Article

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MORPHOLOGY AND COMPOSITION OF TWO LATE WISCONSINAN SOILS FORMING IN TILL AND LACUSTRINE DEPOSITS SCARBOROUGH BLUFFS AREA, SOUTH-CENTRAL ONTARIO

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ABSTRACT Halton Till and Glacial Lake Iroquois lacustrine sand and gravel deposits are the major surficial materials exposed at the surface of Scarborough Bluffs in South-Central Ontario. Luvisols formed in these deposits have different morphologies, including depth of weathering, complexity of horizonation, and strength of structural grades which result from parent material differences and pedogenesis. Particle size variations between the two paleosols result, in part, from different modes of deposition, and show that variable amounts of clay were produced pedogenically in the two systems. Clay mineral genesis, involving the transformation of illite and illite-smectite to vermiculite, appears to be restricted to the Iroquois sand paleosol, while some chloritization of illite occurs in both profiles. Changes in the primary mineral contents in the two paleosols suggest a similar magnitude of weathering in both systems. Distributions of vermiculite and dithionite-extractable Fe suggest some preweathering effects in the Halton Till paleosol. Morphological, mineralogical and some soil chemical properties are closely related to the physical attributes of the two different parent materials (till *vs* lacustrine sand and gravel).

RÉSUMÉ *Morphologie et composition de deux sols du Wisconsinien supérieur formés dans le till et des dépôts lacustres, régions des falaises de Scarborough, centre-sud de l'Ontario.* Le Till de Halton et le sable lacustre et les dépôts graveleux du lac glaciaire Iroquois sont les principaux matériaux qui apparaissent à la surface des falaises de Scarborough. Les luvisols, qui se sont formés dans ces dépôts, présentent diverses morphologies, dont la profondeur de l'altération, la complexité des horizons et le degré d'agrégation du sol, qui dépendent de la nature du matériau d'origine et de la pédogenèse. Les différences de grosseur des particules entre les deux paléosols sont en partie le résultat des modes de dépôt et démontrent que des quantités variables d'argile ont été produites pédogénétiquement dans les deux cas. La genèse de l'argile minérale, qui implique la transformation de l'illite et de l'illite-smectite en vermiculite, ne touche que le paléosol de sable du lac Iroquois, mais la chroliritisation de l'illite apparaît dans les deux profils. La modification du contenu minéral primaire dans les deux paléosols démontre que le degré d'altération est à peu près le même. La répartition de la vermiculite et de la dithéonite-Fe extractible suppose que des effets de pré-altération se sont manifestés dans le paléosol du Till de Halton. Les propriétés morphologiques et minéralogiques et certaines propriétés chimiques des sols sont étroitement liées aux caractéristiques physiques de deux matériaux d'origine (till, dans un cas, sable lacustre et gravier, dans l'autre.)

ZUSAMMENFASSUNG *Morphologie und Komposition zweier Böden aus dem späten Wisconsin in Grundmoräne und Seeablagerungen im Gebiet der Steilküsten von Scarborough, südliches Zentrum von Ontario.* Das Till von Halton und Seesand- und Kiesablagerungen aus dem Iroquois Eiszeit-See sind die hauptsächlichen Materialien, die an der Oberfläche der Steilküsten von Scarborough im südlichen Zentrum von Ontario sichtbar sind. Die Luvisols, die sich in diesen Ablagerungen gebildet haben, haben unterschiedliche Morphologien, wie die Tiefe der Verwitterung, die Komplexität der Horizonte und die Stärke der Bodenanhäufung, welche von den Unterschieden zwischen verwandtem Material und der Pedogenese abhängig sind. Die Unterschiede in der Größe der Partikel zwischen den beiden Paläoböden resultieren zum Teil aus unterschiedlichen Ablagerungsarten und zeigen, daß unterschiedliche Mengen von Ton in den zwei Systemen pedogenetisch produziert wurden. Die Genese des Minerlal-Tons einschließlich der Verwandlung von Illit und Illit-Smektit zu Vermikulit scheint sich auf den Iroquois Sand-Paläoboden zu beschränken, während in beiden Profilen eine Chloratisierung des Illits vorkommt. Veränderungen in den primären Mineral-Inhalten in den beiden Paläoböden legen eine ähnliche Bedeutung der Verwitterung in beiden Systemen nahe. Die Verteilung von Vermikulit und des herauslösbaren Dithionit-Fe lassen einige Verwitterungseffekte im Paläoboden des Halton-Till vermuten. Morphologische, mineralogische und einige chemische Boden-Eigenschaften werden mit den physikalischen Eigenschaften der zwei verschiedenen verwandten Materialien eng in Verbindung gebracht (Till versus See-Sand und Kies).

INTRODUCTION

Investigators of soil development and plant succession are often handicapped by a lack of time controls. Only in a few locations in North America is it possible to determine the precise time required to form a soil profile, and most of these dated profiles are in the midwestern and western regions of the continent. In most cases studies with dated profiles have been carried out around the margins of the Wisconsinan glacial limit, where differences between soils in Wisconsinan and pre-Wisconsinan glacial deposits can be described and discussed (FOLLMER, 1978; KREBS and TEDROW, 1958: OLSON *et al.*, 1978). Also, in the mountains of western North America numerous investigations of dated profiles and chronosequences have been reported by BIRKELAND (1973), CROCKER and MAJOR (1955), DICKSON and CROCKER (1953, 1954); MAHANEY (1978); MAHANEY *et al.* (1984a and 1984b); MAHANEY and FAHEY (1976, 1980); and RUTTER *et al.* (1978). In eastern North America few chronosequences have been reported north of the Wisconsinan glacial limit (McKEAGUE *et al.*, 1978; FILION, 1984; PROTZ *et al.*, 1984).

Till and lacustrine sand terraces along the north shore of Lake Ontario are found in an area where the age of the deposits is known with reasonable certainty. Between the Don River and the eastern boundary of Metropolitan Toronto (Fig. 1) a number of exposures of till and beach sand and gravel are found about 100 m above the level of Lake Ontario. Although Halton Till is older than the Iroquois beach gravels, following the retreat of Late Pleistocene ice, the entire area was covered with water of Glacial Lake Iroquois. As a result, it was not until a drop in the level of Glacial Lake Iroquois, approximately 12,000 years BP (COATES, 1976; TERASMAE and DREIMANIS, 1976; KARROW, 1984) that both deposits were exposed to weathering and pedogenic activity. Vegetation colonization, plant growth, and soil formation must have started soon after the deposits were exposed, for there is no evidence of an intervening period of blowouts or significant redistribution of beach sand. It is quite possible, however, that at the beginning beach deposits were frozen most of the year, even as the lake lowered, which would have deterred any such redistribution.

This till and these beach sand and gravel deposits represent some of the oldest known surficial materials with soil cover along the north shore of Lake Ontario. It is the objective of this paper to compare the effects of different physical characteristics in the two parent materials, on the morphological and chemical characteristics of the soils.

FIELD AREA

ORIGIN AND NATURE OF THE DEPOSITS (PARENT MATERIALS)

Halton Till. This till was formerly called Leaside Till by TERASMAE (1960), who correlated the surface glacial deposit in the Seminary Section (KARROW, 1967) with till in the Leaside railway cut described by COLEMAN (1932). This same deposit (in the Seminary Section) was later considered

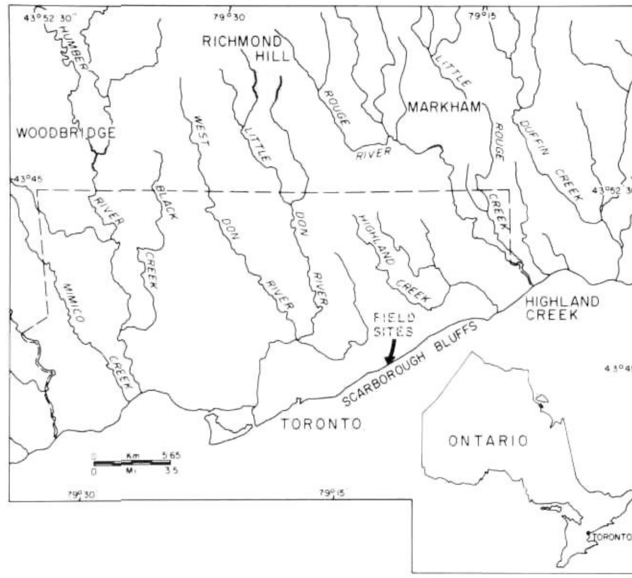

FIGURE 1. Study area at Scarborough Bluffs along the north shore of Lake Ontario.
La région à l'étude, falaises de Scarborough, rive nord du lac Ontario.

coeval with the Meadowcliffe Till (KARROW, 1967; MORGAN, 1981; SHARPE, 1980). On the basis of physical and mineralogical characteristics discussed in this report, it is considered correlative with Halton Till. In the Scarborough Bluffs, Halton Till has a sandy silt clay texture and ranges from 4 to 6 m in thickness (Fig. 2).

X-ray analysis of the $< 2\ \mu m$ fraction of several samples of Halton Till in the Scarborough Bluffs shows that it contains abundant quartz and calcite, as well as intermediate amounts of mica and plagioclase feldspar. Clay minerals include abundant illite and mixed-layer illite-smectite; vermiculite and chlorite are present in moderate amounts. This distinguishes it from Meadowcliffe Till which contains less calcite and quartz, less illite and no vermiculite. On the basis of clay mineralogy the uppermost till at Brimley Road appears to correlate with Halton Till.

Glacial Lake Iroquois deposits. These consist of stratified fine and coarse sand that occasionally are interbedded with gravel in places. Fine-grained deep water sediments are rare. At several locations along the Scarborough Bluffs exposures ($\pm$ 2 m thick) through Glacial Lake Iroquois beach deposits show an erosional surface cut into the sand and clay facies of the underlying Thorncliffe Formation of Middle Wisconsinan age (Fig. 3).

CLIMATE

The study area is in the humid continental, cool summer, no dry season, climatic region of Canada (BROWN *et al.*, 1968). The mean July temperature is 20°C, mean January temperature is −7°C, and extremes range from 40°C to −34°C. The frostfree period averages 150 days, from mid-May to early October; the maximum is 173 days. Along the Lake Ontario shoreline the frostfree period exceeds that of the

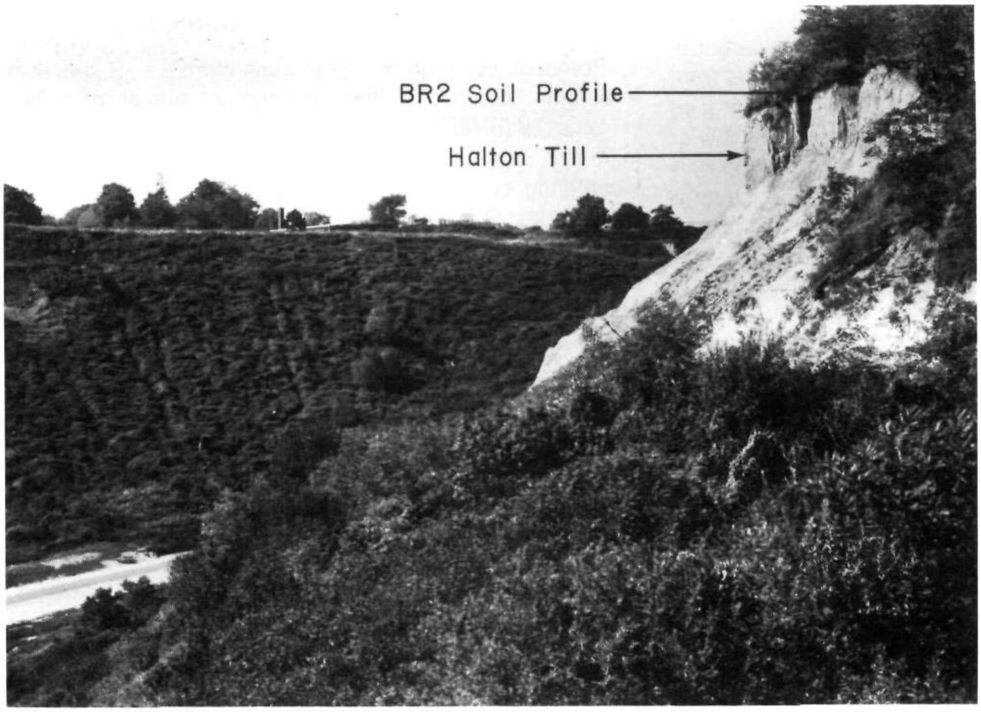

FIGURE 2. Halton Till at Brimley Road showing the location of site BR2.
Le Till de Halton, près de Brimley Road; localisation du site de BR2.

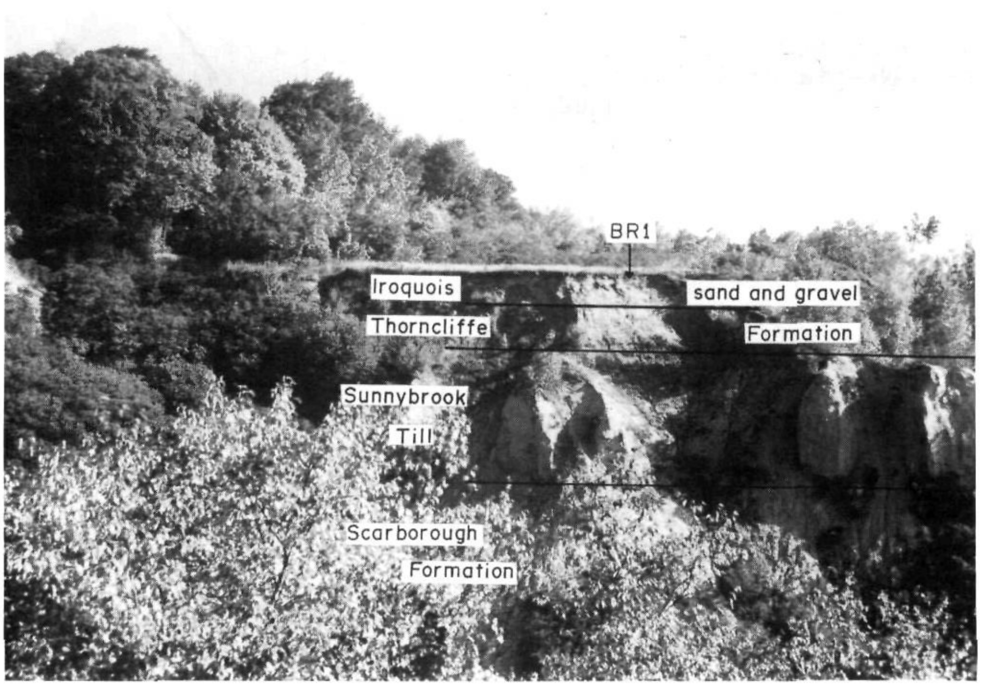

FIGURE 3. Lake Iroquois shoreline cut acoss the clay member of the upper Thorncliffe Formation and site BR1.
La ligne de rivage du lac Iroquois traverse l'unité argileuse de la partie supérieure de la Formation de Thorncliffe et le site BR1.

inland areas by as much as two weeks. Mean annual precipitation is 850 mm, and precipitation is lowest in the winter months from December through March (MAHANEY and ERMUTH, 1984). Mean annual potential evapotranspiration is 610 mm, mean annual actual evapotranspiration is 530 mm, giving a moisture deficiency of only 80 mm. Considering the data available for the last fifty years, the soils discussed herein appear to have sufficient moisture available for leaching effectiveness.

As deglaciation progressed in Southern Ontario, forest species migrated northward and westward, eventually forming the modern zonal vegetation belts (DAVIS, 1981). A mean annual paleotemperature curve for southeastern Ontario and Québec (TERASMAE, 1961) for the period starting 14,000 yrs BP, shows a range of 13°C, with approximately −10°C mean annual temperature at the time of deglaciation, increasing close to modern values at 7500 yrs BP with a Hypsithermal of +3°C at 5000 yrs BP. The Hypsithermal was inferred from a minimum of *Tsuga* (McANDREWS, 1981), but recent evidence (DAVIS, 1981) suggests that *Tsuga* was nearly destroyed by disease. Using numerous pollen diagrams from southern and eastern Ontario, McANDREWS (1981) argues that following deglaciation, temperatures rose from $-2°C$ or lower in southern Ontario to $+9°C$ at approximately 8000 yrs BP. Moreover, he concludes that there is no evidence for a Mid-Holocene Hypsithermal in southern Ontario, suggesting that climate at the two sites in this study were unaffected by *major* shifts in climate after 8000 yrs BP. Assuming that both sites were exposed following a drop in the level of Lake Iroquois between ~ 11,500 and ~ 12,000 yrs BP (COATES, 1976), both soils adjusted to changing biotic influences as the surface vegetation shifted, presumably from forest-tundra → boreal forest → mixed forest over ~ 3000 yrs BP. No buried soils have been uncovered in the field area that might yield palynological information on paleoclimate during the early stages of soil formation.

VEGETATION

The BR2 soil profile (in Halton Till exposed in the Seminary Section; formerly Meadowcliffe Till exposure of KARROW, 1967) is forming under a hardwood forest of beech and maple that has been thinned, but not farmed. The BR1 soil profile (in Glacial Lake Iroquois sand and gravel in the Seminary Section) site has been cleared, plowed and used as an orchard. Abandoned for ~ 20 years, it is now under second growth of sumac, aspen and grasses.

METHODS

Soil descriptions follow CANADA SOIL SURVEY COMMITTEE (1977) and BIRKELAND (1984), whereas soil color was determined from the Standard Soil Color Charts of OYAMA and TAKEHARA (1970). Duplicate soil samples were collected from each soil profile described in detail. The samples were air dried and passed through a 2 mm sieve. For particle size analysis, which is based on the Wentworth scale (FOLK, 1969), all samples were treated with H_2O_2 to remove organic matter. They were then agitated with a Branson 350 cell dismembrator to separate clay constituents. Sand was then wet sieved using 63 μm sieves, and coarse grade sizes were determined by weighing. Fine grade sizes of silt plus clay were determined by sedimentation following the method of BOUYOUCOS (1962) and DAY (1965). Organic carbon was determined by the WALKLEY BLACK (1934) method and $CaCO_3$ by gravimetric methods (RICHARDS, 1954). Soil pH was measured by electrode from a 1:1 paste. Cation exchange capacity (CEC) and extractable cations were determined by the ammonium saturation methods of PEECH *et al.* (1947). Iron was extracted with dithionite-citrate following procedures established by HOLMGREN (1967). Nitrogen was determined on an autoanalyzer following BREMNER (1965). The < 2 μm fraction was centrifuged onto ceramic tiles, air dried and X-rayed on a Toshiba ADG-301H diffractometer with Ni-filtered Cuk ∝ radiation following procedures outlined by WHITTIG (1965). Semi-quantitative determinations of clay mineral amounts in individual samples were made from peak heights.

RESULTS AND DISCUSSION

Some of the morphological characteristics of the soils forming in Glacial Lake Iroquois sand and gravel (BR1) and in Halton Till (BR2) are given on Figure 4. The major differences in morphology between the two profiles include: depth of weathering, complexity of horizonation, and strength of structural grades. Soil depth is much greater within Iroquois sand and gravel than in Halton Till, and subsolum horizonation probably reflects the original stratification in the beach deposit, at least to some degree. Structure in the topsoil is difficult to compare, since plowing has affected the surface of the BR1 profile; however, the B horizons give different strengths of blocky structure, probably resulting from different clay contents.

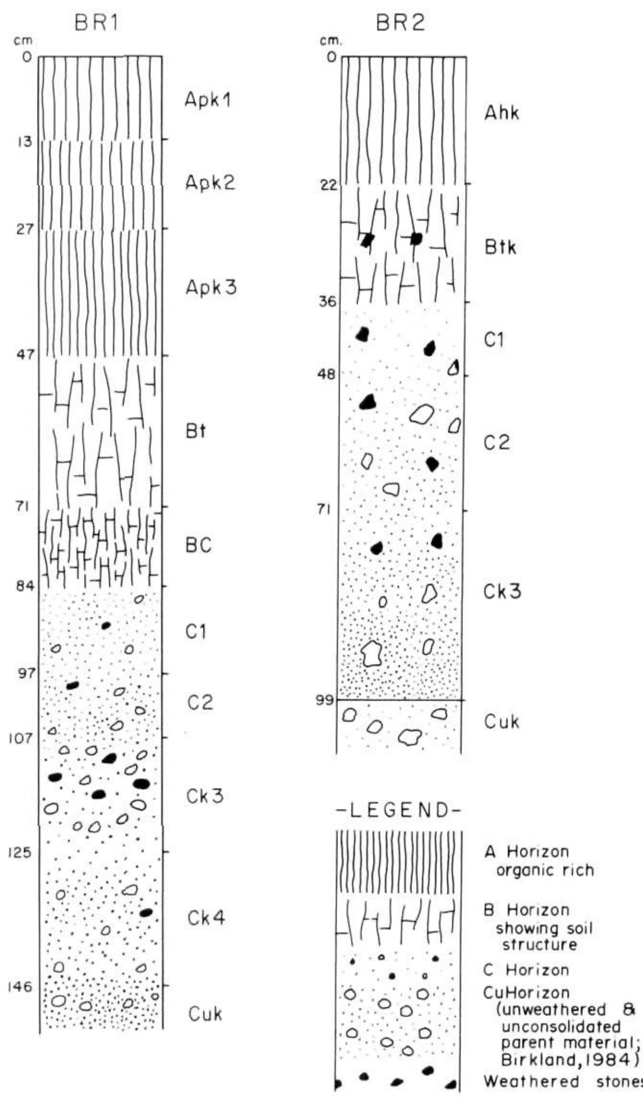

FIGURE 4. Diagramatic sketch of BR1 and BR2 soil profiles. The Cuk horizon is equivalent to parent material as defined by BIRKELAND (1984).
Schéma des profils de sol BR1 et BR2. L'horizon Cuk correspond au matériau d'origine comme l'a défini BIRKELAND (1984).

Shear strengths of the two soils varied considerably, reflecting the different nature of the parent materials. In Table I the shear strength, or force per unit area, decreases with depth in the solum and then generally increases with depth beneath the solum. Soils were tested in the dry state to represent, as closely as possible, the usual condition of the soil material in the field. Unconfined compressive strengths of the two soils give a quantitative expression of their different clayey soil consistencies. Although the values are reliable only to ± 20% (DAVIDSON, 1965), the results indicate the contrasting shearing strengths of the two soils.

TABLE I

Shear Strength[1] values (Kg/cm²) for BR1 and BR2 soil profiles, Scarborough Bluffs, Ontario

BR1	Shear Strength (Kg/cm^2)	BR2	Shear Strength (Kg/cm^2)
Apk1	0.3	Ahk	1.0
Apk2	0.7	Btk	0.5
Apk3	1.2	C1	1.0
Bt	0.8	C2	3.0
BC	1.7	Ck3	4.5
C1	2.5	Cnk	4.5 +
C2	4.0		
Ck3	1.1		
Ck4	0.5		
Cuk	1.1		

1. Determined by penetrometer.

PARTICLE SIZE

The results of the particle size analysis of the two soils are shown in Table II. The distributions of pebbles with depth in the two profiles reflect the origin of the parent materials. Silt increases in the upper solum of both profiles, presumably as a result of eolian influx of material in late glacial and postglacial time, which is similar to that reported in Quaternary soils to the north of this study area (MAHANEY and ERMUTH, 1975). Comparing the amount of clay in the parent materials (Cuk horizons) of the two soils, with the highest clay contents in the soil bodies, it is apparent that pedogenic processes have produced variable amounts of clay over ~ 12,000 years. In the BR1 soil profile pedogenic clay is highest in the Bt and C2 horizons, whereas in the BR2 soil profile the greatest increase is in the C2 horizon.

MINERALOGY

Results of X-ray diffraction analysis of the two profiles are given in Table III. A comparison of individual horizons with the parent materials shows that high amounts of illite and illite-smectite in the subsoil and parent materials decrease upward into the sola of the two soils, where other clay minerals, such as vermiculite in profile BR1 and chlorite in profile BR2, begin to appear. Kaolinite and halloysite, found in small amounts mainly in the sola of the two soils, may result from rapid hydration of feldspars, or from eolian influx of preweathered material (MAHANEY, 1978). Comparison of the primary mineral contents in the parent material, with the sola

TABLE II

Particle-size distribution for two late-Pleistocene soils, Scarborough Bluffs, Ontario

Size	Horizon	Depth (cm)	Cumulative % Pebble (64-2mm)	< 2 mm Sand-Silt-Clay	Sand % (2 mm-63μm)	Silt % (63-4μm)	Clay % (< 4μm)
BR1	Apk1	0-13	—	100	57.9	37.1	5.0
	Apk2	13-27	—	100	64.6	32.6	2.8
	Apk3	27-47	—	100	60.4	32.8	6.8
	Bt	47-71	—	100	53.6	35.9	10.5
	BC	71-84	—	100	59.4	33.6	7.0
	C1	84-97	1.2	99.8	67.4	25.6	7.0
	C2	97-107	1.0	99.0	61.5	14.5	24.0
	Ck3	107-125	24.3	75.7	88.1	5.9	6.0
	Ck4	125-146	4.4	95.6	96.9	1.1	2.0
	Cuk	146 +	0.8	99.2	98.7	0.5	0.8
BR2	Ahk	0-22	1.1	99.9	42.0	41.0	17.0
	Btk	22-36	2.6	97.4	44.6	33.4	22.0
	C1	36-48	5.3	94.7	57.2	26.3	16.5
	C2	48-71	6.1	93.9	29.4	20.6	50.0
	Ck3	71-99	4.4	95.6	28.2	28.8	43.0
	Cuk	99 +	4.9	95.1	28.9	30.1	41.0

TABLE III

X-ray analysis of the clay size (<2µm) material in two Late Pleistocene sites, Scarborough Bluffs, Ontario

Site	Horizon	Depth (cm)	Mineralogy of the <2µm Fraction[1]							
			K	H	I	I-S	V	C	Q	F
BR1	Apk1	0-13	tr	tr	tr	tr	tr	tr	xx	x
	Apk2	13-27	tr	tr	tr	tr	tr	tr	xx	x
	Apk3	27-47	x	x	tr	tr	x	tr	xx	x
	Bt	47-71	tr	tr	—	—	xx	tr	x	tr
	BC	71-84	tr	—	?	—	x	tr	xx	tr
	C1	84-97	tr	—	x	tr	x	tr	xxx	tr
	C2	97-107	—	—	xxx	xx	tr	—	xxx	xx
	Ck3	107-125	—	—	x	x	tr	—	xx	x
	Ck4	125-146	—	—	—	—	—	—	xxx	x
	Cuk	146 +	—	—	tr	—	—	—	xxx	x
BR2	Ahk	0-22	tr	—	—	—	x	—	xx	tr
	Btk	22-36	tr	—	—	tr	x	tr	xx	tr
	C1	36-48	tr	—	x	x	x	tr	xxx	tr
	C2	48-71	—	—	x	—	x	—	xxx	x
	Ck3	71-99	tr	—	x	x	x	—	xxx	x
	Cuk	99 +	tr	—	xxx	xx	x	—	xxx	xx

[1] Mineral abundance is based on peak height: — nil; minor amount (tr); smalll amount (x); moderate amount (xx); abundant (xxx). Clay minerals are kaolinite (K); halloysite (H); illite (I); mixed-layer illite-smectite (I-S); vermiculite (V); chlorite (C). Primary minerals are quartz (Q); and plagioclase feldspar (F).

TABLE IV

Selected chemical properties[1] of the <2 mm fractions of two late-Pleistocene soils, Scarborough Bluffs, Ontario

Site	Horizon	Depth (cm)	pH (1:1)	extractable meq/100g				CEC meq/100g	Base Saturation %	Salts mmhos/cm 25°C	Organic carbon %	N %	Fe_2O_3 %	Carbon/Nitrogen	$CaCO_3$ %
				Na^+	K^+	Ca^{+2}	Mg^{+2}								
BR1	Apk1	0-13	6.8	0.2	0.1	7.5	0.3	8.3	98	0.48	1.12	0.107	0.30	11	35.1
	Apk2	13-27	7.1	0.1	0.1	6.6	0.3	4.1	100	0.42	1.00	0.126	0.26	8	33.7
	Apk3	27-47	7.2	0.1	0.1	6.8	0.3	6.7	100	0.40	1.06	0.101	0.49	11	11.8
	Bt	47-71	7.3	0.1	0.1	6.6	0.2	9.0	78	0.50	0.61	0.062	0.80	10	—
	BC	71-84	7.4	0.1	0.1	3.3	0.1	6.4	56	0.54	0.37	0.034	0.64	11	—
	C1	84-97	7.5	0.1	0.2	3.9	0.1	4.1	100	0.43	0.32	0.020	0.49	16	—
	C2	97-107	7.5	0.1	0.1	6.3	0.2	9.0	74	0.45	0.22	0.034	1.00	7	—
	Ck3	107-125	7.5	0.1	0.1	6.8	0.1	4.8	100	0.42	0.17	0.026	0.67	7	22.6
	Ck4	125-146	7.5	0.1	tr	5.0	0.1	2.3	100	0.36	0.05	0.014	0.26	4	76.9
	Cuk	146 +	7.7	0.1	tr	5.0	0.2	0.9	100	0.29	0.04	0.004	0.19	10	65.6
BR2	Ahk	0-22	6.7	0.2	0.1	11.5	0.7	16.9	74	0.78	4.00	0.190	0.80	21	4.8
	Btk	22-36	6.8	0.2	0.1	6.8	0.3	9.5	78	0.68	1.31	0.070	0.90	18	3.9
	C1	36-48	6.9	0.2	0.1	4.0	0.2	5.9	76	0.64	0.62	0.030	0.71	20	—
	C2	48-71	6.7	0.2	0.3	10.0	1.1	20.5	57	0.61	0.60	0.051	1.51	12	—
	Ck3	71-99	7.1	0.2	0.2	10.3	0.8	13.9	83	0.80	0.61	0.050	1.30	12	4.7
	Cuk	99 +	7.0	0.2	0.2	12.8	1.1	14.1	100	1.50	0.43	0.042	1.30	10	6.0

[1] nil.

of the two soils, shows that in both deposits abundant quartz and small to moderate amounts of plagioclase feldspar decrease to moderate and small amounts of quartz and trace quantities of feldspar, suggesting similar magnitudes of weathering in the two soils.

SOIL CHEMISTRY

Soil pH (Table IV) is similar in the two profiles, with neutral reactions in the sola increasing slightly in the lower subsoil and parent materials. With the exception of Ca^{+2}, extractable cations are similar between the two profiles. Cation exchange capacity (CEC) and Ca^{+2} content are higher in the BR2 profile, probably as a result of higher clay and organic carbon contents. Base saturation (%) and total salt content differ slightly in both profiles suggesting that the average depth of leaching is slightly greater in the BR1 profile. Organic carbon, nitrogen, and C/N ratios are higher in the BR2 profile, reflecting its location in a maple-beech hardwood forest stand unaffected by agriculture. Investigations of agricultural effects on local Luvisols and Brunisols (MAHANEY and ERMUTH, 1974) showed that agricultural soils in southern Ontario have lost almost half their original organic carbon and nitrogent content.

Insoluble iron (dithionite-citrate extractable) is present in similar amounts in both soil sola (~0.9 percent). In the BR2 soil, however, Fe_2O_3 increases to 1.51 percent in the subsoil and then drops to 1.30 percent in the parent material. The increase in "free" Fe_2O_3 in the parent material of the BR2 soil profile may be due to preweathering of Wisconsinan interstadial soils, with their subsequent incorporation into Halton Till (DREIMANIS, 1981). The $CaCO_3$ distributions with depth in the two soils indicate greater leaching in the BR1 profile, which presumably results from lower bulk density, higher pore space, and higher infiltration capacity.

CONCLUSIONS

These results show a number of differences and similarities between the two soils, with differences reflecting mainly the constrasting physical characteristics of the two profiles. Both soils have formed over the same time span, in similar topographic settings, under a climate and biota only recently disturbed (in the case of the BR1 soil profile) by agricultural activity, and in parent materials with different origin, and hence different lithologies. The morphological differences, therefore, are a result of different physical characteristics of the two parent materials. Soil depth is related to the relative rates at which water moves through different materials, which is predominantly greater in beach sand and gravel (BR1) than in till (BR2). Thickness of the soil sola in BR1 is partly due to agricultural activity; however, B horizon thickness is also greater than in the BR2 soil profile. A somewhat higher grade of structure in the BR2 soil profile is probably related to the greater amount of clay and higher organic carbon content.

Clay mineral genesis in the BR1 soil profile suggests that illite and mixed-layer illite-smectite are weathering into vermiculite. In the BR2 profile vermiculite is present in a small amount from the soil solum into the parent material, suggesting that while it might be inherited from preweathering and incorporation into glacial deposits, there is no evidence for a pedogenic origin. While chlorite is missing in the parent materials of both profiles, trace amounts in the soil sola suggest it may form from illite. While these profiles probably developed initially under forest-tundra and later boreal forest (~ 3000 yrs), there is no evidence for the development of an Ae (eluvial) horizon. Both profiles are important in the Quaternary record of South-Central Ontario because they represent the two most common types of surficial deposits found along the north shore of Lake Ontario, and they represent the sum total of weathering effects that have occurred over the last ~ 12,000 years. Both profiles have formed in two of the most common Late Quaternary deposits in South-Central Ontario.

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