

GUIDEBOOK /

37th Reunion
Friends of the Pleistocene

University of Toronto

May 17-19, 1974

Hosts

Dr. W. G. Dean
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Dr. J. McAndrews.

This guidebook has been prepared for the 37th Reunion of the Friends of the Pleistocene held at the University of Toronto between May 17-19, 1974. The guidebook consists of two parts: Trip A - Oak Ridges moraine in Whitchurch and Uxbridge townships - Saturday, May 18; and Trip B - Crawford Lake - Sunday, May 19.

Section A - Oak Ridges moraine in Whitchurch and Uxbridge townships.

Introduction

One of the most distinctive features of glacial origin on the landscape of south-central Ontario is the Oak Ridges interlobate moraine. The moraine is located about 20 mi. (32 km.) inland from Lake Ontario, and extends from Schomberg, east, almost 100 mi. (160 km.) to Colborne near the Trent Valley (Map 1). The field trip will cover the part of the moraine in Whitchurch and Uxbridge townships, about 25 mi. (40 km.) north-east of Toronto. Earlier writers (Chapman and Putnam, 1966) mapped the moraine east from the Niagara escarpment, but recent work by White (1971) suggests that outwash along the escarpment represents a different series of events.




The Oak Ridges moraine forms the drainage divide between the Lake Ontario and the Georgian Bay - Trent River basins. The southern edge of the moraine is relatively straight except for a secondary ridge that extends from the vicinity of Oak Ridges to Maple (Map 1). In contrast the northern edge is distinctly scalloped. Average elevations over the length of the ridge are between 1000 and 1100 ft. (305 to 335 m.) above mean sea-level, with maximum elevations of 1300 ft. occurring in the south-east corner of Uxbridge township. Relief between the ridge and the lowlands to the north and south varies from 100 to 400 ft. (30 to 122 m.).

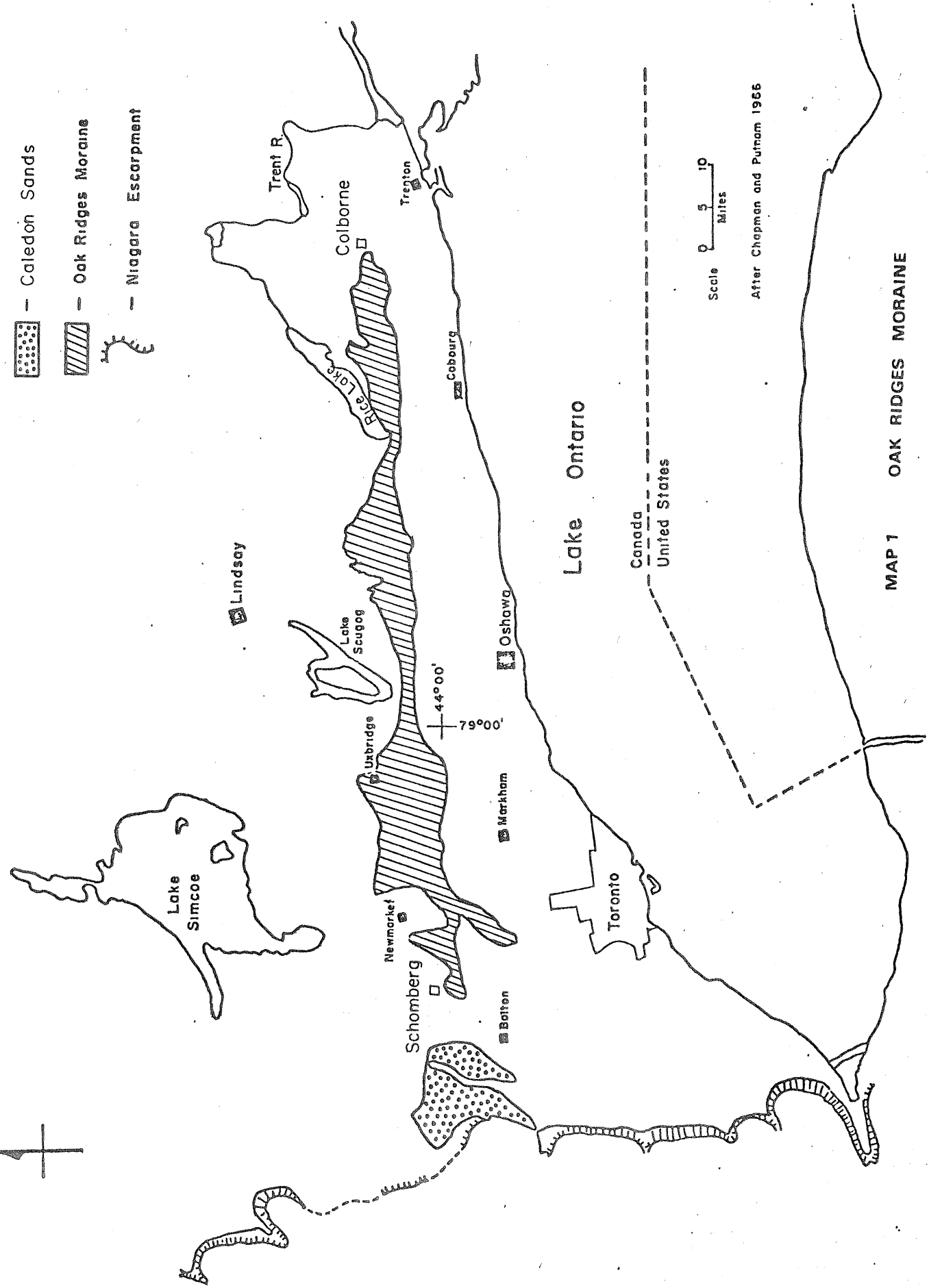
The most rugged topography in the Oak Ridges moraine is generally found near the south flank, and is associated with a complex of ridges, kames, and ice contact faces. Near Glen Major in south-east Uxbridge, the relief is particularly striking, and the area has been developed for skiing.

The width of the moraine varies from about one-half mile (0.8 m.) south of Lake Scugog to a maximum of 7 mi. (11 km.) in Uxbridge township.

Although very few bore holes have been drilled to bedrock in the Oak



-  - Caledon Sands
-  - Oak Ridges Moraine
-  - Niagara Escarpment



Scale 0 5 10
Miles

After Chapman and Putnam 1966

MAP 1 OAK RIDGES MORaine

Ridges moraine, maximum thicknesses of sediment appear to be in the order of 700 ft. (213 m.). The general sequence of sediments in the deep borings consists of between 0 and 30 ft. (0 and 9 m.) of surface till which overlies between 150 and 200 ft. (48 and 61 m.) of sand and/or gravel. These deposits in turn overlie a complex of clays, varved clays, sands and possibly tills. Because of the generally poor quality of most of the drill logs further differentiation of the deep sediments is impossible at this time.

The maximum thickness of sediment exposed in open cuts is about 120 ft. (37 m.). Although the lower clays and tills are not exposed in these excavations, there are many excellent sections of the surface till and later outwash sands. Many of the best sections are found in Whitchurch and Uxbridge, where there has been considerable exploitation of sand and gravel in recent years.

Surface drainage within the Oak Ridges moraine is for the most part poorly developed due to the permeable nature of much of the surface sediment. Another contributing factor is the rolling, hummocky topography that makes continuous overland flow difficult. Drainage patterns along the north and south flanks differ. North flank streams such as Pepperlaw Brook and the Beaverton River rise in swamp filled valleys and have low gradients. In contrast the south flank streams have generally steeper gradients, and large swamp filled depressions are rare. In the field trip area the Don River, Rouge River and Duffin Creek are the principal south flank drainage basins.

Between elevations of 1000 and 1100 ft. (304 and 335 m.) in the townships of Whitchurch and Uxbridge there are numerous kettle lakes. The largest of these are Wilcocks Lake and Musselman Lake, which are about 0.2 mi.² (0.5 km.²) in area. Both lakes are drained by surface streams but most of the kettles are internally drained.

Bedrock Geology

The glacial sediments of the Oak Ridges moraine overlie shales and thinly bedded limestones of the Simcoe and Nottawasaga groups of the middle and upper Ordovician (Liberty, 1969). In Whitchurch and Uxbridge the underlying bedrock is a brown, slightly petroliferous shale of the middle Whitby Formation. No outcrops of this formation occur within the moraine but

exposures can be found to the south along the Rouge River valley in Scarborough township. Underlying the middle Whitby is a black petroliferous shale which outcrops to the north and east. Pebbles of this shale are common in some of the outwash gravels in Whitchurch and Uxbridge.

Glacial Deposits

Although it seems probable that southern Ontario was covered by four major glaciations during the Pleistocene - Nebraskan, Kansan, Illinoian and Wisconsin, only deposits of Illinoian and later have been identified. Exposures of Illinoian, Sangamon interglacial and early Wisconsin sediments are rare. The most outstanding exposures of these deposits are found in the Don Valley and along the Scarborough Bluffs near Toronto (Coleman, 1932, Karrow, 1967). Illinoian till (York till) has also been identified in a roadcut, northwest of Toronto, near Woodbridge (Karrow, 1964), and probably underlies much of the area south of the Oak Ridges moraine (Karrow, 1970).

The deposits that will be seen on this field trip, except for those at the Don Valley Brickyard were all deposited during or following the Port Bruce substage (15000 BP) of the late Wisconsin (Dreimanis and Karrow, 1972).

Tills

Following retreat of the Wisconsin ice from the Niagara escarpment, the ice sheet appears to have split into two lobes along line between Caledon, near the Niagara escarpment, and Colborne. In the split the upper outwash sands and gravels of the Oak Ridges moraine were deposited.

Four tills have been identified in Whitchurch and Uxbridge townships. Three tills were deposited by the southward flowing Georgian Bay - Simcoe lobe, and one by the northwestward flowing Ontario lobe.

The earliest of the northern tills, named Bogarttown by Gwyn (1972) was probably deposited by the Georgian Bay - Simcoe lobe during or soon after withdrawal of ice from the Niagara escarpment. This till is not exposed at the surface in the vicinity of the Oak Ridges moraine, but overlies ice contact sands and gravels in a till sequence near Newmarket (Gwyn and DiLabio, 1973).

A readvance of the Georgian Bay - Simcoe lobe south and southwest to the Niagara escarpment built the Singhampton moraine and deposited the Newmarket till (lower northern till of White, 1971). This till has a silty sand matrix with about 10% pebbles, and was mapped by Gwyn and DiLabio (1973) over a wide area to the north of the moraine. In Whitchurch and Uxbridge retreat of the Newmarket ice ponded meltwater against the northern flank of the

Oak Ridges moraine, forming the early Schomberg Ponds. Several meters of varved clays and silts were deposited in these ice marginal lakes. Remnants of these sediments have been found at elevations up to 1000 ft. (305 m.) above mean sea-level.

A final minor advance of the northern ice deposited the Kettleby till (Gwyn, 1972). This till is typically brown with a matrix of clayey silt derived from the early Schomberg pond deposits, and contains about 1% stones (Gwyn and DiLabio, 1973). The Kettleby ice does not appear to have overridden the Oak Ridges moraine in Whitchurch and Uxbridge townships.

The final advance of ice from the Lake Ontario basin deposited the Halton (upper Leaside) till on the southern flank of the Oak Ridges moraine. The maximum northerly advance of the Ontario lobe is well marked by the line of kettle lakes and ice-block depressions extending from the town of Oak Ridges east to the vicinity of Musselman Lake. White (1971) in his mapping of the Bolton area to the west associated this advance with deposition of the Palgrave moraine against the south flank of the Oak Ridges moraine. This interpretation was extended into Whitchurch and Uxbridge by Gwyn and DiLabio (1973). The Halton till is primarily a sandy silt till that weathers yellowish-brown and contains about 5% stones (Gwyn and DiLabio, 1973). There is no evidence in the area to indicate the relative ages of the Kettleby and Halton till sheets, however, White (1971) suggested that the latter was probably slightly older.

This writer found one section in the south-eastern part of Uxbridge township (Concession 6, Lot 3) where two southern tills were exposed. In this section 3 to 10 ft. (0.9 to 3.0 m.) of surface till overlies 25 ft. (7.6 m.) of cross-bedded sands and gravels which in turn cover 3 ft. (0.9 m.) of sandy silt till. Textural analysis of the upper and lower tills indicated that the upper till had a slightly coarser overall grain size distribution. Till fabric analysis of both tills showed almost identical orientations. My feeling at this time is that these tills are indicative of minor fluctuations of the southern ice front rather than two distinct advances.

Ice-Contact Sediments

Along the margin of the Halton till sheet, the surface is generally hummocky, and appears typical of kame moraine. As can be seen on the topographic maps, this is particularly true of the south-eastern part of Uxbridge

township. For the most part the near surface materials in this area are poorly differentiated silts, sands and gravels that are characteristic of an ice-contact environment. Excavation of the hummocks, however, does not always reveal such materials. Although capped with till the hummocks are often composed of undisturbed cross-bedded sands that are perhaps more typical of outwash plain.

Outwash Deposits

North and west of the Halton till margin the cross-bedded sands and interfingering, cross-bedded, gravels are typical of outwash sediments.

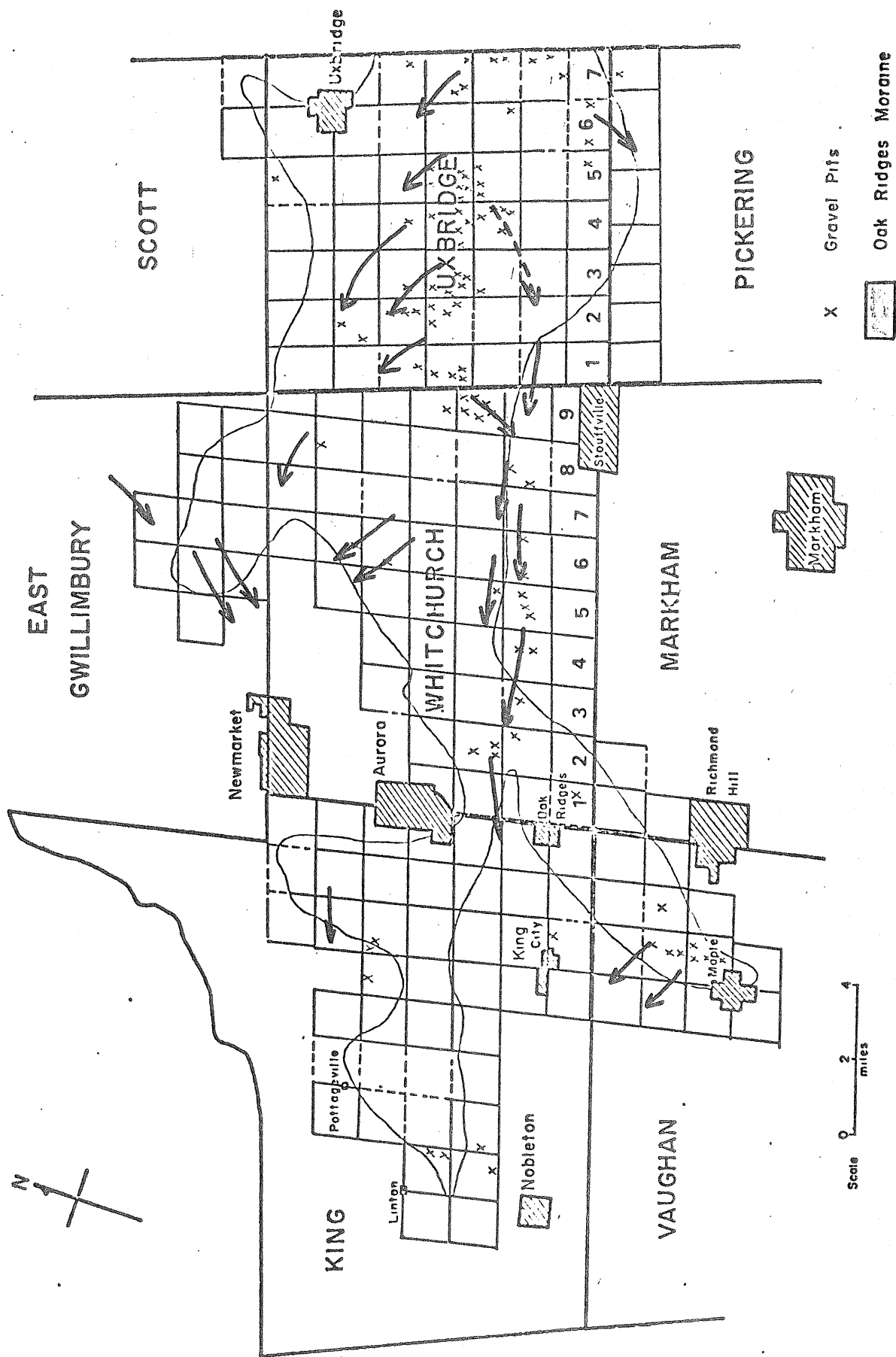
A study of paleocurrent trends and textural characteristics of the outwash sediments in Whitchurch and Uxbridge (Duckworth, 1974) indicated that the paleoflow was toward the north-west in the eastern part of the area and became more westerly toward the west (Map 2). Major concentrations of gravel occur primarily along the margin of the Halton till sheet. The deposit becomes finer toward the north-west and west.

Outwash sands and minor gravel underlie the Halton till along the south flank of the Oak Ridges moraine in Whitchurch and Uxbridge at an elevation of about 950 ft. (290 m.) above sea-level. Paleocurrent analysis indicates that these sands were deposited by westward flowing pre-Halton streams held between the ice in the Ontario basin and the moraine.

Gravel along the south flank seems to be concentrated in Uxbridge. A possible headwater area for the south flank drainage is located in Concession 4, Lot 12 of this township. The elevation of this area is 1100 ft. (33 m.). Gravel fabrics and cross-bedding azimuths indicate that flow was south-east through Concession 3, Lot 11 and Concession 2, Lot 10 to the south flank spillway (Map 2). Through this area the Halton till cap is broken which suggests that the headwater area was active following the Halton advance.

Lacustrine Deposits

Remnants of several small ice marginal lakes are found just north of the Halton ice margin in Concessions 2, 3, 4 and 5 of Uxbridge township. Accumulations of up to 20 ft. (6.1 m.) of rhythmite clays were deposited in these pondings. The typical stratigraphic sequence associated with the clays consists of; 1 to 10 ft. (0 to 3m.) wind blown sand at the surface; 20 to 30 ft.



MAP 2 GENERALIZED PALEOCURRENT TRENDS
IN THE OAK RIDGES MORaine

(6.1 to 9.1 m.) of cross-bedded sand; 3 to 20 ft. (0.9 to 6.1 m.) rhythmite clays and silts; 3 to 6 ft. (0.9 to 1.8 m.) of cross-bedded cemented gravels; 10 to 20 ft. (3.0 to 6.1 m.) cross-bedded coarse sand; and more than 10 ft. (3.0 m.) of cross-laminated silty sand. The sequence suggests steadily increasing flow conditions probably associated with the melting of the Halton ice. These conditions suddenly terminated and were followed by a period of low energy deposition (rhythmites) on the upper outwash plain. Further melting of the Halton ice resulted in deposition of the upper cross-bedded fine sand. An example of the above sequence will be seen at stop 4 (Consolidated Sand & Gravel, Uxbridge township, Concession 5 Lot 18).

Wind Blown Deposits

Wind deposited fine sand overlies the outwash sands through the central parts of Whitchurch and Uxbridge. The largest area is found near Ballantrae in Concessions 6 and 7 of Whitchurch.

Field Trip Maps

The areas to be visited during the Reunion are covered by the following Canada National Topographic System 1:50,000 maps:

Oak Ridges moraine (Saturday trip)

Markham - 30M/14E; 30M/14W

Newmarket - 31D/3E; 31D/3W

Guidebook prepared by Peter Duckworth.

Field Trip Route Log: - Map 4

The field trip will procede from the University of Toronto east over the Lake Iroquois nearshore to the Don Valley Brickyard.

Stop 1Sequence

Wisconsin	Late	- Leaside Till	- silty clay
	Middle	- Thorncliffe Fm.	- deltaic sands and warped clays
	Early	- Sunnybrook Till	- silty clay till
		- Scarborough Fm.	- clay, silt, sand, wood.
Sangamon		- Don Beds	- clay, sand, wood
Illinoian		- York Till	- clayey sand till.

Adapted from Karrow, 1967.

1 picture of whole section
2 pictures of Don beds
close-ups of ~~till~~/sand contact (Don)
Looks like till but isn't

- North on the Don Valley Parkway to Shepard Avenue. At Eglinton Avenue the low bluff to the left is the Lake Iroquois shoreline. This shoreline extends north from Eglinton Avenue along the line of the Don Valley Parkway to north of Lawrence Avenue (see Map 3).
- As we cross Highway 401 you will see a broad valley (approx. 1 mile wide) to your left. This north south depression, presently occupied by the west branch of the Don River marks the location of a pre-glacial bedrock valley that is believed by Karrow (1970) to pass under the Oak Ridges moraine to connect with Georgian Bay. The presence of this valley was first suggested by Spencer (1888)
- Proceeding northward on Woodbine Avenue over the South-Slope the land surface is fluted, and slightly drumlinized. Occassional flat areas mark the location of lacustrine silts that were deposited in proglacial ponds during final retreat of the Ontario lobe.
- As we approach Buttonville, the drumlinization of the till plain becomes more apparent. Woodbine Avenue passes over Heise's Hill a small drumlin oriented NW-SE. The Oak Ridges Moraine is the height of land extending east and west. At Gormley we turn east along the Stouffville Road. This road passes along the bottom of the south flank of the Palgrave moraine. At



MAP 4 FIELD TRIP ROUTE
1:250,000
MAY 18, 1974

TORONTO

Concession 6, Whitchurch township we proceed north up the south slope of the moraine to an excavation owned by Parkway Sand and Gravel

Leaside (old term) ?

Stop 2 Parkway Sand and Gravel

1 long shot of Halton till over x-bedded gravels

- The Parkway pit is situated in the south flank spillway mentioned earlier, and has some of the best examples of fluvial sedimentary structures exposed in the moraine. The sedimentary sequence consists of 8 to 15 ft. (2.4 to 4.6 m.) of Halton till overlying 60 ft. (18.3 m.) of cross-bedded and cross-laminated sands. Paleocurrent trend based on 69 observations of cross-bedding is 242 degrees. (Duckworth, 1974).

- Gravel is confined to occasional pockets associated with bar formation in the glacial streams. Visible bedding types include ^{pic.} tabular, ^{pic.} trough, and plane bedded sands, and cross-laminationed silt.

Several pic. of fluvial structures + till contact

- From the Parkway pit we proceed north a short distance to the Bloomington Road, and then east about three miles along the edge of the Palgrave moraine to Whitchurch Concession 9. Proceeding one mile north on Concession 9 brings us to the edge of the Halton ice sheet, bordering which, is a string of kettle lakes. Musselman Lake is on your left. Very little work has been done on the sedimentation of these lakes except for the palynological study of Jock McAndrews in Van Nostrand Lake to the west.

- North of Musselman Lake we enter an area of sand plain, and proceed east to Whitchurch Concession 10. South on Concession 10 you will see Island Lake on your right, and further down the road on your left are several dry ice block depressions. Proceeding south we encounter the Halton till sheet again near the Stouffville plant of Consolidated Sand and Gravel.

Lunch

Stop 3. Consolidated Sand and Gravel

several pics of gravel + structures

- The most interesting sedimentary sequence in this pit is associated with the concentrations of gravel. The gravel occurs in 'plug-like' deposits which may extend vertically for up to 50 ft (15 m.). Within these structures is considerable faulting, and adjacent beds appear to be draped over the 'plugs'. Laterally the material fines rapidly away from the gravel. This writer has traced several of these gravel accumulations over distances of up to 800 ft.

(243 m.). In this pit five of these structures have been noted trending generally to the south west and separated by about 200 ft (61 m.) of primarily silty sand. Vector mean of cross-bedding in the pit as determined from 116 observations was 182 degrees. (Duckworth, 1974).

- Proceeding east along Highway 47 to Goodwood the hummocky nature of much of the moraine complex can be seen. Beyond Goodwood we again proceed along the northern edge of the Halton till sheet. Turning south on the Brock Road we arrive at another property owned by Consolidated Sand and Gravel in Uxbridge, Concession 5, Lot 18.

Stop 4 Consolidated Sand and Gravel

- The Halton till is absent in this section which shows in the sequence about 10 ft. (3.1 m.) of rhythmites overlying cemented gravel. Worm tracks have been observed on the surface of the individual clay silt layers. Paleocurrent direction in the cross-bedded sands and gravels based on 30 observations is 347 degrees. *3 pics looking NE. at face in draw folds over x-bedded gravel*
- Continuing south we turn east onto Ontario County 1A and proceed to Uxbridge, *pit. of eolian sand + topsoil* Concession 6. In this area the Halton till is absent. South on Concession 6 we climb the north slope of the Palgrave moraine. Elevations along this road reach 1200 feet (366 m.). Passing over the moraine we travel through an area of ice block depressions. Starting down the south slope of the Palgrave moraine you will see a small pit on the left. This exposure is the only location where this writer has observed two south flank tills. Because the pit has been extensively changed in the last year the upper till is not visible from the road, but the lower till can be seen along the base of the pit to the left of the weigh scale.
- The route home is along the base line of Uxbridge to the Brock Road and then south to Highway 401.

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FRIENDS OF THE PLEISTOCENE

37th Annual Reunion

Toronto, Ontario

May 17-19, 1974

INVESTIGATIONS AT CRAWFORD LAKE

Geological and vegetational History

Jock McAndrews and Maria Boyko, Dept. Geology, Royal
Ontario Museum and Dept. Botany, Univ Toronto
Roger Byrne, Dept. Geography, Univ. California, Berkeley

Karst

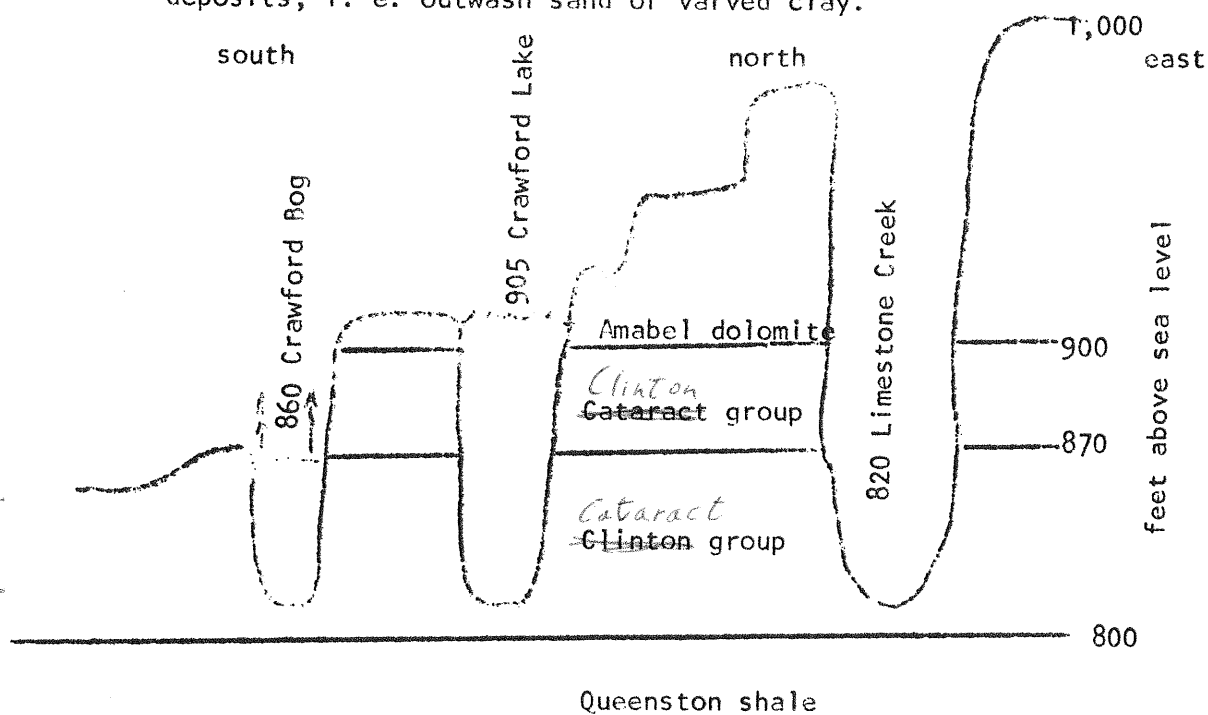
Len Kalas, Canada Centre for Inland Waters, Burlington
Ralph Ewers, Dept. Geography, McMaster University,
Hamilton

Archaeology

Bill Finlayson, Dept. Anthropology, Univ. Western
Ontario, London

BEDROCK STRATIGRAPHY AND POSITION OF DEPRESSIONS

In the vicinity of Crawford Lake there are approximately 2,000 feet of Palaeozoic rock of Ordovician and Silurian age. The elevation of the bedrock datum, the top of the Queenston Formation, is uncertain. The bottom of the basins is approximately the top of the late Pleistocene deposits, i. e. outwash sand or varved clay.



Cataract group	Irondequoit limestone	6 ft.
	Reynales dolomite	10 ft.
	Thorold sandstone	13 ft.
<hr/>		
Clinton group	Grimsby shale	12 ft.
	Cabot Head shale	34 ft.
	Manitoulin dolomite	11 ft.
	Whirlpool sandstone	12 ft.

Fig. 1. Bedrock stratigraphy of Crawford Lake

PRESENT DAY VEGETATION

Present day vegetation around Crawford Lake consists of a mosaic of disturbed forest, abandoned fields, limestone pavement, bog and shrub carr. Forest is the predominant vegetation type.

The forest within 100 m of the lake consists mainly of white cedar, sugar maple, white birch, white ash, and hemlock. In general, however, the surrounding forest is dominated by sugar maple, white cedar and to a lesser extent white birch. Sugar maple has become a dominant by succession. White cedar is common because of numerous wet depressions and thin soils. Other important species include ironwood, white pine, hemlock, white elm, red oak, and to a smaller extent white ash, yellow birch, black ash, basswood and black cherry. Beech is abundant locally about 200 m NE of the lake where it occurs on deep soils.

Interesting species are Abies balsamea and Hamamelis virginiana which reach their southernmost and northernmost limits, respectively, in this area.

Throughout the forest there are numerous cut white pine stumps that reach a maximum diameter of 1 m. The stumps are recognized by distinct spires on the outside rim of the stump. Yellow and white birch, hemlock and cedar often grow on the rotting stumps. These stumps reflect selective lumbering activities which by the 1800's had greatly reduced not only white pine but also white oak. Surveyor Sherwood (1819) noted that the forest around Crawford Lake (4.7 sq. mi., 120 ha) consisted mainly of hardwoods such as (white) oak, ash, beech, maple, but intermixed with "tall growth of pines." In the area today there are only a few white oaks. White pine is more common but not as abundant as it was in earlier times. Today it grows in open areas; along the forest edges, along edges of abandoned fields and in areas of former pasture.

LATE PLEISTOCENE GEOLOGICAL HISTORY

Crawford Lake lies on the Niagara Escarpment between two northeast-southwest trending re-entrants. Straw (1968) suggests they were formed by glacial erosion during the early Wisconsin. However, Karrow (1973) on the basis of bedrock topography, regards most of the re-entrants to have originated as stream-eroded valleys.

Surficial drift around Crawford Lake was deposited by the late-Wisconsin Lake Ontario lobe during Port Huron time. Drumlins indicate a westward advance to the Galt Moraine and deposition of Wentworth Till. Glacial retreat eastward was followed by a re-advance to or just onto the Escarpment, the formation of the Waterdown Moraines and the deposition of Halton Till (Karrow 1963).

The westernmost position of the re-advance is marked by kame deposits that indicate an ice front stood across the valley of Limestone Creek. Meltwater was channelled southward through the Crawford Lake spillway and truncated a previously formed drumlin of Wentworth Till. No outwash is present in the spillway.

We suggest that the spillway water subsequently descended through the joints of the surficial Amabel dolomite. The water then eroded a cavern in the underlying less resistance sandstones, shales, dolomites and limestones of the Clinton and Cataract groups but probably not the underlying Queenston shale. Collapse of the cavern roof accounts for the basins of both Crawford Lake and Crawford Bog as well as smaller depressions.

Meltwaters abandoned the Crawford Lake spillway when the ice front retreated eastward to the outermost Waterdown Moraine. The new ice marginal stream flowed down the valley of Limestone Creek and southeastward across the Lowville re-entrant into Lake Warren or later lakes. This stream deposited outwash.

Further retreat and a subsequent still stand formed the Trafalgar Moraine. Disappearance of ice from the eastern Lake Ontario basin resulted in the formation of Glacial Lake Iroquois about 12,000 years ago.

CARBONATE-ORGANIC VARVES OF CRAWFORD LAKE

Crawford Lake ($43^{\circ} 28.1' N$, $79^{\circ} 56.9' W$) is a small lake (area 2.5 ha, depth 24 m) situated about 1 km west of the Niagara Escarpment and about 65 km west south-west of Toronto.

The sediment of Crawford Lake is rhythmically laminated throughout the upper 1.5 m of its approximate 4 m Holocene deposit. The laminae are con-

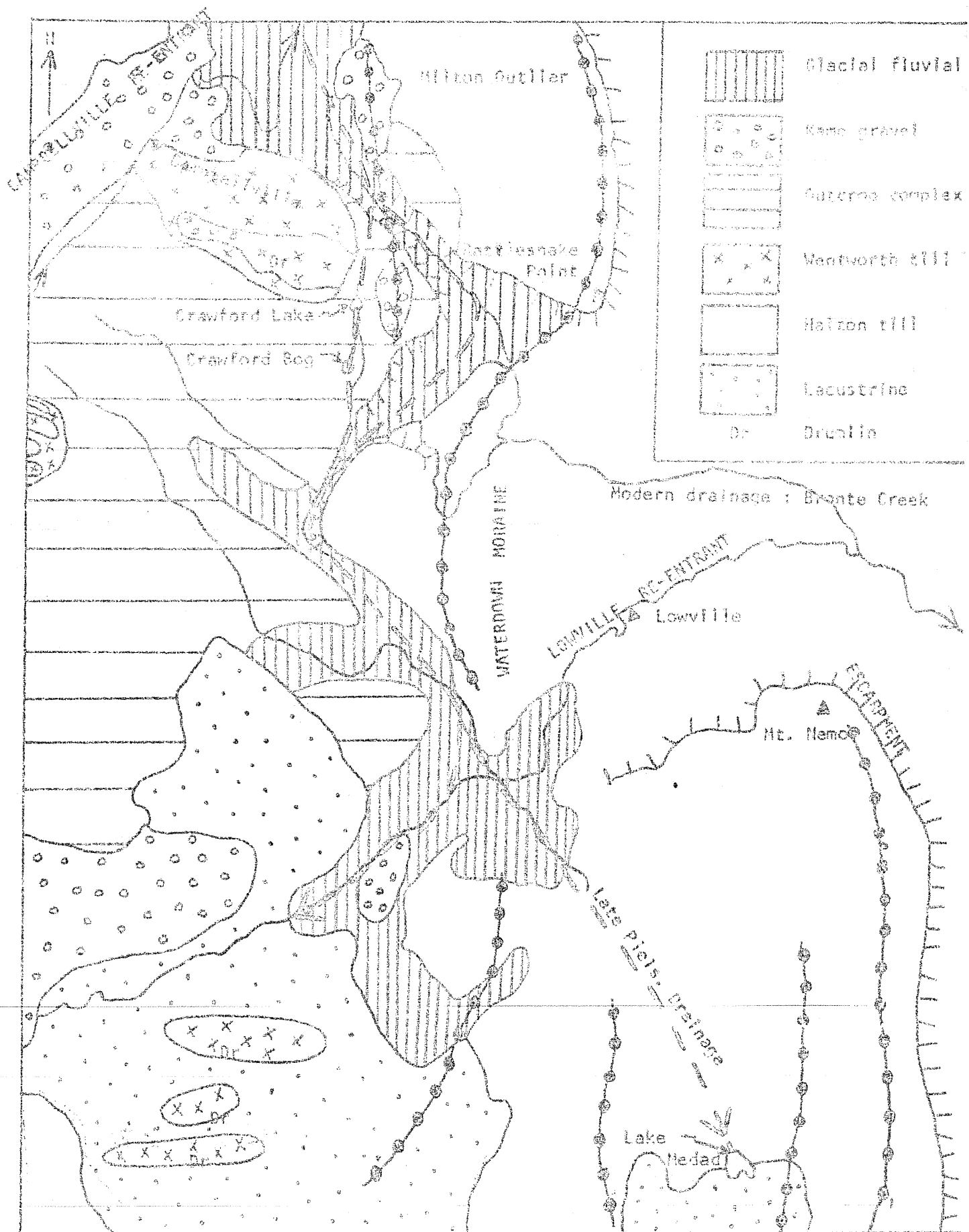


Fig. 3. Late Pleistocene Landscape

fined to the deeper water and occur as successive couplets of a white carbonate-rich lamina overlain by a dark organic-rich lamina. The white lamina characteristically grades into the overlying dark lamina, the latter forming a distinct boundary with the overlying white lamina.

Limnological studies on Crawford Lake (Moenig *et al.* 1971) and Fayetteville Green Lake (Culver and Brunskill 1969; Brunskill 1969; Brunskill and Ludlam 1969; Ludlam 1969), another lake currently depositing carbonate-organic couplets, indicate that both are "meromictic," or partly circulating. The bottom waters (minolimnion) are constantly cold, oxygen poor and noticeably more dense than the surface waters (mixolimnion). These conditions reduce or exclude sediment disturbing bottom fauna, which in "holomictic," or entirely circulating, lakes disturb the upper few centimeters of sediment (Davis 1968; R. Davis 1967).

Three independent observations, including microfossil analysis, sediment budget studies and seasonal sampling, indicate that the laminae are seasonal, a couplet representing one year's accumulation of sediment. By comparing the seasons of pollen dispersal, diatom proliferation and Chrysophycean algal blooms with the fossil pollen, diatom and cysts in Little Round Lake and McKay Lake, Tippet (1964) showed that the white carbonate laminae represent spring and early summer sediment and the dark laminae represent late summer and winter sediment. Seasonal sediment measurements in the water column and sediment traps in Fayetteville Green Lake, Brunskill and Ludlam (1969) showed the seasonal input of calcite to be the factor responsible for couplet formation with organic sedimentation relatively constant throughout the year. Our sampling of Crawford Lake sediment (1973) showed the uppermost lamina to be light in summer (June) and dark the following winter (March).

Thus by analogy and by personal observation we conclude that a couplet of lower white and upper dark lamina represents one year's sediment accumulation, and hence by definition, a "varve."

SAMPLING MODERN VARVES: FRIGID FINGER SAMPLER

Sampling modern varves with a gravity-type tube sampler creates disturbance that is too great for accurate varve counting. The upper meter of loose, watery sediment is precisely sampled with a freezing tube (Swain 1973).

Our freezing tube, known informally as the "frigid finger," is an aluminum or iron tube 2 to 4 m long and 5 to 8 cm in diameter. The lower end is fitted with a pointed plug of wood or metal and sealed with plastic tape. The upper end of the tube has holes drilled in it and a pair of wires looped through the holes. A rope longer than the anticipated depth of the lake is attached to the wires. If an aluminum tube is used, lead weights are put in the bottom of the tube to counteract the tube's buoyance. One or two liters

of n-butanol or ethanol is poured into the tube followed by crushed or pelletized dry ice. The tube is shaken while the dry ice is being introduced, but the dry ice is not otherwise compacted. After the tube is full a rubber glove with a slit finger is taped to the top of the tube. The glove functions as a valve, preventing water from entering but allowing CO₂ gas to escape. The tube is lowered into the sediment and pulled up after 15 to 20 minutes. The 2 to 4 cm thick crust of sediment is removed from the tube by pouring warm water into the tube thereby melting the inner surface of the crust and allowing the sleeve-like crust to be slipped from the lower end of the tube. The sediment is wrapped in plastic and aluminum foil and placed together with dry ice in a sleeping bag for transportation to the laboratory and storage in a freezer.

The depth of penetration of the tube into the sediment (80 to 150 cm) is a function of the weight of the tube and the velocity with which it enters the sediment. The total depth of the sediment (<400 cm) cannot be sampled with the freezing tube and the stationary piston sampler is used.

With the frigid finger sampler a core 1 m long was collected beneath 22.5 m of water. The upper 21.5 cm were laminated with white and dark green laminations. The winter laminae below this depth were red-brown. From 53.3 to 55.6 cm there were unusually prominent white bands.

The chronology of the varved sediment was obtained by initially embedding the frozen sediment crust in Carbowax 1540 and making thin radial sections (Tippett 1964; R. McNeely, personal communication). The varves were counted consecutively from 1971 to 1441 A.D. (Boyko 1973) and less accurately below this level. Pollen analyses were done on 125 essentially contiguous 5, 10 or 25-year intervals between 1971 and ca. 200 A.D.

POLLEN ANALYSIS

The vegetation history of the Crawford Lake area is known through pollen diagrams from Crawford Bog and Crawford Lake.

Crawford Bog is located 600 m south of the Lake. It lies within the "plunge pool" at the base of the "waterfall" where the Crawford Lake Spillway descended the escarpment (Karrow 1963). The elevation of the bog surface is 960 ft. The bog has a small central pool, but is mostly dominated by white cedar with small amounts of white pine, aspen, tamarack, and white and yellow birch.

A 15 m long core was lifted from the moss mat adjacent to the pool. The upper 11 m of moss peat was underlain by 2.5 m of pond marl. Beneath the marl was 1.5 m of sand and varved clay containing 139 varves. There are probably deeper varves. Varve couplets consisted of red and gray clastic lamina and a pebble of red Queenston-like shale was found in the varves.

The pollen diagram (fig. 4) was constructed on a basic sum of tree and shrub (except willow) pollen. The pollen zonation follows McAndrews (1972, 1973).

Zone 1 (Pleistocene) is dominated by spruce with substantial amounts of shrubs and herb pollen suggesting a forest-tundra vegetation. At Crief Kettle Bog, 25 km southwest in the Galt Moraine, the upper part of this zone is dated at $11,950 \pm 350$ B.P. (Karrow 1973).

Zone 2, the earliest Holocene zone, lacks abundant shrub and herb pollen and is dominated by jack pine-type pollen suggesting a boreal forest. The upper boundary is dated at $9,750 \pm 135$ B.P. (McAndrews 1972).

In zone 3 jack pine-type is replaced by white pine and oak with small amounts of beech, maple and hemlock indicating a vegetation similar to the southern Great Lakes Forest.

Zones 4, 5, and 6 are rather similar, i. e. dominated by beech, maple, birch and elm and varying small amounts of hemlock suggesting an almost wholly deciduous forest. Zone 5 is defined by a poorly developed hemlock minimum. The zone 4/5 boundary is dated $5,710 \pm 135$ B.P. (McAndrews 1972).

Zone 7 is defined by a rise in white pine pollen and the varve date at Crawford Lake is 580 years ago. This zone also has peaks in oak and bracken.

Zone 8 is dominated by ragweed and other weed pollen and represents European agriculture. The 7/8 boundary is varve dated at 120 years ago (Boyko 1973).

Sedimentation has been continuous since the abandonment of the late-Pleistocene spillway some 12,000 to 13,000 B.P. The trend of the pollen curves shows a general symmetry around zone 5 with zone 4=6 and zone 3=7. If these pollen zones reflect first northward then southward movement of thermally controlled vegetation zones, then our Holocene interglacial has a future of only 2,000 years or less. Support of recent climatic cooling lies in the coincidence of the invasion of the northern white pine with the onset of the "little ice age." However, an alternate explanation of zone 7 is suggested by the Crawford Lake diagram.

In Crawford Lake a 4 m long core was lifted from beneath 23 m of water. Only the upper 150 cm was varved. The bottom of the core was sand that contained the pollen assemblage of zone 1, and thus the lake is at least 10,000 years old.

The percentage pollen diagram from Crawford Lake (Fig. 5) for the last millenium is divided into zones 8, 7 and 6 (McAndrews 1972). The two grass

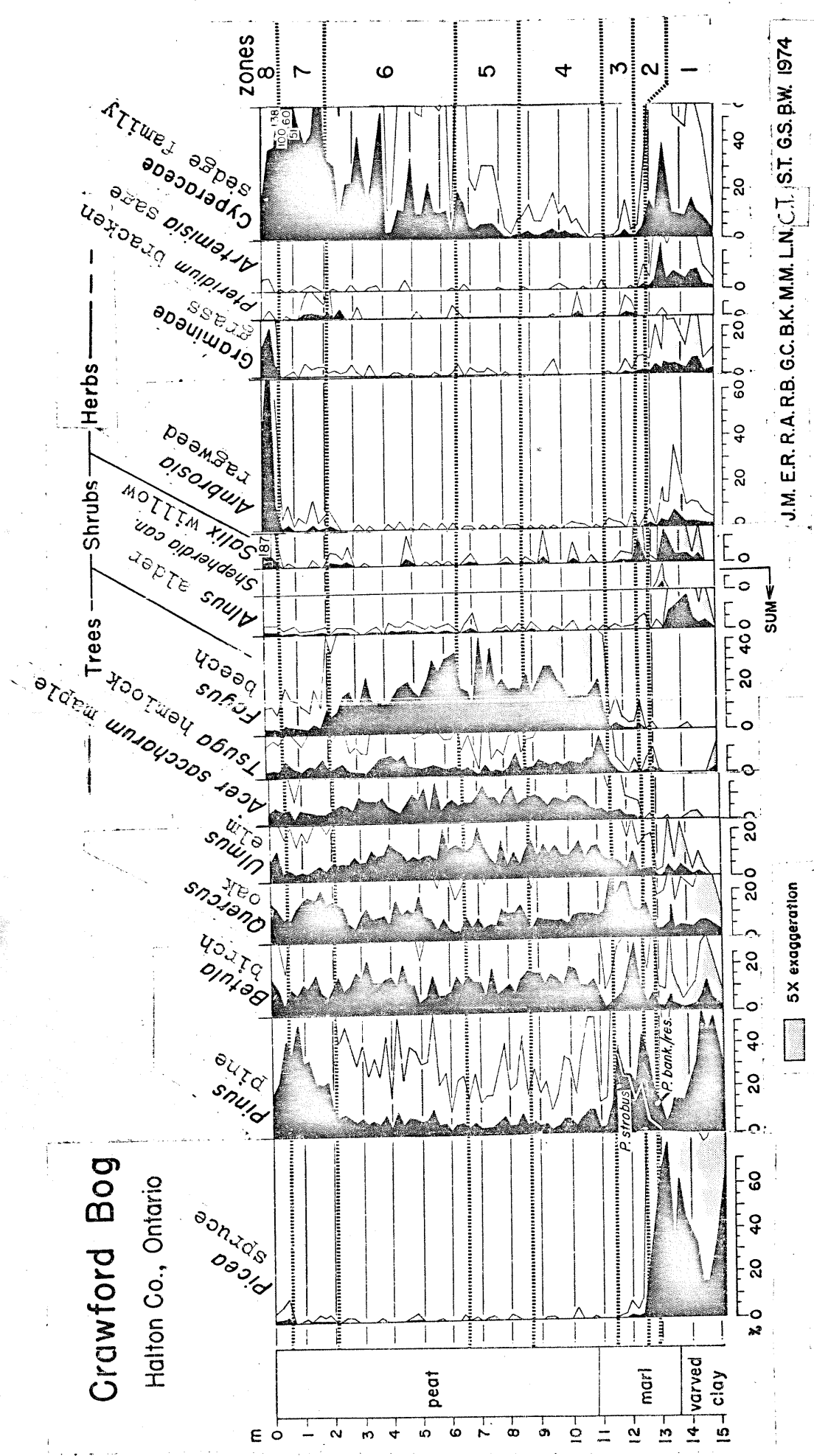
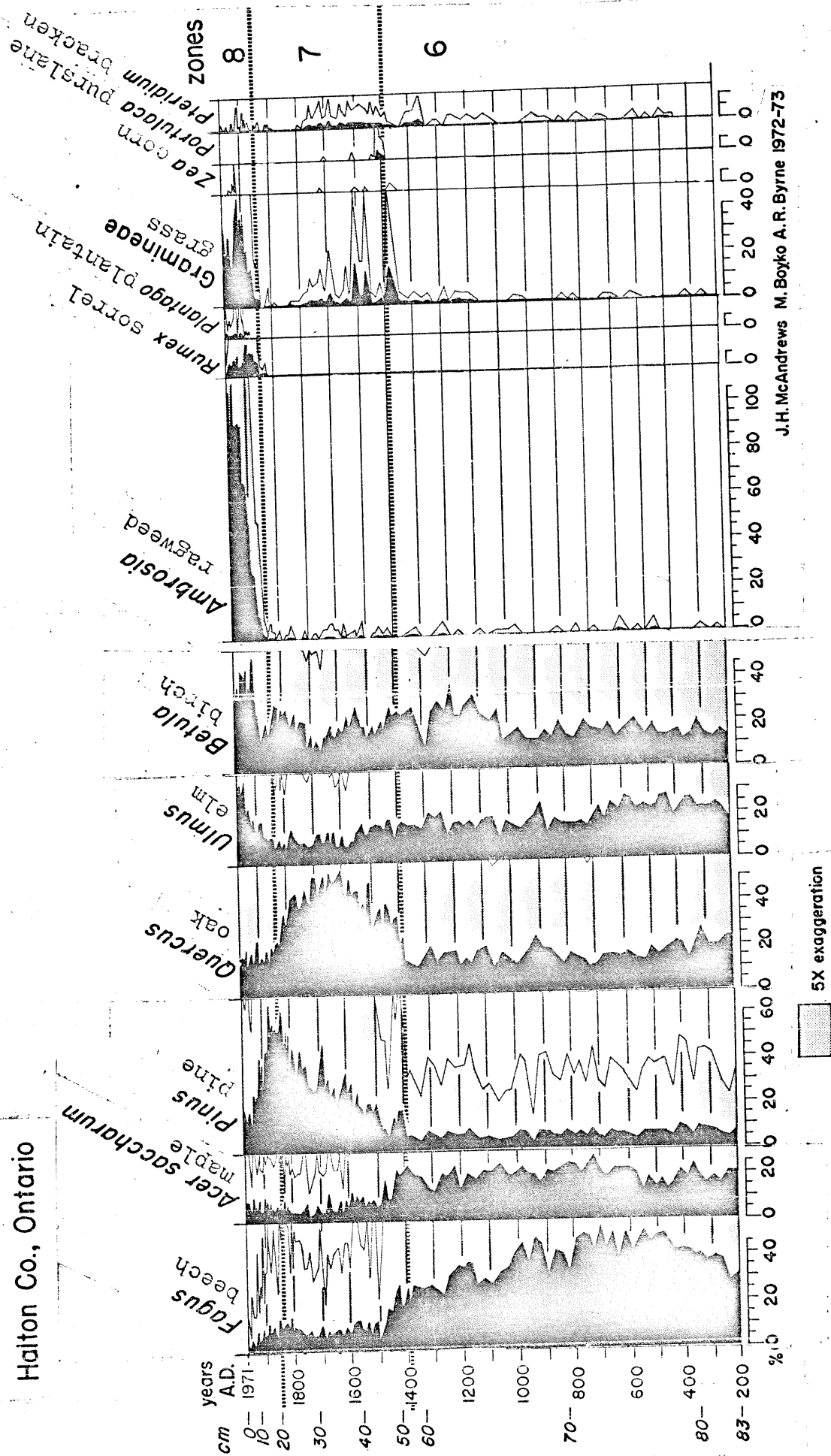


Fig. 4. Pollen diagram from Crawford Bog. Only the main types are shown

The basic sum is trees and shrubs. Cyperaceae in zones 3 through 8 represent local aquatics.

Crawford Lake

Halton Co., Ontario



J.H. McAndrews M. Boyko A.R. Byrne 1972-73

Fig. 5. Pollen diagram from Crawford Lake. Only the main types are shown.

The basic sum is trees and shrubs.

peaks within the last millenium are unusual but not wholly unexpected. Many Gramineae pollen represent cultivated grass species, including maize. The Gramineae peak of zone 8 which is accompanied by a sharp increase in Ambrosia has been recognized in several diagrams from the lower Great Lakes region (Ogden 1966, Davis 1968, McAndrews 1972, 1973). Ragweed and European-introduced cereals and weeds are present in the pollen diagram to the present day, reflecting continuing agriculture.

Patent records and early 19th century land use censuses (Smith 1846) provide insight into land clearance activities at the time of the Ambrosia rise in mid-19th century (Boyko 1973). A "patent" was a title to land ownership given to a settler after he had performed "settlement duties." These duties included clearing 5 acres of land, building a house and clearing the way between his house and the road. A priori a study area of 1500 sq. mi. (22 mile radius) around Crawford Lake was selected. By 1850 80% of this area was patented but only about 25% (of 1500 sq. mi.) was cleared. Twenty years later an additional 50% had been cleared. The remaining 25% consisted of wetlands and woodlots. Thus, with the inherent problems of pollen source in mind, it is cautiously stated that at Crawford Lake Ambrosia begins to show a sharp increase when at least 25% of the surrounding land had been cleared. This percent remained unchanged as the study area was reduced to 200 sq. mi.

The other Gramineae peak, centering around the 6-7 pollen zone boundary, represents Indian maize agriculture (Byrne and McAndrews, unpublished). The peak coincides with the prominent white laminae mentioned above. The virtual absence of Ambrosia pollen at this time indicates that ragweed did not occur in Indian maize fields probably because ragweed immigrated only during the European period (McAndrews 1974).

A 14th century Iroquian village about 150 m northwest of the lake was excavated in summer 1973 after the pollen record indicated the presence of nearby maize fields. From archeological sources agricultural Indians are known to have been present in southern Ontario as early as 600-700 A.D. and in the lower Great Lakes region from 300 B.C. - 400 A.D. (W. Finlayson, personal communication). Pollen evidence for Indian agriculture in the lower Great Lakes region is recorded thus far only at Silver Lake, Ohio (Ogden 1966) where Zea pollen was found below the Ambrosia zone. Since 1971 when we began our studies at Crawford Lake weed evidence suggestive of pre-settlement agriculture has also been found in another lake in southern Ontario.

Prior to the grass peaks the predominance of tree pollen indicates a forested landscape. However, during the time of the grass peaks there is a decrease in tree pollen, indicating forest clearance. The difference in the magnitude of forest destruction between Europeans and Indians is significant and reflects different economic bases and probably population.

Total pollen influx (no. pollen grains/cm²/yr) in zone 8 drops to 1/3 of the presettlement value, from 10,000 - 3,000/cm²/yr (Boyko 1973). The influx values for the Indian period have not been worked out in detail because the chronology has not yet been adequately determined. Preliminary investigations indicate a relatively small tree pollen influx during Indian occupation.

After village abandonment the closed forest is restored, but its composition has changed significantly from pre-Iroquian settlement. Before the Iroquians migrated into the Crawford Lake area the forest surrounding the lake consisted mainly of beech and maple with some oak, elm and birch. There was little or no pine (fig. 5). Archeobotanical remains in the nearby village middens, including charred seeds and charcoal, indicate that maize and beans were cultivated and that beech and maple constituted most of the firewood. The pollen diagram parallels this evidence and indicates that white pine and oak succeeded beech and maple on abandoned Indian fields. This explanation seems adequate when archeological and palynological evidence for agriculture are present. However, there are many more sites which show the characteristic white pine increase before European settlement but for which no archeological or palynological evidence of Indian agriculture exists, i.e., Van Nostrand Lake, Rice Lake, Found Lake, Bass Lake. Thus the other possible explanation for white pine increase is proposed, namely, response to the Little Ice Age (McAndrews 1968, Le Roy Ladurie 1971, La Marche 1974). Crawford Lake lies today at the southern boundary of the Great Lakes conifer-hardwood forest. White pine probably would migrate southward in response to climatic cooling.

In conclusion, we state that two distinct episodes of agriculture can be recognized in the Crawford Lake sediments of the last millenium. An important application of varve chronology to vegetation reconstruction is that the dates for regionally recognized pollen events may be correlated with neighbouring lakes having massive sediments. Rates of sedimentation and pollen influx may then be calculated.

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MACROFOSSILS FROM CRAWFOLD LAKE: A PRELIMINARY LIST

POLLEN ZONE	DEPTH (cm)	Tsuga needles	Tsuga seeds	Thuja needles	Thuja seeds	Larix needles	Larix seeds	Pinus strobus needles	Betula papyrifera seeds	Betula lutea seeds	Betula bracts	Acer seeds	Tilia seeds	Fagus leaf	Helianthus seeds	Portulaca seeds	Eleocharis seeds	Polygonum lapathifolium seeds	Carex seeds	Unknown seeds	Feathers
8	0 - 22								X											X	
7	27 - 51	X	X	X	X	X		X	X		X				X	X	X	X	X	X	X
6	51 - 83	X	X	X	X		X	X	X	X	X				X					X	X
76	83 - 105	X		X	X	X				X	X			X						X	

ARCHAEOLOGICAL INVESTIGATIONS IN THE CRAWFORD LAKE REGION

by

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Introduction

Crawford Lake is a small meromictic lake located on top of the Niagara Escarpment, approximately 40 miles southwest of Toronto, Ontario. Palynological studies on the varved sediments from the lake bottom have been conducted by Dr. John H. McAndrews of the Geology Department of the Royal Ontario Museum and his colleagues, Dr. Roger Byrne and Ms. Maria Boyko. One of the results of this work was the documentation of the shift from a beech-maple climax forest to an oak-pine secondary forest during the fourteenth and fifteenth centuries A.D. Associated with this change was the recovery of grass pollen in the sediments dating to the fourteenth, fifteenth and early sixteenth centuries. This included maize (*Zea mays*) pollen which was present between 1330 and 1509 A.D. Since maize pollen is carried no more than a half mile from the fields in which it is grown, the presence of prehistoric agricultural fields and one or more Iroquoian villages was predicted. Preliminary investigations by Byrne resulted in the location of a possible village site--the Crawford Lake site--approximately 180 meters northwest of the lake. The presence of the village site along with the accurate annual record of vegetation change throughout the period of Indian occupation documented in the pollen core presented a unique opportunity to investigate Iroquoian settlement and subsistence patterns and the effects of prehistoric agriculture on the landscape of a limited portion of Southern Ontario.

Previous Investigations of the Ontario Iroquois

Archaeological investigations during the last few decades in Southern Ontario have succeeded in outlining the development of the Ontario Iroquois tribes--Huron, Petun, Neutral and Erie--from approximately 900 A.D. to their defeat by the New York Iroquois in the first half of the seventeenth century (Wright 1966, 1972 [see Figure 1]). However, it is only in the last decade that any detailed attempts have been made to investigate the settlement and subsistence patterns of the Ontario Iroquois and their effect on the local vegetation. Much of the information is derived from the comparatively detailed ethnohistoric documents of early missionaries, such as Sagard and the Jesuits and early explorers such as Champlain, who visited and lived among the Huron and other Ontario Iroquois tribes.

From these accounts, we know that the Iroquois were shifting agriculturalists whose diet was based largely on corn, beans and squash. This was supplemented by a variety of wild plant foods, wild game and fish. They lived in villages, some of which were palisaded. These were made up of a number of longhouses, the number varying from a few up to a possible maximum of 200 with an average of approximately 40. The houses ranged from 20 to 30 feet in width and were of a similar height. Their length varied from 40 feet to more than 300 feet although the average, at least in the early seventeenth century was between 90 and 100 feet. The structures were constructed from sheets of bark attached to a framework of saplings. There were a series of fireplaces along a corridor which extended for the length of the house. Sleeping platforms were constructed along either side of the house and two families shared each fireplace, one living on each side of the corridor.

From a detailed study of the ethnohistoric documents, it has been possible to reconstruct the nature of historic Huron settlement and subsistence patterns and to study the effects of their way of life on the vegetation of Huronia (e.g. Heidenreich 1971).

The unparalleled situation at Crawford Lake provided an opportunity to attempt similar studies for the prehistoric period. Accordingly, a Project was initiated last summer to investigate the nature of Iroquoian settlement and subsistence patterns in the area adjacent to the Lake. This Project was supported by a Canada Council grant to McAndrews and Byrne, by the Royal Ontario Museum, and by the Halton Region Conservation Authority who owns the property on which the site is located.

The Results of the Investigations at the Crawford Lake Site

For five weeks in June and July, excavations were carried out at the Crawford Lake site with a crew averaging six students. The aims of the excavations were: (1) to determine the size of the site in order to allow estimates to be made about the population of the village; (2) to obtain a sample of artifacts in order to place the site in the cultural historical framework for the Ontario Iroquois; and (3) to obtain a sample of floral and faunal remains to allow an investigation of the subsistence practices of the occupants of the site.

In order to determine the size of the site, two test trenches, 3 meters wide and 144 and 126 meters long, were excavated parallel to one another across the probable site area as defined by preliminary investigative techniques such as surface collecting. A bulldozer was used to remove the upper portion of the plough zone while trowelling and/or a shovel-shining technique were used to expose features in the subsoil such as post moulds or pits. These trenches revealed the presence of six longhouses, the walls of which were delimited by trenching (see Figure 2). The widths of the houses ranged from 23 to 26 feet with a mean of 24 feet. The lengths of three houses were determined to be 148, 116 and 82 feet while the remaining three were found to have minimum lengths of 147, 109 and 87 feet. The lengths of the latter could not be determined due to the presence of recent disturbances such as barn foundation. The 82 foot long

structure was completely excavated. No evidence was found to indicate the presence of a palisade surrounding the village.

Estimates as to the populations of Iroquoian villages are based on: (1) the number of houses in the village; (2) the number of families per house; and (3) the number of individuals per family. The ethno-historic data for the Huron contains only limited references as to the size of families. One estimate by a Jesuit, Paul Ragueneau, indicates that 8 to 10 families consisted of 60 to 80 individuals. In assessing the data on the Huron and on shifting agriculturalists in other parts of the world, Heidenreich (1971) has suggested that Huron family size might have averaged 6 with a range from 4 to 8.

The number of families occupying a longhouse varied considerably and was directly related to its length. Heidenreich has reviewed the relevant ethnohistorical and archaeological data on the amount of space utilized by each pair of families. He proposed that each would have occupied anywhere from 10 to 20 linear feet of house with an average of 15 feet. In studying the floorplan of the one completely excavated house at the Crawford Lake site, it would appear that it could have been occupied by 4 pairs of families, that is, there was 19.7 linear feet of house per pair of families. If this figure is applied to the complete or minimum lengths of the other five houses at the site, it can be suggested that 74 families could have occupied the space available. If Heidenreich's data on family size are applied, the minimum population for the site might have ranged from 296 to 592 individuals with a mean of 444. At present, the maximum population for the site cannot be determined since it is likely that there are a few more houses which remain to be delimited.

The excavations at the site produced a small but significant artifact assemblage which is diagnostic of the Middleport substage of the Middle Ontario Iroquois stage as defined by Wright (1966). A comparison of the assemblage with other Middleport sites in Southern Ontario suggests that the Crawford Lake site is most closely related to similar sites in the Toronto area which form part of the ancestral population of the historic Huron. Ceramic comparisons suggest that the site was probably occupied about 1380 A.D.

Subsistence practices of the occupants of the site were investigated by collecting macrofaunal remains by screening archaeological deposits. Microfaunal and floral remains were gathered by subjecting cultural deposits to a flotation technique. An identification of the mammal bone by Ms. Isobel Heathcote indicates that deer was the most important species being hunted. However, a variety of other animals including elk, wolf or dog, muskrat and squirrel were also being used. The examination of the fish bones by Mr. Jim Burns has indicated that catfish, pike, sucker and lake sturgeon were the most predominant species being utilized although a variety of other fish are present including longnose gar, bowfin, drum, chubb, bass or sunfish and perch or pickerel.

The use of the flotation technique resulted in the recovery of a variety of carbonized wild and cultivated plant remains which have been identified by McAndrews and Mr. Larry King. This suggests the use of the

following as food resources: corn, beans, raspberry, elderberry, sumac, lambsquarterblueberry, hawthorn, dogwood, hickory nut, butternut and beech-nut. S

Conclusions

The work carried out at the Crawford Lake site to date is only of a preliminary nature and certainly much more work will be necessary before any conclusive statements can be made about the nature of Iroquoian settlement and subsistence patterns in the area. However, the work has produced some important results. First, it has been demonstrated that the Crawford Lake site is one of the sites whose agricultural fields were depositing maize pollen in the lake sediments. If the pollen core is recounted in 5 year intervals, as is being planned, it should be possible to produce a more accurate chronology for at least a portion of the pre-historic Iroquoian sequence in Ontario. Also, the recounting should permit some detailed conclusions to be made about the effects of Indian agriculture on the vegetation in the area around Crawford Lake.

The use of a flotation technique has resulted in a much better documentation of the subsistence practices of a prehistoric Iroquoian population. The sample of wild plant food remains is by far the largest to be reported from any Ontario Iroquois site, and indicates a wider utilization of wild plant foods than is normally documented. Finally, the recovery of beans is the first evidence for the cultivation of this crop during the Middleport substage. This would suggest the possibility that the introduction of bean agriculture into Ontario at this time might have been responsible for the population increase which has been proposed at the beginning of this substage (Wright 1966).

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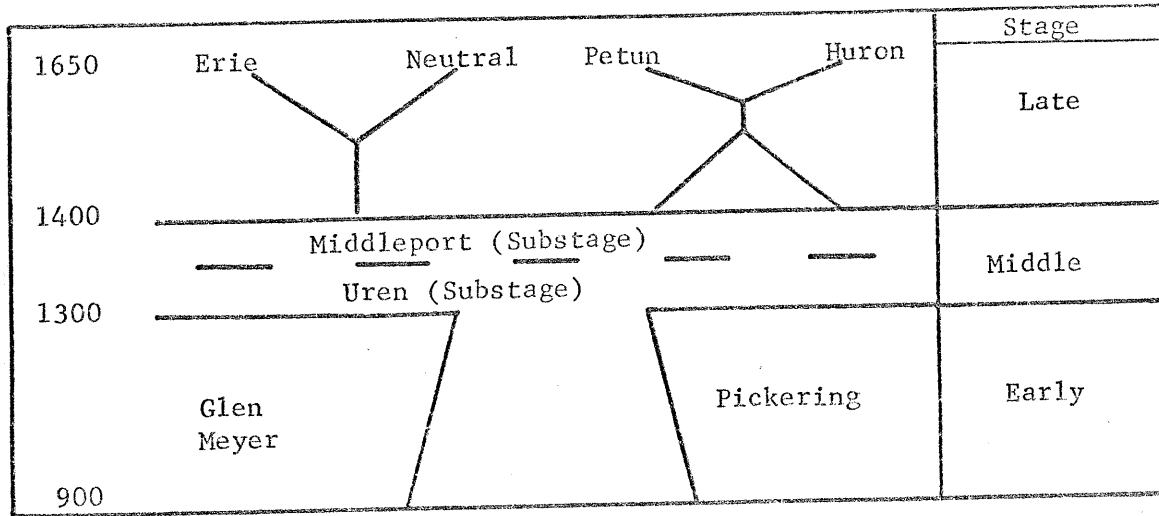


Figure 1: Diagrammatic Presentation of Development of Ontario Iroquois Cultures (after Wright 1966, 1972).

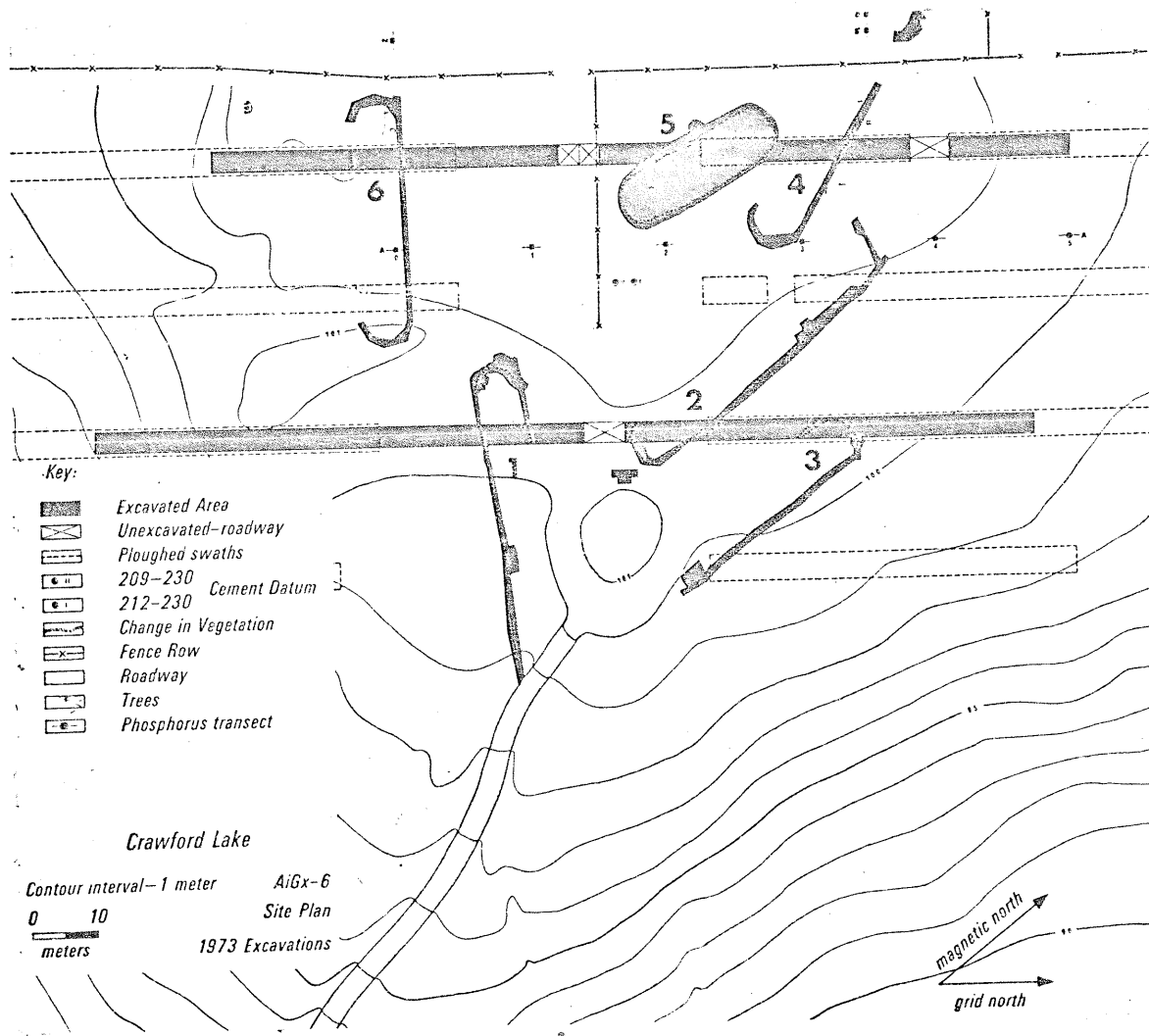


Figure 2: Crawford Lake Site Map.

FRIENDS OF THE PLEISTOCENE,
37th ANNUAL REUNION, TORONTO, ONTARIO,
MAY 17 - 19, 1974.

Crowford Lake area - Sunday, May 19, 1974.

(Guide to Karst, glacial geomorphology, and
glacitectonics.

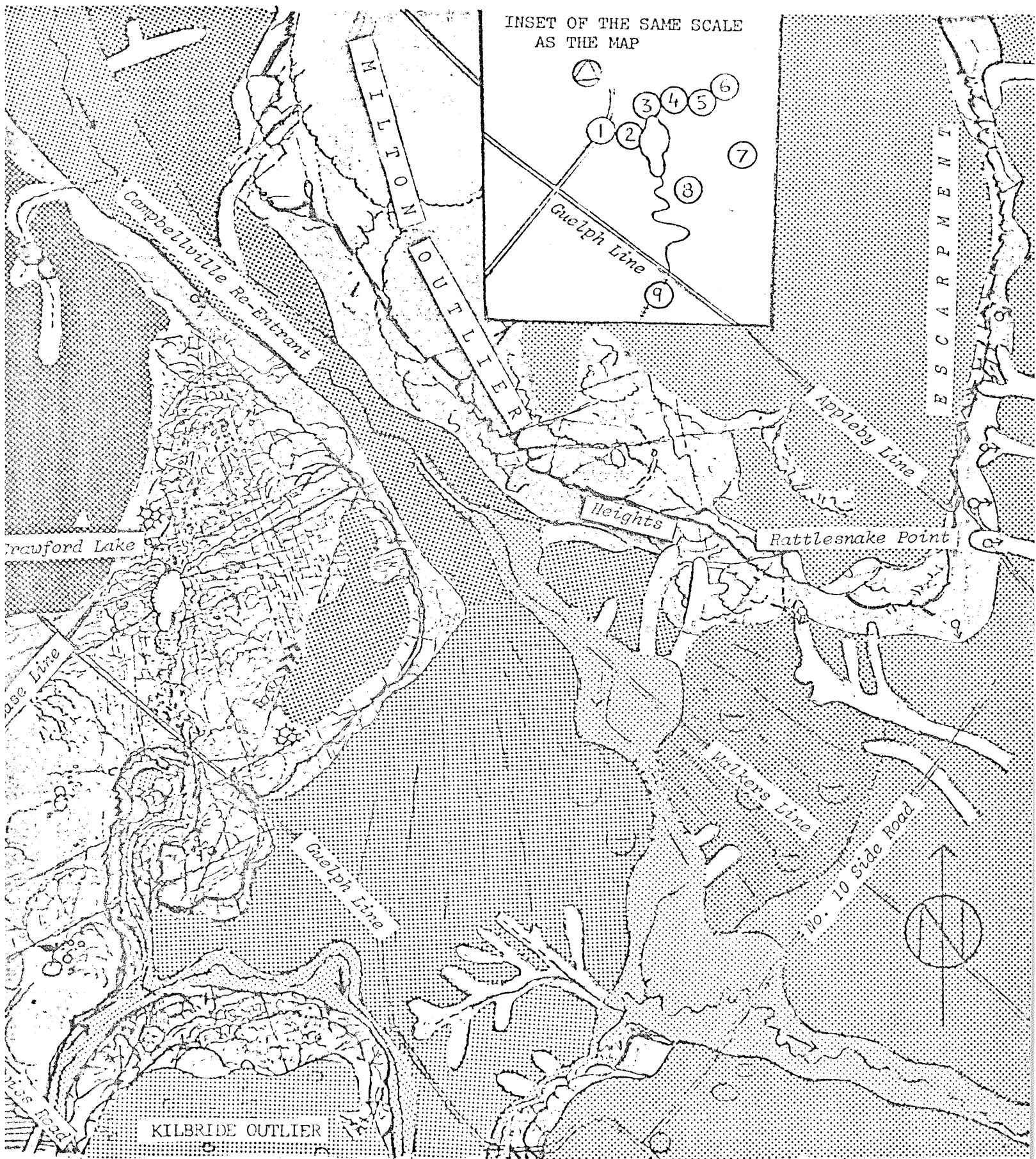
Topographic Maps - Hamilton - 30 M/SW 1:50,000

Cedar Springs - 30 M/SE 1:25,000.)

Dr. Leonard L. Kalas,
Paleoenvironmental Research,
Canada Centre for Inland Waters,
Burlington, Ontario.

&

Ralph O. Ewers,
Geographical Department,
McMaster University,
Hamilton, Ontario.



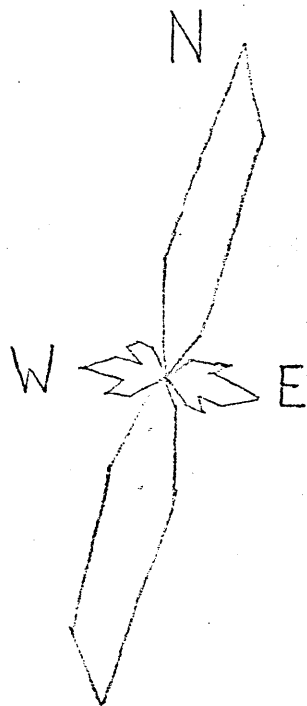
Burlington 12 mi.

GEOMORPHOLOGICAL MAP OF THE CRAWFORD LAKE AREA,

1 mi.

LEGEND WITH EXPLANATORY NOTES TO GEOMORPHOLOGICAL MAP OF THE
CRAWFORD LAKE AREA.

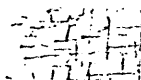
BEDROCK



Soluble Silurian carbonates forming bioherms -
Station 1.



Less soluble crinoidal limy dolostone and dolostone.



Joint patterns.



Main distribution of joints - Station 8.

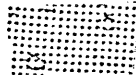
ELEMENTARY STRUCTURAL FORM



Levelled karst plateau developed as a cuesta on highly
resistant carbonate rock and erosionally differentiated
from the Lake Ontario basin.

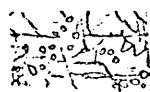
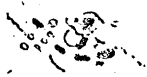
RELIEF OF KARST MODELATION (rugged, broken topography)

Covered karst :



Sediment draped sinks.

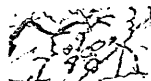
Uncovered Karst :



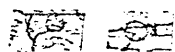
Sink-holes (collapse sinks, shallow, saucer-like sinks and sink ponds) - Station 4.



Blind valleys.



Elongated and coalescent sinks.



Hums (haystacks) - Station 5.



Lapies or karren - Stations 1,2,4,7,8.

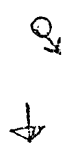


Flooded polje (structurally controlled karst depression).



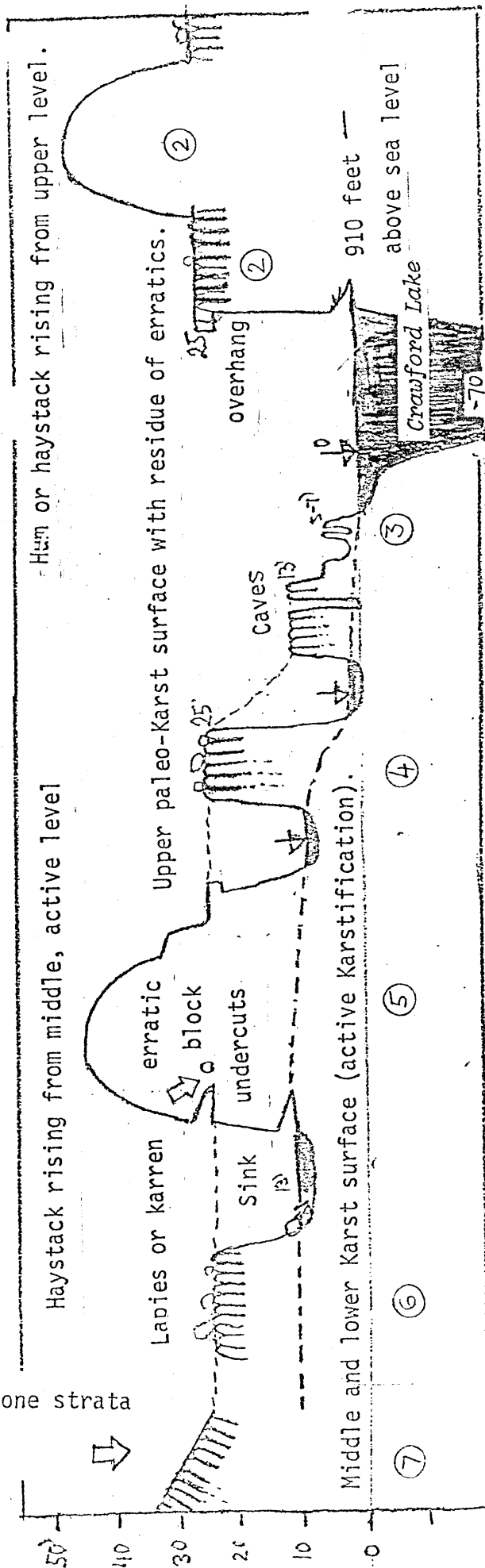
Karst canyon (dolina) - Station 9.

Fig 1.

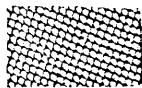


Springs,
Table of karst
waters.

Glacitectonically tilted dolostone strata
(roof-like).



RELIEF OF GLACIAL MODELATION (smooth, gently rolling topography)



Till west of Crawford lake - Station 1.



Kama terrace and Kama-like moraine near
Crawford Lake - Station 6, 7.



Till of last ice recession.

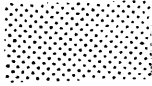


Glacitectonically tilted dolostone strata.
(roof-like). - Station 7.



Outwash gravel plain.

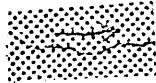
RELIEF OF RIVER MODELATION:



Flood plains.



Gorge in fluvio-glacial material.



Stream direction.



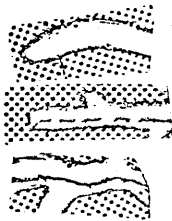
Cascad

Station 9.

RELIEF OF SLOPE MODELATION.



Escarpment (vertical walls with gravitational deposits below).

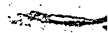


Dells and gullies:

dry

with intermittent streams

with permanent streams



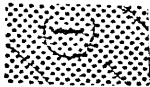
Caves along edge of the escarpment and shores of
the Crawford lake Station 3.

FORMS OF PERIGLACIAL SHAPING:



Sorted polygons.

RELIEF OF ANTHROPOGENE ACTIVITY

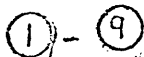


Gravel -pits.

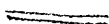
SPECIFIC SYMBOLS



Archaeological site.



Station numbers relating to excursion (inlet map
and Fig.1).



Roads.