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CHRONOLOGY AND SIGNIFICANCE OF A HOLOCENE SEDIMENTARY PROFILE FROM CLEAR CREEK, LAKE ERIE SHORELINE, ONTARIO

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MANAGEMENT PERSPECTIVE

This report outlines an analysis of sediments to reconstruct past water levels in Lake Erie. The origin of sediment is useful for interpretation of present day processes or for the evaluation of shore developments or dump sites.

T.M. Dick
Chief
Hydraulics Division

PERSPECTIVE-GESTION

Le présent rapport décrit une analyse des sédiments effectuée dans le but de déterminer les niveaux d'eau antérieurs du lac Erié. L'origine des sédiments permet de comprendre les processus actuels ou d'étudier l'évolution des rives ou des décharges.

Le Chef,
T.M. Dick
Division de l'hydraulique

ABSTRACT

An abandoned channel of Clear Creek, cut approximately 5 metres below the present level of Lake Erie, was cored and the infilling sediments examined. The postglacial history of this channel was reconstructed based on sedimentological, palynological and chronological studies.

The channel was cut initially some 15 metres, into Wentworth Till, during the low water Early Lake Erie stage. The infilling or aggradation of the channel began about 9500 to 9000 years B.P., probably in response to rising water levels in the Lake Erie basin.

This channel was cut off from the main channel shortly afterwards and an ox-bow lake formed. By 7000 years B.P., complete cut-off of the channel from the main stream system had occurred allowing peat to accumulate. Eventually trees grew on this site, 4000 years B.P.

The diversion of Glacial Lake Nipissing drainage into the Lake Erie basin may be reflected in the greater abundance of silt laminations in the peat of the upper part of the channel fill beween 5975±150 (BGS-899) and 3900±100 (BGS-898) years B.P.

A rise in water level in the Lake Erie basin possibly over the Clear Creek site is recorded by the "drowning" of the forest, shortly after 3900±100 (BGS-898) and the truncation of the Clear Creek site pollen diagram.

RÉSUMÉ

On a prélevé et analysé des échantillons de sédiments de colmatage provenant d'un chenal abandonné de Clear Creek, dont le niveau est d'environ cinq mètres inférieur au niveau actuel du lac Érié. L'histoire postglaciaire du chenal a pu ainsi être reconstituée grâce à l'analyse des sédiments et du pollen et grâce à des études chronologiques.

À l'origine, le chenal était une tranchée de 15 mètres qui s'était creusée dans le dépôt morainique de Wentworth au cours du stage d'étiage du lac Érié. Le processus de colmatage ou d'alluvionnement du chenal, qui a débuté aux environs de 9 500 à 9 000 B.P., était probablement dû à l'élévation du niveau de l'eau dans le bassin du lac Erié.

Peu de temps après, ce chenal a été coupé du cours d'eau principal et un bras mort s'est formé. Vers 7 000 B.P., le chenal s'est complètement séparé du cours d'eau principal, ce qui a permis à la tourbe de s'accumuler. Au fil des siècles, vers 4 000 B.P., des arbres se mirent à pousser à cet endroit.

L'accroissement du feuilletage de limon dans la tourbe de la partie supérieure du remblai du chenal, qui s'est produit entre 5 975 ± 150 B.P. (BGS-899) et 3 900 ± 100 B.P. (BGS-898) est dû à la déviation du drainage du lac glaciaire Nipissing dans le bassin du lac Érié.

Le fait que la forêt ait été engloutie peu après 3 900 ± 100 B.P. (BGS-898) et qu'il y ait troncature dans le diagramme pollinique du site du ruisseau semble indiquer que l'élévation du niveau de l'eau dans le bassin du lac Érié a éventuellement causé une inondation du site de Clear Creek.

Introduction

The sediments infilling an abandoned channel of Clear Creek were examined with the aim of providing additional information on postglacial changes to this creek and possibly on postglacial water levels in the Lake Erie basin.

Clear Creek enters Lake Erie about 12 kilometres west of Long Point, Ontario (Fig. 1). The study site is located immediately north of the Lake Erie shoreline approximately 500 metres west of the mouth of Clear Creek. At the site, shore erosion on Lake Erie has exposed a one metre high section of peat containing numerous logs and pieces of wood. This exposure extends about 75 metres between bluffs composed of Wentworth Till which rise to over 10 metres above the present lake surface (Fig. 1).

A topographic low extends for about 200 metres inland from the lake shore. In plan view (Fig.1), the shape of this topographic low and its proximity to Clear Creek suggests that it was a former channel reach of Clear Creek when the shoreline of Lake Erie stood further south.

Methods

The upper 415 centimetres of the channel fill was sampled continuously with a Hiller Sampler. An Oakfield Soil Probe was used for sampling the lower 223 centimetres. Samples, approximately 1 cm^3 in volume, were collected for pollen analysis at 10 centimetre intervals. Larger samples for radiocarbon dating were collected where there was sufficient organic material. Standard palynological techniques, as described by Erdtman (1943) were followed. A minimum of 200 aboreal pollen grains were counted for each sample, where possible. All percentages shown on the pollen diagram are based on total arboreal pollen. Where insufficient number of arboreal pollen or a legitimate count occurred, the number of actual grains counted is placed on the pollen diagram. Radiocarbon dating was carried out at Brock University, St. Catharines, Ontario.

Description of Sediments

The sediments encountered in the bore hole are presented graphically in Figure 2. These sediments can be divided into four basic units which are described below. The description of the sediments is based on examination in the field only.

The lowermost material encountered was a reddish grey, apparently massive, clayey silt containing some grit and one small limestone pebble (Unit 1). It is similar in appearance and texture to the material exposed in the Lake Erie shorebluffs on either side of the site which has been previously interpreted as Wentworth Till (Fig. 1) (Barnett, 1983).

Resting directly on the upper surface of Unit 1 is 203 cm of grey fine- to medium-grained sand (Unit 2). Stratification and organic matter were not noticed in the lower 58 cm of this unit (Unit 2A), whereas, in the upper part, stratification was present and accentuated by concentratons of fine detrital organic material (Unit 2B). Several small wood fragments and gastropods were also observed in Unit 2B.

A transition zone, 50 centimetres thick, separates Unit 2 from Unit 3. The transition zone consists essentially of interbeds and interlaminations of fine sand and silty clay in roughly equal proportions. Organic detritus is present throughout.

Unit 3, approximately 130 cm thick, is predominantly composed of grey, faintly stratified silty clay. Several thin bands or laminations of grey silt and very fine sand are present. Plant detritus and wood fragments are also common in this unit.

The 232 cm thick uppermost unit consists of dark brown to brown fibrous peat (Unit 4). Intermittent bands of grey brown silty peat and thick laminations of silt are present, especially in the upper 90 cm of the unit. The upper 50 cm contain numerous well-preserved logs and branches of large trees in a peat matrix.

Palynological Results

A stratigraphic series of samples for pollen analysis was collected from the sediments recovered by coring at the Clear Creek site. The generalized stratigraphic units are also shown in the pollen diagram (Fig. 3), for the purpose of cross-referencing with the description, interpretation and discussion of the sedimentary sequence with respect to the geological history of the deposits.

Occasonal pollen grains were found in Unit 1, the glacial till, but they are too few to permit any environmental or stratigraphic interpretation. The sand of Unit 2A did not contain any pollen.

The oldest fossil pollen assemblages were recovered from Unit 2B, comprising fine to medium-grained sand with plant detritus and a few gastropod shells. The pollen assemblages in Unit 2B are characterized by dominance of pine (*Pinus*) pollen, presence of some hemlock (*Tsuga*) pollen, and scattered occurrence of a few pollen grains of spruce (*Picea*) and fir (*Abies*) and some hardwood species. The non-tree pollen component is consistently present at low percentage values. Samples were not recovered from the upper part of Unit 2B and hence, there is a hiatus in the pollen diagram.

The "Transition zone", comprising fine sand and silty clay, has been distinguished on sedimentological grounds.

From a palynological viewpoint, the transition zone is similar to Unit 2B.

Pollen concentration of Unit 3 is very low, although preservation of pollen appears to be good. Fine plant detritus and occasional wood fragments are present in the silty clay and fine sand matrix of Unit 3, together with some shell fragments. From a palynological viewpoint, the upper part of Unit 3 is similar to the base of Unit 4.

Unit 4 is generally characterized by hardwood forest pollen assemblages, including oak (Quercus), beech (Fagus), elm (Ulmus), maple (Acer), hickory (Carya), ash (Fraxinus), and basswood (Tilia). The two hemlock pollen maxima in Unit 4 are considered to be significant from a palynostratigraphic point of view. Pine pollen percentages are generally low, and there appears to be a slight increase of pine pollen towards the top of Unit 4. The non-tree pollen (and spores) component is rather high and probably represents a contribution from local species growing on the channel fill.

When compared with other pollen diagrams from southern Ontario, the Clear Creek sequence seems to be truncated at the top of Unit 4 because the Ambrosia (ragweed) pollen zone is missing (Bassett and Terasmae, 1962; McAndrews, 1972; Mott and Farley-Gill, 1978; Winn, 1978). The Ambrosia zone is attributed to land clearing by European settlers in the Great Lakes region during the last 100-150 years (McAndrews, 1972).

Geological Interpretion of Sediment Sequence

The sediment sequence encountered and the geomorphology of the site are interpreted as representing an alluvial channel cut and fill sequence. The stream channel was incised into Wentworth Till approximately 5 metres below the present level of Lake Erie. The base of the present active channel of Clear Creek is cut approximately 1.5 metres below the level of Lake Erie. Therefore, this abandoned channel had to be cut when the water level in the Erie basin was at least 3 metres lower than present.

The remaining sediments overlying the till record the infilling of the channel. The sand unit (unit 2A, B) directly overlying the till indicates active stream transport in the channel. This unit could be explained by a subsequent gradual rise in base level, leading to channel aggradation or by the initial stages of meander cut-off. The increasing presence of organic matter (Unit 2B) may be associated with meander cut off.

Unit 3, the faintly stratified silty clay, could have been deposited in several alternate fluvial environments. A possible interpretation is that this unit reflects sedimentation in a cut-off meander (ox-bow lake) environment. Such a development, through chute- or neck-cut-off, is compatible with the eventual fate of stream meanders in erodible terrains (Collinson, 1978). The resultant bypassing of the coarser stream traction components could explain the fine-grained texture and the increasing organic content of this unit. In this environment, sediment input would be periodic, corresponding to occasional or seasonal overbank flooding.

The upper unit (Unit 4) of the valley fill is predominantly composed of fibrous peat with varying amounts of silt. Such sediments are recognized as the last stage of ox-bow lake sedimentation, as such lakes eventually become sites for dense vegetation and accumulation of organic matter (Collinson, 1978). The peat sediments at the site apparently supported considerable vegetative growth, culminating in large trees.

Conditions at the site must have changed, however, to bring about the decline of the forest cover. The greater abundance of silt laminations towards the top of the peat sequence is somewhat unusual, given the general fining-upwards trend of the sequence. It may indicate more numerous periods of flooding by the main Clear Creek channel or rising Lake Erie waters.

Palynological Interpretation

The rare pollen grains in Unit 1 probably can be explained by redeposition from older sediments. The absence of pollen in Unit 2A most likely is related to the coarse grain size of sediment because pollen is normally deposited with silt and clay size particles. It is also possible that oxidation at the time of deposition of Unit 2A destroyed pollen that may have been present in the sand.

Pollen assemblages in Unit 2B indicate a closed forest cover surrounding the site, and pollen was probably deposited in the oxbow lake during early stages after the meander was cut off from the main stream during this period. At this time, the common presence of wood fragments, other plant detritus and an occasional gastropod shell in generally sandy sediment may relate to bank erosion during spring run-off periods.

Palynostratigraphic correlation of Unit 2B assemblages with other pollen diagrams from southwestern Ontario (for example, Forest Pond, Lake Hunger, Colles Lake I, and Pond Mills I; in Winn, 1978; Maplehurst Lake in Mott and Farley-Gill, 1978; central basin of Lake Ontario, Van Nostrand Lake in McAndrews, 1972) indicates that Unit 2B may represent deposition about 9000 to 9500 years B.P.

Sediments of Unit 3 probably represent deposition in an ox-bow lake that was still periodically flooded during spring peak run-offs. This postulation might account for the paucity of pollen if the flooding episodes coincided with the seasonal release and dispersal of tree pollen, and the bulk of the pollen, which would be normally deposited in the lake could have been flushed downstream by flood waters. The relatively few remaining pollen grains, although well preserved, would have been further 'diluted' by the high rate of sediment influx.

The oxbow lake was probably cut off completely from the stream system and regular flooding by 6980±120 (BGS-901) years ago, and Unit 4 represents the subsequent peat depositional environment. By 7000 years B.P. the surrounding vegetation had changed into a mixed hardwood forest, as indicated by a change in the fossil pollen assemblages.

The two hemlock pollen maxima in the Clear Creek pollen diagram are of palynostratigraphic significance and a correlation with other radiocarbon dated pollen chronologies (McAndrews, 1972; Winn, 1978; Terasmae, 1973 and 1981) suggests an age in the range of 6500 to 7500 years B.P. for the early hemlock maximum which agrees reasonably well with the radiocarbon dates of 6980±120 (BGS-901) and 6460±125 (BGS-900) years B.P. in the Clear Creek pollen sequence.

The hemlock pollen minimum after the first maximum ocurred about 4800 years ago according to Davis (1981) who postulated that it was caused by an outbreak of a virulent pathogen specific for hemlock in eastern North America. It took hemlock some 1000 to 2000 years to recover and the hemlock minimum provides a useful palynostratigraphic marker.

The radiocarbon date of 3900±100 ((BGS-898) years B.P. relates to the younger hemlock pollen maximum at the Clear Creek site and, furthermore, suggests an age for the event or events that caused the decline in the forest cover at this site.

As mentioned above, the Clear Creek site sediment sequence is truncated at the top (the Ambrosia pollen zone is missing). This truncation could be partly due to the approaching lake shore erosion as the water level in the Lake Erie basin was rising. This erosion could have resulted in lowering of the water table in the bog and increased oxidation (decomposition) of the peat surface. It is also possible that recent lake level fluctuations may have controlled the process of peat deposition and decomposition in the Clear Creek bog, including some flooding events that might explain the decline of the forest that had grown on the bog surface, and deposition of silt layers in the upper part of Unit 4 of the peat sequence. A third possibility is that the lake level in the Erie basin rose above the site, completely flooding it. This may have stop the accumulation of peat and may also explain the death of the forest cover of this site.

The palynological data and radiocarbon dates also indicate that rates of sedimentation during deposition of Units 2 and 3 were much higher than during deposition of Unit 4. There has been no net accumulation of peat during the last 100 to 150 years, possibly because decomposition exceeded deposition of organic matter.

Discussion and Conclusions

The profile of the sediments infilling the abandoned channel at Clear Creek provides indirect but useful information on lake levels in the central sub-basin of Lake Erie. The detailed pollen profile (Fig. 3) along with the spot radiocarbon dates provide adequate chronologic control (Fig. 2 and 3).

The post-glacial record of water levels in the Erie basin has been summarized by Lewis (1969) and more recently by Coakley and Lewis (1984). Coakley and Lewis (1984) suggested that post-glacial water levels in the Erie basin were initially lower than 30 m below the present level of Lake Erie about 12,000 years B.P. They concluded that the water level then rose fairly rapidly, due mainly to isostatic uplift in the outlet area, to a position less than 10 metres below present lake level and maintained this level between 9,000 and 5,000 years B.P. Lewis (1969) concluded that between 5,000 and 3,800 years B.P. a rapid rise in the water level occurred which he related to the transfer of Nipissing drainage into the Lake Erie basin. This was followed by a slow rise to the present day Lake Erie level (Lewis 1969).

Herdendorf and Braidech (1972, p.16, 17) suggested that a much later date was necessary for the flooding of the western sub-basin of Lake Erie based on radiocarbon dates ranging from 9,440 to 4,335 year B.P. and the presence of oak and pine pollen in sediment cores from this area.

Barnett and Zilans (1983) identified several abandoned deltas, approximately 5 metres above the present level of Lake Erie, along creeks which flowed into Inner Bay, north of Long Point. They related these features to the transfer of Nipissing drainage into the Lake Erie basin. Organic matter and wood from near the base of the older alluvium graded to these deltas have been dated at 960±80 years B.P. (BGS-980) and 1900±80 years B.P. (BGS-928) (Barnett, in press).

Coakley and Lewis (1984, in press) have suggested that these deltaic features could be older than what the dates indicate, possibly older than 3500 years B.P.

Miller (1983) recently presented information on sediments infilling an abandoned meander of the Cugahoga River near Cleveland, Ohio. The channel was cut 10 metres below the present level of Lake Erie and the infilling sediment sequence was similar to that of the present study. Dates of 8,780±80 (DIC-1135), 8,760±90 (DIC-1136) and 8,540±(DIC-1137) years B.P. are minimum dates for the aggrading of the lower Cuyahoga River in response to water levels rising from the Early Lake Erie level (Miller, 1983). Similarly, aggradation in the abandoned channel of Clear Creek, cut 5 m below present Lake Erie level, began 9,500 to 9000 years ago, also probably in response to rising water levels in the Erie basin.

The remaining fining-upwards sediment fill sequence at Clear Creek can be explained solely by deposition occurring during the transition from an active stream channel to that of a more restricted environment of an ox-bow lake. The complete cut-off of this channel from the stream system and flooding allowed peat to accumulate (approximately 7000 years B.P.) and eventually trees to grow (about 4000 years B.P.) at this site.

The upper portion of Unit 4, however, where the peaty sediments become silty and contain numerous silt and fine sand laminations may be the result of increased flooding and may indirectly reflect the rising of lake levels in the Lake Erie basin in response to the diversion of Glacial Lake Nipissing drainage into this basin. If this is so, this event appears to have occurred at Clear Creek between 5975±150 (BGS-899) and 3900±100 (BGS-898) years B.P. or about 5,000 years B.P. by interpolation. Anderson and Lewis (1982) suggested that the effects of this Nipissing drainage transfer were recorded even in Lake Ontario sediments and suggested a date of 5200 years B.P. for this event.

The truncation of the upper part of the pollen diagram, combined with the possible "drowning" of the forest at the Clear Creek site suggests that the high level lake represented by the deltaic features in Inner Bay (Barnett and Zilans, 1983) probably did not occur until shortly after 3900±100 (BGS-898) years B.P.

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List of Figures

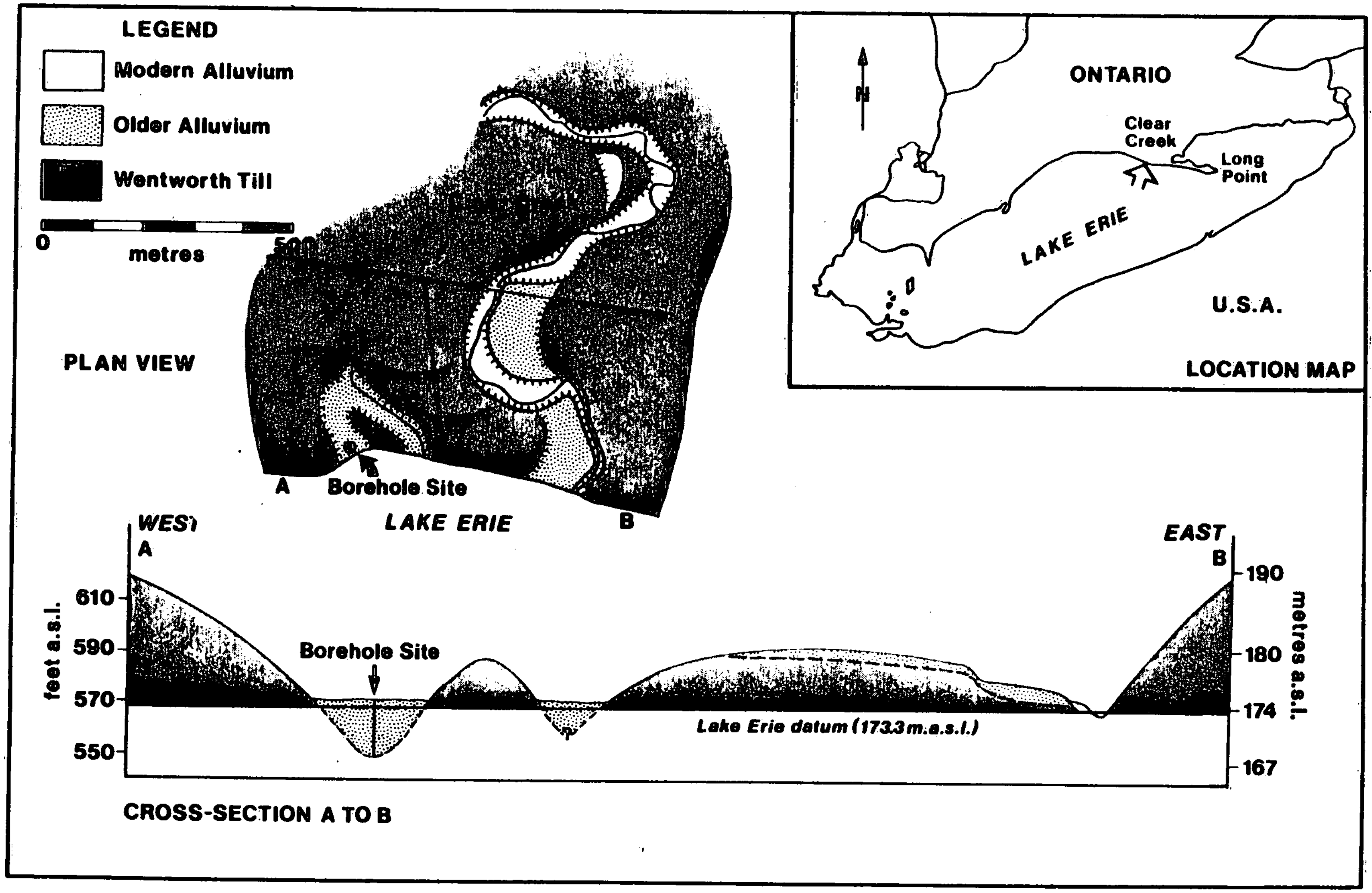
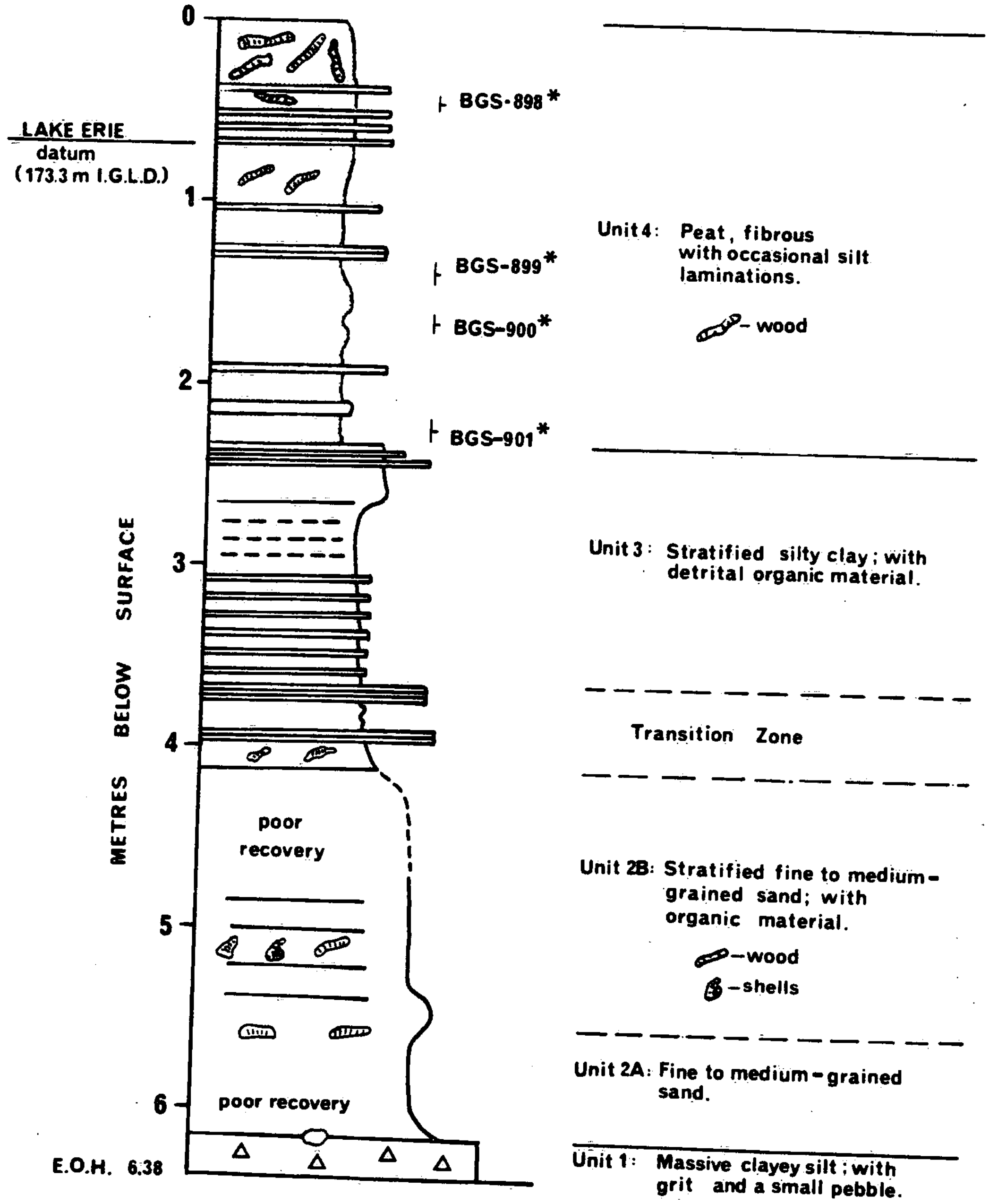
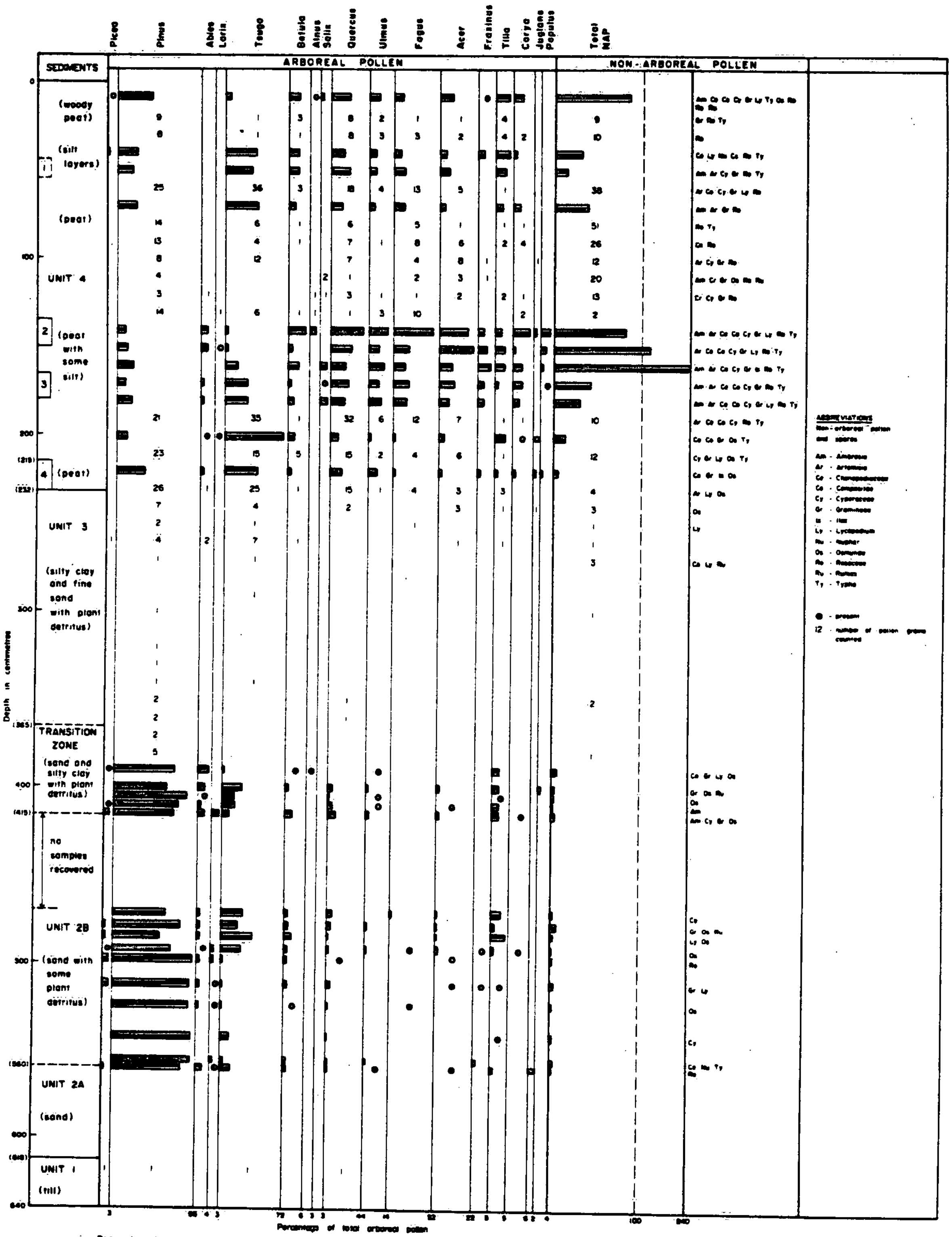

LEGEND
Modern Alluvium
Older Alluvium
Wentworth Till
0
metres
500
PLAN VIEW
A
Borehole Site
LAKE ERIE
B
ONTARIO
N
Clear Creek
Long Point
LAKE ERIE
U.S.A.
LOCATION MAP
WEST
A
EAST
B
610
590
570
550
feet a.s.l.
190
180
174
167
metres a.s.l.
Borehole Site
Lake Erie datum (173.3 m.a.s.l.)
CROSS-SECTION A TO B

Figure 1



* ^{14}C Date No.	Years B.P.	Material
BGS-898	3900 ± 100	wood
BGS-899	5975 ± 150	peat
BGS-900	6460 ± 125	peat
BGS-901	6980 ± 120	peat

Figure 2



Radiocarbon dates

1 3800 ± 100 yrs BP (BGS-888)
2 5975 ± 130 yrs BP (BGS-899)
3 6460 ± 125 yrs BP (BGS-900)
4 6980 ± 120 yrs BP (BGS-901)

Pollen diagram of inorganic and organic sediments

CLEAR CREEK SITE, ONTARIO

Figure 3