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Chapter 2

Geoarchaeology of the Cummins site on the beach of proglacial Lake Minong, Lake Superior Basin, Canada

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INTRODUCTION

Paleoindian sites (approximately 7,500 to 11,500 B.P.) on "raised beach terraces" and "strandlines" in the Great Lakes region are a well-documented aspect of early settlement patterns. In the lower Great Lakes region of Ontario, research on the early (fluted-point) cultures (approximately 9,500 to 11,500 B.P.) has been particularly productive over the past two decades, with survey and excavations concentrated on proglacial Lake Algonquin strandlines (Deller, 1976; Storck, 1982, 1984). Radiometrically dated materials from these beaches were used to establish maximum geological dates for Lake Algonquin strandlines; for sites along the north shore of Lake Ontario there are bracketing geological dates (Roberts, 1984).

In the northwestern Lake Superior Basin there is a similar pattern of numerous late Paleoindian (Plano) sites of the Lakehead Paleoindian complex (Fox, 1975, 1980; Dawson, 1983; Julig, 1984, 1988) found on or near beaches of an earlier, deeper stage of Lake Superior: Lake Minong (Fig. 1). Prehistoric groups often favored shorelines for settlement sites due to their high biological productivity (and subsistence resources), as well as a ready supply of fresh water. Along the north shore of the upper Great Lakes there are regional loci of Paleoindian sites at coastal locations where there was also abundant lithic material for stone-tool manufacture. Several such loci of large coastal quarry/workshop sites, surrounded by numerous smaller sites, include the Cummins site and the Lakehead Paleoindian Complex in the northwestern Lake Superior Basin (Fox, 1975; Julig, 1988), and the Sheguiandah and George Lake Complex of sites in northern Lake Huron (Lee, 1954, 1955, 1957; Greenman, 1966).

Archaeological interpretations of these shoreline sites are linked to and constrained by the geological interpretations and lake-level chronologies. For the western Lake Superior Basin the traditional geological model was based on the work of Farrand (1960, 1969) and the earlier research of Taylor (1894, 1895, 1897), Leverett (1929), and others. The traditional model, of generally declining basin levels following an initial Lake Duluth high, was revised in the past decade when the Marquette glacial readvance into upper Michigan at approximately 9,900 B.P. was recognized by Drexler and others (1983), and correlations were made to dated levels in the Lake Agassiz basin (Clayton, 1983). The Marquette glacial advance resulted in fluctuating water levels in the western Superior Basin (and the connecting Lake Huron and Michigan Basins), and post-Marquette interbasin drainage from Lake Agassiz into the Superior Basin may have been catastrophic in nature, causing short-term transgressions of possibly 20 m in magnitude (Teller and Thorliefson, 1983; Farrand and Drexler, 1985, p. 24; Teller, 1985).

The results of major geologic events, and short-term transgressions during Lake Minong times, may be found in the sedimentary record of Minong beach sites. If people were present and using these sites, transgressions would disrupt the archaeological context and produce water-worn artifacts. Correlating and geological dating of early archaeological components should be possible.

In this chapter, we examine the contextual environment of artifact assemblages at the stratified Cummins Paleoindian site at Thunder Bay, Ontario (Fig. 1). Our objectives are: (1) to review relevant geological, biological, and archaeological background research; (2) to document and explain site-formation processes, including geomorphology and site stratigraphy; (3) to refine the local pollen record; and (4) to develop intra- and extra-site temporal contexts. Finally, we examine the nature and effect of post-occupational disturbances on artifact and assemblage context.

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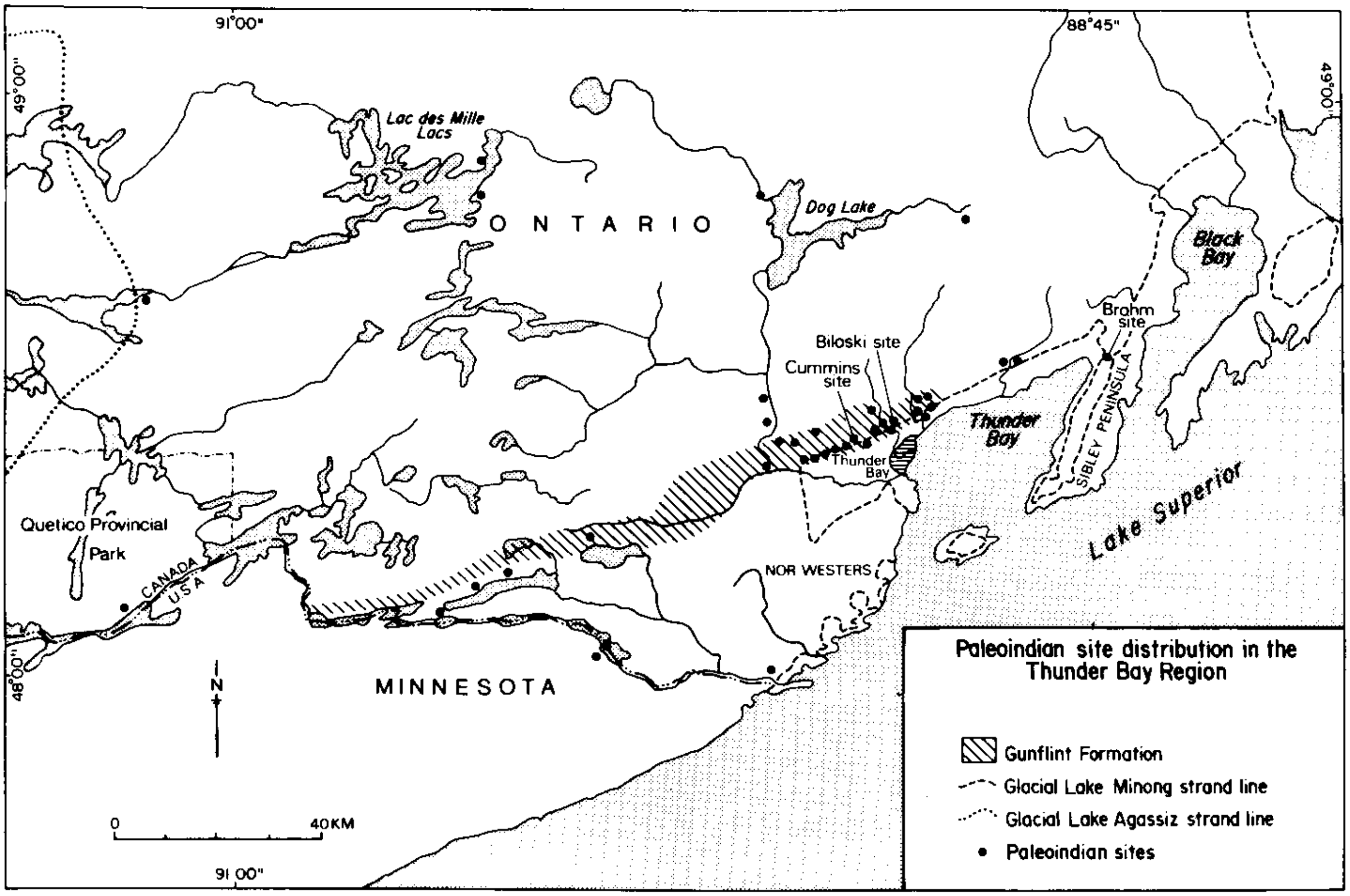


Figure 1. Paleoindian site distribution in the Thunder Bay region, northwestern Lake Superior, Ontario, Canada (modified from Julig, 1988).

THE LAKEHEAD PALEOINDIAN COMPLEX AND CUMMINS SITE

Archaeological research on early postglacial sites in the Thunder Bay region began in 1950 with the excavations at Brohm site (MacNeish, 1952), located on the Sibley Peninsula (Fig. 1). Subsequently, amateur collectors located sites along beach ridges in the Kaministikwia River Valley and to the north of Thunder Bay, including the Cummins site. Test excavations at the Cummins site in 1963 were used to determine the approximate site limits, the preliminary nature of archaeological deposits, and the cultural affiliation (Dawson, 1983). The site was reported to be nonstratified. Regional survey and excavations continued during the next decade, and Fox (1975) designated the regional Paleoindian manifestation the "Palaeo-Indian Lakehead Complex."

Paleoindian sites in the Thunder Bay region are shown on Figure 1. Only five of the 39 sites were excavated; the remainder were surface collected and/or test pitted. The Cummins site is the largest of these and extends for about 1 km along the Minong Beach ridge. The majority of the sites are Paleoindian, based on diagnostic Plano-type artifacts (parallel-flaked lanceolate points). The sites are closely related to both the Minong Beach and the Gunflint Formation (Fig. 1), the source of jasper and black taconites, which were the predominant lithic artifact materials.

Fox (1975, p. 30) and Steinbring (1976) hypothesized that Lakehead Complex Paleoindian sites were contemporaneous with Lake Minong (about 10,000 to 9,500 yr B.P.). Subsequently, Fox (1980, p. 137) revised his age estimates of Lakehead Complex sites to about 9,500 B.P. maximum. Phillips (1982) and Dawson (1983) questioned the geological dating of the Cummins site to Minong time, and Dawson proposed a 2,000-yr span of occupation for the site (about 9,000 to 7,000 B.P.), although he reported it (1983) as a nonstratified site. Thus, unresolved geoarchaeological issues prior to our research included: (1) temporal position and duration of the Cummins and other Lakehead Complex site occupations, (2) cultural and natural stratigraphy, (3) local environmental reconstruction, and (4) postoccupational factors affecting artifact context.

In eastern Paleoindian archaeology the primary research focus has been on analysis of the artifact assemblages, with less consideration of the surrounding sedimentary matrix and microenvironmental context. To study artifact assemblages without adequate consideration of the surrounding matrix and postdepositional effects (context) is to study only a portion of the archaeological record (Stein and Farrand, 1985). Contextural considerations are important for all archaeological interpretations; however, when considerable time and major environmental changes are involved, it becomes more difficult to interpret artifact and assemblage contexts. On early sites near active glacial margins, or on proglacial beaches, changes to the landscape, site-formation processes, and postdepositional effects may render normal geomorphic models inadequate. In the past, geoarchaeological studies of eastern Paleoindian sites have been minimal (Julig, 1988). Major discharge events from glacial Lake Agassiz into the Superior Basin during Minong time affected Lakehead Complex beach sites such as the Cummins site, and probably those in the northern Lake Huron Basin such as the Sheguiandah site (Julig, 1985).

REGIONAL DEGLACIATION

Deglaciation in the western Lake Superior region was investigated by Elson (1957), Farrand (1960, 1969), Zoltai (1961, 1963, 1965a, 1965b), Prest (1970), Saarnisto (1974, 1975), Clayton (1983), Clayton and Moran (1982), Drexler and others (1983), Teller and Thorliefson (1983), Teller and Mahnic (1988), and Bjorck (1985). Prest's (1970) and Dyke and Prest's (1987) interpretation of the glacial-margin positions in the Upper Great Lakes region remains the generally accepted model; however, difficulties exist in accurately correlating late Quaternary sequences throughout the Superior region (Dreimanis, 1977; Saarnisto, 1974, 1975). The glacial chronology, and specifically the nature, extent, and movement of the Western Superior lobe between about 9,900 and 11,800 B.P. was recently revised (Clayton and Moran, 1982; Clayton, 1983; Drexler and others, 1983; Farrand and Drexler, 1985). The major change in interpretation was the recognition of the Marquette phase of the Superior lobe, which at about 10,000 B.P. advanced into northern Michigan, raised water levels in the western Superior Basin, and redirected drainage from glacial Lake Agassiz into the Mississippi River system.

Late Wisconsinan deglaciation of the northwestern Lake Superior region began around 12,500 B.P., with a locally oscillating ice margin west of Thunder Bay until about 11,000 B.P. Three prominent terminal moraines are present between Lake of the Woods (on the Minnesota-Ontario boundary) and Sioux Lookout to the northeast. The most southern is the Eagle-Finlayson–Brule Creek Moraine, which dates between about 11,000 and 12,000 B.P.; the Hartman and Lac Seul Moraines to the north formed later (Elson, 1957, 1967; Prest, 1970; Clayton and Moran, 1982; Bjorck, 1985). The easternmost extent of the 300-km-long Eagle–Finlayson–Brule Creek Moraine is shown in relation to the Cummins site in Figure 2.

Other prominent moraines near Thunder Bay include the Dog Lake and Marks End Moraines and the interlobate Mackenzie Moraine, all believed deposited at about 10,000 B.P. (Clayton, 1983; Teller and Thorliefson, 1983; Drexler and others, 1983). The Marks Moraine (Zoltai, 1963) forms a ridge to the north and west of Thunder Bay (Fig. 2) and was formed by the last major northwesterly advance of the Superior lobe into this area (Burwasser, 1977; Phillips, 1982; Teller and Thorliefson, 1983). The Dog Lake and Mackenzie Moraines are evidence of the extent of the Hudson Bay lobe at about 11,000 B.P. The Dog Lake Moraine and Marquette lobe acted as a dam in which ponded glacial Lake Kaministikwia (Fig. 2). As a result of the Marquette advance, water levels rose in the west end of Lake Superior Basin, and drained for a short time westward into Lake Agassiz (Clayton, 1983; see also Fig. 3).

The Marquette advance probably deposited the ground moraine around the Cummins site (Teller, 1985). However, this final surge of the Superior Lobe into Upper Michigan at about 10,000 B.P. (Drexler and others, 1983) may not have affected all of the western part of the Superior Basin (Farrand and Drexler, 1985, p. 22), although it caused water levels to rise to Duluth levels (Fig. 3). As is discussed later, based on evidence from Oliver Pond (Fig. 4), some portions of the northwestern basin may not have been affected by the Marquette advance.

PROGLACIAL LAKE LEVELS AND SHORE LINES

The ages and sequence of proglacial lake levels in the Superior Basin and links to the Agassiz Basin were recently modified. Earlier researchers (Hough, 1958, 1963; Farrand, 1960, 1969; Prest, 1970; Saarnisto, 1974, 1975) suggested generally declining levels from an initial ponding in the western end of the basin (glacial Lakes Duluth and Beaver Bay). Geological events are now recognized to be more complex. The regional geological events, water levels, climate, vegetation, and associated cultural chronology are shown on Figure 3.

The Marquette advance of the Superior lobe is now dated at about 10,000 B.P. (Drexler and others, 1983), and until its retreat at about 9,600 B.P. water levels in the western end of Lake Superior were elevated and drained west and south via the Mississippi River. Clayton (1983) reinterpreted the highest strand lines north of Duluth, Minnesota, as being Marquette in age, and provided evidence that Lake Minong levels (230 to 250 meters above sea level in the Thunder Bay area) were present in the Superior Basin during two periods, from about 10,400 to 10,100 B.P. and about 9,600 to 9,400 B.P., with a higher stand (Lake Duluth levels) occurring between these two Minong stands during the Marquette advance. After about 9,400 B.P., the water level in the Superior Basin declined rapidly (Fig. 3). Clayton's interpretation is supported by correlation of interbasin flow between the Agassiz and Superior Basins (Teller and Mahnic, 1988).

This interpretation is not accepted by Blewett and Riech (1987) who reinterpreted the Marquette advance and provided evidence that parts of the Munsing Moraine may be ice-recessional features. Also, based on seismic reflection studies of moraines on the bottom of the western Lake Superior Basin by Landmesser and others (1982), there was no glacial readvance at

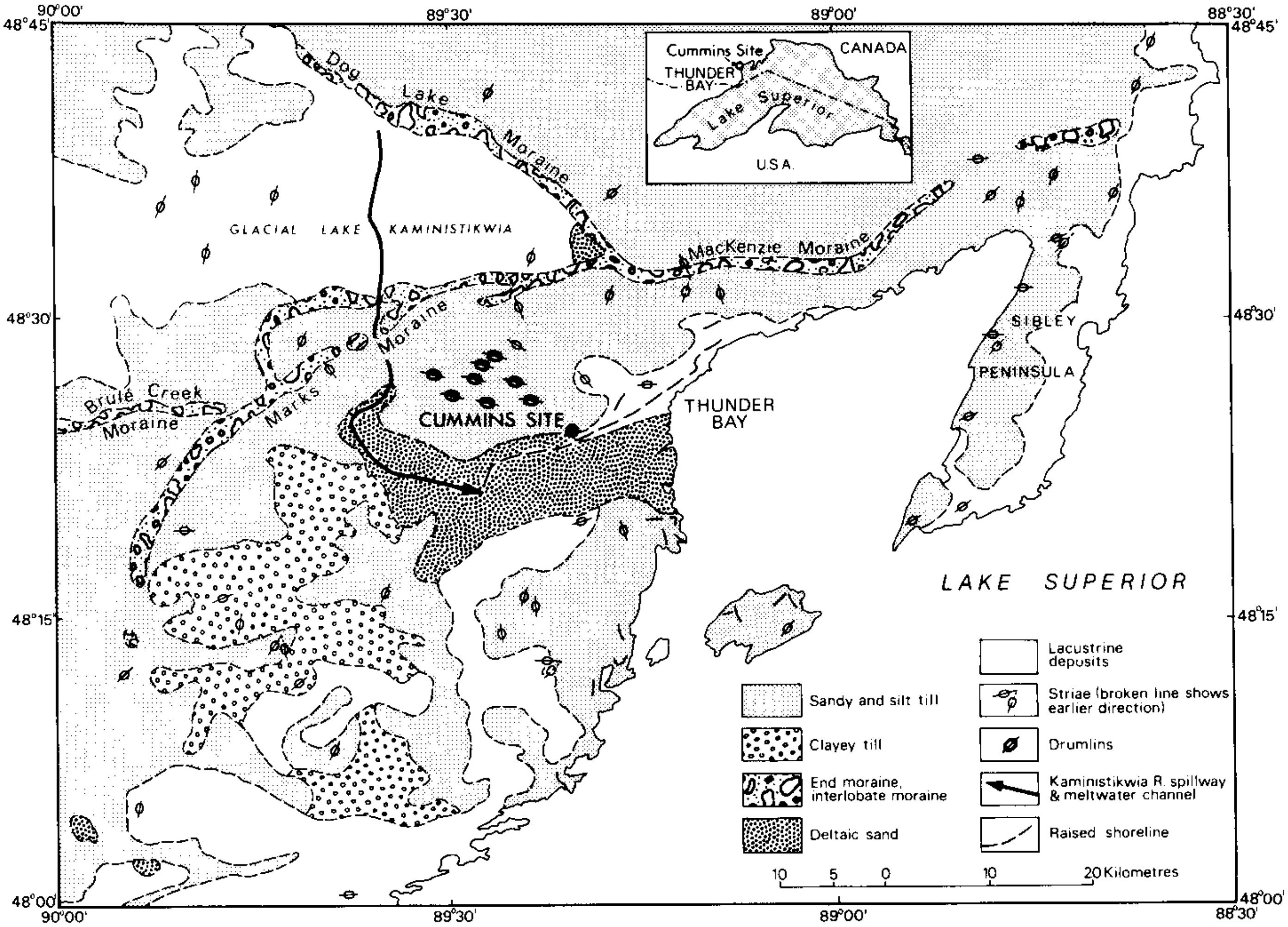


Figure 2. Generalized surficial geology of the Thunder Bay vicinity, northwestern Lake Superior, Ontario, Canada (modified from Burwasser, 1977). Reprinted with permission from *American Journal of Science* (Mahaney and others, 1988).

about 10,000 B.P. However, the most recent evaluations of both the Superior (Teller, 1985; Farrand and Drexler, 1985; Teller and Mahnic, 1988) and lower Great Lakes Basins (Lewis and Anderson, 1989) indicate that the late-glacial Marquette readvance crossed the Superior Basin, redirecting drainage patterns in support of the model suggested by Clayton (1983). By about 9,500 B.P. the Superior lobe had receded so that proglacial Lake Minong in the Superior Basin received inflow from Lake Agassiz (Fig. 3).

Minong beaches around Thunder Bay are well developed at about 225 to 240 m, with some wave-cut features at higher elevations (Burwasser, 1977; Phillips, 1982). The final Lake Minong level in the area is dated at 9,380 ± 150 B.P. (GSC-287) by wood from a gravel pit at Rosslyn Village (Zoltai, 1965b), 8 km west of Thunder Bay. This is supported by the date of 9,260 ± 170 B.P. (TO-547) on conifer wood from the base of Cummins Pond, located on the Minong beach (Julig, 1988). Both dates agree with a date of 9,345 ± 240 B.P. (GX-4883) on wood in a Minong beach at Grand Marais (Drexler and others, 1983).

Lake Minong dropped rapidly after 9,400 B.P. (Clayton, 1983), exposing a broad coastal plain, until the low Houghton levels were reached at approximately 8,000 B.P. (Farrand, 1960; Phillips, 1982). Then isostatic recovery of the St. Mary's River outlet at Sault Ste. Marie caused a rise to the Nipissing levels (Fig. 3). This level dates at approximately 5,500 to 4,500 B.P., and exists as a well-developed wave cut feature at 210 m around Thunder Bay (Phillips, 1982; Farrand and Drexler, 1985; Eschman and Karrow, 1985; Hansel and others, 1985).

Lake Agassiz was the largest of the North American proglacial lakes; it inundated nearly 1,000,000 km^2 (Teller and others, 1983). The lake occupied the western and northern borders of the study area until it gradually receded northward after 9,000 B.P. (Teller, 1985). Its maximum eastern extent, about 150 km from Thunder Bay, occurred when it was at the Campbell level (Fig. 1). Fluctuations of Lake Agassiz during the early postglacial period greatly affected the terrestrial landmass between the two basins. The significance of Lake Agassiz on regional aspects of this study include: (1) the lake probably was a barrier to human

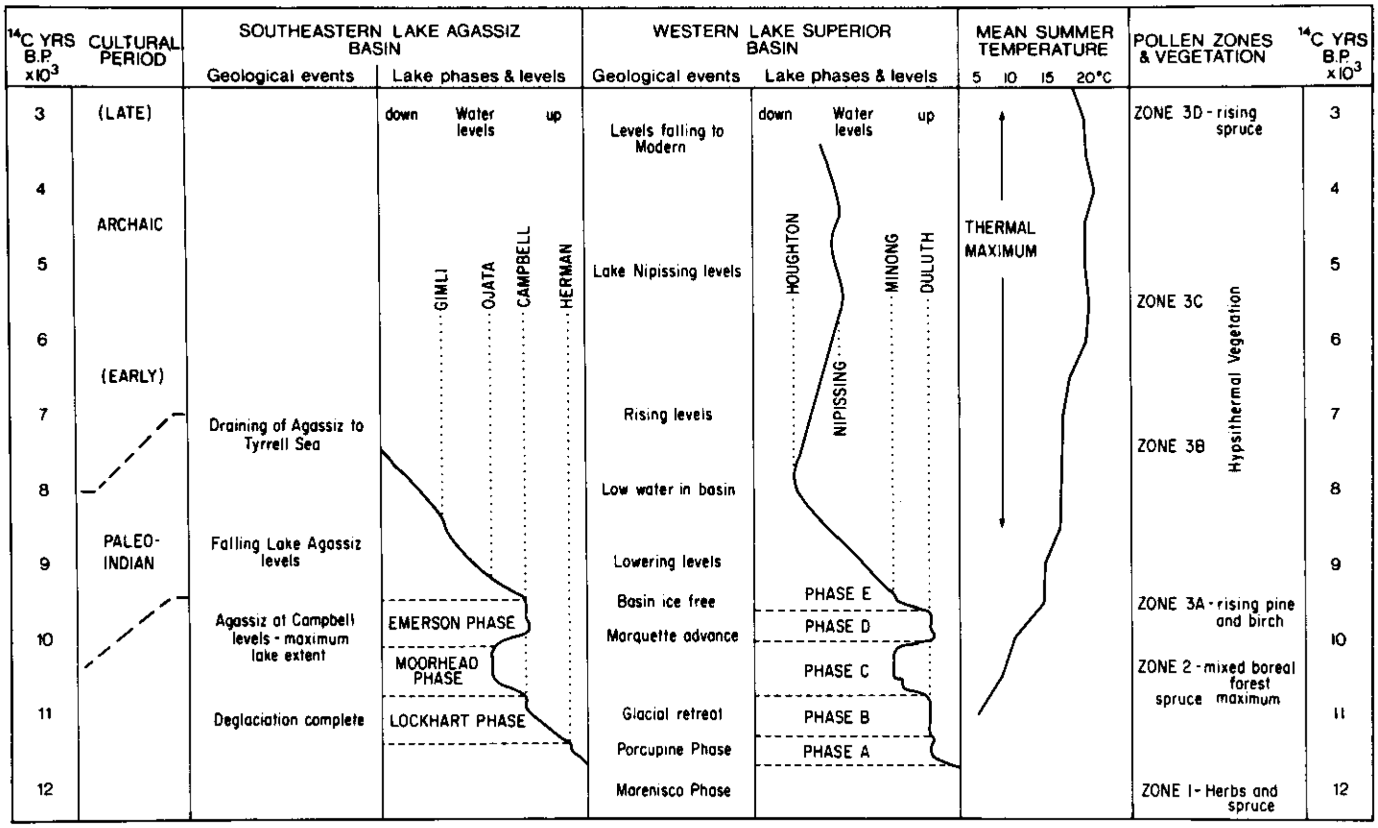


Figure 3. Cultural and environmental chronology of the southeastern Lake Agassiz and western Lake Superior Basins during prehistoric times. Geological events after Clayton (1983); summer temperatures and pollen zonation from Craig (1972), McAndrews (1982), and Ritchie (1983).

and animal colonization from the west and southwest into the region between the Agassiz and Superior Basins during early (high-water) lake phases, (2) Agassiz beaches were probably travel routes around the basins, and (3) Plano period sites are often on or near strand lines, from which we have maximum geological dates and regional settlement pattern data.

Paleoindian sites are found on or near Campbell level beaches (Fox, 1975) in the Quetico Park Boundary Waters area (Julig, 1988) and west to Lake of the Woods (Reid, 1980). In general, this association with fossil beaches in the western Great Lakes is similar to reports elsewhere in the Great Lakes region (Quimby, 1959; Deller, 1976; Storck, 1982, 1984).

GEOARCHAEOLOGICAL INVESTIGATIONS AT THE CUMMINS SITE

Introduction

The Cummins site (DcJi-1) is situated on beaches of proglacial Lake Minong near the northwestern city limits of Thunder Bay, Ontario (Fig. 4). The site's elevation ranges between 220 and 240 m, and it is 11 km from Lake Superior. Lithic artifact scatters appear in recent disturbances; however, on the well-drained Minong beach terraces, multiple overlapping lithic workshops resulted in an almost continuous "paving" of taconite artifacts and debitage in upper parts of the soil profile. Contrary to Dawson (1983, p. 6–7), parts of the site are culturally stratified. A thin, discontinuous Archaic horizon below the humus is underlain by the late Paleoindian (Plano) occupation, and within lower Minong beach gravels are waterworn taconite artifacts (Julig, 1984; Julig and others, 1986). Artifacts and cultural features were located in bog sediments at the edge of Cummins Pond. The precise spatial extent of the Cummins site is difficult to accurately define, with taconite debitage present over about 80 ha (Fig. 5), thinning to scattered occurrences on the east and west along the Minong beach (Fig. 4).

Minong, Nipissing, and intermediate beach ridges and terraces (Figs. 4 and 5) are based on mapping and paleogeographic reconstructions of Phillips (1982). The main Minong beach at 230 to 235 m is a significant coastal geomorphic feature. The lower terraces (225 to 228 m) are more subdued, although they are readily observed in the field where they have not been mined for gravel.

Sand-dune deposits cap the beach ridges west of Maple Ward Road (loc. 4, 5) and to the east of the rock island (Fig. 5). The eolian sediments range to 2 m in depth, and there is eolian input in surface sediments over much of the site. Shore-zone dunes are common along the coasts of the Great Lakes during periods of declining water levels (Larsen, 1985, p. 105).

Much of the site and vicinity is poorly drained, particularly below the Minong beach, due to bedrock near the surface, the presence of lacustrine clays in surface sediments, and generally low relief. A small first-order stream, a tributary of the Neebing River, cuts through the beach ridges in the middle of the site. Cummins Pond is formed in a depression in the bedrock, and is part of this drainage system (Figs. 4, 5). The pond was formerly a lagoon or embayment of Lake Minong (Phillips, 1982, p. 28).

The excavations at the Cummins site by K.C.A. Dawson and J. V. Wright in 1963 were carried out at two locations: (1) on the main Minong beach immediately west of Cummins Pond (near loc. 1, Fig. 5), and (2) on top of the rock island, just above the quarry cliff face (Fig. 5). The "heavily disturbed" remains of a cremation burial were recovered from an exposed face of the gravel pit east of the rock island (Fig. 5), with occasional flakes found in situ above water-laid sands (J. V. Wright, personal communication, 1985). Most of the remains were removed by gravel extraction, but bone fragments were accelerator dated to 8,480 ± 390 yr BP (NMC 1216), and are the oldest dated human remains in Ontario (Dawson, 1983) (see Table 6).

During three seasons (1983 to 1985), excavations were done at locations 1 to 5 (Fig. 5). Larger block excavations were dug at locations 1, 2, and 3 to obtain settlement pattern data and a large unified artifact sample (Julig, 1988). For geoarchaeological objectives, test trenches were dug to bedrock or till at locations 1 to 5 (Fig. 5). In addition, cores for pollen analysis were taken from Cummins Pond (loc. 6, Fig. 5) and from Oliver Pond, located 2 km to the northeast just above the highest Minong features (Fig. 4). Oliver Pond was selected for coring because it is the nearest pond above the Minong beach in the area. This second pollen profile from a higher elevation was necessary to determine effects of proglacial Lake Minong, to attempt to determine the time of deglaciation, and to assist in our interpretation of local paleoenvironment.

The Cummins stratigraphic sections are shown in Figures 6 (DT section), 7 (WTT section), 8 (HTT section), 9 (LM section), 10 (bog edge), and 11A (core "D" of Cummins Pond). Their locations are shown on Figure 5, and listed on Table 1, along with their geomorphic setting.

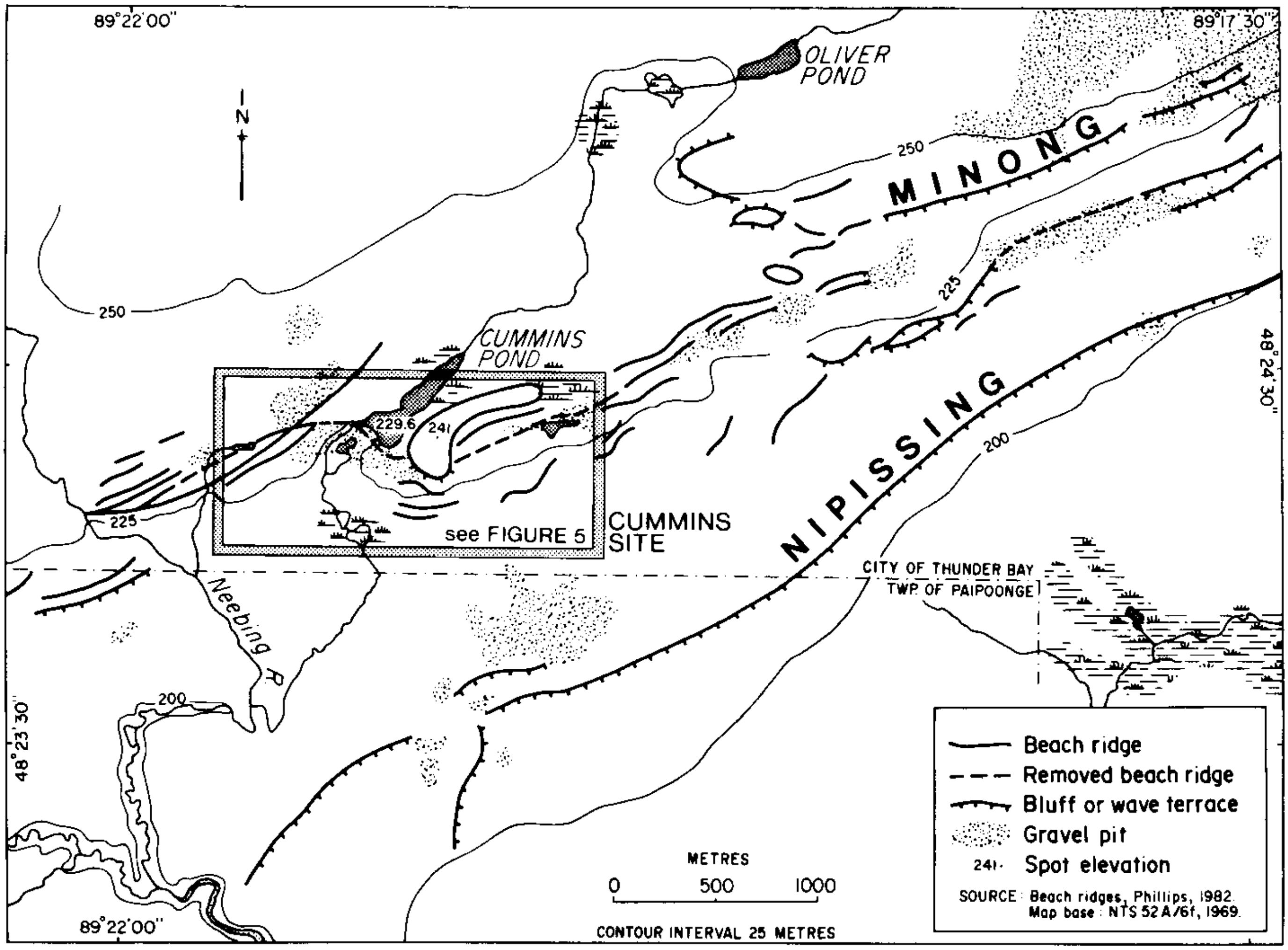


Figure 4. Cummins site, northwestern Lake Superior, Ontario, Canada, and beach ridges in the vicinity.

Methods

The sediment samples (Table 2) were analyzed for particle size and clay minerals. Particle-size analysis is based on the Wentworth scale (Folk, 1968; Soil Survey Staff, 1975); coarse grade sizes (2 mm to 63 μm) are determined by dry sieving (Day, 1965) and fine grade sizes (<63 μm) by hydrometer (Bouyoucos, 1962). Soil and sediment samples were dispersed in a solution of sodium pyrophosphate, and clay was separated by gravity sedimentation. For samples with high calcite content, an artifact of Ca-phosphate was produced from the dispersing agent; the amount produced did not significantly affect the x-ray analysis.

Particle-size data were plotted on grain-size distribution diagrams (for example, Figs. 12 through 14) after conversion to phi units (ϕ). Weight percentages from 2,000 to 0.98 μm were calculated from the grain-size curve (Table 2), and are shown in Figures 6 through 10.

Following separation of the clay fraction, the <1.95 μm size was siphoned off and placed on a porous ceramic tile by centrifugation, then air-dried and x-rayed on a Toshiba ADG-301H x-ray diffractometer with Ni-filtered Cu K alpha radiation at 35 KV and 20 Ma (Mahaney, 1981; Whittig, 1965). Samples were given several runs: (a) air dry (3° to 35°), (b) glycolated at 65°C

TABLE 1. SEDIMENT SAMPLING LOCATIONS FOR THE CUMMINS ARCHAEOLOGICAL SITE, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Section	Site Location*	Geomorphic Features
DT Section (dozer trench)	1	Base of main Minong Beach
WTT Section (west test trench)	4	Top of main Minong Beach
HTT Section (hydro test trench)	5	Base of main Minong Beach
LM Section (lower Minong)	2	Lower Minong Beach bar
Bog-edge Section	3	Dry portion of Cummins Bog edge
Core D, Cummins Pond	6	Top of main Minong Beach

*See Figure 5

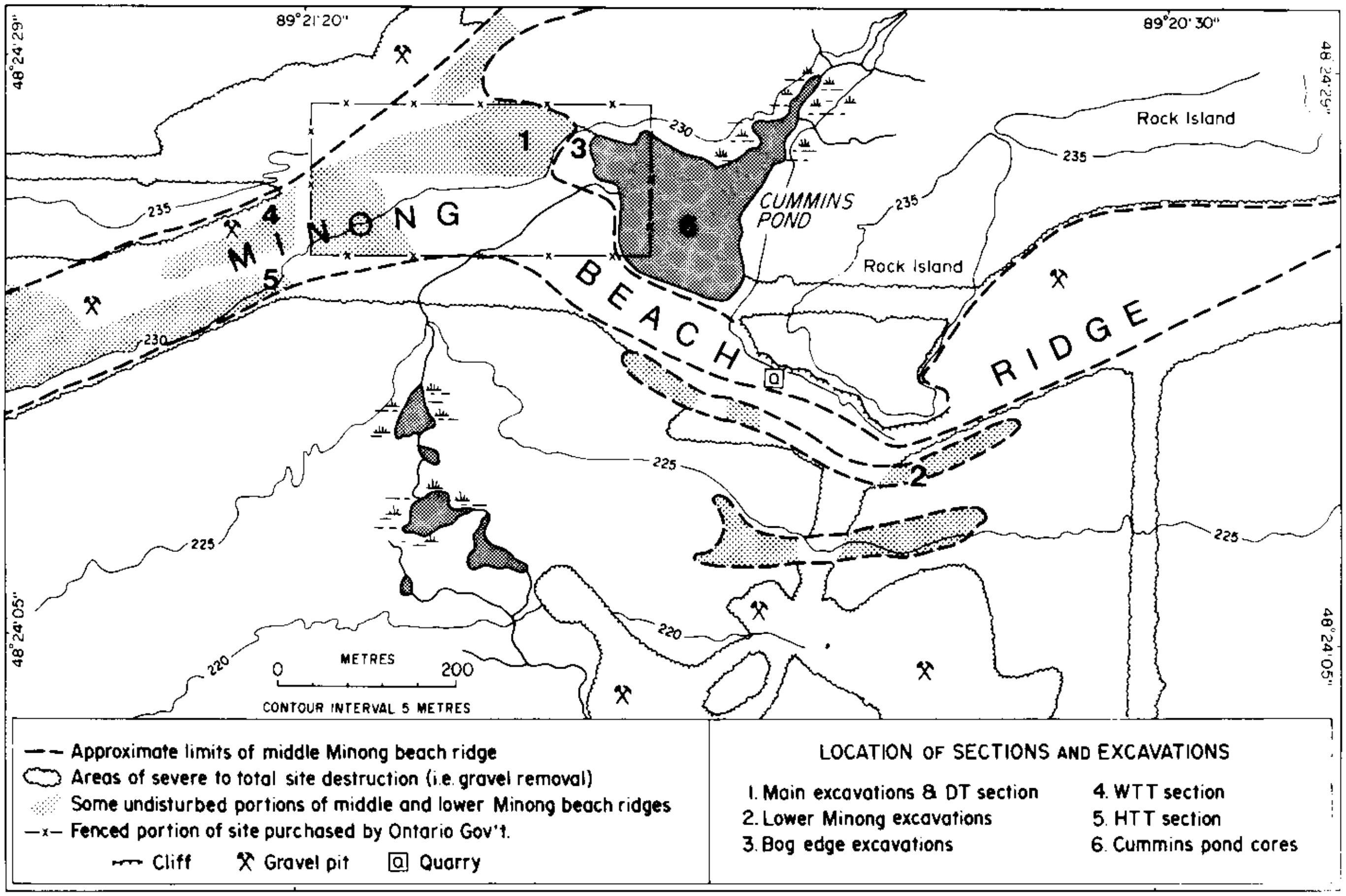


Figure 5. Cummins archaeological site, northwestern Lake Superior, Ontario, Canada, and location of excavations and sections.

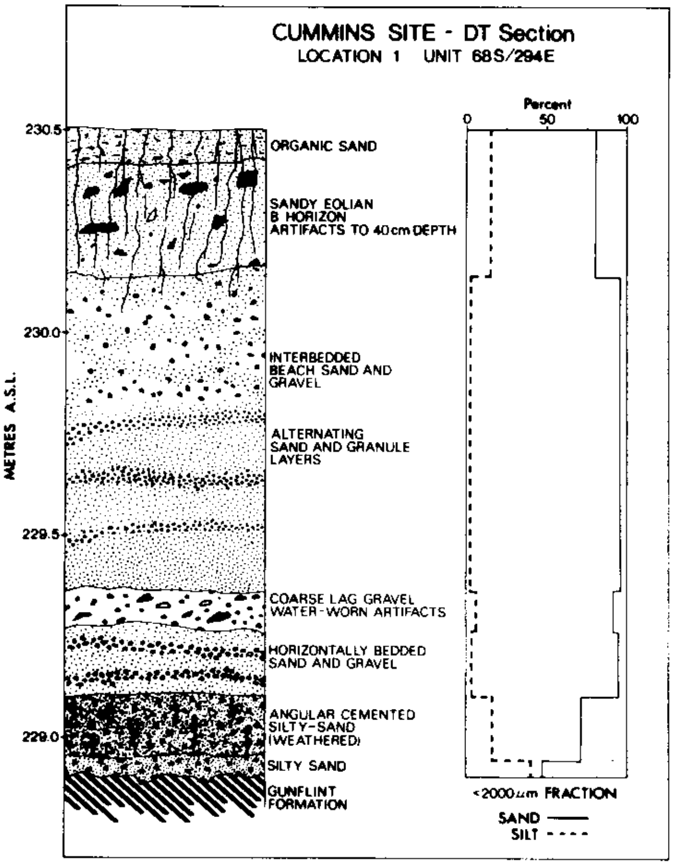


Figure 6. Sediment profile of the DT section at the Cummins site, northwestern Lake Superior, Ontario, Canada.

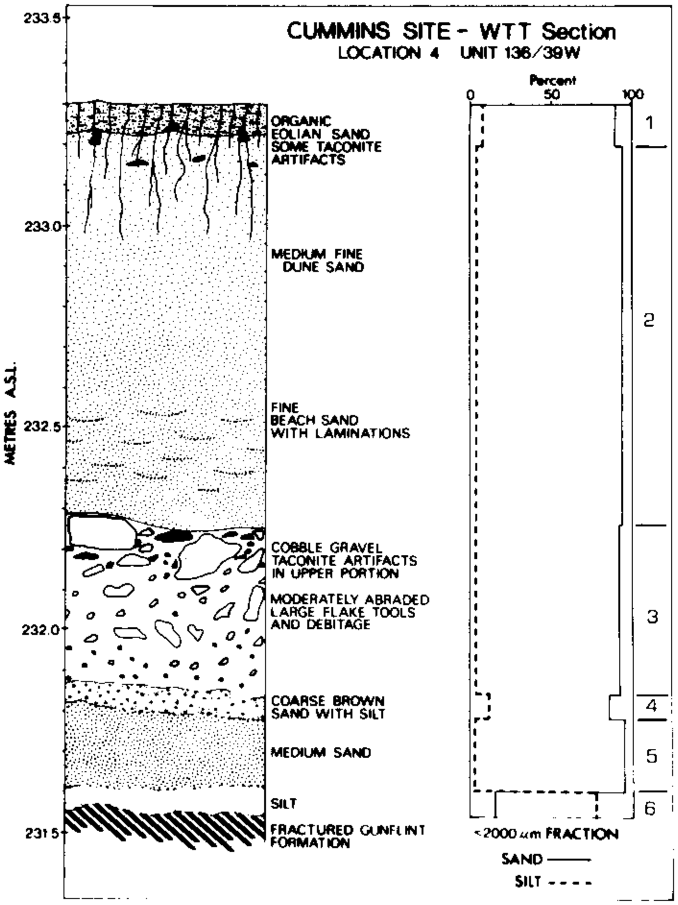


Figure 7. Sediment profile of the WTT section at the Cummins site, northwestern Lake Superior, Ontario, Canada.

for 15 hours (3° to 15°), (c) after heating to 300°C for two hours, and (d) after heating at 500°C for two hours, and (e) 550°C at two hours (3° to 15°; Mahaney, 1981). From the resultant traces, we identified the clay minerals and estimated the relative abundances (Table 3).

The percentage of organic matter and $CaCO_3$ was determined by thermal analyses (Dean, 1974). The residues were determined to be largely clay and silt, except for nearly 50 percent fine to very fine sand in the 440- to 450-cm level of Cummins Pond core. Sample preparation for pollen analysis included treatment with KOH, HC, HF, and acetolysis solution. In each sample, 300 fossil pollen of upland plants were counted together with fossil pollen of aquatic plants, and spores.

Quartz sand grains in the fine to very fine size fractions (250 to 63 μm) were retained from various Cummins site samples. The samples included known dune sands (WTT-1), till (B-5), fine beach sands (LM-1 to 6), and the sandy sample (D2-2) from Cummins Pond core.

All samples were pretreated with H_2O_2 to remove organic matter, and with sodium pyrophosphate to achieve deflocculation prior to particle-size analysis (Bouyoucos, 1962; Day, 1965). In addition, all samples were lightly sonified in distilled H_2O to remove clay particles. Quartz-sand grains from each sample were then selected using an optical microscope, placed on SEM stubs, sputter coated with gold, and examined with a JEOL-820 scanning electron microscope. About 20 specimens from each sample were viewed, representative features noted, and photomicrographs taken. Textures and characteristics were compared with descriptions in Krinsley and Doornkamp (1973) and Mahaney and others (1988). They were also compared to samples from known local depositional environments (that is, glacial, subaqueous, and eolian).

Results and discussion of sections

DT section. The DT section (Fig. 6), excavated to bedrock, contains the natural and cultural stratigraphy for location 1 (Fig. 5). Two cultural strata were recorded. The lowest, about 1.0 m below the surface, consisted of water-worn taconite artifacts recovered from a coarse gravel. However, most of the cultural materials (taconite debitage and tools) were in the upper 45 cm of the post-Minong soil. In some squares at location 1, multiple

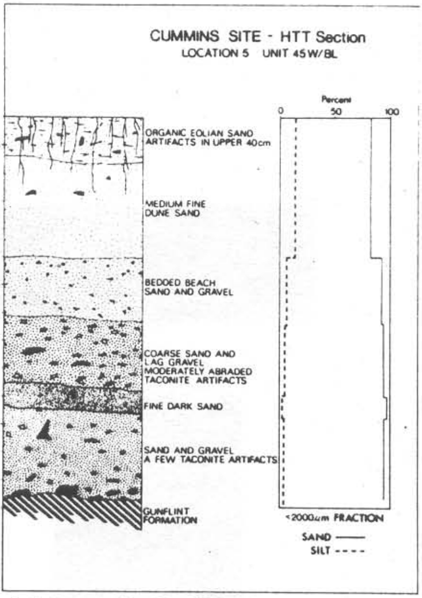


Figure 8. Sediment profile of the HTT section at the Cummins site, northwestern Lake Superior, Ontario, Canada.

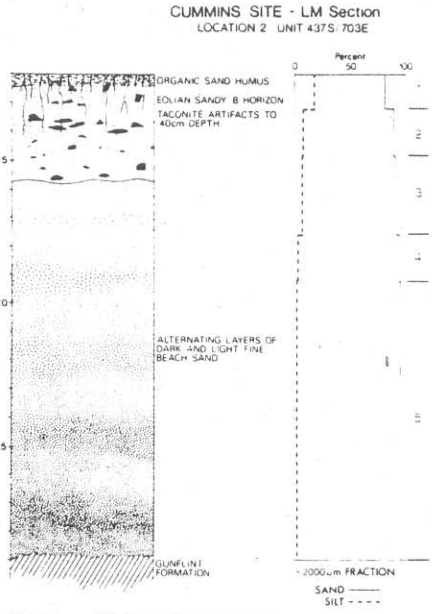


Figure 9. Sediment profile of the LM section at the Cummins site, northwestern Lake Superior, Ontario, Canada.

cultural strata occurred within the upper 40 cm, but in others the upper natural and cultural deposits were mixed by postdepositional processes.

Grain-size analyses and sediment descriptions for the DT section are given in Table 2 and Figure 6. In general, the lacustrine sediments from this part of the Minong beach (Samples DT-2 to DT-5) are poorly sorted, all with standard deviations (σI) above 1.0 (Table 2). The sediments are poorly sorted beach sands, gravels, and lag deposits. The pebbles are well rounded, except for the angular gravel of sample DT-2, which may be a reworked till or lag deposit. The few taconite artifacts found within the coarse DT-4 sedimentary unit are water-worn and abraded, probable evidence of a high-energy lacustrine environment. Minong beach deposits overlying these artifacts probably date to about 9,000 to 9,500 B.P.; however, the amount of time involved in the formation of this sedimentary sequence is difficult to estimate. Because there was abundant sediment available, and basin levels fluctuated due to catastrophic inflows from Lake Agassiz at this time (Teller and Thorliefson, 1983), the beach formation may have occurred over a short time (B. Phillips, personal communication, 1983).

The mineralogy of the DT section (Table 3) contains a small to moderate amount of quartz and feldspar, while the other minerals (clays) are present mainly in trace amounts. The smectite (S) in the (lowermost) DT-1 sample is evidence that this silty lacustrine deposit probably dates to the time when Minong received inflow from Lake Agassiz. Such expandable clays commonly develop in source regions in a dry environment (Birkeland, 1984). Smectite was not present in the basal till at Cummins (Table 3, Sample B-5), and was absent in nearby till of Marquette age (Fig. 11 *in* Teller and Mahnic, 1988); however, expandable clays are relatively abundant in sediments of Lake Agassiz origin (Fig. 5 in Teller and Mahnic, 1988).

WTT section. In excavations at the WTT section west of Maple Ward Road (Loc. 4, Fig. 5), a cultural stratigraphy was exposed similar to that in the DT section, 300 m to the east. The ≈2 m of sediment overlying bedrock (Fig. 7) once again contained two cultural strata. The sediments in the upper part (above on altitude of 232.6 m) of the profile were medium-fine sands, whereas the lower deposits (WTT-3 to 6) contained variable granulometry (Fig. 11). The lowest cultural material was recovered from the upper part of a cobble gravel (WTT-3), about 1.5

m below the surface. On the basis of field observation, this variable archaeological-geological facies was probably somewhat thicker when deposited, and was eroded and truncated by beach action.

The two uppermost samples (WTT-1, 2) are medium-fine sand with a mean ϕ of about 2.0 (Table 2). Based on field observation and SEM analysis of quartz sands, the upper part of section WWT is predominantly eolian. The medium-fine sand of sample WTT-2 (50 cm depth) with a standard deviation of 0.44, is within the range of well-sorted dune sands (Friedman, 1961). This interpretation is also supported by the lack of a coarse tail in the sediment curve (WTT-1, WTT-2, Fig. 11), a characteristic of sand-dune deposits; the wind is normally unable to move the coarser sand (Blatt and others, 1972, p. 61). Phillips (1982) noted that dune deposits topographically enhance the beach ridges in this part of the site.

Below an altitude of 232.3 m there is an abrupt sedimentary change; sample WTT-3, a cobble gravel, contains small boulders up to 380 mm in diameter. The upper part of. this geological-archaeological facies is overlain by finely laminated sands and was water eroded, with most of the larger cobbles concentrated along the upper contact. Some taconite late Paleoindian artifacts at the interface between the two strata had little polish or damage. The mean ϕ of the <2,000 μm fraction was +0.03, the coarsest of

TABLE 2. GRAIN-SIZE SUMMARY STATISTICS FOR SECTIONS AT THE CUMMINS SITE, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Cummins Site Locations	Sample	Depth (cm)	Sediment Description	Median ϕ	Mean ϕ	Dispersion σI	Skewness SkI
1 (DT Section)	DT-6	25	Mixed beach and eolian sand	+1.25	+2.02	2.52	+0.49
	DT-5	65	Beach sand and gravel (lag)	+0.30	+0.23	1.51	+0.70
	DT-4	95	Coarse gravel and sand	+0.90	+0.95	1.63	+0.17
	DT-3	120	Sand and gravel	+0.35	+0.48	1.55	+0.35
	DT-2	155	Reddish cemented sand and gravel	+1.10	+2.80	3.99	+0.63
	DT-1	165	Silty sand with taconite cobbles	+4.00	+4.53	3.24	+0.34
2 (LM Section)	LM-1	10	Medium-fine eolian sand	+2.10	+3.07	1.93	+0.70
	LM-2	17	Medium-fine beach sand	+2.15	+2.30	1.38	+0.59
	LM-3	47	Medium-fine beach sand	+2.00	+2.17	0.85	+0.64
	LM-4	62	Fine beach sand	+2.30	+2.32	0.51	+0.25
	LM-5	122	Medium-fine beach sand	+1.90	+1.93	0.56	+0.12
3 (Bog-edge)	B-2	25	Sandy silt clay	+6.80	+6.83	4.54	+0.02
	B-3	40	Silty clay sand with pebbles	+3.70	+5.29	4.97	+0.42
	B-4	50	Clayey silt sand	+5.60	+6.03	4.48	+0.16
	B-5	90	Till	+7.30	+7.63	3.02	+0.14
4 (WTT Section)	WTT-1	10	Medium-fine eolian sand	+2.00	+2.17	1.26	+0.58
	WTT-2	50	Medium-fine sand	+2.00	+2.13	0.44	+0.41
	WTT-3	115	Cobble gravel and sand	-0.10	+0.03	1.25	+0.50
	WTT-4	140	Coarse sand	+1.30	+1.05	1.74	+0.35
	WTT-5	145	Medium sand	+1.00	+0.93	1.03	-0.16
	WTT-6	160	Silt	+5.10	+5.40	2.05	+0.08
5 (HTT Section)	HTT-1	30	Medium eolian sand	+2.00	+2.37	1.60	+0.56
	HTT-2	55	Beach sand with pebbles	+1.80	+1.90	1.18	+0.37
	HTT-3	75	Beach sand with pebbles	+1.40	+1.37	1.49	+0.17
	HTT-4	100	Dark beach sand	+2.20	+2.27	0.46	+0.21
	HTT-5	120	Sand and gravel with cobbles	+1.80	+1.87	0.68	+0.14
6 (Cummins Pond Core)	B M/M	325	Clayey silt marl	+6.70	+7.43	2.49	+0.47
	DI-2	430	Silt marl	+5.15	+5.55	1.06	+0.72
	D2-2	456	Silty fine sand	+3.80	+4.12	2.32	+0.33
	D3-2	480	Silt marl	+6.40	+6.73	2.40	+0.36
	D4-2	494	Silt marl	+6.30	+6.87	2.28	+0.47

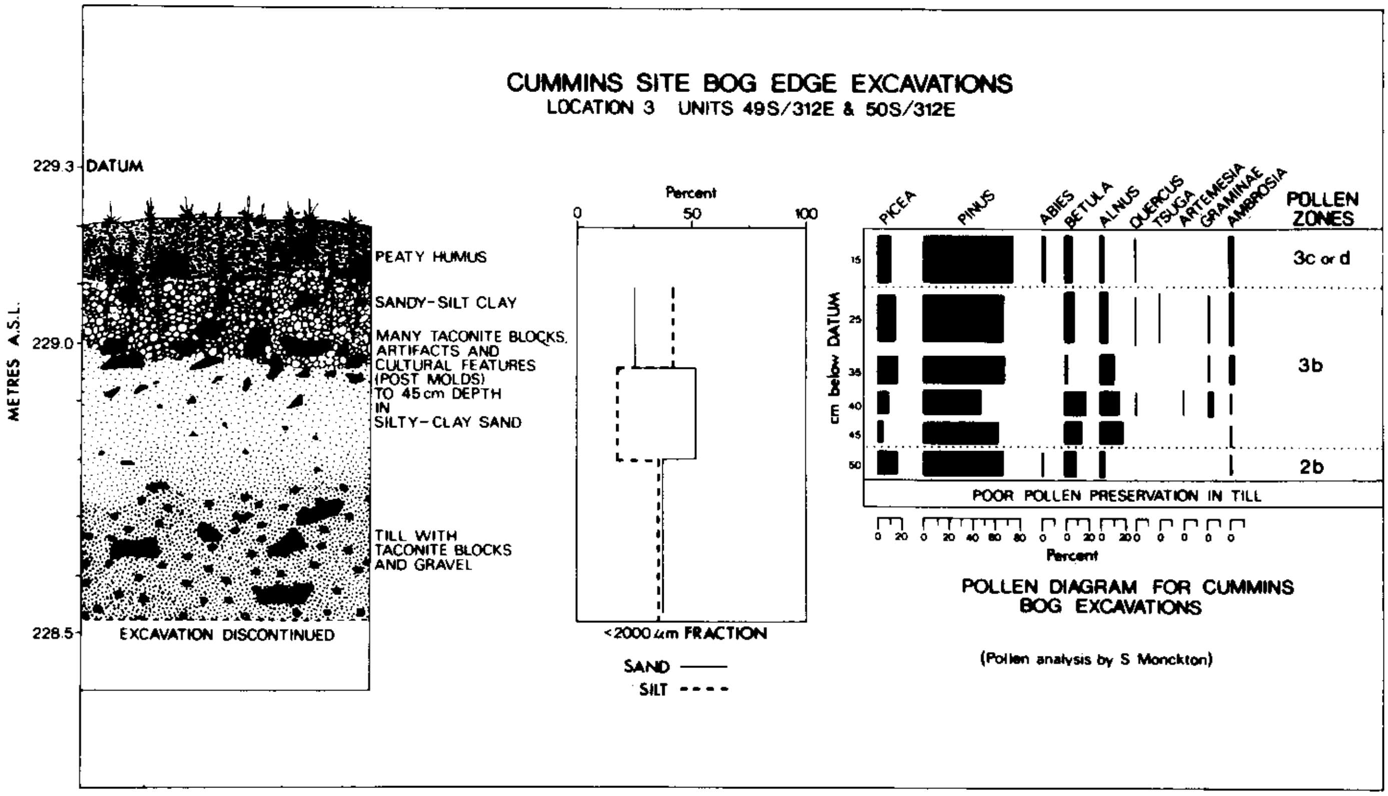


Figure 10. Sediment profile and pollen diagram for the bog excavations at the Cummins site, northwestern Lake Superior, Ontario, Canada.

all sediment samples analyzed (Table 2). In general the unit becomes finer with depth. Clay-mineral concentrations are shown on Table 3. Orientations of 30 oblong pebbles in the deposit are random, evidence that it is probably not till. Also, the unit was deposited conformably over WTT-4, the underlying sandy strata (Fig. 7); based on the cobbles, it may be a storm or flood gravel (possibly relating to the basin-level fluctuations due to abrupt inflows from Lake Agassiz, or a high-energy storm event). Various artifacts (complete formal scraping tools, cores, and debitage) in its upper part are evidence that it was a stable surface suitable for camping and lithic working. Thus this boulder and gravel beach was occupied and then eroded, truncated, and buried by terminal Lake Minong beach sands at approximately 9,500 yr BP.

HTT section. From test excavations and power augering on a grid pattern at location 5 (Fig. 5), we found a cultural and natural stratigraphy similar to the DT and WTT locations along the main Minong beach. The upper part of the section (samples HTT-1, 2) was medium-fine sand (Table 2). A few taconite artifacts were scattered in the upper 30 to 40 cm. Waterworn taconite artifacts were recovered from coarse, poorly sorted sand and gravel at depths of about 1.0 m.

All three locations sampled along the main Minong beach have a similar cultural stratigraphy. At locations 1, 4, and 5, there were artifacts below Lake Minong beach deposits in coarse and poorly sorted gravels and lag deposits. Artifacts from these sands and gravels were not in their original context, but had been moved and modified by lacustrine action. Small flakes were uncommon and probably were moved offshore by wave action. The artifacts from the archaeological gravels varied in their degree of surface weathering and battering (Julig, 1988).

LM section. Block excavations of 18 m^2 were conducted at location 2 (Fig. 5) on a lower Minong beach bar. The lower bars at the Cummins site mimic the shape of the main Minong beach, and formed offshore as water levels declined in late Minong time (about 9,000 B.P.; Phillips, 1982, p. 27). Based on field observations and granulometry (Table 2, Fig. 12), the LM section (Fig. 9) contained predominantly fine and medium-fine lacustrine sands, with some eolian sand in the upper part of the soil profile. Except for the artifacts and small amounts of finely fractured rock introduced by the prehistoric inhabitants, coarse particles were uncommon. Taconite artifacts were distributed throughout the upper 40 to 45 cm of the section, except for a pit feature with debitage to 60 cm depth.

The lower parts of the LM section are mainly fine sands (mean ϕ of 2.0, Table 2, Fig. 12). Alternate dark and light sand layers are present; the darker facies contains more weathered mica and magnetites, but no significant textural variation. Only traces of clay minerals were present, except for vermiculite within the post-Minong soil (Table 3).

TABLE 3. MINERALOGY OF THE <2µm FRACTION OF SEDIMENT SAMPLES FROM THE CUMMINS SITE, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Cummins Site Locations	Sample	Depth (cm)	K	H	I	I-S	S	V	Chl	Q	F	Calc
1	DT-6	25	-	-	Tr	-	-	x	-	xx	Tr	-
(DT Section)	DT-5	65	Tr	-	Tr	-	-	Tr	-	xx	x	-
	DT-4	95	Tr	-	-	-	-	Tr	-	xx	x	-
	DT-3	120	Tr	-	-	Tr	-	Tr	-	x	x	-
	DT-2	155	-	-	-	-	-	Tr	-	Tr	-	-
	DT-1	165	Tr	-	Tr	-	x	Tr	-	x	Tr	-
2	LM-1	10	-	-	Tr	Tr	-	x	Tr	x	Tr	-
(LM Section)	LM-2	17	Tr	-	-	-	-	x	-	x	Tr	-
	LM-3	47	Tr	-	-	-	-	Tr	-	xx	x	-
	LM-4	62	-	-	-	-	-	-	-	xx	x	-
	LM-5	122	-	-	-	-	-	-	-	xxx	x	-
3	B-2	25	-	-	Tr	-	xx	Tr	Tr	x	Tr	-
(Bog-edge)	B-3	40	-	-	Tr	-	x	x	Tr	x	-	-
	B-4	50	-	-	Tr	-	xx	x	-	x	Tr	-
	B-5	90	x	Tr	x	x	-	x	Tr	xxx	x	-
4	WTT-1	10	Tr	-	Tr	-	-	Tr	-	x	Tr	-
(WTT Section)	WTT-2	50	-	-	Tr	-	-	-	-	x	x	-
	WTT-3	15	Tr	-	Tr	-	-	Tr	-	xx	x	-
	WTT-4	140	Tr	-	x	x	Tr	x	Tr	xx	Tr	-
	WTT-5	145	Tr	-	Tr	-	-	-	-	xx	x	-
	WTT-6	160	Tr	-	Tr	-	Tr	Tr	-	x	Tr	-
5	HTT-1	30	-	-	-	-	-	Tr	-	Tr	Tr	-
(HTT Section)	HTT-2	55	-	-	Tr	-	-	Tr	-	x	x	-
	HTT-3	75	Tr	-	Tr	-	-	Tr	-	xx	x	-
	HTT-4	100	-	-	-	-	-	-	-	xx	x	-
	HTT-5	120	-	-	-	-	-	-	-	xx	x	-
6	B M/M	325	-	-	-	-	-	-	-	x	Tr	xxx
(Cummins	DI-2	430	-	-	-	-	-	Tr	Tr	xx	x	xx
Pond	D2-2	456	x	x	Tr	-	-	x	x	xx	x	-
Core)	D3-2	480	x	x	x	-	x	x	x	xx	x	x
	D4-2	494	x	-	x	-	x	x	xx	xx	x	Tr

Minerals identified as follows: Kaolinite (K), Meta Halloysite (H), Illite (I), Illite-Smectite (I-S), Smectite (S), Vermiculite (V), Chlorite (Chl), Quartz (Q), Feldspar (F), and Calcite (Calc).
- = Nil, Tr = Trace, x = Small amount, xx = Moderate amount, xxx = Abundant amount, based on relative peak heights (from Mahaney, 1981).

Bog-edge excavations. The excavated section of location 3 (Fig. 5) at the edge of Cummins Bog is shown in Figure 10. The upper part of the profile was 10 to 15 cm of peaty humus over a clay loam. Taconite blocks, some with flakes removed (cores), were present at the base of the peat and throughout the underlying clay loam (Fig. 10). Artifacts were present to a depth of about 45 cm below the surface. The section's grain-size curves are shown on Figure 13.

The relatively sandy strata (sample B-3, Table 2 and Fig. 10) is probably from dune activity at approximately 8,000 B.P., as a fine sandy eolian layer was deposited at about the same time near the base elsewhere in Cummins Pond (Fig. 14).

Pollen preservation was good, and the archaeological horizon contains pollen characteristic of zones 2b and 3b of the ^{14}C dated cores from Cummins Pond (Fig. 14A, Table 4). The pollen stratigraphy thus is evidence of an approximately 7,500 to 8,000 B.P. date for this bog-edge occupation.

The clay mineral record from this location is of interest. The

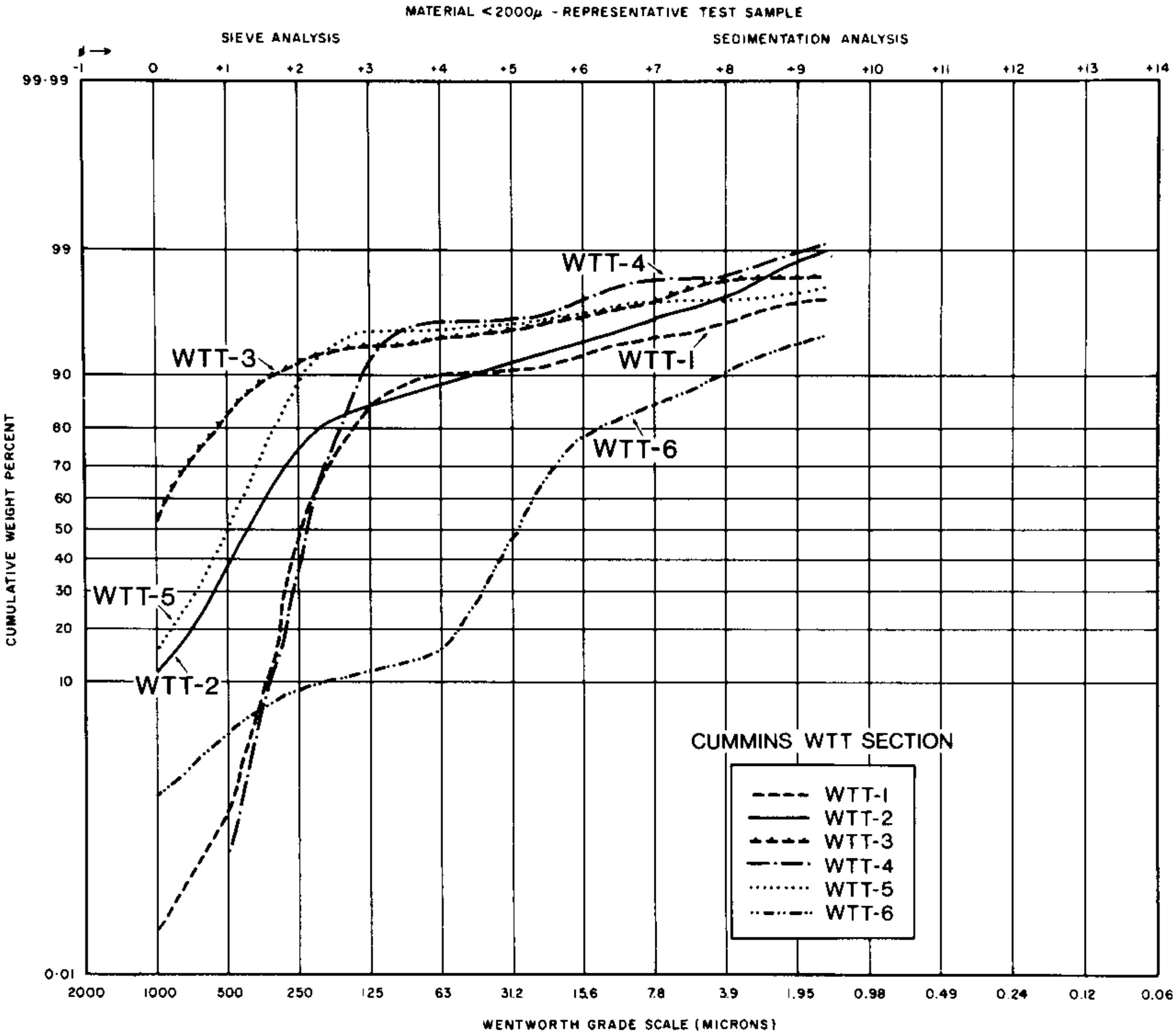


Figure 11. WTT section grain-size curves, Cummins site, northwestern Lake Superior, Ontario, Canada. See Figure 7 for stratigraphic levels.

presence of smectite in the overlying, mainly alluvial bog sediments may be due to the overflow from Agassiz to Minong during the final Minong period. The absence of smectite and presence of illite-vermiculite-kaolinite minerals in the basal till (sample B-5) reflects the source area of the ice.

The origin of the numerous taconite blocks in primarily alluvial deposits in the upper part of the sedimentary profile at location 3 (Fig. 10) is unclear. Approximately one-third are prehistoric cores and fire spalled, but in many there are no cultural modifications. The underlying till contains taconite cobbles, and frost action and bioturbation may have contributed to the near-surface accumulation. Also, some taconite blocks may have functioned as "site furniture" for prehistoric occupants. Another possible explanation is that some cobbles were thrown from the adjacent higher ground by prehistoric inhabitants.

Cummins Pond core lithology and dates. The lithology of the nearly 480-cm-long Cummins Pond core "A" is shown in Figure 14A. The granulometry (Table 2) and clay minerals (Table 3) are from the adjacent slightly deeper core "D." The base of the cores was sand, with recovery too small to determine the granulometry. Overlying the basal sand was 20 cm of silty marl, with less than 15 percent clay. Clay minerals include smectite (Table 3), only present in the lowest part of the core, and probably deposited as a result of discharge from Lake Agassiz into the Superior basin (Julig and others, 1986, p. 80).

The 440 to 460-cm level of Cummins Pond is a silty-sand unit, with over 50 percent fine and medium-fine sand. The unit was present in the same stratigraphic position in other Cummins Pond cores, and we believe it was deposited by eolian activity during the declining water levels of post-Minong time. Based on SEM analysis, the fine and very-fine quartz sand grains have eolian surface features. The absence of smectite in the unit (Sample D2-2, Table 3) also is evidence that it was not deposited by waters of Lake Minong, which received inflow from Lake Agas-

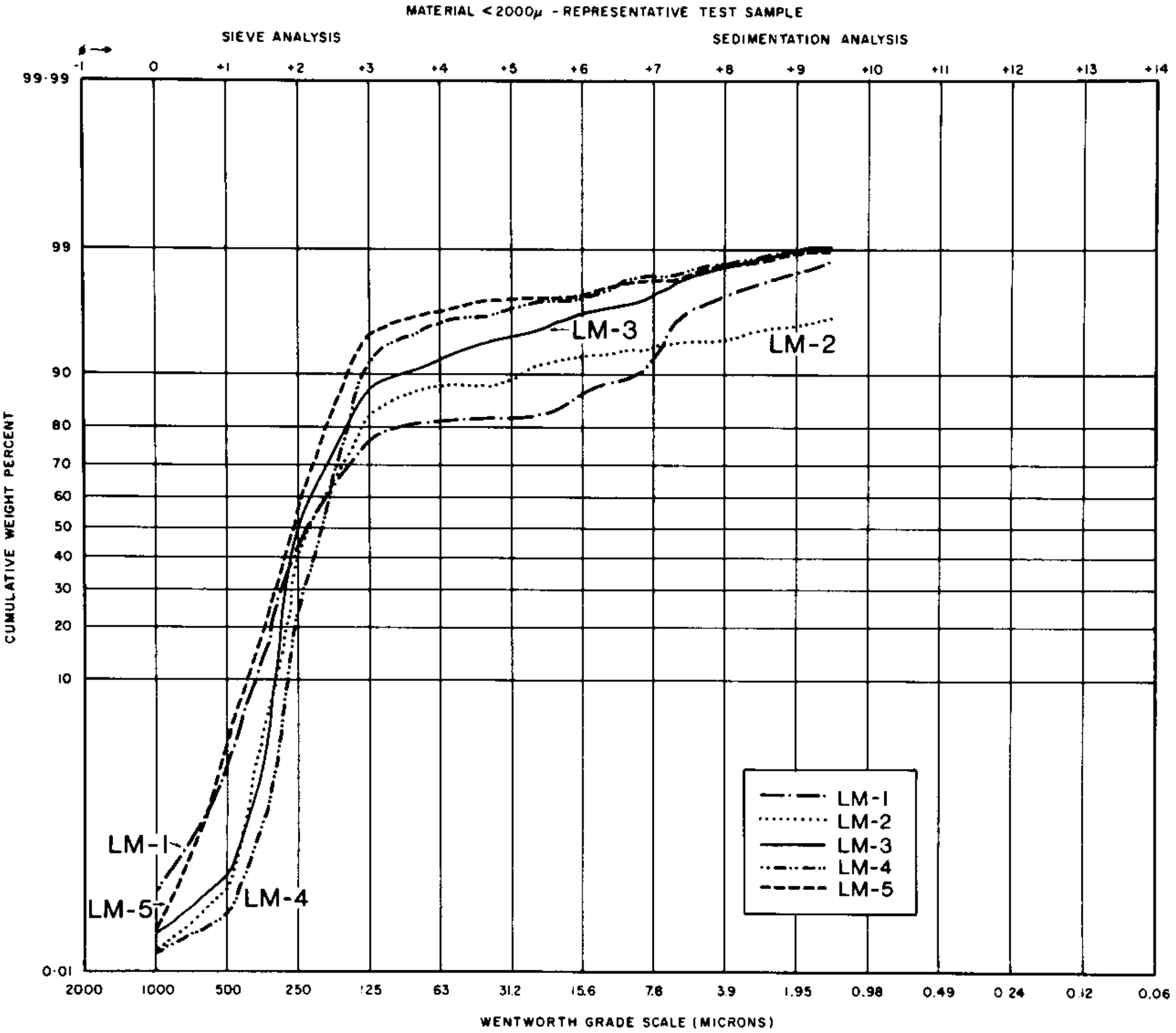


Figure 12. LM section grain-size curves, Cummins site, northwestern Lake Superior, Ontario, Canada. See Figure 9 for stratigraphic levels.

siz at the time; alternatively, the bay-mouth bar across the mouth may have formed a restricted lagoon (Phillips, 1982).

Nearly 2 m of shell-rich marl make up the middle section of Cummins core. Only traces of vermiculite and chlorite clays were present, and no smectite (Table 3). Organic matter was about 10 percent, with $CaCO_3$ ranging from 60 to 80 percent (Fig. 14A).

Above 250 cm the sediment was peat, and granulometry was not attempted. Organic matter was about 90 percent, with $CaCO_3$ relatively low.

Four of the Cummins Pond dates are from the lower marl unit: two are from the bottom of the unit, and two are from the contact with the overlying sandy silt. As expected, the basal dates from core C (11,080 ± 190 B.P. on marl) and core D (9,260 ± 70 B.P. on conifer wood) are not in agreement, but two dates from the upper part of this unit (8,110 ± 110 and 8,100 ± 135 B.P. on spruce wood) agree. Near the middle of Cummins core A, the 2b/3b pollen zone boundary was dated at 7,730 ± 95 B.P., and the 3b/3c boundary was dated at 6,250 ± 55 B.P..

Oliver Pond lithology and dates. Oliver Pond is a permanent shallow water body 2 km northeast of the site, along the creek that also drains Cummins Pond (Fig. 4). Its altitude is just over 250 m: above the major terrace of the lake, but below the highest proglacial Minong and/or Lake Duluth levels (259 m) identified near Thunder Bay (Phillips, 1982, p. 12).

The lithology of the 2.5-m core (Fig. 14B; Table 5) is similar to the Cummins Pond sequence, with lower and middle marl units, separated by 20 cm of noncalcareous organic silt. The lower 30-cm-thick marl unit rests on dense clay. Organic matter in the lower marl is about 10 percent, with a $CaCO_3$ content of >40 percent. Overlying that is 20 cm of organic silt, evidence of a different depositional environment. Organic-matter content is about 20 percent, and $CaCO_3$ varies from 10 to 25 percent. Above the organic silt is about 0.5 m of marl, with $CaCO_3$ con-

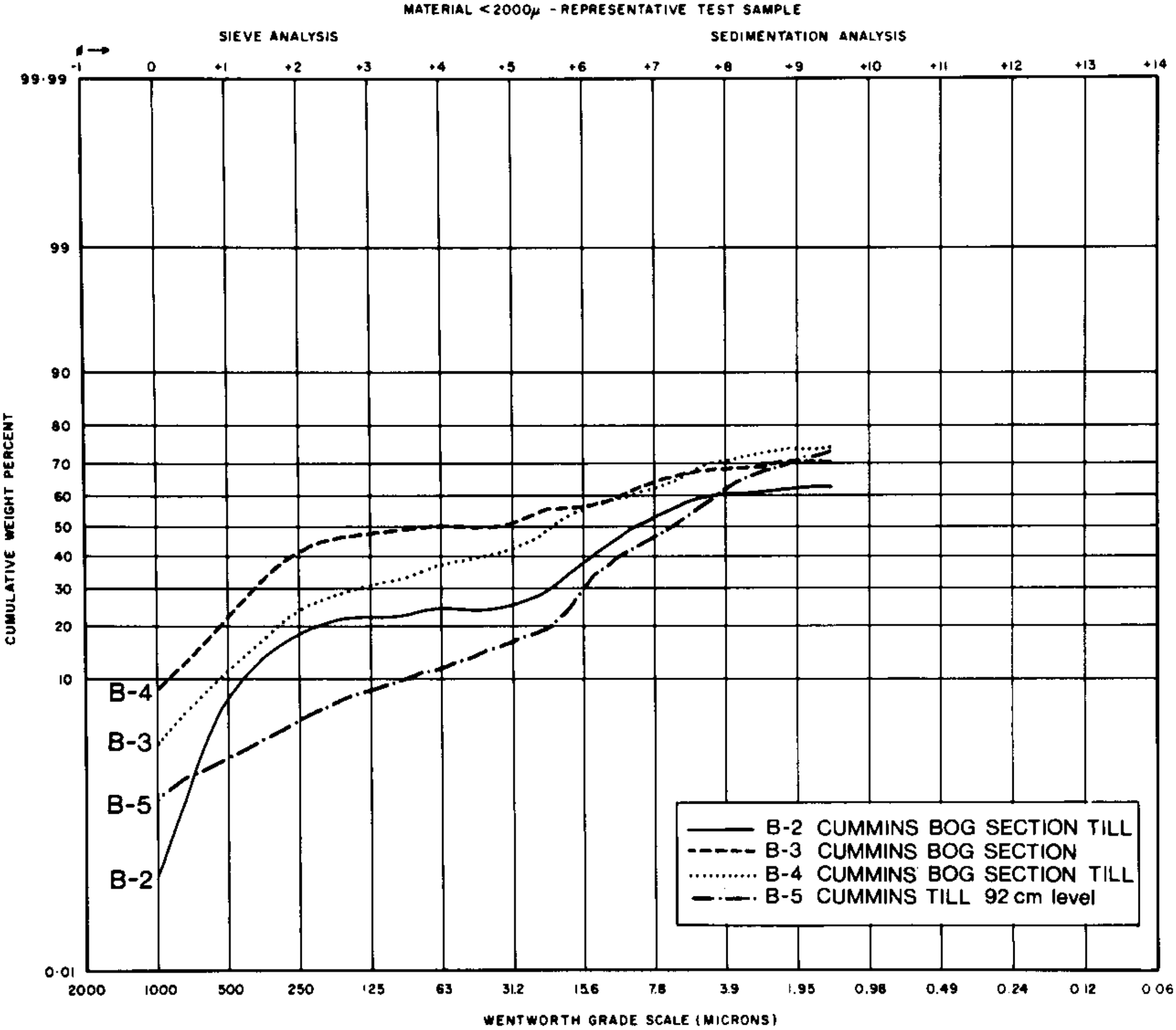


Figure 13. Bog section (location 3) grain-size curves, Cummins site, northwestern Lake Superior, Ontario, Canada.

tent >60 percent; the uppermost unit is 1.5 m of gyttja. As yet no granulometry or clay mineralogy has been carried out on Oliver Pond sediments.

The basal ^{14}C date (Table 6) of 11,950 ± 70 B.P. is on marl, and therefore suspect (Karrow and Geddes, 1987), but the amount of organic matter (about 10 percent) is within acceptable limits (Bjorck, 1985, p. 854). Samples from the 195- to 205-cm level (pollen zone 2/3a boundary) and the 100- to 110-cm level (3c/3d boundary) are dated at 8,210 ± 70 B.P. and 4,210 ± 70 B.P., respectively. The rates of sedimentation for the lower part of this core were low. This may be due in part to the flat bottom of the basin (determined by probing prior to coring).

DISCUSSION OF VEGETATIONAL HISTORY AND ^{14}C DATES

The pollen zonation follows that of McAndrews (1982). The initial postglacial pollen spectra for the region (zone 1) contain high percentages of herb pollen, and are evidence of sparse vegetation and tundra-like conditions (Craig, 1972, p. 52; McAndrews, 1982, p. 43; Bjorck, 1985, p. 856). The basal sediments of small basins along the shore of proglacial Lake Minong contain mixtures of pollen from various sources: local pollen rain, long-distance wind transport, and pollen introduced by the waters of proglacial Lakes Minong and Duluth, which covered the ponds at various times in early postglacial time. The basal sediments of Oliver Pond and Pass Lake (McAndrews, 1976) contain total herb pollen ranging from 20 to 30 percent, plus variable percentages of nontundra species such as oak, elm, and considerable pine. Spruce percentages in regional zone 1 assemblages are generally around 20 percent (Fries, 1962; Craig, 1972; McAndrews, 1982), and do not peak until approximately 10,500 to 10,000 B.P. (within zone 2), when 30 to 40 percent spruce is common.

The Cummins Pond core does not include zone 1 pollen

TABLE 4. MISCELLANEOUS POLLEN AND SPORES FROM THE CUMMINS POND, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Depth (cm)	A*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	-	1	-	-	-	2	-	-	-	-	22	-	-	-	-	1	12	4	Umbelliferae 1,
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Onagraceae 1,
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Plantago 1,
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Thalictrum* 1,
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Liguliflorae 1
100	366	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2	9	-	*Tsuga* 1, *Equisetum* 1
110	242	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	*Tsuga* 2
120	411	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	*Lycopodium* 1
130	197	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	1	
140	255	1	-	-	-	-	-	-	-	1	-	-	2	1	-	-	5	2	*Equisetum* 1, *Galium* 1
150	107	-	-	-	-	-	-	-	-	-	5	1	1	2	-	-	1	1	
160	161	-	-	-	-	-	-	-	-	-	1	1	-	1	-	-	2	2	
170	78	-	-	-	-	-	-	-	-	-	3	1	1	-	-	-	-	1	
175	124	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	3	1	
195	70	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	3	1	
200	153	1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	3	-	
210	51	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	1	-	
220	121	-	-	-	-	3	-	-	-	-	2	-	2	3	-	-	6	-	*Utricularia* 1
230	109	-	2	-	-	2	-	-	-	-	-	-	1	-	-	-	3	-	*Equisetum* 1
240	215	-	-	-	-	-	-	-	-	1	-	-	1	1	-	1	3	-	
250	231	-	-	-	-	1	-	1	-	-	1	-	-	6	-	-	1	-	
260	131	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	2	-	
265	111	-	-	-	-	-	-	-	-	3	-	-	1	-	-	-	2	-	
270	100	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	5	-	*Iva ciliata* 1
290	68	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	
300	87	-	2	2	-	2	-	-	1	-	-	-	-	3	-	-	4	-	
310	42	-	-	-	-	-	-	-	-	-	-	-	1	8	-	-	4	-	*Iva* ciliata 1
320	180	-	-	-	-	-	-	1	-	2	3	-	2	-	-	-	4	-	*Cornus* 1
330	73	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	11	1	
340	61	-	-	1	-	-	-	-	-	-	-	-	-	3	-	1	4	-	*Lycopodium* 2
350	139	-	-	-	-	-	-	-	-	-	1	-	2	2	-	-	5	-	*Iva xanthifolia* 1
360	43	1	-	-	-	-	-	1	-	-	-	-	1	3	-	-	8	-	*Iva ciliata* 1
370	32	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	4	-	
380	27	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	8	-	
400	23	-	-	1	-	-	-	1	-	-	-	-	-	4	-	-	13	-	
410	51	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	5	-	
420	19	-	-	1	1	-	-	-	1	-	-	-	4	-	-	-	8	-	*Equisetum* 1, *Potamogeton* 1
430	35	-	1	-	-	-	1	-	-	-	-	-	1	4	-	1	5	2	
440	17	-	-	-	-	-	-	-	-	-	-	-	8	1	1	-	9	1	*Iva ciliata* 1, - Rosaceae 1
455	6	-	-	-	-	-	1	-	-	-	-	-	3	1	-	-	12	2	Onagraceae 1
460	18	-	3	2	1	-	1	-	1	-	-	-	2	5	-	-	17	4	Ranunculaceae 1
470	24	-	-	1	1	-	1	-	-	-	-	-	4	8	1	1	4	3	*Potamogeton* 1
480	18	-	-	-	-	-	2	-	-	-	-	-	-	-	6	-	8	5	*Elaeagnus* 1, Caryophyllaceae 1, *Selaginella rupestris* 1

*A = Pollen sum density $mL^{-1}(x10^3)$; B = *Acer saccharum*; C = *Ostrya/Carpinus*; D = *Carya*; E = *Juglans cinera*; F = *Corylus*; G = *Shepherdia canadensis*; H = *Sarcobatus*; I = *Myriophyllum exalbescens*; J = *Nuphar*, K = *Typha latifolia*; L = *Sparganium* type; M = *Dryopteris* type; N = *Pteridium*; O = *Selaginella selaginoides*; P = *Sphagnum*; Q = Indeterminable; R = Unknown.

TABLE 5. MISCELLANEOUS POLLEN AND SPORES FROM THE OLIVER POND, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Level (cm)	A*	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	31	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	*Acer rubrum* 1
10	107	-	-	-	-	-	1	-	-	1	-	1	1	-	3	1	*Tsuga* 1, Nuphar 2
20	149	-	-	-	-	1	1	-	-	-	-	-	1	-	2	3	Ericales 1, *Iva xanthifolia* 1
30	151	-	2	-	-	-	-	-	1	-	1	-	7	-	2	1	*Rumex* 1, *Sparganium* type 1
40	129	-	1	1	-	-	-	-	-	-	-	1	-	-	2	2	
50	228	2	1	-	-	-	1	-	-	1	-	-	-	-	5	1	
60	243	-	-	-	-	-	1	-	-	-	-	-	-	-	4	1	
70	251	1	1	-	-	-	-	-	-	-	-	-	7	-	3	-	*Tsuga* 1
80	337	2	-	-	1	-	1	-	1	-	-	1	1	-	2	-	
90	217	3	1	-	-	-	1	-	-	-	-	-	1	-	-	-	
100	248	-	-	-	-	-	-	-	-	-	-	1	-	-	4	-	*Tsuga* 1
110	294	-	1	-	-	-	-	-	-	1	-	1	2	-	-	-	*Tsuga* 1
120	403	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	
130	383	-	-	-	-	-	1	-	-	-	-	1	1	1	1	-	
140	257	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	
150	435	1	-	-	1	-	-	-	-	2	-	-	1	-	8	-	
155	181	-	1	1	-	-	-	-	-	-	-	-	-	-	5	-	
160	254	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	*Humulus* 1
165	111	-	-	-	1	-	1	-	-	1	-	-	-	-	2	-	*Iva ciliata* 1, *Equisetum* 1
170	145	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Xanthium* 1
175	135	-	1	1	-	-	-	-	-	-	-	-	-	1	2	-	
180	149	-	2	-	-	-	-	-	-	-	-	-	-	-	3	-	
185	171	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
190	163	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	*Iva ciliata* 1, *Sparganium* type 1
195	108	-	2	-	-	-	-	-	-	1	-	-	-	1	-	-	
200	114	-	1	-	-	-	-	-	-	1	-	-	-	1	-	-	*Lycopodium* 1
205	84	-	3	1	-	1	-	-	-	-	-	-	-	-	5	-	
210	105	-	6	2	-	-	-	-	-	-	-	1	-	-	4	1	
215	64	1	7	1	1	1	-	-	-	-	-	1	-	-	5	-	
220	62	2	-	-	-	-	-	1	1	1	-	-	-	-	17	-	
225	38	1	9	4	1	-	-	-	1	-	1	-	-	1	4	1	*Ephedra* 1, *Equisetum* 3
230	29	-	-	-	1	-	-	1	-	-	-	-	-	-	4	-	
235	19	1	10	3	-	1	-	-	-	-	-	-	-	2	11	-	
240	20	1	7	2	1	-	-	-	1	-	-	-	-	1	7	1	
245	38	-	7	2	1	-	-	-	-	-	-	-	-	2	16	-	
250	20	-	6	-	3	-	-	1	1	-	-	1	2	4	16	1	

*A = Pollen sum density $mL^{-1}(x10^{3})$; B = *Acer saccharum*; C = *Ostrya/Carpinus*; D = *Carya*; E = *Juglans*; F = *Tilia*; G = *Corylus*; H = *Shepherdia canadensis*; I = *Sarcobatus*; J = *Typha latifolia*; K = *Potamogeton*; L = *Dryopteris* type; M = *Sphagnum*; N = *Pteridium*; O = Indeterminable; P = Unknown.

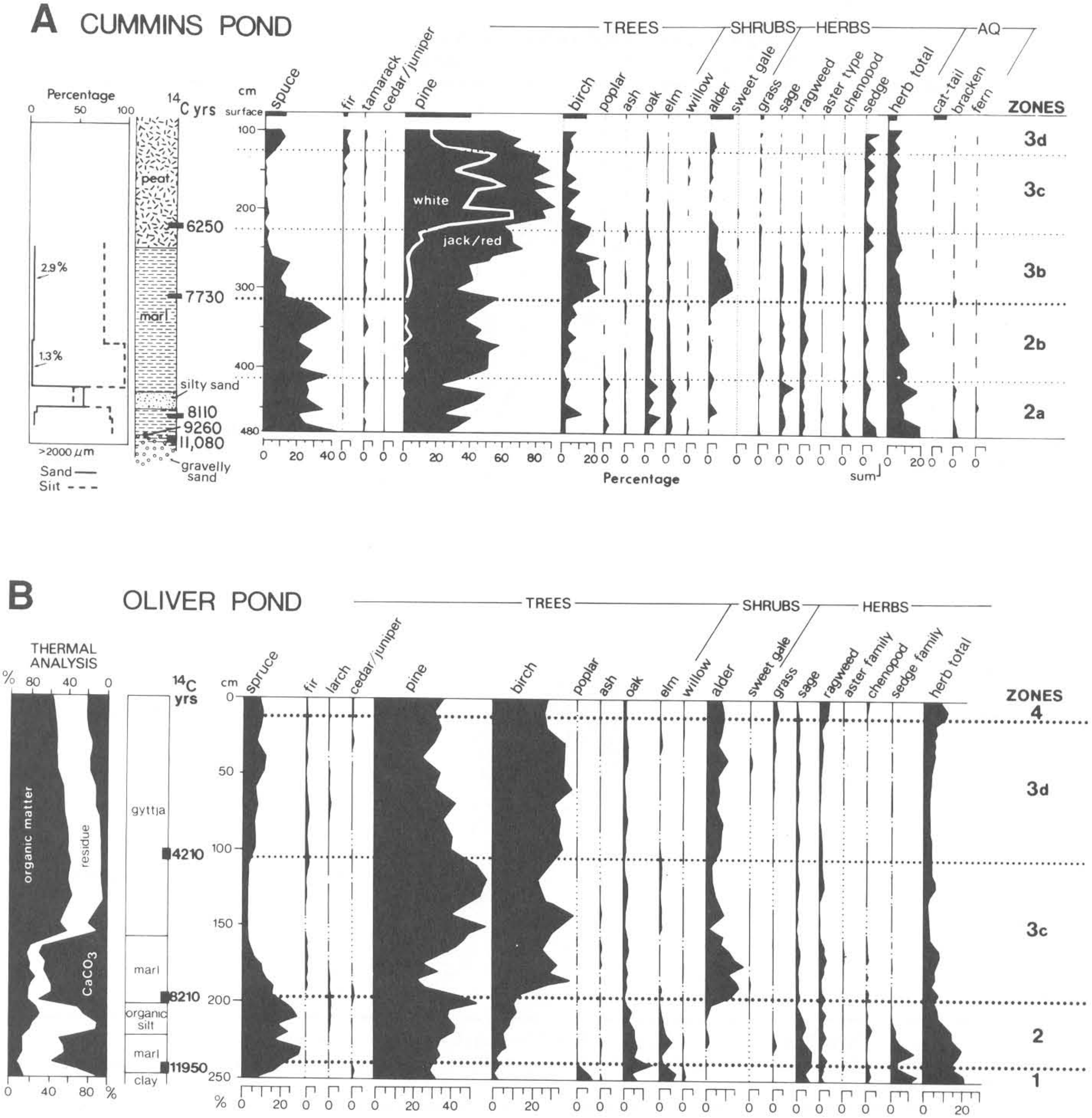


Figure 14. A. Pollen profile for Cummins Pond, northwestern Lake Superior, Ontario, Canada. See Table 4 for pollen density and miscellaneous pollen and spores. B. Pollen profile for Oliver Pond, northwestern Lake Superior, Ontario, Canada. See Table 5 for pollen density and miscellaneous pollen and spores.

(Fig. 14A; Table 4), as the near-basal samples contain high (20 to 40 percent) spruce percentages. The basal ^{14}C date of 11,080 ± 190 B.P. (Table 6) is considered too old and unreliable because: (1) conifer wood (spruce or tamarack) from the same level, but a different core, was accelerator dated to 9,260 ± 70 B.P.; (2) Cummins Pond was on a stream where old organics may have washed in from upstream around Oliver Pond; and (3) the percentage of organic matter was very low (<5 percent), with high marl content. Most importantly, there is a potential problem with "old carbon" in marl lakes on the Canadian Shield when dating basal organics (Karrow and Geddes, 1987).

The basal date of 11,950 ± 70 B.P. from Oliver Pond, on marl, is also suspect. However, organic matter is about 10 percent, and the near-basal sediments contain low spruce (10 to 15 percent) and high herb (20 percent total herb) and poplar pollen (5 percent); (Fig. 14B; Table 5). Thus, zone 1 pollen is present at the base of Oliver Pond, but not at Cummins Pond. The relatively high pine pollen (30 percent) in this zone 1 assemblage is not unlike Peggy Lake and Pass Lake (McAndrews, 1976), and results in part from long-distance transport by air and proglacial lake waters. McAndrews and Jackson (1988) designated such basal pollen assemblages from proglacial lake sediments as a 'P' (proglacial lake) zone, to distinguish them from upland zone 1 assemblages.

The basal date at Oliver Pond of 11,950 ± 170 B.P. (on marl) is probably too old by about 500 to 1,500 years (Karrow and Geddes, 1987). However, this date and zone 1 pollen are evidence that deglaciation may have occurred around Thunder Bay before 10,000 yr BP, and that the approximately 10,000 B.P. Marquette glacial advance into northern Michigan (Drexler and others, 1983) may not have affected this part of western Lake Superior. This also agrees with data from offshore Lake Superior cores, evidence that the Laurentide ice began to retreat from the western basin by at least 10,500 B.P. (Maher, 1979, p. 41), and prior to 11,000 B.P. inland to the northwest of Lake Superior (Craig, 1972; Fries, 1962). Thus, the upland regions adjacent to the western Lake Superior Basin were probably at least partly ice free a millenium or more before ice retreated completely from the north shore of Lake Superior at approximately 9,500 B.P.

Based on the Oliver Pond core, spruce dominated around Thunder Bay at about 10,000 to 10,500 B.P. along with shrubs (birch, soap berry) and various herb species including sage and sedges. Some of the pine, oak, and ragweed pollen in zone 1 at Pass Lake (McAndrews, 1976) and Oliver Pond is the result of long-distance transport. Vegetation cover was probably quite sparse, being mostly open tundra, with trees growing only in the more protected areas and on south-facing slopes where soil conditions permitted.

TABLE 6. RADIOCARBON DATES FROM CUMMINS AND OLIVER PONDS, AND FROM UPLAND LOCATIONS AT CUMMINS SITE, NORTHWESTERN LAKE SUPERIOR, ONTARIO, CANADA

Core	Depth (cm)	Yrs B.P.	Lab. No.	Material and Comments
Cummins Pond				
A	225-230	6,250 ± 55	DIC-2503	peat and gyttja
A	310-320	7,730 ± 95	DIC-2504	marl
A	454-457	8,110 ± 110	BETA-4486	spruce wood
A	454-457	8,100 ± 135	DIC-2579	spruce wood
D	485-490	9,260 ± 70	TO-547	conifer wood (accelerator date)
C	485-495	11,080 ± 190	DIC-3241	marl (low organic C)
Oliver Pond	100-110	4,210 ± 70	WAT-1571	gyttja
Oliver Pond	195-205	8,210 ± 70	WAT-1572	marl
Oliver Pond	240-250	11,950 ± 70	WAT-1584	marl

Location	Yrs B.P.	Lab. No.	Material, Context, and Comments
Gravel pit east of Rock Island	8,480 ± 390	NMC-1216	Fragmentary calcined human remains
Location 1 feature 34S/295E	2,380 ± 125	S-2460	Charcoal, possible pit feature with debitage and tools (intrusive tree throw)
Location 1 51S/259E	1,765 ± 200	S-2461	Charcoal, possible hearth with debitage and tools (intrusive tree throw)
Location 1 49S/295E	2,300 ± 125	S-2462	Charcoal, pit feature with burnt debitage (instrusive tree throw)
Location 1 31S/259E	RECENT	AA-368	Charcoal from within Minong beach gravels (intrusive tree throw, or rodent introduced)
Location 1 29S/259E	340 ± 430	AA-369	Charcoal from within Minong beach gravels (intrusive tree throw, or rodent introduced)

Closed spruce forest (zone 2) prevailed after about 10,000 B.P. on the till plains around Thunder Bay, with increasing jack pine and white birch due to climatic warming. In the glaciolacustrine plains, opportunistic species such as willow, balsam poplar, and grasses flourished, with sage and other shrubs in the dryer areas. Other tree species present included elm, black ash, and tamarack, growing in adjacent wetlands.

The onset of the regional Hypsithermal woodland occurred at about 9,200 B.P. to the west of Thunder Bay (McAndrews, 1982, p. 41). However, closed spruce forest persisted on the upland till plains and on north-facing slopes in the Thunder Bay area until about 8,000 B.P., when pine, birch, and alder became locally dominant (Figs. 14A, B).

The major period of human occupation at the Cummins site occurred during the time of spruce forest (zone 2); however, the herb pollen totals (sage, sedge, grasses) exceed modern values. Therefore, open woodlands were present on the south-facing slopes, beach ridges, and sandy outwash plains. The lowlands were grassy willow meadows; alder had not yet colonized these areas. Both birch and pine increased during zone 2 time, with birch more common on the upland till plains near Oliver Pond (Fig. 14B), compared with the glaciolacustrine plains and beach ridges at the Cummins site (Fig. 14A).

The Cummins site continued to be occupied during zone 3 time (after approximately 8,000 B.P.), when pine replaced spruce as the dominant forest species. The archaeological assemblage at the bog edge of Cummins Pond (loc. 3, Fig. 10) was correlated by pollen stratigraphy to zone 3b. Most of the cultural materials and features were present between 40 and 25 cm depth, where the associated pollen indicates the rise in birch and alder, as well as low spruce, all characteristic of the 3b pollen assemblage.

Climatic warming continued until about 6,250 B.P. when spruce pollen values fell to less than 5 percent, with white pine replacing jack pine and spruce (zone 3b). Although there is little poplar pollen evident (it does not preserve well), poplar was probably abundant in this pine and deciduous Hypsithermal woodland. Zone 3d, beginning at 4,200 B.P., is marked by a rise of spruce and the replacement of white pine by jack pine and balsam fir; white birch remains dominant. This is a response to a cooling trend following the Hypsithermal. Zone 4 is marked by a rise in ragweed pollen; ragweed plants do not grow this far north; thus, the pollen was blown from weedy disturbed habitats in the south over the past century.

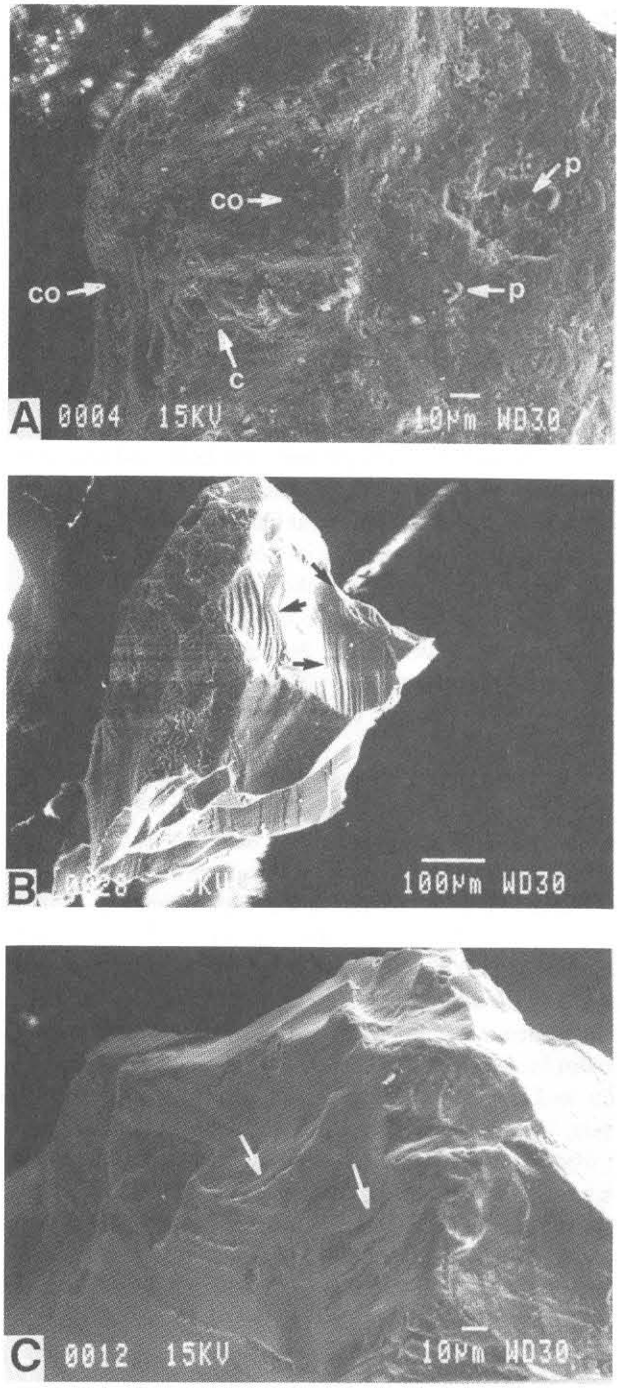


Figure 15. A. Eolian quartz sand grain from dune sediments, Cummins site, northwestern Lake Superior, Ontario, Canada, WTT section. Features: well-rounded, adhering particles (=arrows-p); smooth concavities (=arrows-co); and weathered crushing features (=arrow-c). For other examples, see Julig (1988). B. Glacially crushed quartz grain from till at the base of Cummins site bog, northwestern Lake Superior, Ontario, Canada. Features: concoidal and linear fractures (=arrows), cleavage planes and sharp edges. (Reprinted with permission American Journal of Science; Mahaney and others, 1988). C. Subaqueous (beach) quartz grain from the Cummins site, northwestern Lake Superior, Ontario, Canada, LM section. Features: weathered concoidal fractures (=arrows) and irregular dissolution features (etched surface).

SEM ANALYSIS OF QUARTZ SAND GRAINS

A fine to very fine sandy stratum was present at the same level in all of the basal core sections of Cummins Pond (Fig. 14A). Because this stratum was an anomaly within a lengthy marl unit, its origin and the nature of the depositional environment (at approximately 8,000 B.P.) are of interest. Grain-size analysis of this stratum (Sample D2-2, Table 2), consisted of 53 percent sand, 40 percent silt, and 6 percent clay, with a mean size of 3.80 ϕ.

Quartz sand-grain morphology is diagnostic of the environmental history of the deposit from which a grain is removed (Krinsley and Doornkamp, 1973, p. 8). However, one must observe several surface features to determine a grain's environmental history, as no single feature is diagnostic.

Characteristics of eolian surface textures on quartz sand grains can include: (1) precipitation features smoothed by eolian action, (2) irregular solution (etched) surfaces, (3) dish-shaped concavities, (4) mechanically upturned clay plates, (5) rounded grains, and (6) adhering particles (clay minerals, etc.). Of these, dish-shaped concavities (3) and well-rounded grains (5) are most characteristic of an eolian environment (Krinsley and Doornkamp, 1973, p. 26–27). An eolian quartz-sand grain from dune sediments (WTT-2) is shown in Figure 15A.

Quartz-sand grains from glacial deposits have very different surface features, which include: (1) sharp edges, (2) fracture faces, (3) linear and conchoidal subparallel crushing planes, and, (4) adhering particles. Such features may be related to thickness of glacial ice and the distance of transport (Mahaney and others, 1988). An example of a quartz-sand grain from till at the edge of Cummins bog (B-5) with typical surface features is shown in Figure 15B.

Quartz grains from subaqueous (beach) environments have more complex surface textures, some of which are inherited from glacial action and may include: (1) irregular solution-precipitation surface, (2) chemically etched and mechanical V-forms, (3) linear and conchoidal fractures, (4) mechanically upturned plates, and (5) fracture faces. A specimen from the lower Minong beach (lower Minong, loc. 2) with some of these features is shown in Figure 15C.

Quartz-sand grains from the sandy stratum (D-2) at the base of Cummins Pond are shown in Figures 16A, B, and C. Many of the sand grains from this stratum are well rounded and have other features of an eolian history such as weathered concavities (Figs. 16B, C). Other features such as irregular solution (etched) surfaces (Figs. 16B, C) and V-forms (Fig. 16A) are evidence of complex environmental histories for certain of the grains (see Julig, 1988). The majority of the grains examined from D-2 were well rounded with weathered concavities, evidence of an eolian origin from coastal dune activity relating to declining water levels in post-Minong time.

CHRONOSTRATIGRAPHY AND CORRELATION

Organic preservation in the buried upland post-Minong soils at the Cummins site is poor, and direct ^{14}C dating of early cultural material is generally not possible. Thus, relative dating techniques, including artifact typology and correlations with the dated bog section, are used to establish temporal contexts of archaeological materials. Wood charcoal was recovered from "pit" features and possible hearths at location 1 (Fig. 5), but in most instances the stratigraphy was disturbed due to tree throws and other post-depositional factors. Carbonized tree-root fragments from forest fires were encountered at depths down to 30 cm.

Dated wood charcoal from pit features at location 1 (2,380 ± 125 to 1,765 ± 200 B.P., Table 6) were found with lithic artifacts, but not with projectile points or other culturally diagnostic implements. These dates were initially interpreted as evidence of Late Archaic use of the site (Julig, 1984); however, further study of site formation and disturbance processes (Julig, 1988) led to a reevaluation, and they are now regarded as the result of intrusive charcoal from forest fires and tree throws (Table 6). Several Archaic artifacts are present, but based on typological and stratigraphic evidence, we suggest an Early Archaic temporal placement.

Wood charcoal was recovered in the Minong beach gravels

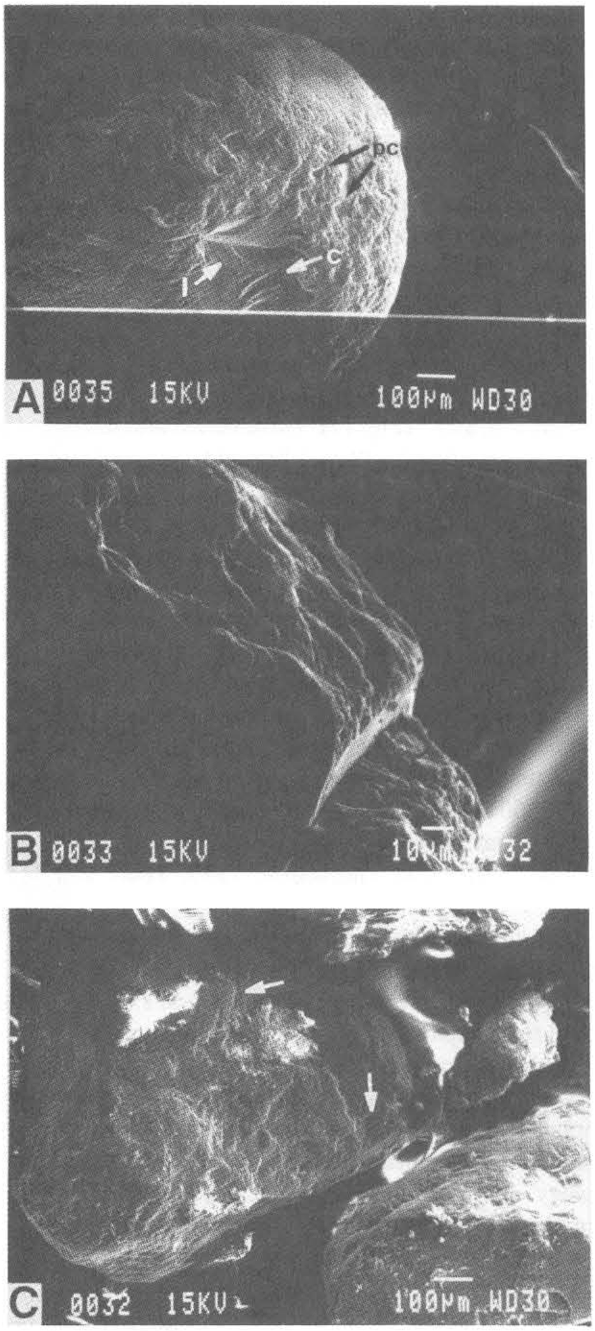


Figure 16. A. Quartz sand grain from D-2 sandy stratum near base of Cummins Pond core, northwestern Lake Superior, Ontario, Canada. Features: well-rounded surface characteristic of eolian sands; mechanical "v"-form percussion cracks (=arrows-pc), also is evidence of exposure to subaqueous environment. Glacial crushing includes linear (=arrow-1) and conchoidal (=arrow-c) features. B. Surface of quartz sand grain specimen from D-2 strata, Cummins Pond core, northwestern Lake Superior, Ontario, Canada. Features: well-rounded edges and weathered concavities (some of which might be weathered glacial crushing features); charactersitics of eolian environment. C. Quartz-sand grain from D-2 stratum, Cummins Pond core, northwestern Lake Superior, Ontario, Canada. Features include rounded edges, dish-shaped concavities caused by dissolution effects and weathered glacial crushing features (=arrow). For other examples see Julig (1988).

at location 1. Several fragments were ^{14}C dated; however, the charcoal dated to recent times and was clearly intrusive (Table 6). The only ^{14}C date on cultural material clearly from late Paleoindian use of the site is a date of 8,480 ± 390 B.P. on the fragmentary cremation burial (human remains) recovered in 1963 (Table 6).

To establish relative dates for the archaeological components sampled, correlations between stratigraphic sections and the Cummins Pond core were made (Fig. 17) based on stratigraphic position, lithology, pollen stratigraphy, and various sediment analyses.

The water-worn archaeological gravel components were all located below the Minong beach deposits on the middle terrace at locations 1, 4, and 5 (Fig. 17). These buried archaeological gravels can be considered a "time" line and are correlated by their stratigraphic position and their general coarseness, particularly at the west end of the site (locs. 4, 5, Fig. 5; Table 2). This archaeological-geological facies cannot be younger than the approximately 9,500 B.P. Minong level. Whether or not these archaeological remains date to the earlier (about 10,400 to 10,100 B.P.) Minong phase in the Superior Basin (Fig. 3) is not yet known, but is unlikely based on sedimentary, geological, and artifact typological evidence. Smectite (montmorillinite) clay minerals, considered to be of Lake Agassiz Basin origin, are present in Cummins Pond at the 480-cm level and below, dating to about 9,500 B.P. We believe the clay was deposited as part of the massive interbasin flow from Lake Agassiz to Lake Minong at this time (Teller and Thorliefson, 1983; Teller and Mahnic, 1988).

All other archaeological assemblages at locations 1 to 5 are post-Minong (that is, younger than approximately 9,500 B.P.) because they are not water worn. At location 1, the post-Minong cultural stratigraphy includes a stratified sequence with both Archaic and Plano components (Julig, 1988).

Location 2, on the lower Minong terrace, contains a single-component assemblage that probably dates to before approximately 8,000 B.P., based on stratigraphic position and artifact typology. At location 3, on the bog edge, the archaeological assemblage is within sediments containing pollen zones 3b and 2b, estimated to date from approximately 7,500 to 8,000 B.P., based on correlation to the Cummins pond core (Fig. 17).

DISTRIBUTION OF ARCHAEOLOGICAL REMAINS

Factors affecting artifact context

Geomorphic, biological, pedogenic, and cultural processes and agencies were responsible for site formation and affected the context of the artifacts after their deposition. Such natural and cultural postdepositional processes, or "transformation," are designated "n-transforms" and "c-transforms" (Schiffer and Rathje, 1973; Schiffer, 1983). Geoarchaeological investigations are used to establish the contextual environment of archaeological remains. Physical context includes the nature of the surrounding sediments, spatial arrangements within the sedimentary matrix, and subsequent movements and alterations (Stein and Farrand, 1985, p. 2). The major geomorphic and biological processes (n-transforms) at the Cummins site include lacustrine processes, eolian deposition and deflation, frost action, the effect of vegetation (growth and tree throws), and burrowing by small mammals. C-transforms, which include human trampling on artifacts, and the throwing of artifacts and other objects into the bog (loc. 3, Fig. 5), probably also affected artifact and assemblage context. Historic human disturbance is a major c-transform that is easy to recognize.

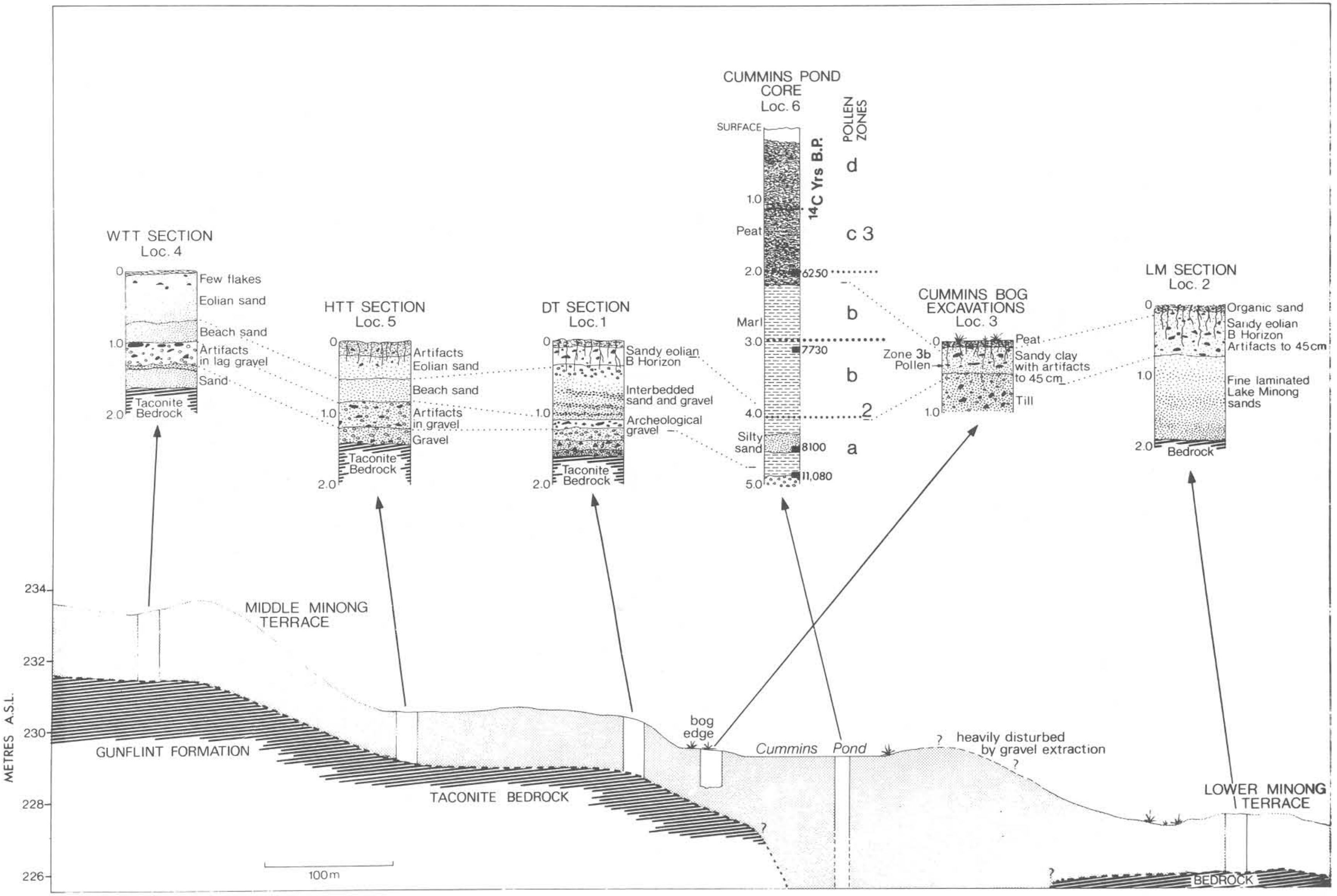
The geomorphic history of the site was described previously. As was discussed above, lacustrine processes were the major factor responsible for site-sediment accumulation, and were also responsible for reworking the initial archaeological assemblages. The lower archaeological-geological facies at locations 1, 4, and 5 were all modified by the formation of Lake Minong beach at the 230- to 235-m level. At location 1 (Fig. 6) and location 5 (Fig. 8) the original lower surface was completely reworked by wave action, and artifacts were battered, polished, and moved. At location 4 (Fig. 7) the lower artifact assemblage was partly modified by wave action, and the artifacts range from essentially undamaged to battered (Julig, 1988).

Large-magnitude discharge events from Lake Agassiz into Lake Minong occurred at approximately 9,600 B.P. The initial overflows past the Nipigon ice dams were of very large scale, probably catastrophic (Teller and Thorliefson, 1983, p. 261). Such events produced small-amplitude transgressions in the Superior Basin (Farrand and Drexler, 1985; Teller, 1985), and may be partly responsible for the coarse and poorly sorted archaeological-geological facies within the lower beach deposits. There are similar transgressions reported in the Minong sequences of valley deltas along the north shore of Lake Superior east of Thunder Bay (C. Kristjansson, personal communication, 1986), with large-scale storm events suggested as possible causes.

Wind affected parts of the site as water levels declined after about 9,500 B.P., particularly the upper soil profile at locations 2, 4, and 5 (Fig. 5), where some artifacts were lightly polished during brief surface exposure.

Vegetation (or floralturbation) is one of the major n-transforms at Cummins, particularly at location 1 (main Minong Beach), which has a southwest exposure. Tree growth and tree throws disturbed the artifact context to a depth of about 50 cm in some excavation units, with the homogenization similar to what was reported at the Debert Paleoindian site in Nova Scotia (MacDonald, 1968). The predominant vegetation on the sandy beaches is jackpine and poplar, with fairly shallow root systems. The periodic wind throws interrupted and folded soil horizons and certain cultural features, although Wood and Johnson (1978) reported jackpine to be more windfirm than other species.

Tree throws are considered less of a factor at location 2 (lower Minong Beach), but the archaeological remains in this location are consistently homogenized (mixed) to a depth of about 45 cm. Here, as at location 1, natural factors causing soil homogenization


WTT SECTION
Loc. 4
0
Few flakes
Eolian sand
Beach sand
1.0
Artifacts in lag gravel
Sand
Taconite Bedrock
2.0
HTT SECTION
Loc. 5
0
Artifacts
Eolian sand
Beach sand
1.0
Artifacts in gravel
Gravel
Taconite Bedrock
2.0
DT SECTION
Loc. 1
0
Sandy eolian B Horizon
Interbedded sand and gravel
1.0
Archeological gravel
Taconite Bedrock
2.0
CUMMINS POND CORE
Loc. 6
SURFACE
POLLEN ZONES
14C Yrs B.P.
d
1.0
Peat
c 3
2.0
6250
b
Marl
3.0
7730
b
4.0
2
Silty sand
8100
a
11,080
5.0
CUMMINS BOG EXCAVATIONS
Loc. 3
0
Peat
Zone 3b Pollen
Sandy clay with artifacts to 45 cm
Till
1.0
LM SECTION
Loc. 2
0
Organic sand
Sandy eolian B Horizon
Artifacts to 45cm
1.0
Fine laminated Lake Minong sands
2.0
Bedrock
234
232
230
228
226
METRES A.S.L.
MIDDLE MINONG TERRACE
GUNFLINT FORMATION
TACONITE BEDROCK
bog edge
Cummins Pond
? heavily disturbed by gravel extraction ?
?
LOWER MINONG TERRACE
?
BEDROCK
100m

also include rodent activity, the action of soil invertebrates such as earthworms, and possibly human trampling. The fine, sandy soil here is less susceptible to freeze-thaw activity than at location 3.

Various small and medium burrowing mammals are present on the site, including woodchucks and beavers (in the pond), and smaller species such as chipmunks, moles, and voles. Krotovina, or filled-in rodent burrows of various sizes, were observed to depths of more than 50 cm. Rodents can cause soil homogenization or mixing (Wood and Johnson, 1978, p. 317–328), and the size of particles may affect the degree and direction of displacement (Bocek, 1986, p. 589). In fact, activities of burrowing rodents and insectivores on archaeological deposits can lead to movement of smaller particles (<25 mm) nearer to the surface and to clustering (or horizonation) of larger particles (>25 mm) slightly below the rodent zone (Bocek, 1986, p. 592). Soil invertebrates such as earthworms can cause both soil homogenization and "horizonization" (Stein, 1983).

The effect of humans trampling artifacts in sand generally results in the smaller objects migrating downward (Gifford and Behrensmeyer, 1977). Stockton (1973) notes that human trampling causes sorting of the material according to size, with the larger particles occurring near the surface and small objects pushed down about 10 cm.

Frost action is considered a potentially important n-transform at the edge of the Cummins Bog (Loc. 3; Fig. 5), because of the clayey soil and high water table. Many taconite blocks and cores were recovered from below the surface peat in primarily alluvial deposit. The concentration of larger taconite blocks in the upper part of the soil profile is attributed to frost heave, which moves larger clasts toward the surface (Bowers and others, 1983, p. 562). The action of needle ice is a similar frost phenomenon that occurs in loamy soils, most commonly in subarctic regions (Washburn, 1979, p. 92). The effect of frost heave and needle ice can also move artifacts horizontally more than 4 cm/year (Bowers and others, 1983). (Cummins was visited for brief fieldwork in November 1984, after a very hard frost [-20°C] with no snow cover. Needle ice was noted in the bog at location 3, but it was not observed on the upland sandy beach ridges, at locations 1 and 2).

Vertical distribution and displacement patterns of lithic debitage

As part of the initial sorting and cataloging, lithic debitage was separated into various size grades based on their longest dimension (compare Anderson, 1980, p. 202). The size grades of lithic debitage used are: (1) <10 mm, (2) 11 to 20 mm, (3) 21 to 30 mm, (4) 31 to 40 mm, (5) 41 to 50 mm, and (6) >50 mm. To test for size segregation (horizonation), the vertical distribution of the smaller material [<21 mm; size-grades (1) and (2)] is compared with that of the larger [>30 mm; size-grades (4), (5), (6)]. Arbitrary 5-cm levels were used in the excavations. A selection of excavation units with adequate quantities of the various debitage sizes for locations 1, 2, and 3 are considered below (see Julig, 1988).

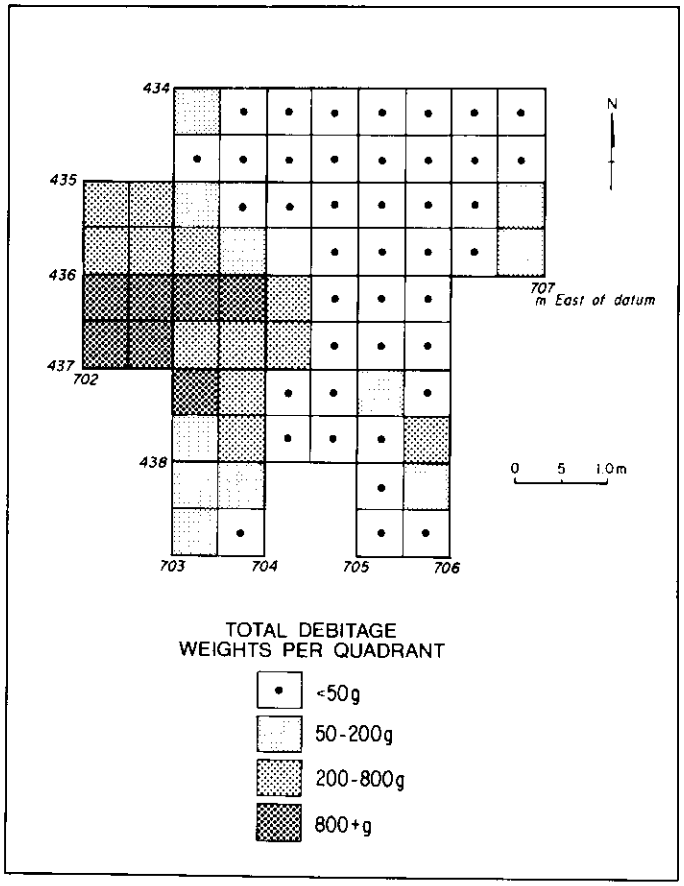


Figure 18. Lithic debitage distribution at Cummins site, location 2, lower Minong beach, northwestern Lake Superior, Ontario, Canada.

Location 2: Debitage distribution. A modest 18 m^2 was excavated at location 2 (Figs. 5 and 18) on the lower Minong terrace. The horizontal and vertical distribution patterns of the artifacts are evidence that this is a single-component assemblage (single occupation). Based on the excavations and adjacent test pitting, the excavated portion (Fig. 18) probably resulted in a recovery of one-third to one-half of the lithic artifacts at this location. Debitage was recovered from near the surface to about 45 cm depth in a fine sandy matrix (Fig. 9). There was little evidence of tree-throws, but abundant evidence of small-mammal activity. Earthworms were present, and several anthills were noted on other parts of the terrace, but soil invertebrate activity did not appear to be a major factor in soil disturbance. On several occasions our partly excavated units were resurfaced overnight by small burrowing mammals, probably moles. A fragment of a Coca Cola bottle was found at a depth of 20 cm, and concentrations of small debitage were occasionally excavated from the bottoms of krotovina features at depths of 35 to 45 cm.

The vertical distribution plots of all debitage from three excavation units are shown on Figure 19 (A, D, and G). These

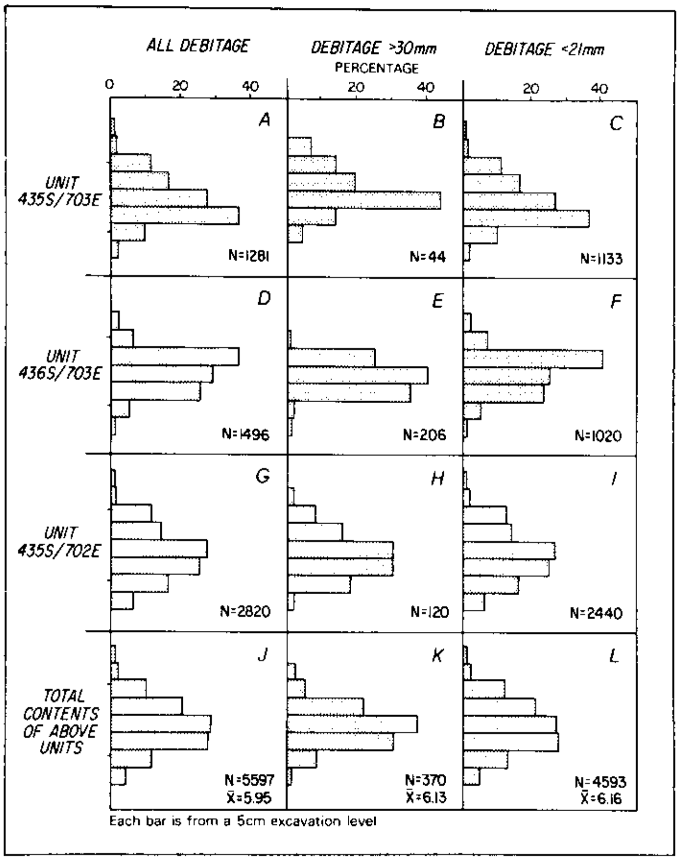


Figure 19. Frequency distribution of lithic debitage by excavation level for Cummins site, location 2, northwestern Lake Superior, Ontario, Canada.

excavation units contained abundant lithic debitage (N = 5597). The vertical distribution frequency plots are all unimodal, with some being slightly skewed (Fig. 19A, D). When the samples from the three units are combined, a nearly normal frequency distribution results, with over 50 percent of the debitage from excavation levels 6 and 7 (Fig. 19J).

To investigate whether size segregation (horizonation) of debitage was present, the large-fraction (>30 mm) distribution was compared with that of the small fraction (<21 mm). As was discussed previously, factors such as burrowing rodents and human trampling can result in material of specific size being concentrated at certain depths. Burrowing rodents cause mixing of soil contents and movement of smaller particles toward the surface. Thus, human trampling and rodent activity may move the small debitage in opposite directions, while intense rodent activity may result in a horizon of the large material at some distance below the surface (Bocek, 1986).

For the larger size fraction (>30 mm), there is evidence for slight horizonation in some units (Fig. 19B) and mixing in others (Fig. 19H). In the combined vertical distribution plot of the three units, the >30 mm fraction is only slightly skewed (Fig. 19K); hence, there is little indication of any horizonation.

For the smaller grade-sizes (<21 mm), the three plots are variable, with both skewed (Fig. 19C, F) and normal distributions (Fig. 19I). The combined plot for the three units (<21 mm samples) has a near-normal distribution, with only a slight skew away from the surface (Fig. 19L).

Although the vertical distribution patterns of the large and small debitage sizes (Fig. 19K, L) are slightly skewed, they have nearly identical mean values (X = 6.16 versus 6.13). There is no significant horizonization of large- or small-sized material. The lithic assemblage is homogenized or mixed, with the smaller artifacts moved vertically more than the larger size grades due to small-mammal burrowing. For the larger fraction (>30 mm), 87 percent of the sample was recovered in excavation levels 5, 6, and 7, between about 21 and 35 cm.

Therefore, at location 2 on the lower Minong Beach, the effects of small-mammal burrowing, tree growth, and possibly other factors such as human trampling resulted in soil-particle and assemblage mixing. Debitage size apparently affected the degree of movement, but not the direction; the small material was moved both upward and downward in the soil profile to a greater extent than the larger material. Our findings generally agree with Wood and Johnson (1978) and Erlandson (1984) for soil-content mixing by rodents, and partly agree with Bocek (1986) for the effect of particle size on the degree of displacement. The results at Cummins location 2 are not evidence of selective displacement of particular size grades of material (that is, horizonation) in site-formation processes, as reported by Bocek (1986).

Location 1: Debitage distribution. The middle (230 to 235 m) beach terraces at the Cummins site were used heavily by prehistoric groups; multiple overlapping (stratified) and partly mixed lithic scatters are present in the soil profile. Discrete cultural stratigraphy is present in some excavation units, but in most the cultural stratigraphy is somewhat mixed (Julig, 1988).

The spatial distribution of lithic debitage varies considerably in the area excavated at location 1 (Fig. 20) where two main lithic concentrations (designated LC-1 and LC-2) were found. Cultural stratigraphy was present in parts of both LC-1 and LC-2 (Fig. 21). A sample of three excavation units (squares) from each was examined in regard to stratigraphy, assemblage homogenization, and distribution of the large and small debitage size fractions. The few deeply buried water-reworked artifacts from the lower gravels at location 1 were not included in our analysis.

The vertical distributions for three units at the north end of the block excavation (LC-1) are shown in Figure 21A, D, G. The three distribution plots are all bimodal, evidence of at least two occupations (or occupational periods). In unit 54S/259E (Fig. 21A) there is clear cultural stratigraphy, with a little upward movement of the small debitage fraction (Fig. 21C). For unit 55S/260E, there is also slight homogenization of the <21-mm debitage fraction (Fig. 21F), in comparison with the >30-mm fraction (Fig. 21E). For unit 55S/261E a large percentage of the <21-mm debitage is near the surface (Fig. 21I); however, this pattern is not attributed to postdepositional factors, but rather to a greater initial percentage of large flake debitage in the lower

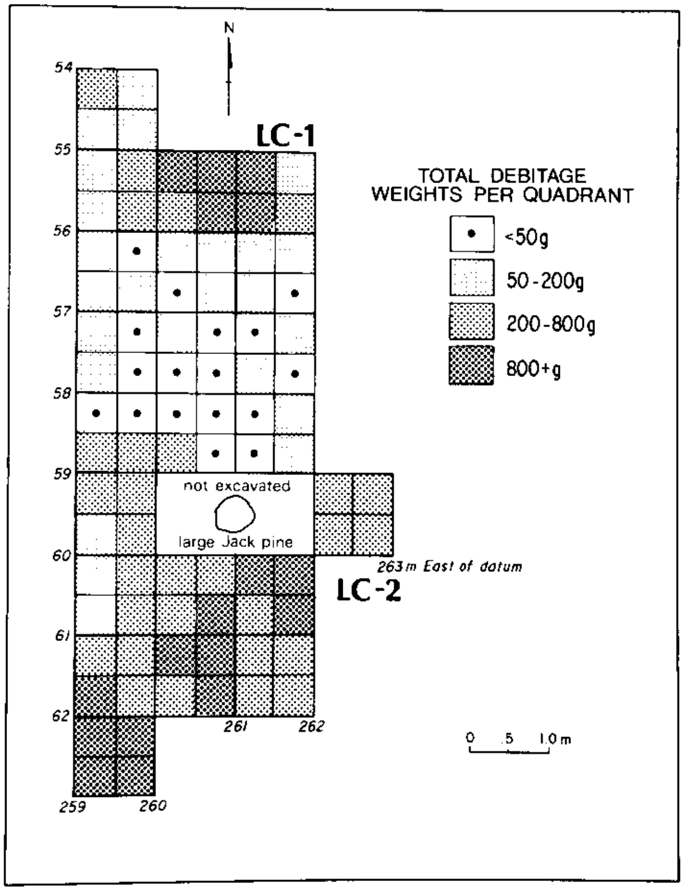
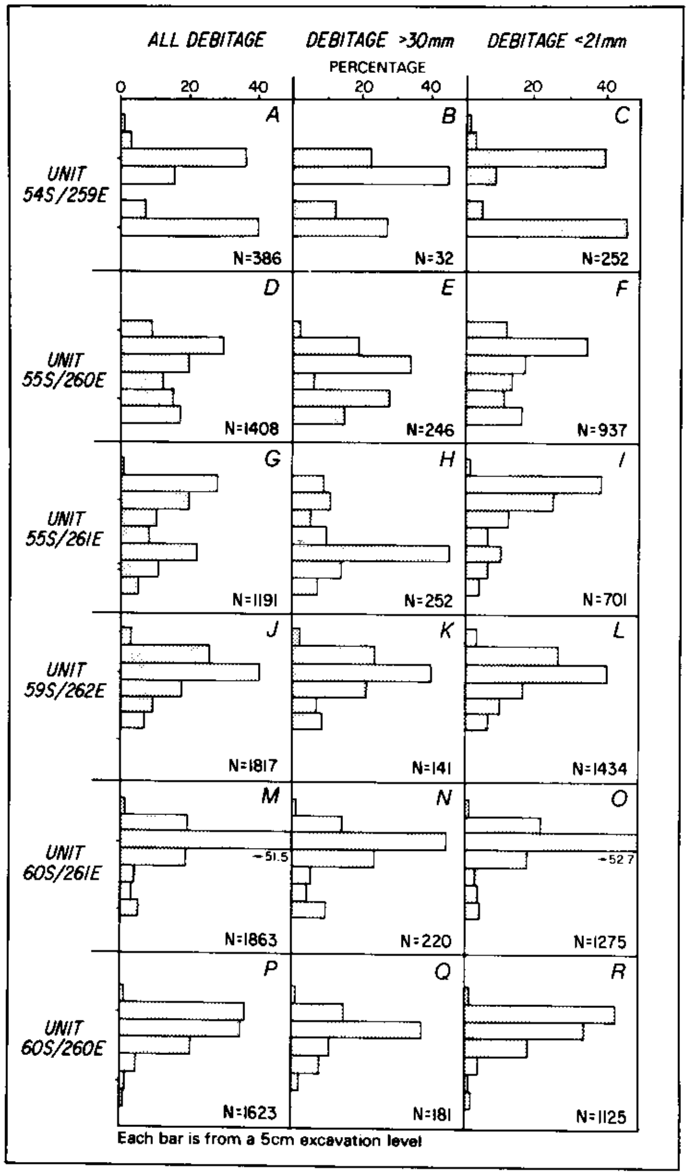


Figure 20. Lithic debitage distribution at Cummins site, location 1, main Minong beach, northwestern Lake Superior, Ontario, Canada. LC-1 and LC-2 are the two main lithic concentrations.



Each bar is from a 5cm excavation level

Figure 21. Frequency distribution of lithic debitage by excavation level for Cummins site, location 1, northwestern Lake Superior, Ontario, Canada.

(Paleoindian) component and smaller debitage in the upper (Archaic) component (Julig, 1988).

At the south end of the block excavations (LC-2), considerable variability was evident in vertical debitage distribution (Fig. 21J, M, P). The vertical distribution plots vary from homogenized (Fig. 21J) to an approximately 15-cm horizon (Fig. 21M, P). In our excavation of the west one-half of unit 60S/260E, we found clearly separated cultural stratigraphy; however, this is not reflected in the total unit distribution data (Fig. 21P).

In spite of the variable vertical debitage distribution at location 1, certain generalizations can be made: (1) distinct cultural stratigraphy is present in the post-Minong soil within small areas, and this permitted clear samples of Paleoindian and Archaic debitage for the detailed lithic studies (Julig, 1988); and (2) although tree-throws (buried, folded, and contorted soil horizons) are more common at location 1 than 2, there are some units that are not heavily disturbed. Also, soil contents were less affected by rodents and insectivores at location 1 than at location 2, possibly as a result of the relative coarseness of the matrix. The soil matrix at location 1 has many more pebbles (Table 2, DT section), with a shingle gravel layer at about 0.5 m depth. This probably discouraged certain burrowing rodents and insectivores, as they are reported to avoid larger soil objects (Bocek, 1986, p. 591).

Location 3: Artifact vertical distribution. The vertical distribution pattern of artifacts at location 3 (Fig. 5) on the edge of Cummins Bog differs from the other beach ridge locations, mainly due to frost action. There is a horizon of larger taconite blocks and cores at 20 to 25 cm within a clay loam matrix (Fig. 10).

Frost action is most pronounced in moist clay soils and wetlands with high water tables (Wood and Johnson, 1978). Artifacts of larger dimensions move upward to a greater extent than those of small dimensions due to frost heave, as ice tends to form beneath stone artifacts and force them upward when it expands.

To determine if selective horizonation of the larger artifacts had occurred due to frost action at location 3, vertical frequency distributions were plotted for various classes of lithic artifacts (Fig. 22). The vertical plot for all debitage (Fig. 22A) approximates a normal distribution, with most of the recoveries between 25 and 40 cm depth. The plots for the lithic tools (Fig. 22B) and the larger debitage size (Fig. 22C) have similar modes at excavation level 6. This contrasts with the smaller debitage size grade (<21 mm), which is skewed downward toward levels 7 and 8 (Fig. 22D). The largest particles, the taconite cores, are highest in the profile, with over 40 percent in excavation level 5 (Fig. 22E). Therefore, apparently frost action concentrated a horizon of larger artifacts nearer the surface at Location 3.

SUMMARY

Prior to our investigations, the Cummins site was recognized as an important Great Lakes site of Plano cultural affiliation, but was reported to be nonstratified and was not well dated (Dawson, 1983). The contemporaneity of the Cummins site and other Lakehead Complex sites with Lake Minong had long been in question (MacNeish, 1952; Lee, 1971; Fox, 1975, 1980; Steinbring, 1976; Dawson, 1983; Phillips, 1982).

Now, however, based on our field investigations, we know that the Cummins site has stratified cultural sequences, including a water-reworked geological-archaeological lag gravel, likely related to rapid water rise due to Lake Agassiz influx. This geologic horizon, which is a time-stratigraphic line, is evident in all deep testings on the main Minong beach at Cummins, and is evidence (1) of human occupation, and (2) that taconite lithic reduction was carried out on the site at approximately 9,500 B.P., or possibly slightly earlier.

Complex depositional processes in differing environments resulted in sediment accumulation and site formation at the various Cummins sections described. Differences in clay mineral spectra were found in the site and bog-core sediments. We attribute smectite in the basal sections of the bog edge and core to inflow from the glacial Lake Agassiz Basin.

A fine- to very fine-grained sandy stratum in the near basal portions of Cummins Pond core was investigated for origin and environment of deposition by SEM analysis of quartz sand grains. The sands were predominantly eolian, resulting from nearshore dune activity as water levels receded in post Minong times.

The local postglacial environmental history was determined from dated pollen cores from Oliver and Cummins Ponds. The pollen zones from the two dated cores are in close agreement; however, zone 1 pollen is only present at Oliver Pond (compare Figs. 14A and B). Dates near the bases of both cores are older than 11,000 B.P., but the early dates from Cummins Pond and Oliver Pond basal organics are probably too old due to contamination by "old carbonate carbon." An upland fossil conifer twig from near the base of the Cummins core was accelerator dated to Lake Minong time (approximately 9,300 B.P.). The twig was probably deposited somewhat after the main Minong beach was formed and organic sedimentation had begun in Cummins Pond.

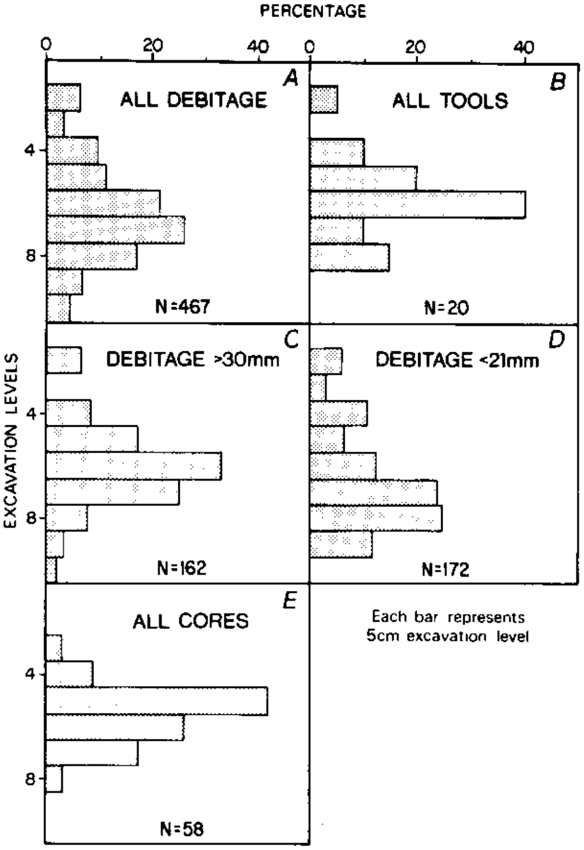


Figure 22. Frequency distribution of lithic debitage by excavation level for location 3, Cummins site bog, northwestern Lake Superior, Ontario, Canada.

Whether the Marquette advance covered all of the upland area west of Thunder Bay (to the Marks Moraine) at approximately 10,000 B.P. is unclear. The topography in the area of Proterozoic bedrock is different from elsewhere on the granitic Canadian Shield of northwestern Ontario, with typically greater relief, occasionally exceeding 300 m. The late-glacial ice was perhaps thin and restricted to the topographic lows (C. Kristjanssen, personal communication, 1986). We propose to test this in the future by coring lakes at the top of the "norwester" mesas near Thunder Bay, to determine time of initial organic sedimentation.

Site formation and postdepositional disturbance processes at the Cummins site were investigated by examining vertical distributions of debitage of differing size grades. The location 3 (bog) assemblage is mixed mainly by frost heave, which moved the larger-sized artifacts and noncultural taconite blocks upward relative to the smaller artifacts and cultural features. At location 2, a fine-grained, sandy, lower Minong terrace, there was significant mixing of lithic artifacts and soil contents due to various natural agents. Tree growth, uprooting, and small burrowing mammals, particularly moles, significantly mixed soil contents. At location 1, on the main Minong terrace, similar mixing by tree growth and tree throws was apparent; however, due to a coarse gravel matrix, the effects of small burrowing mammals was less than on the fine, sandy lower Minong terrace, resulting in an intact cultural stratigraphy in some squares.

In attempting to date upland archaeological components, wood charcoal recovered from possible hearth features yielded unacceptably recent ^{14}C dates, and is regarded as intrusive. The bog-edge artifact concentration was correlated with pollen (zone 3b) of the dated core from Cummins Pond. Thus, in regard to dating we conclude that: (1) a minimum geological age for the lowest artifact horizon (water reworked) is approximately 9,500 B.P.; (2) based on a pollen date, bog-edge occupation occurred at approximately 8,000 yr BP, and (3) there is a stratified post-Minong Plano to Archaic section at location 1 (Julig, 1988).

Geoarchaeological studies of sediments in the field and laboratory are essential in archaeological investigations to fully understand the contextual environment of the cultural remains and to integrate paleoecological data. Such studies must be well integrated in all stages of investigation including research design, field investigations, laboratory analyses, and reporting of results. Contextual considerations of artifact assemblages may become more complex and difficult to interpret when variable depositional environments and considerable time depth is involved. A geoarchaeological focus is important in Paleoindian field research, as studies of artifact assemblages and distributional patterns without due consideration of the surrounding matrix and long-term postdepositional effects result in only a partial understanding of the cultural and ecological record.

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