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Iron and Aluminum in Pennsylvania Soils

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William J. Waltman,
and
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Introduction

Iron and aluminum are two of the most abundant elements of the earth's crust. Iron (expressed as Fe_2O_3) makes up approximately 7 percent of the earth's crust and from 1 to 7 percent of various rocks (Jackson, 1964). The iron content of soils usually ranges from 1 to 6 percent (as Fe_2O_3) but can be as much as 20 to 80 percent in some highly weathered tropical soils (Jackson, 1964). Aluminum (expressed as Al_2O_3) makes up from 2 to 12 percent of most soils but can be concentrated to as great as 20 to 60 percent by weathering processes (Jackson, 1964).

Iron and aluminum occur as both primary and secondary minerals in the soil. As the soil weathers, the iron in primary silicate minerals is released and forms secondary iron oxide minerals such as geothite (FeOOH) and hematite (Fe_2O_3). The aluminum in primary silicate minerals frequently weathers into secondary silicate minerals such as kaolinite, although aluminum oxide minerals such as gibbsite can also be formed. The formation of secondary iron oxides is a function of weathering processes over time. Methods to extract the various iron oxides offer a unique opportunity to use ratios of the amount of iron in the oxide minerals to the total amount of iron in the soil as an index of soil development.

Because of the lack of good information on the rate of soil development in Pennsylvania, a study was initiated to compare the iron and aluminum content of red and brown Wisconsinan Age (18,000 years old) glacial till soils to Pre-Wisconsinan Age (greater than 120,000 years old) till soils. Some Pre-Wisconsinan Age soils that had been truncated and had Wisconsinan Age colluvium deposited on their surface were also included in the study. A second set of samples that were part of a soil-radon study (Washington, 1991; Greeman, 1992) were also included in this study. These soils have developed from an array of parent materials.

Materials and Methods

Twenty-six soil profiles (pedons) -- nineteen from Pennsylvania and seven from southeastern New York -- are included in the study. Eight pedons from Pennsylvania are from the radon study; the remaining pedons are from the till-colluvium study. Analyses were performed on the fine earth (< 2 mm) soil material from all of the soils. Total analysis (Fe, Al, Ti, Mn, and K) of the till-colluvium study samples was done by the Cornell University College of Agricultural and Life Sciences (CALS) analytical laboratory. The Cornell Laboratory used the HF dissolution method of Lim and Jackson (1982) and inductive coupled plasma (ICP) spectrometry to determine elemental concentrations (McClenahan and Ferguson, 1989). For the till-colluvium samples, iron and aluminum were also extracted by the oxalate-in-the-dark method (SSLS, 1992) and the citrate-bicarbonate-dithionite (CBD) method of Mehra and Jackson (1960) as presented by Thurman et al. (1992). The extracted iron and aluminum were then determined by ICP or atomic absorption spectrometry (Thurman et al., 1992). These data are given in Table 1.

Total analysis of the radon study samples was done by the Penn State Mineral Characterization Laboratory using plasma spectrometry after fusion in $LiBO_3$ (Suhr and Gong, 1983). CBD-extractable iron was determined by the method of Mehra and Jackson (1960) as presented by Thurman et al. (1992). These data are presented in Table 2. The soil characterization data for the Pennsylvania soils are given by Ciolkosz and Thurman (1993); data for the New York soils were obtained from the Cornell University Soil Characterization Laboratory.

A number of the Pennsylvania soils were also included in the following studies:
(1) Amorphous material in Pennsylvania soils (Ciolkosz et al., 1989);
(2) Total elemental analysis of Pennsylvania soils (Ciolkosz et al., 1993); and
(3) Metals in Pennsylvania soils (Ciolkosz et al., 1993).

Results and Discussion

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

Iron

1. The iron content in the soils shows concentration trends in the order of:

   oxalate-extractable Fe < CBD-extractable Fe < total Fe (Table 1).

   This result has been reported for terrace chronosequences in Nevada (Alexander, 1974) and in Italy (Arduino et al., 1984). The order of the sequence is expected since oxalate extracts amorphous iron and very little iron from crystalline materials (McKeague et al., 1991), while CBD extracts iron from amorphous and crystalline oxides but not from silicate minerals (Blume and Schwertmann, 1969). The total iron extract includes amorphous and crystalline iron oxides and silicate iron.

2. The amount of total iron does not vary greatly among the soils in this study except where it has been concentrated by in situ weathering (e.g., the Allenwood and Hagerstown soils), eluviation/illuviation processes (E and Bt horizons), or various oxidation/reduction processes (Pope 2C2 horizon). The one major exception appears to be that soils developed from sandstone generally show a lesser amount of total iron than do other soils (Tables 1 and 2). Of particular note is the observation that the red and brown Wisconsinan Age till soils do not vary greatly in total or CBD iron, although their colors are strikingly different.

3. In general, horizons that have more clay also have a greater amount of total iron. This relationship is much stronger in well drained, well developed (older) soils such as Leck Kill and Allenwood. The strong relationship between clay and total iron in well developed, well drained argillic horizons is evident in the relatively constant, low total iron to clay ratio (Table 3).

4. The amount of oxalate iron is highest in the younger soils (Wisconsinan age tills). According to Alexander (1974) this trend results from a release of iron from primary minerals during the initial stages of weathering at a rate that exceeds the rate of crystallization of secondary iron oxide minerals. As soils age, the release rate of iron decreases and the amorphous, oxalate iron crystallizes into iron oxide minerals. In the soils studied, particularly the till soils from New York, the upper horizons show the effect of Podzolation, in which amorphous iron and aluminum have been complexed and eluviated into Bw horizons. This trend shows up in the oxalate iron and aluminum data in Table 1 as well as in the oxalate to total iron and aluminum ratio data in Table 3.

5. The amount of crystalline iron oxides (CBD iron) is higher in the older soils (Pre-Wisconsinan vs. Wisconsinan Ages). This type of relationship has been used by a number of researchers in an attempt to show soil development and relative age differences between soils (Alexander, 1974; Arduino et al., 1984; Swanson et al., 1993; Blume and Schwertmann, 1969). In particular, ratios of oxalate to CBD iron (Alexander, 1974) and CBD minus oxalate to total iron have been used (Arduino et al., 1984). The second of these ratios separates Wisconsinan Age till from early-Wisconsinan and Pre-Wisconsinan till soils while the first ratio does not make a useful separation (Table 3). In addition, the CBD to total iron ratio also appears to make this separation. In fact, this ratio also appears to make a separation between the early and Pre-Wisconsinan soils and may be the best ratio for the separation of these soils into age groupings. Although these ratios appear to make separations, care must be taken in their use because pre-weathered material may give a false impression of age. For example, the Pope soil (young soil on a floodplain) gives a moderate CBD to total iron ratio, and this ratio should not be interpreted to indicate significant soil development.

Aluminum

6. The amount of total aluminum is generally greater than total iron. The amount of CBD-extractable aluminum is slightly higher than oxalate-extractable aluminum, and older soils appear to have slightly greater CBD aluminum than the younger soils. These slight trends and the complicating factor that different parent materials can impact on these type of data led Swanson et al. (1993) to conclude that oxalate and CBD aluminum are of little use for relative dating of glacial deposits.

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Table 1. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
					Late Wisconsinan Brown Till Soils											
Bath	45-79-01	0-25	Ap	10YR 4/2	41.4	42.8	15.8	0.09	0.09	0.56	0.24	3.68	5.70	0.24	0.03	0.98
PA	45-79-02	25-38	Bw1	10YR 5/4	44.3	40.5	15.2	0.09	0.08	0.63	0.21	3.87	6.15	0.23	0.02	1.10
Well	45-79-03	38-64	Bw2	10YR 5/6	45.5	41.3	13.2	0.06	0.05	0.63	0.18	3.82	5.59	0.21	0.03	1.10
drained	45-79-04	64-79	Bx1	10YR 5/4	55.9	35.3	8.8	0.06	0.05	0.63	0.12	5.28	7.51	0.16	0.08	1.95
	45-79-05	79-112	Bx2	10YR 5/4	53.5	36.9	9.6	0.09	0.05	0.63	0.11	4.53	6.90	0.24	0.06	1.61
	45-79-06	112-145	Bx3	10YR 5/4	46.7	39.5	13.8	0.10	0.06	0.63	0.09	5.55	9.09	0.25	0.09	2.23
	45-79-07	145-173	Bx4	10YR 5/3	46.8	37.5	15.7	0.09	0.04	0.63	0.09	5.44	8.01	0.18	0.09	2.36
	45-79-08	173-201	2C	5Y 5/4	57.8	31.7	10.5	0.08	0.05	0.63	0.11	4.55	6.97	0.16	0.07	1.71
	45-79-09	201-216	2R	5Y 5/4	.	.	.	.	.	.	.	.	.	.	.	.
Mardin	25-06-01	0-20	Ap	10YR 4/3	24.4	54.0	21.6	1.00	0.32	1.61	0.53	.	.	.	.	.
NY	25-06-02	20-42	BE	2.5YR 6/4	27.0	53.1	19.9	0.47	0.20	1.42	0.38	5.00	7.30	0.22	0.06	1.50
Moderately	25-06-03	42-66	Bw	10YR 5/4	36.7	50.0	13.3	0.43	0.21	1.07	0.34	4.90	7.00	0.25	0.06	1.50
well	25-06-04	66-91	Bx1	2.5YR 4/3	35.6	54.1	10.3	0.21	0.14	0.80	0.21	4.70	6.70	0.22	0.11	1.50
drained	25-06-05	91-112	Bx2	10YR 4/4	36.2	51.6	12.2	0.38	0.20	0.86	0.26	4.80	6.90	0.27	0.09	1.70
	25-06-06	112-150	Bx3	10YR 4/2	38.1	47.0	14.9	0.18	0.09	0.84	0.11	4.60	6.10	0.19	0.10	1.60
Volusia	25-07-01	0-18	Ap	10YR 4/3	18.3	57.7	24.0	1.33	0.33	1.53	0.46	.	.	.	.	.
NY	25-07-02	18-35	Bw1	10YR 5/6	20.1	56.3	23.6	1.20	0.44	1.76	0.59	4.80	6.50	0.32	0.04	1.20
Somewhat	25-07-03	35-50	Bw2	10YR 5/4	26.3	58.7	15.0	0.41	0.09	0.92	0.19	4.60	6.50	0.28	0.05	1.60
poorly	25-07-04	50-91	Bx1	10YR 4/3	27.8	52.5	19.7	0.20	0.07	1.10	0.13	5.10	7.20	0.24	0.12	2.00
drained	25-07-05	91-146	Bx2	10YR 4/3	27.1	52.5	20.3	0.07	0.05	1.14	0.10	5.20	7.10	0.26	0.10	1.90
	25-07-06	146-160	BC	10YR 4/3	31.5	51.9	16.6	0.02	0.05	1.00	0.11	4.70	6.60	0.21	0.10	1.70
Chippewa	25-08-01	0-9	Ap1	2.5YR 3/2	23.5	41.1	35.4	1.04	0.27	1.00	0.27	.	.	.	.	.
NY	25-08-02	9-22	Eg1	10YR 8/1	28.5	37.4	34.1	1.31	0.29	1.28	0.32	3.70	7.10	0.19	0.17	1.60
Poorly	25-08-03	22-33	Eg2	5YR 6/1	29.7	43.3	27.0	0.59	0.13	0.84	0.18	3.60	7.30	0.22	0.07	1.80
drained	25-08-04	33-49	Bx1	7.5YR 5/3	28.8	56.8	14.4	0.46	0.07	0.82	0.11	4.20	6.20	0.23	0.10	1.80
	25-08-05	49-77	Bx2	10YR 4/3	22.1	59.6	18.3	0.55	0.09	1.06	0.08	4.80	6.60	0.25	0.15	1.90
	25-08-06	77-108	Bx3	2.5YR 5/3	38.1	51.3	10.6	0.20	0.06	1.03	0.08	4.50	5.40	0.20	0.09	1.40

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
					Late Wisconsinan Red Till Soils											
Lackawanna	45-80-01	0-18	Ap	7.5YR 5/4	42.3	45.6	12.1	0.11	0.13	0.98	0.27	2.96	3.76	0.16	0.03	0.65
PA	45-80-02	18-36	Bw1	5YR 4/3	44.8	42.4	12.8	0.08	0.08	0.77	0.19	3.35	5.01	0.19	0.03	0.83
Well	45-80-03	36-51	Bw2	5YR 4/3	44.4	43.9	11.7	0.11	0.09	0.77	0.09	3.25	4.80	0.13	0.03	0.84
drained	45-80-04	51-71	Bw3	5YR 4/3	47.0	40.9	12.1	0.10	0.08	0.70	0.07	3.20	4.58	0.11	0.07	1.15
	45-80-05	71-109	Bx1	2.5YR 4/4	51.7	37.6	10.7	0.07	0.04	0.91	0.05	3.36	4.84	0.17	0.07	0.93
	45-80-06	109-135	Bx2	2.5YR 4/4	49.8	38.5	11.7	0.15	0.07	0.84	0.05	3.63	5.09	0.11	0.08	1.17
	45-80-07	135-163	Bx3	2.5YR 4/4	53.0	36.5	10.5	0.09	0.04	0.91	0.05	3.36	4.84	0.16	0.07	1.15
	45-80-08	163-175	C	5YR 5/3	66.9	24.0	9.1	0.07	0.04	0.84	.	3.56	3.95	0.13	0.06	1.31
	45-80-09	175-201	R	10R 4/2	.	.	.	.	.	.	.	.	.	.	.	.
Lackawanna	25-01-01	0-16	Ap	7.5YR 4/2	38.1	41.9	20.0	0.93	0.28	1.61	0.34	.	.	.	.	.
NY	25-01-02	16-40	BE	7.5YR 4/3	44.9	40.3	14.8	0.42	0.17	1.05	0.26	4.20	5.70	0.20	0.05	1.40
Well	25-01-03	40-57	Bw	7.5YR 4/4	42.8	41.5	15.7	0.53	0.20	0.70	0.14	4.40	6.00	0.23	0.05	1.50
drained	25-01-04	57-107	Bx1	5YR 4/3	43.3	39.5	17.2	0.08	0.11	0.91	0.14	4.40	5.60	0.23	0.09	1.70
	25-01-05	107-150	Bx2	5YR 3/3	52.6	31.4	16.0	0.11	0.08	0.91	0.13	4.20	5.40	0.20	0.10	1.80
	25-01-06	150-200	BC	5YR 3/3	60.1	28.8	11.1	0.62	0.07	0.84	0.10	4.00	4.80	0.20	0.09	1.60
Wellsboro	25-02-01	0-15	Ap	7.5YR 4/3	25.0	46.7	28.3	1.05	0.48	1.33	0.48	.	.	.	.	.
NY	25-02-02	15-50	Bw1	7.5YR 4/4	26.5	46.6	26.9	0.85	0.37	1.54	0.45	4.90	6.70	0.24	0.02	1.90
Moderately	25-02-03	50-68	Bw2	7.5YR 4/4	60.2	30.3	9.5	1.05	0.48	1.54	0.18	3.80	5.10	0.23	0.09	1.40
well	25-02-04	68-100	Bx1	7.5YR 4/2	56.3	35.7	8.0	0.03	0.09	0.56	0.11	3.80	5.30	0.16	0.08	1.30
drained	25-02-05	100-150	Bx2	5YR 4/2	49.0	38.4	12.6	0.15	0.30	0.70	0.12	4.30	5.70	0.21	0.08	1.70
Morris	25-03-01	0-15	Ap	7.5YR 3/2	22.8	48.0	29.2	1.06	0.31	1.40	0.36	.	.	.	.	.
NY	25-03-02	15-38	Bw	7.5YR 4/3	36.1	36.2	27.7	1.25	0.39	1.47	0.45	4.80	6.20	0.24	0.20	1.50
Somewhat	25-03-03	38-58	BE	7.5YR 5/3	45.4	42.4	12.2	0.20	0.07	0.70	0.09	4.20	5.40	0.26	0.09	1.60
poorly	25-03-04	58-75	Bx1	5YR 4/3	44.3	39.7	16.0	0.18	0.07	0.91	0.11	4.50	6.00	0.21	0.21	1.60
drained	25-03-05	75-111	Bx2	5YR 4/3	43.4	39.4	17.6	0.17	0.07	0.98	0.10	4.70	5.70	0.21	0.10	1.80
	25-03-06	111-150	Bx3	5YR 4/3	39.6	40.2	20.2	0.13	0.06	1.19	0.13	4.90	5.40	0.28	0.10	1.80

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
					Late Wisconsinan Red Till Soils											
Norwich	25-04-01	0-16	Ap	7.5YR 4/2	35.6	43.1	21.3	0.29	0.19	1.05	0.26	.	.	.	.	.
NY	25-04-02	16-27	Bw	5YR 4/3	23.9	43.7	32.4	1.14	0.34	2.10	0.43	6.00	7.40	0.34	0.24	2.00
Poorly	25-04-03	27-43	Eg/Bx1	7.5YR 5/3	42.2	44.3	13.5	0.21	0.10	0.98	0.13	4.00	4.40	0.28	0.09	1.30
drained	25-05-04	43-75	Bx2	5YR 4/3	34.5	43.5	22.0	0.19	0.07	1.19	0.14	4.90	6.30	0.24	0.09	1.90
	25-05-05	75-125	Bx3	5YR 4/3	34.8	42.4	22.8	0.10	0.04	1.40	0.13	5.10	6.50	0.23	0.09	2.20
	25-05-06	125-175	Bx4	5YR 4/3	33.7	42.2	24.1	0.08	0.04	1.40	0.14	5.30	6.20	0.28	0.11	2.00
	25-05-07	175-200	2R		.	.	.	.	.	.	.	.	.	.	.	.
					Early Wisconsinan Till Soils											
Leck Kill	41-39-01	0-23	Ap	10YR 3/3	31.2	56.2	12.6	0.20	0.14	1.12	0.18	2.48	2.93	0.23	0.14	0.75
PA	41-39-02	23-30	E	7.5YR 5/6	21.5	56.4	22.1	0.12	0.08	1.12	0.16	3.48	3.66	0.28	0.04	1.10
Well	41-39-03	30-41	BE	5YR 5/6	23.7	52.4	23.9	0.12	0.08	1.26	0.16	3.90	3.63	0.27	0.02	1.04
drained	41-39-04	41-66	Bt1	5YR 4/5	27.9	42.3	29.8	0.11	0.10	2.24	0.29	4.25	3.56	0.25	0.02	1.19
	41-39-05	66-84	Bt2	5YR 4/5	33.9	38.8	27.3	0.16	0.16	1.96	0.20	4.40	3.83	0.25	0.02	1.16
	41-39-06	84-104	BC1	5YR 4/4	38.9	39.9	21.2	0.11	0.09	1.19	0.11	3.87	3.19	0.23	0.02	1.01
	41-39-07	104-124	BC2	5YR 4/4	44.7	38.6	16.7	0.12	0.07	1.12	0.11	3.19	2.42	0.20	0.03	0.81
	41-39-08	124-160	C1	5YR 4/4	42.1	39.9	18.0	0.11	0.07	1.26	0.08	3.56	2.84	0.21	0.04	0.92
	41-39-09	160-206	C2	5YR 4/4	45.7	41.9	12.4	0.11	0.08	1.47	0.10	3.27	2.73	0.19	0.06	0.91
	41-39-10	206-254	C3	5YR 4/4	44.8	40.6	14.6	0.11	0.10	1.47	0.11	3.34	2.66	0.21	0.04	1.06
Leck Kill	41-40-01	0-25	Ap	7.5YR 4/4	31.2	55.6	13.2	0.21	0.14	1.26	0.21	2.98	3.36	0.23	0.11	1.08
PA	41-40-02	25-38	BA	5YR 4/4	33.5	46.5	20.0	0.10	0.07	1.40	0.27	3.63	3.90	0.26	0.02	1.45
Well	41-40-03	38-58	Bt1	5YR 4/5	29.7	45.2	25.1	0.09	0.06	2.17	0.27	4.78	3.81	0.27	0.02	1.61
drained	41-40-04	58-89	Bt2	5YR 4/5	29.8	43.7	26.5	0.12	0.09	2.17	0.24	4.80	3.70	0.29	0.03	1.36
	41-40-05	89-107	BC1	5YR 4/5	30.9	51.5	17.6	0.11	0.09	1.96	0.19	4.16	3.35	0.27	0.04	1.30
	41-40-06	107-132	BC2	5YR 4/4	25.0	53.8	21.2	0.11	0.08	1.82	0.19	4.67	3.63	0.24	0.05	1.57
	41-40-07	132-157	BC3	5YR 4/4	35.5	47.7	16.8	0.09	0.10	1.75	0.16	4.05	3.28	0.26	0.04	1.32
	41-40-08	157-188	C1	5YR 4/4	47.9	40.7	11.4	0.10	0.10	1.61	0.11	4.11	3.23	0.24	0.04	1.18
	41-40-09	188-216	C2	5YR 4/4	45.5	40.4	14.1	0.13	0.12	1.61	0.13	4.25	2.72	0.26	0.07	1.14
	41-40-10	216-249	C3	5YR 4/4	46.2	35.4	18.4	0.13	0.11	1.61	0.15	4.21	2.78	0.23	0.08	1.48

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
								Pre-Wisconsinan Till Soils								
Allenwood	41-42-01	0-23	Ap	10YR 4/3	24.3	56.3	19.4	0.20	0.19	1.75	0.33	2.98	3.94	0.22	0.13	1.04
PA	41-42-02	23-30	E	7.5YR 5/4	21.0	54.6	24.4	0.11	0.08	2.38	0.34	3.88	4.39	0.25	0.04	1.62
Well	41-42-03	30-43	BA	7.5YR 5/6	21.3	46.6	32.1	0.09	0.07	2.73	0.35	4.81	4.89	0.22	0.01	1.87
drained	41-42-04	43-66	Bt1	5YR 5/8	18.0	41.6	40.4	0.11	0.08	2.94	0.38	5.78	4.71	0.26	0.01	2.02
	41-42-05	66-89	Bt2	5YR 5/8	12.7	37.0	50.3	0.15	0.17	2.94	0.39	5.94	4.75	0.31	0.01	1.65
	41-42-06	89-114	Bt3	5YR 5/8	15.6	34.8	49.6	0.14	0.17	2.94	0.39	6.08	4.95	0.30	0.01	1.80
	41-42-07	114-135	Bt4	5YR 5/6	19.3	39.9	40.8	0.12	0.08	2.87	0.34	5.94	5.07	0.29	0.02	2.35
	41-42-08	135-157	BC1	5YR 5/4	22.2	39.7	38.1	0.14	0.12	2.80	0.32	5.72	4.61	0.27	0.04	2.19
	41-42-09	157-188	BC2	5YR 5/4	19.9	41.1	39.0	0.15	0.12	2.80	0.32	5.81	7.04	0.19	0.05	1.89
	41-42-10	188-221	BC3	5YR 5/4	27.6	38.5	33.9	0.17	0.12	2.66	0.32	5.18	5.63	0.20	0.08	1.59
	41-42-11	221-274	C1	7.5YR 5/4	25.9	41.9	32.2	0.19	0.13	2.24	0.22	5.16	5.08	0.20	0.07	1.55
	41-42-12	274-312	C2	7.5YR 5/4	28.3	40.7	31.0	0.21	0.09	2.73	0.29	5.50	7.69	0.22	0.11	2.29
	41-42-13	312-356	C3	7.5YR 5/4	27.4	41.7	30.9	0.28	0.10	2.45	0.27	5.49	5.79	0.22	0.08	1.71
	41-42-14	356-386	2Cr	7.5YR 5/6	26.0	38.2	35.8	.	.	.	.	.	.	.	.	.
Allenwood	60-08-03	0-8	A	10YR 4/3	41.8	49.4	8.8	0.33	0.18	0.56	0.18	1.90	2.73	0.17	0.04	0.69
PA	60-08-04	8-28	E	10YR 6/4	38.3	49.8	11.9	0.13	0.18	0.70	0.22	2.11	3.42	0.16	0.06	0.77
Well	60-08-05	28-43	BA	10YR 6/4	31.2	46.2	22.6	0.08	0.15	1.75	0.32	3.38	4.70	0.23	0.02	1.09
drained	60-08-06	43-66	Bt1	7.5YR 5/6	26.7	31.9	41.4	0.11	0.21	2.52	0.38	5.16	6.50	0.27	0.01	1.41
	60-08-07	66-97	Bt2	5YR 5/6	27.7	33.6	38.7	0.10	0.21	2.52	0.40	5.26	6.55	0.29	0.01	1.42
	60-08-08	97-140	Bt3	5YR 5/8	29.0	30.8	40.2	0.10	0.21	2.87	0.41	5.57	8.61	0.37	0.01	1.87
	60-08-09	140-170	Bt4	5YR 5/8	27.7	28.0	44.3	0.10	0.24	3.36	0.40	5.87	8.89	0.48	0.01	2.00
	60-08-10	170-213	BC	5YR 5/8	30.4	25.7	43.9	0.09	0.25	2.87	0.38	6.72	9.15	0.41	0.01	2.11
	60-08-11	213-239	C1	7.5YR 6/6	34.3	24.9	40.8	0.08	0.21	2.59	0.33	7.18	8.65	0.33	0.01	2.05
	60-08-12	239-279	C2	7.5YR 6/6	36.6	28.7	34.7	0.10	0.16	2.59	0.28	6.54	9.01	0.37	0.01	2.37
	60-08-13	279-335	2Bt1b	7.5YR 5/6	23.1	49.7	27.2	0.12	0.17	.	.	9.02	9.00	0.52	0.03	3.09
	60-08-14	335-391	2Bt2b	7.5YR 5/6	21.5	19.6	58.9	0.21	0.27	.	.	9.06	9.53	0.47	0.04	2.56

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
					Colluvial/Residual Soils											
Sweden	41-56-03	0-5	E	7.5YR 7/2	64.2	32.0	3.8	0.03	0.03	0.14	.	0.37	1.27	0.13	0.01	0.25
PA	41-56-04	5-10	Bhs	7.5YR 5/6	53.0	34.0	13.0	0.26	0.36	1.26	.	2.21	4.42	0.16	0.03	0.58
Well	41-56-05	10-18	Bw1	10YR 6/6	56.5	35.2	8.3	0.12	0.14	0.98	.	1.77	3.16	0.13	0.01	0.50
drained	41-56-06	18-33	Bw2	10YR 6/6	56.1	32.7	11.2	0.13	0.08	1.12	.	2.28	4.25	0.17	0.01	0.61
	41-56-07	33-51	Bt1	5YR 5/6	47.9	28.0	24.1	0.15	0.12	2.31	.	3.44	6.03	0.23	0.01	0.73
	41-56-08	51-71	Bt2	5YR 5/6	46.3	26.3	27.4	0.18	0.13	2.45	.	3.46	5.83	0.20	0.01	0.74
	41-56-09	71-91	2Btb1	5YR 5/6	45.6	25.2	29.2	0.17	0.14	2.73	.	3.97	6.86	0.27	0.01	0.76
	41-56-10	91-114	2Btb2	2.5YR 4/8	41.7	25.4	32.9	0.11	0.15	2.94	.	4.22	6.56	0.26	0.01	0.76
	41-56-11	114-127	2Btb3	2.5YR 4/6	41.9	24.4	33.7	0.12	0.15	3.01	.	4.18	6.22	0.21	0.01	0.69
	41-56-12	127-150	2Btb4	2.5YR 4/6	44.6	24.4	31.0	0.11	0.14	3.01	.	4.29	7.53	0.23	0.01	0.80
	41-56-13	150-163	2Btb5	2.5YR 4/8	52.3	23.6	24.1	0.08	0.10	2.52	.	3.58	6.92	0.25	0.01	0.82
	41-56-14	163-188	3BC1	2.5YR 4/8	30.5	40.4	29.1	0.06	0.07	1.19	.	2.42	9.09	0.32	0.01	1.88
	41-56-15	188-206	3BC2	2.5YR 4/8	29.9	41.2	28.9	.	.	0.84	.	.	.	.	.	.
	41-56-16	206-221	3Cg1	5YR 7/2	14.2	57.1	28.7	0.05	0.07	.	.	1.24	11.00	0.35	0.00	2.51
	41-56-17	221-236	3Cg2	5YR 7/2	30.5	46.8	22.7	.	.	.	.	.	.	.	.	.
	41-56-18	236-251	3Cg3	5YR 7/2	35.8	43.6	20.6	0.05	0.05	0.14	.	0.94	10.30	0.31	0.00	2.26
	41-56-19	251-267	3Cg4	5YR 7/1	38.5	43.1	18.4	.	.	.	.	.	.	.	.	.
	41-56-20	267-284	3Cg5	5YR 7/2	.	.	.	0.04	0.05	0.42	.	0.92	10.10	0.34	0.00	2.40
Sweden	53-05-04	0-3	E	5YR 6/2	38.6	53.0	8.4	.	.	0.63	.	.	.	.	.	.
PA	53-05-05	3-18	Bw1	10YR 5/4	31.8	51.7	16.5	0.28	0.23	1.40	.	2.83	5.04	0.23	0.10	0.87
Well	53-05-06	18-36	Bw2	10YR 5/4	30.6	52.8	16.6	0.17	0.18	1.47	.	3.27	5.81	0.24	0.06	0.82
drained	53-05-07	36-58	Bw3	10YR 5/4	34.0	50.5	15.5	0.15	0.15	1.54	.	3.67	6.08	0.17	0.04	1.06
	53-05-08	58-89	Bt1	7.5YR 4/6	39.0	46.3	14.7	0.13	0.12	1.89	.	3.91	6.49	0.17	0.04	1.12
	53-05-09	89-117	2Btb1	5YR 5/6	38.6	27.7	33.7	0.08	0.17	3.43	.	5.66	9.58	0.22	0.03	1.49
	53-05-10	117-147	2Btb2	5YR 4/6	38.4	24.0	37.6	0.10	0.19	3.78	.	6.09	10.30	0.22	0.03	1.45
	53-05-11	147-170	2Btb3	2.5YR 5/6	40.9	29.5	29.6	0.08	0.15	3.50	.	5.78	9.73	0.19	0.06	1.43
	53-05-12	170-185	2Btb4	2.5YR 4/6	51.0	22.8	26.2	0.06	0.13	3.01	.	4.86	8.06	0.17	0.03	1.16
	53-05-13	185-211	2Btb5	5YR 5/6	47.4	19.8	32.8	0.12	0.17	3.43	.	5.76	10.40	0.21	0.13	1.54
	53-05-14	211-236	3Crt1	5YR 5/6	44.3	22.3	33.4	0.05	0.17	3.08	.	6.69	9.84	0.19	0.11	1.42
	53-05-15	236-259	3Crt2	5YR 5/6	60.0	18.6	21.4	0.06	0.11	2.59	.	4.38	8.63	0.19	0.07	1.27
	53-05-16	259-287	3Crt3	5YR 5/6	56.9	21.7	21.4	.	.	3.15	.	.	.	.	.	.

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
								Colluvial/Residual Soils								
Sweden	59-27-03	0-8	E	10YR 6/1	63.6	30.6	5.8	0.05	0.04	0.28	.	0.59	2.19	0.21	0.08	0.42
PA	59-27-04	8-10	Bhs	7.5YR 4/6	52.0	35.0	13.0	0.45	0.20	1.26	.	2.29	4.13	0.27	0.02	0.72
Well	59-27-05	10-23	Bw1	10YR 5/4	56.4	34.4	9.2	0.14	0.24	0.84	.	2.42	5.32	0.30	0.02	0.99
drained	59-27-06	23-36	Bw2	10YR 5/4	51.7	33.9	14.4	0.12	0.13	1.26	.	2.77	5.89	0.29	0.02	1.16
	59-27-07	36-48	Bt1	7.5YR 5/6	53.0	30.6	16.4	0.07	0.10	1.75	.	3.11	6.71	0.29	0.02	1.33
	59-27-08	48-58	2Btb1	5YR 5/6	46.0	33.3	20.7	0.07	0.13	2.31	.	3.86	8.49	0.38	0.01	1.53
	59-27-09	58-71	2Btb2	5YR 5/6	41.0	23.8	35.2	0.07	0.13	2.73	.	3.96	8.90	0.38	0.01	1.57
	59-27-10	71-89	2Btb3	5YR 5/6	47.9	22.2	29.9	0.07	0.13	2.73	.	4.19	9.46	0.34	0.01	1.58
	59-27-11	89-102	2Btb4	5YR 5/6	57.2	17.4	25.4	0.06	0.11	2.24	.	3.44	9.22	0.31	0.01	1.84
	59-27-12	102-122	2Btb5	2.5YR 6/8	62.0	14.6	23.4	0.06	0.10	2.24	.	3.34	9.04	0.32	0.01	1.78
	59-27-13	122-140	2Btb6	2.5YR 5/6	62.9	15.1	22.0	0.06	0.10	2.45	.	3.65	9.10	0.37	0.01	1.84
	59-27-14	140-168	2Btb7	2.5YR 5/6	57.8	14.9	27.3	0.05	0.11	2.24	.	3.36	9.34	0.30	0.01	1.89
	59-27-15	168-183	2Btb8	5YR 5/6	58.2	13.5	28.3	0.06	0.11	2.59	.	3.75	9.49	0.35	0.01	1.91
	59-27-16	183-208	2Btb9	5YR 5/8	64.6	14.2	21.2	0.05	0.08	1.75	.	2.91	7.25	0.35	0.01	1.75
	59-27-17	208-218	2BC	2.5YR 5/6	73.2	12.6	14.2	0.04	0.06	1.47	.	2.18	7.46	0.33	0.01	1.88
	59-27-18	218-234	2Crt1	5YR 5/8	55.8	15.7	28.5	0.06	0.09	3.15	.	4.98	9.07	0.40	0.02	1.92
	59-27-19	234-249	2Crt2	5YR 6/6	55.5	11.1	33.4	0.08	0.11	3.14	.	4.70	8.83	0.28	0.01	1.70
	59-27-20	249-269	2R	7.5YR 7/8	.	.	.	0.02	0.00	0.35	.	0.68	4.39	0.08	0.00	1.19
Cookport	41-53-03	0-3	A	10YR 3/1	75.6	22.4	2.0	.	.	.	.	.	.	.	.	.
PA	41-53-04	3-18	E	7.5YR 7/2	66.6	26.7	6.7	0.24	0.12	0.20	.	0.28	1.65	0.13	0.03	0.20
Moderately	41-53-05	18-28	Bt1	10YR 6/4	57.6	32.8	9.6	0.19	0.12	1.19	.	2.11	4.34	0.15	0.09	0.78
well	41-53-06	28-43	Bt2	10YR 7/2	43.7	39.1	17.2	0.17	0.13	1.61	.	3.38	5.75	0.20	0.14	1.18
drained	41-53-07	43-69	Bxt1	7.5YR 5/4	53.0	37.3	9.7	0.19	0.07	1.12	.	2.39	4.96	0.17	0.39	1.07
	41-53-08	69-89	Bxt2	7.5YR 5/6	52.2	37.9	9.9	0.16	0.06	1.05	.	2.49	5.02	0.14	0.35	1.06
	41-53-09	89-114	Bxt3	7.5YR 5/6	54.3	35.7	10.0	.	.	.	.	.	.	.	.	.
	41-53-10	114-132	Bxt4	7.5YR 5/6	50.8	38.2	11.0	0.23	0.06	1.26	.	2.63	5.17	0.16	0.47	1.08
	41-53-11	132-152	Bxt5	7.5YR 5/6	58.6	28.5	12.9	0.21	0.07	1.26	.	2.57	5.05	0.14	0.40	0.95
	41-53-12	152-168	BC1	7.5YR 5/6	61.9	27.8	10.3	0.16	0.07	.	.	2.35	4.79	0.17	0.30	0.93
	41-53-13	168-183	BC2	5YR 5/6	56.8	31.7	11.5	0.18	0.08	1.19	.	2.61	5.15	0.19	0.37	0.98
	41-53-14	183-193	BC3	5YR 5/6	55.4	27.7	16.9	0.16	0.09	.	.	2.74	6.55	0.21	0.33	1.17
	41-53-15	193-203	2Btb1	5YR 5/6	43.4	29.4	27.2	0.07	0.08	2.59	.	4.25	7.87	0.23	0.18	1.11
	41-53-16	203-224	2Btb2	5YR 5/8	39.3	34.7	26.0	0.09	0.10	2.73	.	4.83	8.02	0.22	0.14	0.97

Table 1. Cont'd. CBD- and oxalate-extractable Fe and Al and total Fe, Al, Mn, Ti, and K data for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent			Percent								
								Oxalate		CBD		Total				
					Sand	Silt	Clay	Fe	Al	Fe	Al	Fe	Al	Ti	Mn	K
								Colluvial/Residual Soils								
Cookport	41-53-17	224-251	2Btb3	10YR 6/8	49.0	32.5	18.5	0.03	0.03	2.10	.	3.26	5.67	0.17	0.06	1.07
PA	41-53-18	251-279	2Btb4	10YR 6/8	47.4	34.2	18.4	0.03	0.02	2.45	.	3.66	6.04	0.20	0.06	1.18
Moderately	41-53-19	279-287	3C1	10YR 5/8	76.6	12.6	10.8	0.08	0.03	1.26	.	2.09	3.63	0.09	0.99	0.62
well	41-53-20	287-305	3C2	7.5YR 6/8	.	.	.	0.04	0.01	.	.	1.25	3.15	0.11	0.06	0.53
drained	41-53-21	305-330	3C3	10YR 7/4	.	.	.	0.05	0.01	1.68	.	2.57	4.11	0.12	0.26	0.76
Nolo	41-54-04	0-5	A	2.5YR 6/1	81.6	13.4	5.0	.	.	.	.	.	.	.	.	.
PA	41-54-05	5-10	Eg	2.5YR 6/2	80.9	14.1	5.0	0.07	0.03	0.21	.	0.72	2.09	0.96	0.01	0.42
Poorly	41-54-06	10-20	Btg1	10YR 6/1	54.1	31.2	14.7	0.27	0.08	1.33	.	2.93	4.72	0.16	0.29	1.00
drained	41-54-07	20-30	Btg2	10YR 6/1	58.4	29.1	12.5	0.14	0.06	0.91	.	2.14	4.23	0.14	0.21	0.87
	41-54-08	30-51	Bx1	7.5YR 5/6	60.7	28.8	10.5	0.13	0.04	1.19	.	3.09	4.43	0.15	0.22	0.88
	41-54-09	51-71	Bx2	7.5YR 5/6	79.0	13.2	7.8	0.15	0.03	0.77	.	1.91	2.92	0.08	0.26	0.50
	41-54-10	71-84	Bx3	7.5YR 5/8	58.8	32.9	8.3	0.12	0.03	0.63	.	1.63	3.96	0.14	1.15	0.79
	41-54-11	84-99	Bx4	7.5YR 5/8	68.2	23.1	8.7	0.11	0.04	0.63	.	1.40	2.98	0.13	0.22	0.47
	41-54-12	99-124	Bx5	10YR 5/8	64.1	27.4	8.5	0.12	0.03	0.56	.	1.49	3.51	0.13	0.19	0.61
	41-54-13	124-147	BC	10YR 6/6	69.5	22.8	7.7	0.13	0.03	.	.	1.29	3.11	0.16	0.21	0.53
	41-54-14	147-180	2Cg1	10YR 8/4	32.0	48.7	19.3	0.05	0.03	.	.	1.27	7.44	0.31	0.00	0.05
	41-54-15	180-206	2Cg2	10YR 8/4	54.7	25.0	20.3	0.05	0.04	0.21	.	0.95	7.19	0.21	0.00	0.04
	41-54-16	206-221	2Cg3	10YR 8/4	61.3	19.8	18.9	0.04	0.03	.	.	0.89	6.42	0.18	0.00	0.03
	41-54-17	221-254	2Cg4	10YR 8/4	60.5	21.2	18.3	0.05	0.03	0.14	.	0.85	6.03	0.17	0.00	0.03

Table 2. CBD-Extractable and Total Fe and Al data for selected Pennsylvania (PA) soils used in a Radon Study. See Washington (1991) and Greeman (1992) for information on the study.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent Sand	Percent Silt	Percent Clay	Percent CBD Fe	Percent CBD Al	Percent Total Fe	Percent Total Al
				Granite and Gneiss							
Glenelg	06-11-02	0-12	A	10YR 2/2	45.3	35.5	19.2	1.61	.	3.42	8.89
PA	06-11-03	12-20	AB	7.5YR 3/2	46.9	39.0	14.1	1.68	.	3.04	9.47
Well	06-11-04	20-46	Bt1	5YR 4/6	50.0	43.1	6.9	1.75	.	3.36	9.15
Drained	06-11-05	46-66	Bt2	7.5YR 5/6	48.4	31.0	20.6	1.96	.	3.67	10.58
	06-11-06	66-86	Bt3	7.5YR 5/6	55.3	26.8	17.9	1.61	.	3.14	11.48
	06-11-07	86-124	BC	7.5YR 5/8	63.6	20.2	16.2	1.61	.	3.87	11.59
	06-11-08	124-160	C1	7.5YR 5/8	69.1	19.6	11.3	1.33	.	3.29	11.59
	06-11-09	160-193	C2	7.5YR 5/8	67.0	23.0	10.0	1.33	.	3.43	11.01
	06-11-10	193-246	C3	7.5YR 8/4	63.9	26.4	9.7	1.54	.	3.40	11.16
	06-11-11	246-322	C4	7.5YR 8/4	60.2	31.8	8.0	2.24	.	4.13	11.20
				Gray and Brown Wisconsinan Glacial Till							
Bath	08-99-02	0- 5	A	10YR 4/4	42.3	46.8	10.9	0.84	.	2.45	4.72
PA	08-99-03	5-15	E	10YR 5/4	45.9	43.1	11.0	0.84	.	2.13	4.24
Well	08-99-05	36-51	Bw1	10YR 4/4	38.3	47.3	14.4	1.12	.	3.70	6.72
Drained	08-99-07	61-99	Bx2	10YR 5/4	19.4	54.9	25.7	1.61	.	4.43	8.78
	08-99-09	135-180	Bx4	10YR 4/4	22.3	56.4	21.3	1.40	.	4.17	7.94
	08-99-12	285-361	Bx7	10YR 4/3	36.0	48.8	15.2	1.12	.	4.21	8.20
				Gray and Brown Acid Shale							
Bedington	06-12-02	0- 5	A	10YR 2/2	36.0	44.5	19.5	1.40	.	2.45	5.24
PA	06-12-03	5-15	E	10YR 5/6	40.1	51.6	8.3	1.54	.	2.78	6.67
Well	06-12-04	15-30	Bt1	7.5YR 5/6	43.1	37.4	19.5	1.61	.	3.34	7.46
Drained	06-12-05	30-58	Bt2	7.5YR 5/6	44.0	37.9	18.1	2.03	.	4.30	8.94
	06-12-06	58-94	Bt3	2.5YR 6/8	38.5	29.0	32.5	3.01	.	5.10	10.79
	06-12-07	94-119	Bt4	2.5YR 6/8	39.5	25.2	35.3	3.29	.	5.57	11.01
	06-12-08	119-150	Bt5	2.5YR 4/6	43.3	21.7	35.0	3.36	.	5.48	10.53
	06-12-09	150-178	BCt	5YR 4/6	50.0	16.9	33.1	3.01	.	5.62	10.69

Table 2. Cont. CBD-Extractable and Total Fe and Al data for selected Pennsylvania (PA) soils used in a Radon Study. See Washington (1991) and Greeman (1992) for information on the study.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent Sand	Percent Silt	Percent Clay	Percent CBD Fe	Percent CBD Al	Percent Total Fe	Percent Total Al
					Limestone						
Hagerstown	14-80-01	0- 8	A	10YR 2/1	19.2	73.4	7.4	1.05	.	2.13	3.63
PA	14-80-02	8-33	E	10YR 6/3	18.9	64.8	16.3	1.26	.	2.47	4.36
Well	14-80-03	33-46	BE	7.5YR 6/6	14.8	54.8	30.4	2.03	.	3.10	5.87
Drained	14-80-04	46-61	Bt1	5YR 5/6	8.7	40.8	50.5	2.80	.	4.06	8.73
	14-80-05	61-89	Bt2	5YR 5/6	9.1	26.3	64.6	3.85	.	4.93	11.38
	14-80-06	89-124	Bt3	5YR 5/6	14.9	19.7	65.4	3.15	.	4.79	10.85
	14-80-07	124-150	Bt4	5YR 5/6	27.9	13.4	58.7	2.73	.	4.55	10.79
	14-80-08	150-183	Bt5	5YR 5/6	9.4	17.5	73.1	3.29	.	5.05	11.38
	14-80-09	183-254	BC	7.5YR 5/6	4.1	45.5	50.4	2.94	.	3.94	10.00
Clarksburg	14-81-01	0- 8	A	10YR 2/1	12.2	69.8	18.0	1.19	.	2.01	4.60
PA	14-81-02	8-25	E	10YR 5/3	9.9	72.6	17.5	1.12	.	2.15	4.83
Moderately	14-81-03	25-36	BE	10YR 5/4	8.8	71.0	20.2	1.68	.	2.51	5.34
Well	14-81-04	36-69	Bt	10YR 5/6	9.1	64.6	26.3	2.17	.	3.31	6.14
Drained	14-81-05	69-104	Bx1	10YR 4/4	22.4	58.1	19.5	1.96	.	3.20	5.66
	14-81-06	104-140	Bx2	10YR 4/4	23.5	57.5	19.0	1.89	.	2.99	5.50
	14-81-07	140-163	BC	7.5YR 4/6	47.7	24.3	28.0	1.89	.	3.97	5.56
	14-81-08	163-193	2C1	7.5YR 5/6	10.6	58.2	31.2	1.89	.	2.36	5.66
	14-81-09	193-223	2C2	7.5YR 5/6	6.6	55.4	38.0	1.82	.	2.54	6.08
	14-81-10	223-259	2C3	7.5YR 5/6	20.8	44.0	35.2	1.96	.	2.93	5.98
					Sandstone						
Cookport	14-82-01	0- 8	A	10YR 2/2	48.6	41.9	9.5	0.35	.	0.96	2.79
PA	14-82-02	8-23	E	10YR 5/4	47.4	39.3	13.3	0.70	.	1.41	5.13
Somewhat	14-82-03	23-41	Bw1	10YR 5/4	48.2	38.5	13.3	0.84	.	1.95	6.24
Poorly	14-82-04	41-61	Bw2	10YR 5/8	42.9	42.2	14.9	1.26	.	2.55	6.61
Drained	14-82-05	61-79	Bx1	10YR 5/8	57.4	31.3	11.3	0.98	.	2.34	5.82
	14-82-06	79-104	Bx2	10YR 5/6	63.9	30.1	6.0	0.70	.	1.63	4.61
	14-82-07	104-132	Bx3	10YR 4/6	67.2	19.1	13.7	1.61	.	3.10	6.88
	14-82-08	132-158	Bx4	7.5YR 5/6	58.5	26.2	15.3	1.96	.	4.50	7.51
	14-82-09	158-203	Bx5	10YR 4/4	68.1	30.3	1.6	0.91	.	2.50	6.14
	14-82-10	203-243	Bx6	10YR 4/4	70.0	21.1	8.9	1.05	.	2.71	6.35
	14-82-11	243-305	2C	10YR 5/4	77.3	13.2	9.5	0.91	.	2.73	5.77

Table 2. Cont. CBD-Extractable and Total Fe and Al data for selected Pennsylvania (PA) soils used in a Radon Study. See Washington (1991) and Greeman (1992) for information on the study.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Color	Percent Sand	Percent Silt	Percent Clay	Percent CBD Fe	Percent CBD Al	Percent Total Fe	Percent Total Al
					Sandstone						
Clymer	14-83-03	0- 8	E	7.5YR 5/2	68.1	30.3	1.6	0.21	.	0.58	1.98
PA	14-83-04	8-13	Bhs	7.5YR 3/3	57.8	35.2	7.0	0.91	.	1.83	4.44
Well	14-83-05	13-23	Bs	10YR 5/6	57.6	33.8	8.6	0.70	.	1.89	5.77
Drained	14-83-06	23-43	Bw1	10YR 5/5	58.4	29.9	11.7	0.91	.	2.03	5.23
	14-83-07	43-71	Bw2	10YR 5/5	59.8	29.8	10.4	0.91	.	2.10	5.87
	14-83-08	71-94	Bt1	5YR 5/6	51.9	22.9	25.2	1.89	.	3.36	7.99
	14-83-09	94-122	Bt2	5YR 5/8	54.1	23.9	22.0	1.96	.	3.22	6.88
	14-83-10	122-137	BC	7.5YR 5/6	64.3	21.3	14.4	1.19	.	2.01	7.20
	14-83-11	137-168	C1	10YR 5/6	69.3	30.3	0.4	0.84	.	2.01	7.09
	14-83-12	168-203	C2	10YR 5/6	72.2	18.7	9.1	1.26	.	2.17	7.30
					Brown Acid Floodplain						
Pope	14-84-01	0-10	A	7.5YR 3/2	34.7	46.8	18.5	1.19	.	2.55	4.68
PA	14-84-02	10-25	Ab	7.5YR 4/4	30.5	52.4	17.1	1.47	.	2.82	5.45
Well	14-84-03	25-46	Bw1	7.5YR 4/4	29.6	49.4	21.0	1.47	.	3.05	5.82
Drained	14-84-04	46-61	Bw2	7.5YR 4/4	27.9	50.3	21.8	1.54	.	3.22	5.77
	14-84-05	61-86	Bw3	7.5YR 4/4	30.2	47.6	22.2	1.47	.	3.20	6.03
	14-84-06	86-104	Bw4	7.5YR 4/4	36.1	45.5	18.4	1.61	.	3.29	5.45
	14-84-07	104-114	BC	10YR 4/4	46.2	38.2	15.6	1.19	.	2.32	4.39
	14-84-08	114-142	2C1	7.5YR 4/4	51.9	31.3	16.8	1.68	.	3.80	5.34
	14-84-09	142-168	2C2	7.5YR 4/4	46.6	36.5	16.9	2.45	.	5.01	5.56

Table 3. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) * Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Late Wisconsinan Brown Till Soils								
Bath	45-79-01	0- 25	Ap	2.4	15.2	16.1	12.8	1.6	4.3	0.6	3.5	23.3
PA	45-79-02	25- 38	Bw1	2.3	16.3	14.3	13.9	1.3	3.4	0.6	4.1	25.5
Well	45-79-03	38- 64	Bw2	1.6	16.5	9.5	14.9	0.9	3.1	0.5	4.8	28.9
drained	45-79-04	64- 79	Bx1	1.1	11.9	9.5	10.8	0.7	1.6	0.7	7.2	60.0
	45-79-05	79-112	Bx2	2.0	13.9	14.3	11.9	0.7	1.5	0.9	6.6	47.2
	45-79-06	112-145	Bx3	1.8	11.3	15.9	9.5	0.7	1.0	0.7	4.6	40.2
	45-79-07	145-173	Bx4	1.7	11.6	14.3	9.9	0.5	1.1	0.6	4.0	34.6
	45-79-08	173-201	2C	1.8	13.8	12.7	12.1	0.7	1.6	0.8	6.0	43.3
	45-79-09	201-216	2R	.	.	.	.	.	.	.	.	.
Mardin	25-06-01	0- 20	Ap	.	.	62.2	.	.	.	4.6	7.4	.
NY	25-06-02	20- 42	BE	9.4	28.4	33.1	19.0	2.7	5.2	2.4	7.1	25.1
Moderately	25-06-03	42- 66	Bw	8.8	21.8	40.2	13.1	3.0	4.8	3.2	8.0	36.8
well	25-06-04	66- 91	Bx1	4.5	17.0	26.3	12.5	2.1	3.2	2.0	7.7	45.6
drained	25-06-05	91-112	Bx2	7.9	17.9	44.2	10.0	2.9	3.8	3.1	7.1	39.3
	25-06-06	112-150	Bx3	3.9	18.2	21.4	14.3	1.5	1.8	1.2	5.6	30.9
Volusia	25-07-01	0- 18	Ap	.	.	86.8	.	.	.	5.5	6.4	.
NY	25-07-02	18- 35	Bw1	25.0	36.7	68.1	11.7	6.8	9.0	5.1	7.5	20.3
Somewhat	25-07-03	35- 50	Bw2	8.9	19.9	44.8	11.0	1.4	2.9	2.7	6.1	30.7
poorly	25-07-04	50- 91	Bx1	3.9	21.5	18.2	17.6	1.0	1.8	1.0	5.6	25.9
drained	25-07-05	91-146	Bx2	1.4	21.9	6.1	20.6	0.7	1.4	0.3	5.6	25.6
	25-07-06	146-160	BC	0.4	21.3	2.0	20.9	0.8	1.7	0.1	6.0	28.3
Chippewa	25-08-01	0- 9	Ap1	.	.	.	.	.	.	2.9	2.8	.
NY	25-08-02	9- 22	Eg1	35.4	34.6	.	.	4.1	4.6	3.8	3.8	10.9
Poorly	25-08-03	22- 33	Eg2	16.4	23.3	70.3	6.9	1.8	2.5	2.2	3.1	13.3
drained	25-08-04	33- 49	Bx1	11.0	19.5	56.2	8.5	1.1	1.8	3.2	5.7	29.2
	25-08-05	49- 77	Bx2	11.5	22.1	51.7	10.7	1.4	1.2	3.0	5.8	26.2
	25-08-06	77-108	Bx3	4.4	22.8	19.5	18.4	1.1	1.5	1.9	9.7	42.5

* The subscripts refer to oxalate-extractable (o), CBD-extractable (d), and total (t) Fe and Al.

Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) *								
				Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Late Wisconsinan Red Till Soils								
Lackawanna	45-80-01	0- 18	Ap	3.7	33.1	11.2	29.4	3.5	7.1	0.9	8.1	24.5
PA	45-80-02	18- 36	Bw1	2.4	23.0	10.4	20.6	1.6	3.7	0.6	6.0	26.2
Well	45-80-03	36- 51	Bw2	3.4	23.7	14.3	20.3	1.9	1.8	0.9	6.6	27.8
drained	45-80-04	51- 71	Bw3	3.1	21.9	14.3	18.7	1.7	1.5	0.8	5.8	26.4
	45-80-05	71-109	Bx1	2.1	27.1	7.7	25.0	0.8	1.1	0.7	8.5	31.4
	45-80-06	109-135	Bx2	4.1	23.1	17.9	19.0	1.4	1.0	1.3	7.2	31.0
	45-80-07	135-163	Bx3	2.7	27.1	9.9	24.4	0.8	1.1	0.9	8.7	32.0
	45-80-08	163-175	C	2.0	23.6	8.3	21.6	1.0	.	0.8	9.2	39.1
	45-80-09	175-201	R	.	.	.	.	.	.	.	.	.
Lackawanna	25-01-01	0- 16	Ap	.	.	57.8	.	.	.	4.6	8.0	.
NY	25-01-02	16- 40	BE	10.0	25.0	40.0	15.0	3.0	4.6	2.8	7.1	28.4
Well	25-01-03	40- 57	Bw	12.0	15.9	75.8	3.8	3.3	2.4	3.4	4.5	28.0
drained	25-01-04	57-107	Bx1	1.8	20.7	8.8	18.8	2.0	2.6	0.5	5.3	25.6
	25-01-05	107-150	Bx2	2.6	21.6	12.1	19.0	1.5	2.5	0.7	5.7	26.2
	25-01-06	150-200	BC	15.5	21.0	73.9	5.5	1.5	2.1	5.6	7.6	36.0
Wellsboro	25-02-01	0- 15	Ap	.	.	79.0	.	.	.	3.7	4.7	.
NY	25-02-02	15- 50	Bw1	17.3	31.4	55.2	14.1	5.5	6.7	3.2	5.7	18.2
Moderately	25-02-03	50- 68	Bw2	27.6	40.5	68.2	12.9	9.4	3.5	11.1	16.2	40.0
well	25-02-04	68-100	Bx1	0.8	14.7	5.4	13.9	1.7	2.0	0.4	7.0	47.5
drained	25-02-05	100-150	Bx2	3.5	16.3	21.4	12.8	5.3	2.1	1.2	5.6	34.1
Morris	25-03-01	0- 15	Ap	.	.	75.8	.	.	.	3.6	4.8	.
NY	25-03-02	15- 38	Bw	26.0	30.6	85.1	4.6	6.3	7.2	4.5	5.3	17.3
Somewhat	25-03-03	38- 58	BE	4.8	16.6	28.6	11.9	1.3	1.7	1.6	5.7	34.4
poorly	25-03-04	58- 75	Bx1	4.0	20.2	19.8	16.2	1.2	1.9	1.1	5.7	28.1
drained	25-03-05	75-111	Bx2	3.6	20.8	17.4	17.2	1.2	1.5	1.0	5.6	26.7
	25-03-06	111-150	Bx3	2.7	24.3	10.9	21.6	1.1	2.5	0.6	5.9	24.3

* The subscripts refer to oxalate-extractable (o), CBD-extractable (d), and total (t) Fe and Al.

Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) *								
				Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Late Wisconsinan Red Till Soils								
Norwich	25-04-01	0- 16	Ap	.	.	27.6	.	.	.	1.4	4.9	.
NY	25-04-02	16- 27	Bw	19.0	35.0	54.3	16.0	4.6	5.8	3.5	6.5	18.5
Poorly	25-04-03	27- 43	Eg/Bx1	5.2	24.5	21.4	19.2	2.3	3.0	1.6	7.3	29.6
drained	25-05-04	43- 75	Bx2	3.9	24.3	16.0	20.4	1.1	2.3	0.9	5.4	22.3
	25-05-05	75-125	Bx3	2.0	27.4	7.2	25.5	0.6	2.0	0.4	6.1	22.4
	25-05-06	125-175	Bx4	1.5	26.4	5.7	24.9	0.6	2.3	0.3	5.8	22.0
	25-05-07	175-200	2R	.	.	.	.	.	.	.	.	.
				Early Wisconsinan Till Soils								
Leck Kill	41-39-01	0- 23	Ap	8.1	45.1	17.9	37.1	4.8	6.0	1.6	8.9	19.7
PA	41-39-02	23- 30	E	3.4	32.2	10.7	28.7	2.2	4.4	0.5	5.1	15.7
Well	41-39-03	30- 41	BE	3.1	32.3	9.5	29.2	2.2	4.5	0.5	5.3	16.3
drained	41-39-04	41- 66	Bt1	2.6	52.7	4.9	50.1	2.8	8.2	0.4	7.5	14.3
	41-39-05	66- 84	Bt2	3.6	44.5	8.2	40.9	4.2	5.1	0.6	7.2	16.1
	41-39-06	84-104	BC1	2.8	30.7	9.3	27.9	2.8	3.5	0.5	5.6	18.3
	41-39-07	104-124	BC2	3.8	35.1	10.7	31.3	2.9	4.4	0.7	6.7	19.1
	41-39-08	124-160	C1	3.1	35.4	8.7	32.3	2.5	2.8	0.6	7.0	19.8
	41-39-09	160-206	C2	3.4	44.9	7.5	41.5	2.9	3.5	0.9	11.8	26.4
	41-39-10	206-254	C3	3.3	44.0	7.5	40.7	3.8	4.2	0.8	10.1	22.9
Leck Kill	41-40-01	0- 25	Ap	7.0	42.2	16.7	35.2	4.2	6.3	1.6	9.5	22.6
PA	41-40-02	25- 38	BA	2.8	38.5	7.2	35.8	1.8	6.8	0.5	7.0	18.2
Well	41-40-03	38- 58	Bt1	1.9	45.4	4.2	43.5	1.6	7.1	0.4	8.6	19.0
drained	41-40-04	58- 89	Bt2	2.5	45.2	5.5	42.7	2.4	6.5	0.5	8.2	18.1
	41-40-05	89-107	BC1	2.6	47.1	5.6	44.4	2.7	5.6	0.6	11.1	23.6
	41-40-06	107-132	BC2	2.4	38.9	6.0	36.6	2.2	5.1	0.5	8.6	22.0
	41-40-07	132-157	BC3	2.2	43.2	5.1	40.9	3.0	4.9	0.5	10.4	24.1
	41-40-08	157-188	C1	2.4	39.1	6.2	36.7	3.1	3.3	0.9	14.1	36.1
	41-40-09	188-216	C2	3.1	37.8	8.1	34.8	4.4	4.7	0.9	11.4	30.1
	41-40-10	216-249	C3	3.1	38.2	8.1	35.1	4.0	5.4	0.7	8.7	22.9

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Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) *								
				Fe_o / Fe_t	Fe_d / Fe_t	Fe_o / Fe_d	(Fe_d-Fe_o) / Fe_t	Al_o / Al_t	Al_d / Al_t	Fe_o / Clay	Fe_d / Clay	Fe_t / Clay
				Pre-Wisconsinan Till Soils								
Allenwood	41-42-01	0- 23	Ap	6.7	58.7	11.4	52.0	4.8	8.4	1.0	9.0	15.4
PA	41-42-02	23- 30	E	2.8	61.3	4.6	58.4	1.8	7.8	0.5	9.7	15.9
Well	41-42-03	30- 43	BA	1.9	56.7	3.3	54.8	1.4	7.2	0.3	8.5	15.0
drained	41-42-04	43- 66	Bt1	1.9	50.8	3.7	48.9	1.7	8.1	0.3	7.3	14.3
	41-42-05	66- 89	Bt2	2.5	49.4	5.1	46.9	3.6	8.3	0.3	5.8	11.8
	41-42-06	89-114	Bt3	2.3	48.3	4.8	46.0	3.4	8.0	0.3	5.9	12.3
	41-42-07	114-135	Bt4	2.0	48.3	4.2	46.2	1.6	6.6	0.3	7.0	14.6
	41-42-08	135-157	BC1	2.4	48.9	5.0	46.5	2.6	7.0	0.4	7.3	15.0
	41-42-09	157-188	BC2	2.6	48.1	5.4	45.6	1.7	4.5	0.4	7.2	14.9
	41-42-10	188-221	BC3	3.3	51.3	6.4	48.0	2.1	5.7	0.5	7.8	15.3
	41-42-11	221-274	C1	3.7	43.4	8.5	39.7	2.6	4.4	0.6	6.9	16.0
	41-42-12	274-312	C2	3.8	49.6	7.7	45.8	1.2	3.8	0.7	8.8	17.7
	41-42-13	312-356	C3	5.1	44.6	11.4	39.5	1.7	4.6	0.9	7.9	17.8
	41-42-14	356-386	2Cr	.	.	.	.	.	.	.	.	.
Allenwood	60-08-03	0- 8	A	17.4	29.4	59.0	12.1	6.6	6.4	3.8	6.4	21.6
PA	60-08-04	8- 28	E	6.2	33.1	18.6	27.0	5.3	6.2	1.1	5.9	17.7
Well	60-08-05	28- 43	BA	2.4	51.7	4.6	49.4	3.2	6.8	0.4	7.7	15.0
drained	60-08-06	43- 66	Bt1	2.1	48.8	4.4	46.7	3.2	5.9	0.3	6.1	12.5
	60-08-07	66- 97	Bt2	1.9	47.9	4.0	46.0	3.2	6.2	0.3	6.5	13.6
	60-08-08	97-140	Bt3	1.8	51.5	3.5	49.7	2.4	4.8	0.2	7.1	13.9
	60-08-09	140-170	Bt4	1.7	57.2	3.0	55.5	2.7	4.5	0.2	7.6	13.3
	60-08-10	170-213	BC	1.3	42.7	3.1	41.3	2.7	4.2	0.2	6.5	15.3
	60-08-11	213-239	C1	1.1	36.0	3.1	34.9	2.4	3.8	0.2	6.3	17.6
	60-08-12	239-279	C2	1.5	39.6	3.9	38.0	1.8	3.1	0.3	7.5	18.8
	60-08-13	279-335	2Bt1b	1.3	.	.	.	1.9	.	0.4	.	33.2
	60-08-14	335-391	2Bt2b	2.3	.	.	.	2.8	.	0.4	.	15.4

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Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) * Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Colluvial/Residual Soils								
Sweden	41-56-03	0- 5	E	8.1	37.8	21.4	29.7	2.4	.	0.8	3.7	9.7
PA	41-56-04	5- 10	Bhs	11.9	57.0	20.7	45.2	8.1	.	2.0	9.7	17.0
Well	41-56-05	10- 18	Bw1	6.8	55.3	12.3	48.5	4.4	.	1.4	11.8	21.3
drained	41-56-06	18- 33	Bw2	5.7	49.1	11.6	43.4	1.9	.	1.2	10.0	20.4
	41-56-07	33- 51	Bt1	4.4	67.1	6.5	62.7	2.0	.	0.6	9.6	14.3
	41-56-08	51- 71	Bt2	5.2	70.7	7.4	65.5	2.2	.	0.7	8.9	12.6
	41-56-09	71- 91	2Btb1	4.3	68.7	6.2	64.4	2.0	.	0.6	9.3	13.6
	41-56-10	91-114	2Btb2	2.6	69.6	3.7	67.0	2.3	.	0.3	8.9	12.8
	41-56-11	114-127	2Btb3	2.9	71.9	4.0	69.1	2.4	.	0.4	8.9	12.4
	41-56-12	127-150	2Btb4	2.6	70.1	3.7	67.5	1.9	.	0.4	9.7	13.8
	41-56-13	150-163	2Btb5	2.2	70.3	3.2	68.1	1.5	.	0.3	10.4	14.9
	41-56-14	163-188	3BC1	2.5	49.1	5.0	46.6	0.8	.	0.2	4.1	8.3
	41-56-15	188-206	3BC2	.	.	.	.	.	.	.	2.9	.
	41-56-16	206-221	3Cg1	4.0	.	.	.	0.6	.	0.2	.	4.3
	41-56-17	221-236	3Cg2	.	.	.	.	.	.	.	.	.
	41-56-18	236-251	3Cg3	5.3	14.9	35.8	9.6	0.5	.	0.2	0.7	4.6
	41-56-19	251-267	3Cg4	.	.	.	.	.	.	.	.	.
	41-56-20	267-284	3Cg5	4.3	45.6	9.5	41.3	0.5	.	.	.	.
Sweden	53-05-04	0- 3	E	.	.	.	.	.	.	.	7.5	.
PA	53-05-05	3- 18	Bw1	9.9	49.4	20.0	39.5	4.6	.	1.7	8.5	17.2
Well	53-05-06	18- 36	Bw2	5.2	44.9	11.6	39.7	3.1	.	1.0	8.8	19.7
drained	53-05-07	36- 58	Bw3	4.1	41.9	9.8	37.8	2.5	.	1.0	9.9	23.7
	53-05-08	58- 89	Bt1	3.3	48.3	6.9	45.0	1.8	.	0.9	12.8	26.6
	53-05-09	89-117	2Btb1	1.4	60.5	2.3	59.1	1.8	.	0.2	10.2	16.8
	53-05-10	117-147	2Btb2	1.6	62.0	2.6	60.4	1.8	.	0.3	10.0	16.2
	53-05-11	147-170	2Btb3	1.4	60.5	2.3	59.1	1.5	.	0.3	11.8	19.5
	53-05-12	170-185	2Btb4	1.2	61.9	2.0	60.6	1.6	.	0.2	11.5	18.5
	53-05-13	185-211	2Btb5	2.1	59.5	3.5	57.4	1.6	.	0.4	10.4	17.6
	53-05-14	211-236	3Crt1	0.7	46.0	1.6	45.2	1.7	.	0.1	9.2	20.0
	53-05-15	236-259	3Crt2	1.4	59.1	2.3	57.7	1.3	.	0.3	12.1	20.5
	53-05-16	259-287	3Crt3	.	.	.	.	.	.	.	14.7	.

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Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) * Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Colluvial/Residual Soils								
Sweden	59-27-03	0- 8	E	8.5	47.4	17.9	38.9	1.8	.	0.9	4.8	10.2
PA	59-27-04	8- 10	Bhs	19.7	55.0	35.8	35.3	4.8	.	3.5	9.7	17.6
Well	59-27-05	10- 23	Bw1	5.8	34.7	16.7	28.9	4.5	.	1.5	9.1	26.3
drained	59-27-06	23- 36	Bw2	4.3	45.4	9.5	41.1	2.2	.	0.8	8.7	19.2
	59-27-07	36- 48	Bt1	2.3	56.2	4.0	54.0	1.5	.	0.4	10.7	19.0
	59-27-08	48- 58	2Btb1	1.8	59.8	3.0	58.0	1.5	.	0.3	11.1	18.6
	59-27-09	58- 71	2Btb2	1.8	68.9	2.6	67.1	1.5	.	0.2	7.7	11.2
	59-27-10	71- 89	2Btb3	1.7	65.1	2.6	63.4	1.4	.	0.2	9.1	14.0
	59-27-11	89-102	2Btb4	1.7	65.1	2.7	63.3	1.2	.	0.2	8.8	13.5
	59-27-12	102-122	2Btb5	1.8	67.0	2.7	65.2	1.1	.	0.3	9.6	14.3
	59-27-13	122-140	2Btb6	1.6	67.1	2.5	65.4	1.1	.	0.3	11.1	16.6
	59-27-14	140-168	2Btb7	1.5	66.6	2.2	65.1	1.2	.	0.2	8.2	12.3
	59-27-15	168-183	2Btb8	1.6	69.0	2.3	67.4	1.2	.	0.2	9.1	13.3
	59-27-16	183-208	2Btb9	1.7	60.1	2.9	58.4	1.1	.	0.2	8.2	13.7
	59-27-17	208-218	2BC	1.8	67.4	2.7	65.5	0.8	.	0.3	10.3	15.4
	59-27-18	218-234	2Crt1	1.2	63.2	1.9	62.0	1.0	.	0.2	11.0	17.5
	59-27-19	234-249	2Crt2	1.7	67.0	2.5	65.3	1.2	.	0.2	9.4	14.1
	59-27-20	249-269	2R	2.9	51.4	5.7	48.5	0.0	.	.	.	.
Cookport	41-53-03	0- 3	A	.	.	.	.	.	.	.	.	.
PA	41-53-04	3- 18	E	85.7	25.0	.	.	7.3	.	3.6	1.0	4.2
Moderately	41-53-05	18- 28	Bt1	9.0	56.3	16.0	47.3	2.8	.	2.0	12.4	22.0
well	41-53-06	28- 43	Bt2	5.0	47.6	10.6	42.6	2.3	.	1.0	9.4	19.7
drained	41-53-07	43- 69	Bxt1	7.9	46.8	17.0	38.9	1.4	.	2.0	11.5	24.6
	41-53-08	69- 89	Bxt2	6.4	42.1	15.3	35.7	1.2	.	1.6	10.6	25.2
	41-53-09	89-114	Bxt3	.	.	.	.	.	.	.	.	.
	41-53-10	114-132	Bxt4	8.7	47.9	18.3	39.1	1.2	.	2.1	11.4	23.9
	41-53-11	132-152	Bxt5	8.2	49.0	16.7	40.8	1.4	.	1.6	9.8	19.9
	41-53-12	152-168	BC1	6.8	.	.	.	1.5	.	1.6	.	22.8
	41-53-13	168-183	BC2	6.9	45.5	15.1	38.7	1.6	.	1.6	10.3	22.7
	41-53-14	183-193	BC3	5.8	.	.	.	1.4	.	0.9	.	16.2
	41-53-15	193-203	2Btb1	1.6	60.9	2.7	59.2	1.0	.	0.3	9.5	15.6
	41-53-16	203-224	2Btb2	1.9	56.5	3.3	54.6	1.2	.	0.3	10.5	18.6

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				Colluvial/Residual Soils								
Cookport	41-53-17	224-251	2Btb3	0.9	64.4	1.4	63.4	0.5	.	0.2	11.3	17.6
PA	41-53-18	251-279	2Btb4	0.8	66.9	1.2	66.1	0.3	.	0.2	13.3	19.9
Moderately	41-53-19	279-287	3C1	3.8	60.2	6.4	56.4	0.8	.	0.7	11.7	19.4
well	41-53-20	287-305	3C2	3.2	.	.	.	0.3	.	.	.	.
drained	41-53-21	305-330	3C3	1.9	65.3	3.0	63.4	0.2	.	.	.	.
Nolo	41-54-04	0- 5	A	.	.	.	.	.	.	.	.	.
PA	41-54-05	5- 10	Eg	9.7	29.1	33.4	19.4	1.4	.	1.4	4.2	14.4
Poorly	41-54-06	10- 20	Btg1	9.2	45.3	20.3	36.1	1.7	.	1.8	9.0	19.9
drained	41-54-07	20- 30	Btg2	6.5	42.5	15.4	35.9	1.4	.	1.1	7.3	17.1
	41-54-08	30- 51	Bx1	4.2	38.5	10.9	34.3	0.9	.	1.2	11.3	29.4
	41-54-09	51- 71	Bx2	7.9	40.3	19.5	32.4	1.0	.	1.9	9.9	24.5
	41-54-10	71- 84	Bx3	7.4	38.6	19.1	31.2	0.8	.	1.4	7.6	19.6
	41-54-11	84- 99	Bx4	7.9	45.0	17.5	37.1	1.3	.	1.3	7.2	16.1
	41-54-12	99-124	Bx5	8.1	37.5	21.4	29.5	0.9	.	1.4	6.6	17.5
	41-54-13	124-147	BC	10.1	.	.	.	1.0	.	1.7	.	16.8
	41-54-14	147-180	2Cg1	3.9	.	.	.	0.4	.	0.3	.	6.6
	41-54-15	180-206	2Cg2	5.3	22.1	23.8	16.8	0.6	.	0.2	1.0	4.7
	41-54-16	206-221	2Cg3	4.5	.	.	.	0.5	.	0.2	.	4.7
	41-54-17	221-254	2Cg4	5.9	16.5	35.8	10.6	0.5	.	0.3	0.8	4.6
				Schist and Granite Soils								
Glenelg	06-11-02	0- 12	A	.	47.0	.	.	.	.	.	8.4	17.8
PA	06-11-03	12- 20	AB	.	55.2	.	.	.	.	.	11.9	21.6
Well	06-11-04	20- 46	Bt1	.	52.0	.	.	.	.	.	25.3	48.7
drained	06-11-05	46- 66	Bt2	.	53.3	.	.	.	.	.	9.5	17.8
	06-11-06	66- 86	Bt3	.	51.2	.	.	.	.	.	9.0	17.5
	06-11-07	86-124	BC	.	41.6	.	.	.	.	.	9.9	23.9
	06-11-08	124-160	C1	.	40.4	.	.	.	.	.	11.8	29.1
	06-11-09	160-193	C2	.	38.8	.	.	.	.	.	13.3	34.3
	06-11-10	193-246	C3	.	45.3	.	.	.	.	.	15.9	35.0
	06-11-11	246-322	C4	.	54.1	.	.	.	.	.	28.0	51.7

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Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) *								
				Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
Gray and Brown Wisconsinan Glacial Till Soils												
Bath	08-99-02	0- 5	A	.	34.2	.	.	.	.	.	7.7	22.5
PA	08-99-03	5- 15	E	.	39.5	.	.	.	.	.	7.6	19.3
Well	08-99-05	36- 51	Bw1	.	30.2	.	.	.	.	.	7.8	25.7
drained	08-99-07	61- 99	Bx2	.	36.3	.	.	.	.	.	6.3	17.3
	08-99-09	135-180	Bx4	.	33.5	.	.	.	.	.	6.6	19.6
	08-99-12	285-361	Bx7	.	26.6	.	.	.	.	.	7.4	27.7
Gray and Brown Acid Shale Soils												
Bedington	06-12-02	0- 5	A	.	57.1	.	.	.	.	.	7.2	12.6
PA	06-12-03	5- 15	E	.	55.4	.	.	.	.	.	18.5	33.4
Well	06-12-04	15- 30	Bt1	.	48.1	.	.	.	.	.	8.2	17.1
drained	06-12-05	30- 58	Bt2	.	47.2	.	.	.	.	.	11.2	23.8
	06-12-06	58- 94	Bt3	.	58.9	.	.	.	.	.	9.3	15.7
	06-12-07	94-119	Bt4	.	59.0	.	.	.	.	.	9.3	15.8
	06-12-08	119-150	Bt5	.	61.2	.	.	.	.	.	9.6	15.7
	06-12-09	150-178	BCt	.	53.5	.	.	.	.	.	9.1	17.0
Limestone Soils												
Hagerstown	14-80-01	0- 8	A	.	49.3	.	.	.	.	.	14.2	28.7
PA	14-80-02	8- 33	E	.	51.0	.	.	.	.	.	7.7	15.1
Well	14-80-03	33- 46	BE	.	65.3	.	.	.	.	.	6.7	10.2
drained	14-80-04	46- 61	Bt1	.	68.8	.	.	.	.	.	5.5	8.0
	14-80-05	61- 89	Bt2	.	78.0	.	.	.	.	.	6.0	7.6
	14-80-06	89-124	Bt3	.	65.7	.	.	.	.	.	4.8	7.3
	14-80-07	124-150	Bt4	.	60.0	.	.	.	.	.	4.6	7.7
	14-80-08	150-183	Bt5	.	65.1	.	.	.	.	.	4.5	6.9
	14-80-09	183-254	BC	.	74.5	.	.	.	.	.	5.8	7.8

* The subscripts refer to oxalate-extractable (o), CBD-extractable (d), and total (t) Fe and Al.

Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) *								
				Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
					Limestone Soils							
Clarksburg	14-81-01	0- 8	A	.	59.2	.	.	.	.	.	6.6	11.2
PA	14-81-02	8- 25	E	.	51.9	.	.	.	.	.	6.4	12.3
Moderately	14-81-03	25- 36	BE	.	66.9	.	.	.	.	.	8.3	12.4
well	14-81-04	36- 69	Bt	.	65.4	.	.	.	.	.	8.2	12.6
drained	14-81-05	69-104	Bx1	.	61.1	.	.	.	.	.	10.0	16.4
	14-81-06	104-140	Bx2	.	63.2	.	.	.	.	.	9.9	15.7
	14-81-07	140-163	BC	.	47.6	.	.	.	.	.	6.7	14.2
	14-81-08	163-193	2C1	.	80.1	.	.	.	.	.	6.1	7.6
	14-81-09	193-223	2C2	.	71.6	.	.	.	.	.	4.8	6.7
	14-81-10	223-259	2C3	.	66.8	.	.	.	.	.	5.6	8.3
					Sandstone Soils							
Cookport	14-82-01	0- 8	A	.	36.5	.	.	.	.	.	3.7	10.1
PA	14-82-02	8- 23	E	.	49.8	.	.	.	.	.	5.3	10.6
Somewhat	14-82-03	23- 41	Bw1	.	43.0	.	.	.	.	.	6.3	14.7
poorly	14-82-04	41- 61	Bw2	.	49.5	.	.	.	.	.	8.4	17.1
drained	14-82-05	61- 79	Bx1	.	41.8	.	.	.	.	.	8.7	20.7
	14-82-06	79-104	Bx2	.	42.9	.	.	.	.	.	11.7	27.2
	14-82-07	104-132	Bx3	.	51.8	.	.	.	.	.	11.7	22.7
	14-82-08	132-158	Bx4	.	43.5	.	.	.	.	.	12.8	29.4
	14-82-09	158-203	Bx5	.	36.4	.	.	.	.	.	56.8	156.0
	14-82-10	203-243	Bx6	.	38.8	.	.	.	.	.	11.8	30.4
	14-82-11	243-305	2C	.	33.2	.	.	.	.	.	9.6	28.8

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Table 3. Cont. Ratios of oxalate- and CBD-extractable Fe and Al to total Fe and Al and to clay content for selected Pennsylvania (PA) and New York (NY) soils.

Soil Name, State, and Drainage	Soil and Horizon Number	Depth in cm	Horizon	Ratios (Percent) * Fe_o/Fe_t	Fe_d/Fe_t	Fe_o/Fe_d	$(Fe_d-Fe_o)/Fe_t$	Al_o/Al_t	Al_d/Al_t	Fe_o/Clay	Fe_d/Clay	Fe_t/Clay
				Sandstone Soils								
Clymer	14-83-03	0- 8	E	.	36.1	.	.	.	.	.	13.1	36.3
PA	14-83-04	8- 13	Bhs	.	49.8	.	.	.	.	.	13.0	26.1
Well	14-83-05	13- 23	Bs	.	37.0	.	.	.	.	.	8.1	22.0
drained	14-83-06	23- 43	Bw1	.	44.8	.	.	.	.	.	7.8	17.3
	14-83-07	43- 71	Bw2	.	43.2	.	.	.	.	.	8.7	20.2
	14-83-08	71- 94	Bt1	.	56.2	.	.	.	.	.	7.5	13.3
	14-83-09	94-122	Bt2	.	60.7	.	.	.	.	.	8.9	14.7
	14-83-10	122-137	BC	.	59.2	.	.	.	.	.	8.3	13.9
	14-83-11	137-168	C1	.	41.8	.	.	.	.	.	209.8	501.7
	14-83-12	168-203	C2	.	57.9	.	.	.	.	.	13.8	23.9
				Brown Acid Floodplain Soils								
Pope	14-84-01	0- 10	A	.	46.6	.	.	.	.	.	6.4	13.8
PA	14-84-02	10- 25	Ab	.	52.1	.	.	.	.	.	8.6	16.5
Well	14-84-03	25- 46	Bw1	.	48.2	.	.	.	.	.	7.0	14.5
drained	14-84-04	46- 61	Bw2	.	47.7	.	.	.	.	.	7.1	14.8
	14-84-05	61- 86	Bw3	.	46.0	.	.	.	.	.	6.6	14.4
	14-84-06	86-104	Bw4	.	48.9	.	.	.	.	.	8.7	17.9
	14-84-07	104-114	BC	.	51.2	.	.	.	.	.	7.6	14.9
	14-84-08	114-142	2C1	.	44.1	.	.	.	.	.	10.0	22.6
	14-84-09	142-168	2C2	.	48.8	.	.	.	.	.	14.5	29.7

* The subscripts refer to oxalate-extractable (o), CBD-extractable (d), and total (t) Fe and Al.

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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.
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