0.03	0.09	2.23	0.25	0.09	622	9.53	<0.01	21.44	52.23	81.45	37.03	104.80	119.70
	45-79-07	Bx4	8.01	5.44				2.36	0.18	0.09									
	45-79-08	2C	6.97	4.55				1.71	0.16	0.07									
	45-79-09	2R																	
Late Wisconsinan Red Glacial Till																			
Lackawanna	45-80-01	Ap	3.76	2.96		0.65	0.16	0.03											
Well	45-80-02	Bw1	5.01	3.35	0.71	0.06	0.14	0.83	0.19	0.03	348	19.28	<0.01	20.41	24.05	35.44	15.21	62.61	56.32
drained	45-80-03	Bw2	4.80	3.25		0.84	0.13	0.03											
	45-80-04	Bw3	4.58	3.20		1.15	0.11	0.07											
	45-80-05	Bx1	4.84	3.36	0.78	0.03	0.14	0.93	0.17	0.07	307	<0.01	<0.01	25.69	26.45	35.68	16.08	62.53	58.96
	45-80-06	Bx2	5.09	3.63		1.17	0.11	0.08											
	45-80-07	Bx3	4.84	3.36	0.83	0.02	0.16	1.15	0.16	0.07	283	<0.01	<0.01	20.48	28.53	36.06	15.78	66.79	64.81
	45-80-08	C	3.95	3.56		1.31	0.13	0.06											
	45-80-09	R																	

Table 3. Cont. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
									Early Wisconsinan Glacial Till										
Leck Kill Well drained	41-39-01	Ap	2.93	2.48	0.33	0.16	0.06	0.75	0.23	0.14	440	243	<0.10	13.13	14.50	32.21	16.07	53.00	40.94
	41-39-02	E	3.66	3.48	0.43	0.12	0.09	1.10	0.28	0.04	335	75	<0.10	14.10	18.62	41.95	16.36	53.94	56.18
	41-39-03	BE	3.63	3.90	0.37	0.13	0.06	1.04	0.27	0.02	269	86	<0.10	16.35	17.42	44.75	11.80	53.47	65.52
	41-39-04	Bt1	3.56	4.25	0.31	0.08	0.04	1.19	0.25	0.02	342	176	<0.10	17.14	17.31	47.73	10.67	45.75	68.15
	41-39-05	Bt2	3.83	4.40	0.25	0.05	0.03	1.16	0.25	0.02	358	194	<0.10	20.55	17.44	77.78	11.64	47.36	72.03
	41-39-06	BC1	3.19	3.87	0.21	0.03	0.03	1.01	0.23	0.02	371	156	<0.10	17.65	15.92	36.95	12.22	46.73	63.15
	41-39-07	BC2	2.42	3.19	0.18	0.02	0.02	0.81	0.20	0.03	216	89	<0.10	18.09	14.37	28.74	16.98	44.81	52.06
	41-39-08	C1	2.84	3.56	0.22	0.02	0.02	0.92	0.21	0.04	409	109	<0.10	19.75	15.77	30.64	15.93	45.96	54.27
	41-39-09	C2	2.73	3.27	0.20	0.01	0.02	0.91	0.19	0.06	361	25	<0.10	21.09	16.67	30.97	19.80	45.48	53.57
	41-39-10	C3	2.66	3.34	0.20	0.01	0.02	1.06	0.21	0.04	236	28	<0.10	19.77	16.60	32.41	14.13	49.30	55.59
Leck Kill Well drained	41-40-01	Ap	3.36	2.98	0.27	0.11	0.05	1.08	0.23	0.11	603	246	<0.10	13.88	12.73	38.34	16.41	56.01	47.57
	41-40-02	BA	3.90	3.63	0.31	0.07	0.05	1.45	0.26	0.02	350	76	<0.10	17.80	17.27	49.35	13.51	50.80	58.52
	41-40-03	Bt1	3.81	4.78	0.28	0.06	0.04	1.61	0.27	0.02	312	132	<0.10	20.59	22.65	50.61	11.52	56.27	76.04
	41-40-04	Bt2	3.70	4.80	0.24	0.03	0.03	1.36	0.29	0.03	438	201	<0.10	21.09	19.99	50.09	19.13	52.91	74.72
	41-40-05	BC1	3.35	4.16	0.20	0.02	0.03	1.30	0.27	0.04	480	150	<0.10	20.68	16.93	42.91	21.60	48.43	67.16
	41-40-06	BC2	3.63	4.67	0.25	0.01	0.03	1.57	0.24	0.05	519	80	<0.10	23.07	23.75	48.75	17.57	56.89	73.35
	41-40-07	BC3	3.28	4.05	0.20	0.01	0.03	1.32	0.26	0.04	1	46	<0.10	19.35	21.07	46.40	17.51	52.10	65.44
	41-40-08	C1	3.23	4.11	0.22	0.01	0.02	1.18	0.24	0.04	422	12	<0.10	19.39	20.16	38.96	16.20	52.13	65.64
	41-40-09	C2	2.72	4.25	0.23	0.01	0.02	1.14	0.26	0.07	676	31	<0.10	21.66	22.42	42.80	21.94	59.32	70.28
	41-40-10	C3	2.78	4.21	0.40	0.15	0.04	1.48	0.23	0.08	512	110	<0.10	27.58	28.29	46.37	24.99	72.69	80.17

Table 3. Cont. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
											Pre Wisconsinan Glacial Till								
Allenwood Well drained	41-42-01	Ap	3.94	2.98	0.32	0.21	0.09	1.04	0.22	0.13	910	313	<0.10	33.66	22.47	51.19	19.00	100.40	54.33
	41-42-02	E	4.39	3.88	0.40	0.14	0.10	1.62	0.25	0.04	365	51	<0.10	21.30	21.87	54.65	16.69	60.66	73.34
	41-42-03	BA	4.89	4.81	0.44	0.15	0.08	1.87	0.22	0.01	295	42	<0.10	31.34	23.22	66.07	12.04	57.20	88.94
	41-42-04	Bt1	4.71	5.78	0.38	0.15	0.06	2.02	0.26	0.01	524	61	<0.10	32.38	26.75	77.67	11.75	63.82	102.90
	41-42-05	Bt2	4.75	5.94	0.30	0.06	0.05	1.65	0.31	0.01	409	314	<0.10	30.15	26.34	79.47	13.09	55.30	99.69
	41-42-06	Bt3	4.95	6.08	0.39	0.05	0.05	1.80	0.30	0.01	391	142	<0.10	32.94	30.17	75.41	13.83	62.35	109.90
	41-42-07	Bt4	5.07	5.94	0.44	0.05	0.06	2.35	0.29	0.02	559	100	<0.10	38.10	36.27	71.54	17.40	69.71	118.40
	41-42-08	BC1	4.61	5.72	0.35	0.03	0.06	2.19	0.27	0.04	657	71	<0.10	36.13	31.95	61.58	51.93	67.26	116.10
	41-42-09	BC2	7.04	5.81	0.46	0.05	0.07	1.89	0.19	0.05	213	105	<0.10	45.74	36.07	70.01	49.28	63.38	110.20
	41-42-10	BC3	5.63	5.18	0.38	0.02	0.06	1.59	0.20	0.08	569	77	<0.10	37.72	39.72	65.09	54.09	60.58	99.33
	41-42-11	C1	5.08	5.16	0.42	0.01	0.06	1.55	0.20	0.07	946	58	<0.10	36.30	42.89	63.01	34.35	65.35	97.91
	41-42-12	C2	7.69	5.50	0.71	0.01	0.08	2.29	0.22	0.11	620	39	<0.10	39.84	40.91	69.53	36.36	67.45	112.90
	41-42-13	C3	5.79	5.49	0.47	0.01	0.06	1.71	0.22	0.08	604	75	<0.10	34.64	45.42	65.92	38.62	73.30	110.10
	41-42-14	2Cr	6.83	7.19	0.51	0.01	0.08	2.13	0.25	0.16	412	76	<0.10	44.27	61.22	89.98	52.00	106.80	140.60
Allenwood Well drained	60-08-03	A	2.73	1.90	0.23	0.08	0.07	0.69	0.17	0.04	550	248	<0.10	10.52	8.69	24.22	5.87	39.18	31.37
	60-08-04	E	3.42	2.11	0.28	0.04	0.07	0.77	0.16	0.06	473	109	<0.10	7.99	8.87	30.79	8.53	31.14	30.35
	60-08-05	BA	4.70	3.38	0.34	0.02	0.07	1.09	0.23	0.02	213	205	<0.10	11.41	14.53	46.12	9.11	30.04	55.34
	60-08-06	Bt1	6.50	5.16	0.36	0.01	0.06	1.41	0.27	0.01	491	262	<0.10	16.85	21.33	72.99	11.06	32.86	92.35
	60-08-07	Bt2	6.55	5.26	0.37	0.01	0.06	1.42	0.29	0.01	77	118	<0.10	17.53	22.03	72.70	11.35	31.12	93.09
	60-08-08	Bt3	8.61	5.57	0.67	0.02	0.07	1.87	0.37	0.01	251	31	<0.10	20.46	22.47	74.38	13.55	45.16	75.10
	60-08-09	Bt4	8.89	5.87	0.68	0.02	0.06	2.00	0.48	0.01	191	37	<0.10	17.09	20.66	78.57	15.56	36.27	82.34
	60-08-10	BC	9.15	6.72	0.69	0.02	0.07	2.11	0.41	0.01	310	22	<0.10	21.13	23.31	82.75	15.71	40.49	90.94
	60-08-11	C1	8.65	7.18	0.70	0.02	0.06	2.05	0.33	0.01	310	10	<0.10	30.26	27.33	71.14	15.01	52.10	94.86
	60-08-12	C2	9.01	6.54	0.75	0.02	0.07	2.37	0.37	0.01	240	0	<0.10	29.98	29.20	71.92	15.74	48.66	88.30
	60-08-13	2Bt1b	9.00	9.02	1.04	0.01	0.07	3.09	0.52	0.03	646	25	<0.10	22.15	38.15	87.63	23.77	54.52	155.50
	60-08-14	2Bt2b	9.53	9.06	0.86	0.01	0.06	2.56	0.47	0.04	595	70	<0.10	30.91	42.25	89.14	25.57	64.91	142.80

Table 3. Cont. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
								Colluvial/Residual											
Sweden Well drained	41-56-03	E	1.27	0.37				0.25	0.13	0.01									
	41-56-04	Bhs	4.42	2.21				0.58	0.16	0.03									
	41-56-05	Bw1	3.16	1.77				0.50	0.13	0.01									
	41-56-06	Bw2	4.25	2.28				0.61	0.17	0.01									
	41-56-07	Bt1	6.03	3.44				0.73	0.23	0.01									
	41-56-08	Bt2	5.83	3.46				0.74	0.20	0.01									
	41-56-09	2Btb1	6.86	3.97				0.76	0.27	0.01									
	41-56-10	2Btb2	6.56	4.22				0.76	0.26	0.01									
	41-56-11	2Btb3	6.22	4.18				0.69	0.21	0.01									
	41-56-12	2Btb4	7.53	4.29				0.80	0.23	0.01									
	41-56-13	2Btb5	6.92	3.58				0.82	0.25	0.01									
	41-56-14	3BC1	9.09	2.42				1.88	0.32	0.01									
	41-56-15	3BC2	.	.				.	.	.									
	41-56-16	3Cg1	11.00	1.24				2.51	0.35	0.00									
	41-56-17	3Cg2	.	.				.	.	.									
	41-56-18	3Cg3	10.30	0.94				2.26	0.31	0.00									
	41-56-19	3Cg4	.	.				.	.	.									
	41-56-20	3Cg5	10.10	0.92				2.40	0.34	0.00									
Sweden Well drained	53-05-04	E	.	.				.	.	.									
	53-05-05	Bw1	5.04	2.83				0.87	0.23	0.10									
	53-05-06	Bw2	5.81	3.27				0.82	0.24	0.06									
	53-05-07	Bw3	6.08	3.67				1.06	0.17	0.04									
	53-05-08	Bt1	6.49	3.91				1.12	0.17	0.04									
	53-05-09	2Btb1	9.58	5.66				1.49	0.22	0.03									
	53-05-10	2Btb2	0.30	6.09				1.45	10.22	0.03									
	53-05-11	2Btb3	9.73	5.78				1.43	0.19	0.06									
	53-05-12	2Btb4	8.06	4.86				1.16	0.17	0.03									
	53-05-13	2Btb5	0.40	5.76				1.54	10.21	0.13									
	53-05-14	3Crt1	9.84	6.69				1.42	0.19	0.11									
	53-05-15	3Crt2	8.63	4.38				1.27	0.19	0.07									
	53-05-16	3Crt3	.	.				.	.	.									

Table 3. Cont. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
								Colluvial/Residual											
Sweden	59-27-03	E	2.19	0.59	0.11	0.03	0.05	0.42	0.21	0.08	206	70	<0.10	4.68	6.65	35.65	6.56	11.87	12.37
Well	59-27-04	Bhs	4.13	2.29	0.23	0.04	0.08	0.72	0.27	0.02	459	164	<0.10	1.54	9.49	32.37	8.51	30.70	32.45
drained	59-27-05	Bw1	5.32	2.42	0.33	0.06	0.10	0.99	0.30	0.02	304	138	<0.10	6.04	16.58	50.36	17.12	70.99	33.78
	59-27-06	Bw2	5.89	2.77	0.50	0.05	0.12	1.16	0.29	0.02	644	219	<0.10	6.70	22.51	58.69	13.44	59.29	39.85
	59-27-07	Bt1	6.71	3.11	0.41	0.03	0.09	1.33	0.29	0.02	196	119	<0.10	11.30	18.43	51.29	14.41	50.62	44.09
	59-27-08	2Btb1	8.49	3.86	0.43	0.02	0.07	1.53	0.38	0.01	218	179	<0.10	16.35	22.48	61.97	16.05	57.57	51.21
	59-27-09	2Btb2	8.90	3.96	0.46	0.02	0.08	1.57	0.38	0.01	221	141	<0.10	17.97	24.66	65.45	16.05	64.42	60.63
	59-27-10	2Btb3	9.46	4.19	0.44	0.02	0.07	1.58	0.34	0.01	214	89	<0.10	17.21	25.87	75.46	14.07	60.35	57.34
	59-27-11	2Btb4	9.22	3.44	0.39	0.02	0.08	1.84	0.31	0.01	276	50	<0.10	12.46	19.47	63.85	11.62	39.37	44.48
	59-27-12	2Btb5	9.04	3.34	0.38	0.01	0.07	1.78	0.32	0.01	217	62	<0.10	12.69	20.32	64.93	12.38	50.82	51.65
	59-27-13	2Btb6	9.10	3.65	0.37	0.01	0.07	1.84	0.37	0.01	207	37	<0.10	13.71	20.66	70.99	13.16	68.84	58.71
	59-27-14	2Btb7	9.34	3.36	0.41	0.02	0.07	1.89	0.30	0.01	283	26	<0.10	16.96	19.20	68.29	12.67	46.83	44.84
	59-27-15	2Btb8	9.49	3.75	0.41	0.01	0.07	1.91	0.35	0.01	152	13	<0.10	23.55	19.97	64.37	14.83	52.53	48.51
	59-27-16	2Btb9	7.25	2.91	0.30	0.01	0.06	1.75	0.35	0.01	229	43	<0.10	12.33	16.46	55.09	12.96	39.86	38.84
	59-27-17	2BC	7.46	2.18	0.28	0.01	0.09	1.88	0.33	0.01	179	0	<0.10	7.87	14.79	55.15	12.65	47.60	40.33
	59-27-18	2Crt1	9.07	4.98	0.37	0.02	0.08	1.92	0.40	0.02	269	20	<0.10	24.88	21.36	65.83	20.89	93.79	66.39
	59-27-19	2Crt2	8.83	4.70	0.43	0.28	0.08	1.70	0.28	0.01	452	51	<0.10	29.78	22.97	64.41	13.85	78.99	59.93
	59-27-20	2R	4.39	0.68	0.15	0.01	0.04	1.19	0.08	0.00	114	0	<0.10	<0.10	4.00	17.33	2.82	9.74	9.88
Cookport	41-53-03	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Moderately	41-53-04	E	1.65	0.28	0.07	0.01	0.02	0.20	0.13	0.03	88	22	<0.10	2.55	2.00	8.99	3.30	<0.10	8.47
well	41-53-05	Bt1	4.34	2.11	0.40	0.05	0.08	0.78	0.15	0.09	135	66	<0.10	4.25	11.97	31.08	7.15	19.24	35.51
drained	41-53-06	Bt2	5.75	3.38	0.68	0.06	0.12	1.18	0.20	0.14	124	38	<0.10	10.58	20.56	48.33	10.26	36.57	60.01
	41-53-07	Bxt1	4.96	2.39	0.52	0.07	0.12	1.07	0.17	0.39	282	0	<0.10	12.51	17.37	33.73	14.23	29.43	44.74
	41-53-08	Bxt2	5.02	2.49	0.54	0.10	0.12	1.06	0.14	0.35	264	0	<0.10	14.68	19.79	31.55	11.27	33.52	43.59
	41-53-09	Bxt3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	41-53-10	Bxt4	5.17	2.63	0.52	0.11	0.12	1.08	0.16	0.47	329	2	<0.10	12.13	18.35	36.07	15.81	31.03	45.80
	41-53-11	Bxt5	5.05	2.57	0.50	0.09	0.09	0.95	0.14	0.40	356	27	<0.10	11.97	19.86	34.74	13.23	30.47	44.02

Table 3. Cont. Total elemental composition of soil horizons from Northeastern Pennsylvania. Physical and additional chemical data are given in Ciolkosz and Thurman (1993). These samples were also a part of a study on iron and aluminum in Pennsylvania soils (Ciolkosz et al., 1993).

Soil			Percent (Parts Per Hundred)								mg/kg (Parts Per Million)								
Name Drainage	Number	Horizon	Al	Fe	Mg	Ca	Na	K	Ti	Mn	P	S	Cd	Cu	Ni	Cr	Co	Zn	B
									Colluvial/Residual										
Cookport	41-53-12	BC1	4.79	2.35	0.46	0.08	0.09	0.93	0.17	0.30	349	44	<0.10	12.78	18.28	32.36	10.66	29.15	40.99
Moderately	41-53-13	BC2	5.15	2.61	0.49	0.10	0.11	0.98	0.19	0.37	400	55	<0.10	10.46	19.74	32.92	12.29	35.53	43.43
well	41-53-14	BC3	6.55	2.74	0.43	0.05	0.07	1.17	0.21	0.33	404	35	<0.10	13.47	20.58	43.03	18.30	32.63	48.96
drained	41-53-15	2Btb1	7.87	4.25	0.43	0.03	0.02	1.11	0.23	0.18	334	28	<0.10	20.31	23.98	55.37	16.10	55.41	72.21
	41-53-16	2Btb2	8.02	4.83	0.42	0.03	0.02	0.97	0.22	0.14	438	39	<0.10	22.41	28.27	57.68	15.28	65.59	77.01
	41-53-17	2Btb3	5.67	3.26	0.31	0.02	0.02	1.07	0.17	0.06	168	0	<0.10	14.83	14.30	36.54	7.32	37.86	56.70
	41-53-18	2Btb4	6.04	3.66	0.33	0.02	0.02	1.18	0.20	0.06	195	18	<0.10	15.29	16.30	43.78	9.40	44.07	62.48
	41-53-19	3C1	3.63	2.09	0.18	0.01	0.01	0.62	0.09	0.99	229	42	<0.10	12.53	10.39	26.65	14.94	20.05	34.59
	41-53-20	3C2	3.15	1.25	0.16	0.01	0.01	0.53	0.11	0.06	161	31	<0.10	10.87	7.80	24.46	7.15	11.65	23.90
	41-53-21	3C3	4.11	2.57	0.19	0.01	0.01	0.76	0.12	0.26	289	37	<0.10	14.99	10.36	24.11	10.72	25.43	40.89
Nolo	41-54-04	A	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poorly	41-54-05	Eg	2.09	0.72	0.20	0.03	0.04	0.42	0.96	0.01	163	36	<0.10	3.19	6.32	18.46	5.15	11.09	14.57
drained	41-54-06	Btg1	4.72	2.93	0.58	0.08	0.10	1.00	0.16	0.29	369	8	<0.10	12.48	18.15	43.30	12.20	43.45	52.18
	41-54-07	Btg2	4.23	2.14	0.50	0.08	0.10	0.87	0.14	0.21	267	14	<0.10	12.68	14.79	35.31	9.93	32.21	38.77
	41-54-08	Bx1	4.43	3.09	0.41	0.09	0.09	0.88	0.15	0.22	394	0	<0.10	12.47	18.33	42.45	10.19	35.65	48.82
	41-54-09	Bx2	2.92	1.91	0.23	0.04	0.03	0.50	0.08	0.26	273	21	<0.10	9.17	10.62	26.75	9.94	104.60	30.77
	41-54-10	Bx3	3.96	1.63	0.31	0.09	0.09	0.79	0.14	1.15	271	3	<0.10	10.24	16.85	32.67	7.95	22.10	30.02
	41-54-11	Bx4	2.98	1.40	0.25	0.06	0.04	0.47	0.13	0.22	205	21	<0.10	7.02	10.91	23.03	6.83	28.82	24.24
	41-54-12	Bx5	3.51	1.49	0.29	0.09	0.11	0.61	0.13	0.19	217	6	<0.10	8.27	12.17	26.62	6.54	32.18	26.01
	41-54-13	BC	3.11	1.29	0.23	0.05	0.04	0.53	0.16	0.21	188	24	<0.10	8.76	10.87	23.67	7.16	27.54	24.27
	41-54-14	2Cg1	7.44	1.27	0.29	0.02	0.05	0.05	0.31	0.00	108	0	<0.10	16.95	20.47	71.37	9.05	34.04	30.83
	41-54-15	2Cg2	7.19	0.95	0.30	0.02	0.04	0.04	0.21	0.00	89	0	<0.10	13.85	19.51	58.98	7.42	46.49	42.10
	41-54-16	2Cg3	6.42	0.89	0.28	0.02	0.03	0.03	0.18	0.00	127	0	<0.10	13.99	19.06	46.79	7.74	47.23	24.62
	41-54-17	2Cg4	6.03	0.85	0.27	0.02	0.03	0.03	0.17	0.00	80	0	<0.10	17.40	20.77	47.63	8.38	48.71	22.37

Table 4. Total elemental composition of a Hagerstown profile sampled in State College, PA, on the Penn State campus Alexander et al., 1939). Additional physical and chemical data are also given by Alexander et al. (1939).

Soil			Percent											
Series Drainage	Number	Horizon	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	SO_3	LOI*	Sum
							Limestone								
Hagerstown	14-00-01(C-798)+	A	68.00	10.00	3.88	0.28	0.22	0.06	1.30	0.74	0.17	0.82	0.15	14.10	99.72
Well	14-00-02(C-799)	E	75.79	10.34	4.15	0.18	0.26	0.11	1.48	0.87	0.14	0.54	0.06	5.86	99.78
drained	14-00-03(C-800)	BE	74.58	12.64	5.10	0.33	0.22	0.04	1.62	0.86	0.11	0.20	0.07	4.50	100.27
	14-00-04(C-801)	Bt	63.09	19.29	7.08	0.54	0.18	0.01	1.47	0.76	0.08	0.10	0.06	7.11	99.76
	14-00-05(C-802)	C	57.18	23.02	8.01	0.67	0.04	0.01	1.76	0.67	0.09	0.09	0.02	8.21	99.76
	14-00-06(C-3336)	R	5.35	1.04	0.32	2.67	48.99	0.01	0.60	0.05	0.02	0.02	0.08	40.37	99.51

* Loss on Ignition

\+ Number used by Alexander et al. (1939).

Table 5. County names and numbers for soils in Tables 1 to 4. The first set of numbers in the listing is the county number; the second, the site number; and the third, the horizon number. For example, in the number 02-20-03, 02 = Allegheny County.

County		County		County	
Number	Name	Number	Name	Number	Name
02	Allegheny	14	Centre	60	Union
04	Beaver	41	Lycoming	63	Washington
06	Berks	45	Monroe	65	Westmoreland
08	Bradford	53	Potter	25*	Delaware
10	Butler	59	Tioga		

* New York County. The rest of the counties are in Pennsylvania.

Agronomy Series Publications on the Pennsylvania State University Soil Characterization Laboratory

No. 25	Cunningham et al. 1972. Laboratory Characterization Data and Field Descriptions of Selected Pennsylvania Soils. (This publication gives all the Pennsylvania soil characterization data up to 1972. Following 1972, data was published in the PA Ag Expt. Station Progress report series Characteristics, Interpretations, and Uses of Pennsylvania Soils: Number 290, Dauphin Co.; 295, Northampton Co.; 300, Huntingdon Co.; 306, Warren Co.; 316, Armstrong Co.; 320, Bradford Co.; 323, Bedford Co.; 324 Bucks Co.; 326, Butler Co.; 341, Soils Developed from Cherty Limestone Material; 344, Soils Developed from Colluvium; 355, Soils Developed from Redbeds and Calcareous Material; 362, Soils Developed from Acid Shale; 381, Minesoils. All of the data listed above plus subsequent data obtained is now in the following computer database: Ciolkosz, E. J. and N. C. Thurman. 1993. Pennsylvania State University Soil Characterization Laboratory Database, Agronomy Dept., Pennsylvania State University, University Park, PA.)
No. 112	Ciolkosz, E. J. and R. R. Dobos. 1991. Pennsylvania State University Soil Characterization Laboratory Data Summary for Standard Samples.
No. 117	Thurman, N. C., E. J. Ciolkosz, and R. R. Dobos. 1992. Pennsylvania State University Soil Characterization Laboratory Methods Manual.
No. 118	Thurman, N. C. and E. J. Ciolkosz. 1992. A Comparison of Soil Characterization Laboratory Methods.
No. 124	Ciolkosz, E. J. and N. C. Thurman. 1992. Pennsylvania State University Soil Characterization Laboratory Database System.
No. 132	Ciolkosz, E. J. and N. C. Thurman. 1994. Listing of Characterized Soils in Pennsylvania.

Agronomy Series Publications on the Distribution and Genesis of Pennsylvania Soils

No. 21	Ciolkosz E. J., G. J. Latshaw, R. L. Cunningham, and W. D. Sevon. 1971. Parent Material, Topography, and Time as Soil Forming Factors in Eastcentral Pennsylvania.
No. 52	Marchand, D. E., E. J. Ciolkosz, M. F. Bucek, and G. H. Crowl. 1978. Quaternary Deposits and Soils of the Central Susquehanna Valley of Pennsylvania.
No. 64	Ciolkosz, E. J. et al. 1980. Soils and Geology of Nittany Valley.
No. 80	Ciolkosz, E. J., G. W. Petersen, R. L. Cunningham, and R. C. Cronce. 1983. Geomorphology and Soils of Nittany Valley.
No. 92	Ciolkosz, E. J., R. C. Cronce, and W. D. Sevon. 1986. Periglacial Features in Pennsylvania.
No. 95	Ciolkosz, E. J. and R. L. Cunningham. 1987. Location and Distribution of Soils of the World, United States, and Pennsylvania.
No. 100	Ciolkosz, E. J., T. W. Gardner, and R. R. Dobos. 1988. Paleosols in Pennsylvania.
No. 103	Ciolkosz, E. J. and R. R. Dobos. 1989. Distribution of Soils of the Northeastern United States.
No. 105	Ciolkosz, E. J., R. C. Cronce, and R. R. Dobos. 1989. Amorphous Material in Pennsylvania Soils.
No. 108	Ciolkosz, E. J. and R. R. Dobos. 1990. Color and Mottling in Pennsylvania Soils.
No. 116	Ciolkosz, E. J. and N. C. Thurman. 1992. Geomorphology and Soils of the Northeastern United States and Pennsylvania: A Series of Reprints.
No. 119	Ciolkosz, E. J., W. J. Waltman, and N. C. Thurman. 1992. Fragipans in Pennsylvania Soils.
No. 120	Clark, G. M. et al. 1992. Central Appalachian Periglacial Geomorphology: A Field Excursion Guidebook.
No. 125	Thorn, C. E., G. M. Clark, and E. J. Ciolkosz. 1993. Frost Action Environments.
No. 126	Ciolkosz, E. J., A. W. Rose, W. J. Waltman, and N. C. Thurman. 1993. Total Elemental Analysis of Pennsylvania Soils.
No. 127	Ciolkosz, E. J., W. J. Waltman, and N. C. Thurman. 1993. Iron and Aluminum in Pennsylvania Soils.
No. 128	Ciolkosz, E. J., M. K. Amistadi, and N. C. Thurman. 1993. Metals in Pennsylvania Soils.
No. 131	Ciolkosz, E. J., N. C. Thurman, W. J. Waltman, D. L. Cremeens, and M. D. Svoboda. 1994. Argillic Horizons in Pennsylvania Soils.
No. 133	Ciolkosz, E. J. and W. J. Waltman. 1995. Cambic Horizons in Pennsylvania Soils.
No. 135	Ciolkosz, E. J., R. C. Cronce, W. D. Sevon, and W. J. Waltman. 1995. Genesis of Pennsylvania's Limestone Soils.

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