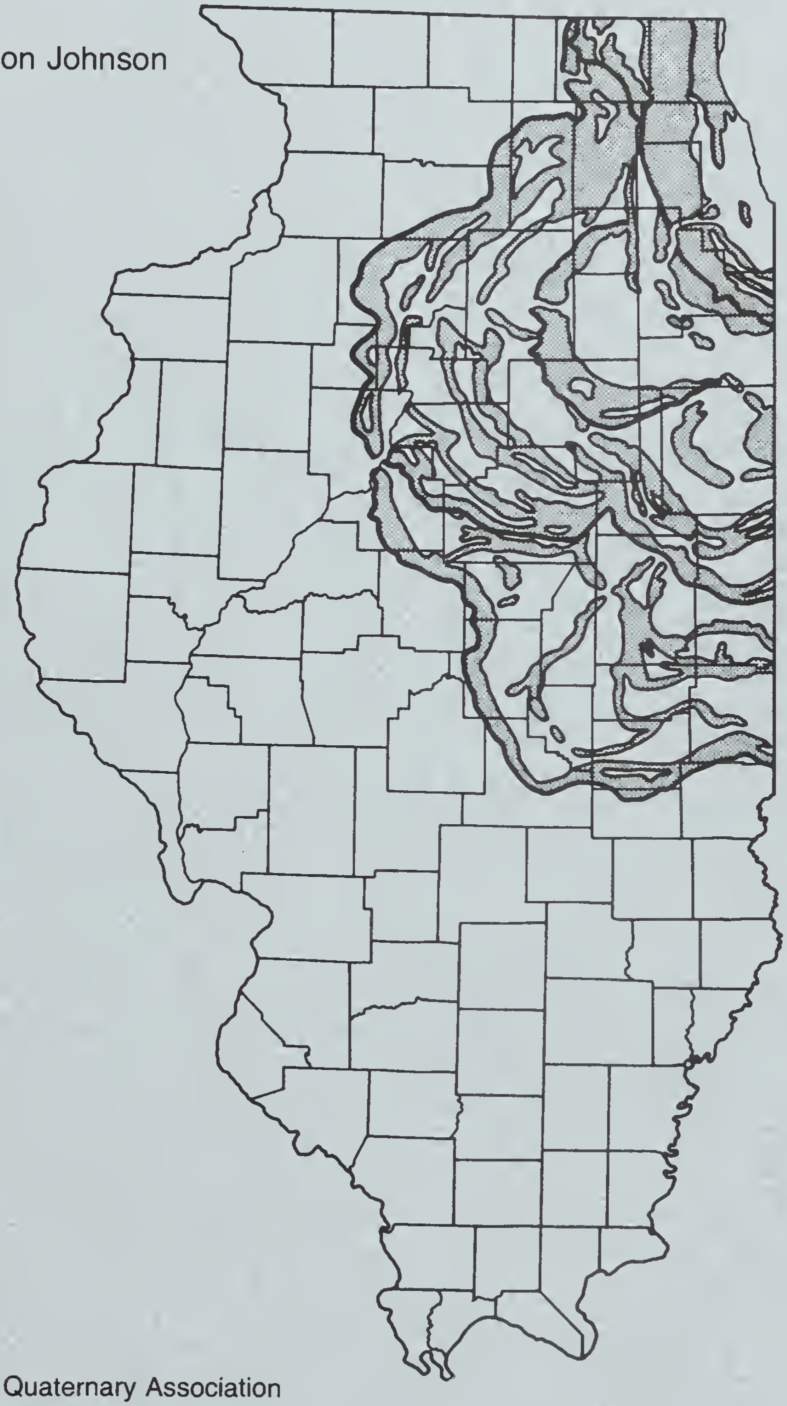
Quaternary records of northeastern Illinois and northwestern Indiana



Ardith K. Hansel and W. Hilton Johnson

with contributions by
Kenneth L. Cole
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Peter Clark
Robert Gergen
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Ninth Biennial Meeting, American Quaternary Association
University of Illinois at Urbana-Champaign, May 31-June 6, 1986

Sponsored by the Illinois State Geological and Water Surveys, the Illinois State Museum, and the University of Illinois Departments of Geology, Geography, and Anthropology.

Quaternary records of northeastern Illinois and northwestern Indiana

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The guidebook was prepared for the Ninth Biennial Meeting of the American Quaternary Association held in Urbana-Champaign, Illinois, May 31-June 6, 1986. Our purpose in compiling this guidebook was to provide the newest information and interpretations and to stimulate discussion. The guidebook was reviewed internally, but not by outside reviewers; the articles reflect the thinking of the individual authors at the time of preparation of the guidebook, not necessarily the current opinions or positions of the Illinois State Geological Survey.

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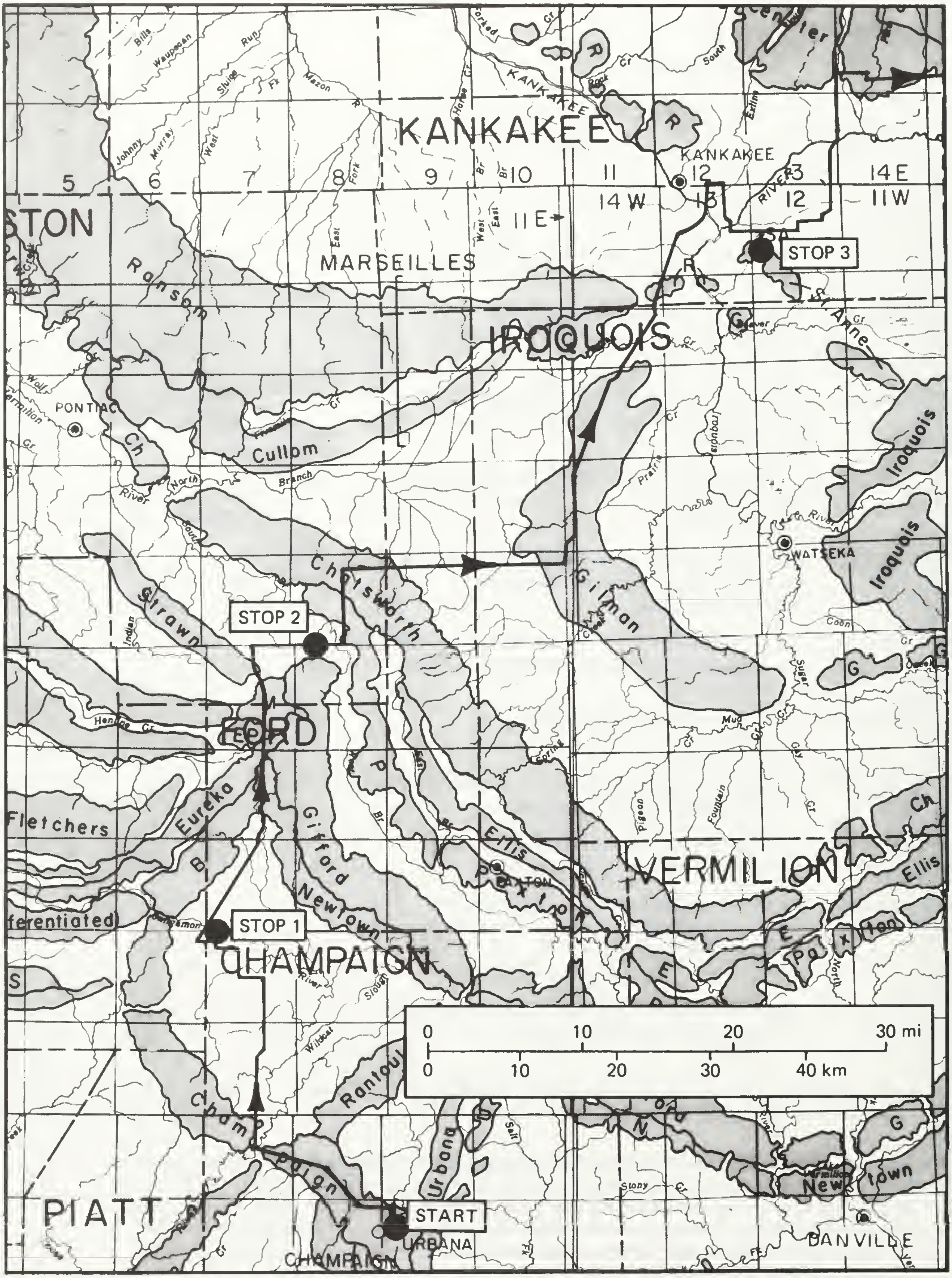

Figure I-1. Location map (Stops 1-3) showing Woodfordian end moraines. From Willman and Frye (1970).

FIELD TRIP STOPS: AN OVERVIEW

This AMQUA fieldtrip focuses on the Quaternary record of northeastern Illinois and northwestern Indiana. We will examine and discuss late Wisconsinan and Holocene sediments at 12 sites (figs. I-1, I-2), visiting seven stops on Thursday and five on Friday. On Thursday, we will make three stops in Illinois and four in Indiana. At Stop 1, we will examine late Wisconsinan ice-wedge casts exposed in a cutbank of the Sangamon River and an historic horse burial site immediately above one of the ice-wedge casts. At Stop 2 our discussion will focus on the late Wisconsinan and Holocene pollen record at the Chatsworth Bog.

Stop 3 will feature a Late Woodland archaeological site associated with a large kettle adjacent to Mt. Langham, a prominent kame on the Woodfordian drift plain.

Stop 4 is a discussion stop in the Kankakee Valley; the topics will be the late Wisconsinan drainage history of the meltwater discharging from the Lake Michigan, Saginaw, and combined Huron-Erie Lobes.

Stops 5, 6, and 7 will be in the Indiana Dunes area, where we will look at the late glacial and Holocene lake and dune record at the south end of the Lake Michigan basin.

Friday will be spent in Illinois. The first two stops will be in the Chicago outlet.

At Stop 8, we will view the outlet channel from an overlook and discuss Lake Michigan basin lake chronology and the role of the Chicago outlet in lake history.

Stop 9 focuses on the late Quaternary record of the Chicago outlet area. Two sections will be examined, a bluff section exposing the glacial succession of clayey Wadsworth Till Member over bouldery Lemont drift, and a bottomland site in which postglacial colluvium grades to the bedrock channel floor and is overlapped by organic sediment. The discussion will center on the age and correlation of the Lemont drift and the age of downcutting of the Chicago outlet.

Stop 10 will be a visit to the Avery Quarry along the Du Page River where huge dolomite blocks are embedded in sand and gravel.

At Stop 11, the proglacial-glacial succession of the Haeger Till Member will be examined and its correlation with the Lemont drift of the Chicago area will be discussed.

Stop 12 is an actively eroding Lake Michigan bluff exposure in the Lake Border Morainic System. Sedimentation of the Wadsworth Till Member will be discussed.

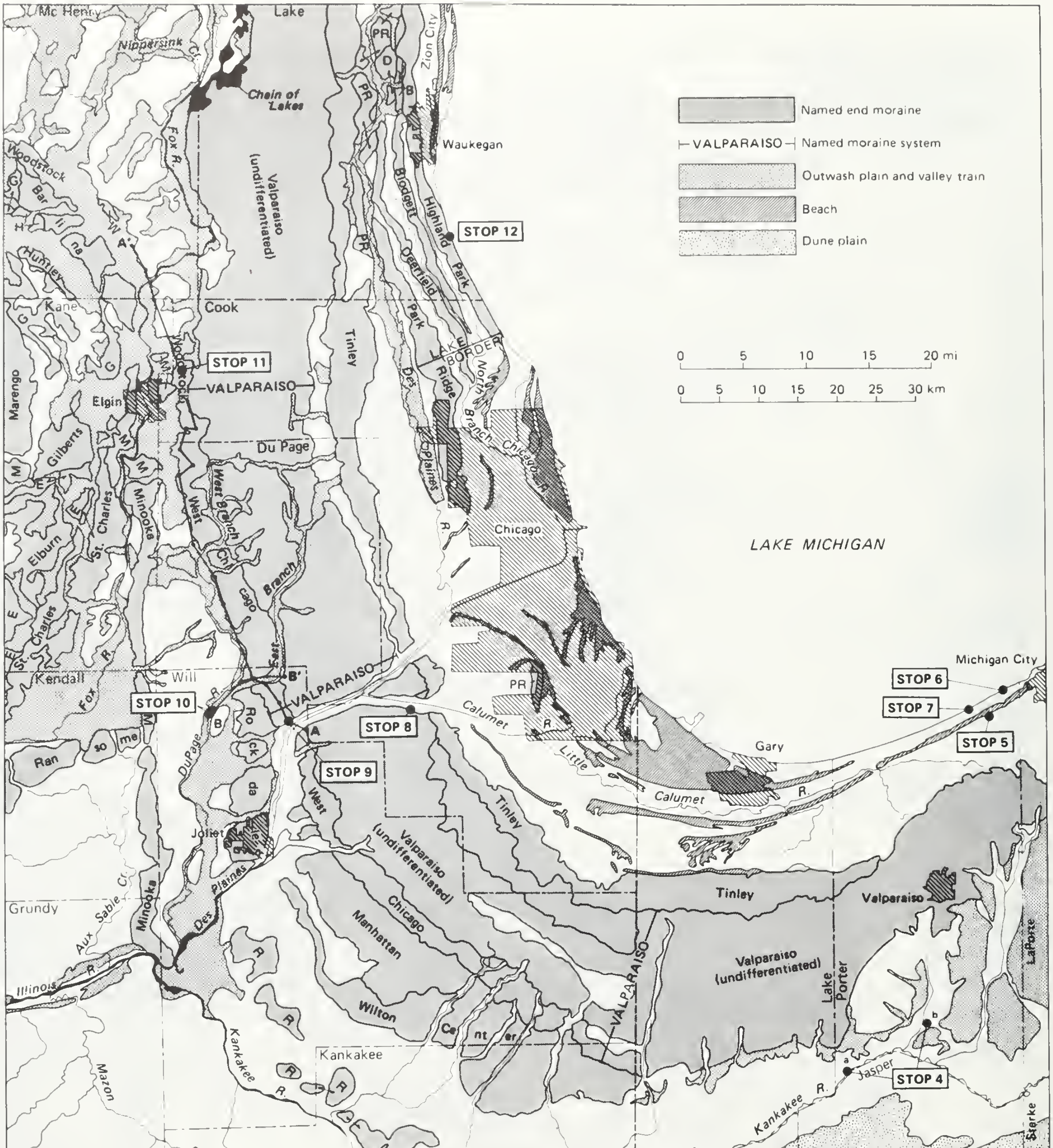

Figure I-2. Landform map of northeastern Illinois and northwestern Indiana (Stops 5-12 located). Lines of cross sections for figures 9-2 and 8-3 are shown. Modified from Willman (1971), Willman and Frye (1970), and Schneider and Keller (1970).

INTRODUCTION

W. Hilton Johnson and Ardith Hansel

During this field trip we will traverse the Woodfordian drift plain from Urbana northward to Chicago over areas covered by the Decatur and Joliet Sublobes of the Lake Michigan Lobe (fig. I-3). Although the Decatur Sublobe commonly has been related to the Erie Lobe (Willman and Frye, 1970), provenance and stratigraphic relationships indicate that the deposits in the sublobe area are related to the Lake Michigan Lobe (Johnson et al., in press; Bleuer et al., 1983).

Late Wisconsinan (Woodfordian) Stratigraphy

In Illinois and Indiana, Woodfordian diamicton (till and sediment flow deposits) deposited by the Lake Michigan Lobe and intercalated gravel, sand, silt, and clay are part of the Wedron Formation (fig. I-4). Comparable early Woodfordian deposits related to the Huron-Erie Lobe are included in the Trafalgar Formation (Wayne, 1963). Only the uppermost unit of the Trafalgar, the Earl Park tongue, occurs in Illinois (fig. I-4); it forms the Iroquois Moraine (Moore, 1981; Bleuer et al., 1983). The Wedron has been subdivided into several till members (Willman and Frye, 1970; Johnson et al., 1971). The Wedron Formation overlies Morton Loess (massive silt), Robein Silt (accretionary, often carbonaceous silt) or older lithostratigraphic units. It is overlain by Richland Loess (massive silt), Henry Formation (gravel, sand, and silt of glaciofluvial origin), or Equality Formation (stratified to massive sand, silt

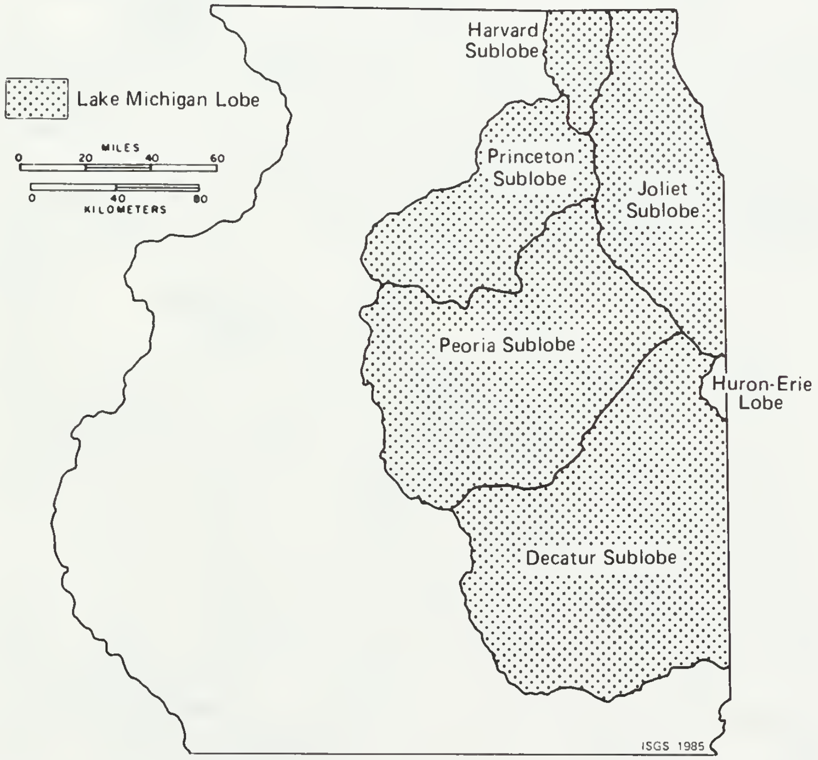

Figure I-3. Woodfordian glacial sublobes in Illinois. Modified from Willman and Frye, 1970.

and clay of glaciolacustrine origin), as well as several other late Pleistocene and Holocene lithostratigraphic units (Willman and Frye, 1970).

The till sequence has a shingled occurrence with till members tending to be thickest near their southernmost extent and locally in end moraines, thinning toward the north, and eventually pinching out in the subsurface beneath younger units. Rarely do more than three till units of the Wedron occur in the same section, and most sections expose only one or two units. The till members are recognized and correlated on the basis of relatively distinct textures and compositions (table I-1), but vertical and lateral variations within units complicate regional correlations.

Glacial History

The history of ice-margin fluctuations is summarized in a time-space diagram (fig. I-5). The diagram differs from earlier interpretations (Frye and Willman, 1973; Johnson, 1976) in that ice-margin retreats during the early Woodfordian (pre-16,000 BP) are reduced significantly. The ice margin may

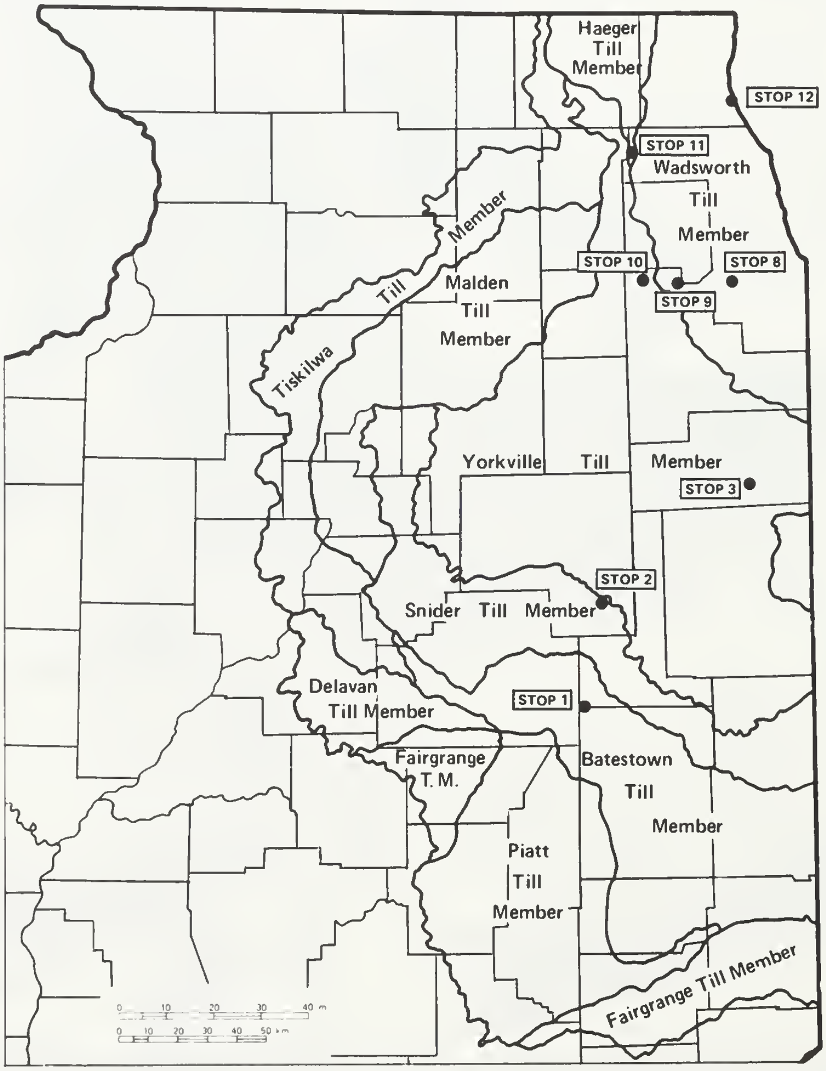

Figure I-4. Areal distribution of Wedron Formation till members and Trafalgar Formation. After Lineback (1979).

Table 1-1. Characteristics of Wedron Formation Till Members in Decatur and Joliet Sublobe Areas.

	Color (unoxidized)	Texture (matrix)	% Illite (unaltered)	Comments
Wadsworth T.M.	dark gray to violet gray	silty clay loam to clay	70-80	Contains abundant black shale fragments; commonly interbedded with lacustrine deposits.
Haeger T.M. Lemont drift	light gray	silt loam to sandy loam	60-75	Contains abundant dolomite; commonly associated with thick proglacial sand and gravel.
Yorkville T.M. Snider T.M.	dark gray	silty clay loam to clay	75-80	Shale and dolomite most common large clasts; commonly interbedded with and overlain by lacustrine deposits.
Batestown T.M.	dark gray	silt loam to loam	75-80	Locally finer textured, equivalent to part of Malden Till in Princeton Sublobe.
Piatt T.M.	gray to violet gray	loam to silt loam	70-75	Intermediate in color and composition between Fairgrange and Batestown units.
Fairgrange T.M.	violet gray to pinkish gray	loam	65-70	Locally basal unit (Oakland facies) is brown, silty and contains less illite; equivalent to Tiskilwa T.M. of northern Illinois.

have retreated farther than shown in some places, but firm evidence of this is lacking. The reinterpretations are the result of restudy of the Wedron Section (Johnson et al., 1985), interpretations of which were the basis for many of Frye and Willman's fluctuations, and of correlation of the Lemont drift with the Haeger Till Member (Johnson et al., 1985, see discussion, Stops 9 and 11). Johnson (1976) had inferred major ice-margin fluctuations based on a suggested correlation of the Lemont with the Malden (Batestown) Till Member (Landon and Kempton, 1971; Bogner, 1973).

Radiocarbon dates and reinterpretation of the stratigraphic sequence in northern Illinois (Berg et al., 1985; Curry and Kempton, 1985) suggest that the state was probably ice-free during the Altonian and Farmdalian (early and middle Wisconsinan). The only drift unit currently considered as possibly being Altonian is the Capron Till Member of the Winnebago Formation (Krumm and Berg, 1985). The Woodfordian ice margin advanced into Illinois about 25,000 BP (Johnson, in press) and reached its southernmost extent about 20,000 BP (Johnson et al., 1971). A sequence of till units was deposited, but radiocarbon datable material, other than that incorporated from pre-Wedron deposits, has not been observed. Timing of deglacial events is tied primarily to two dates (fig. I-5), one on plant debris and the other on peat. Both are from lacustrine deposits above outwash, one from near Urbana in central Illinois and the other from near West Chicago in northern Illinois.

Geomorphology of the Woodfordian Drift Plain

The Woodfordian drift plain in Illinois consists of a series of arcuate end moraines, low-relief ground moraines, lake plains, coastal landforms, outwash plains, valley trains, dune fields, and eolian sand plains (fig. I-1, I-2). The end moraines are most conspicuous, particularly in northern Illinois, but many are subtle (we will point them out as we go).

End moraines in the southern part of the drift plain are rounded and ice-contact slopes are not common. These characteristics are the result of a dominance of subglacial sedimentation, slope modifications by mass wasting

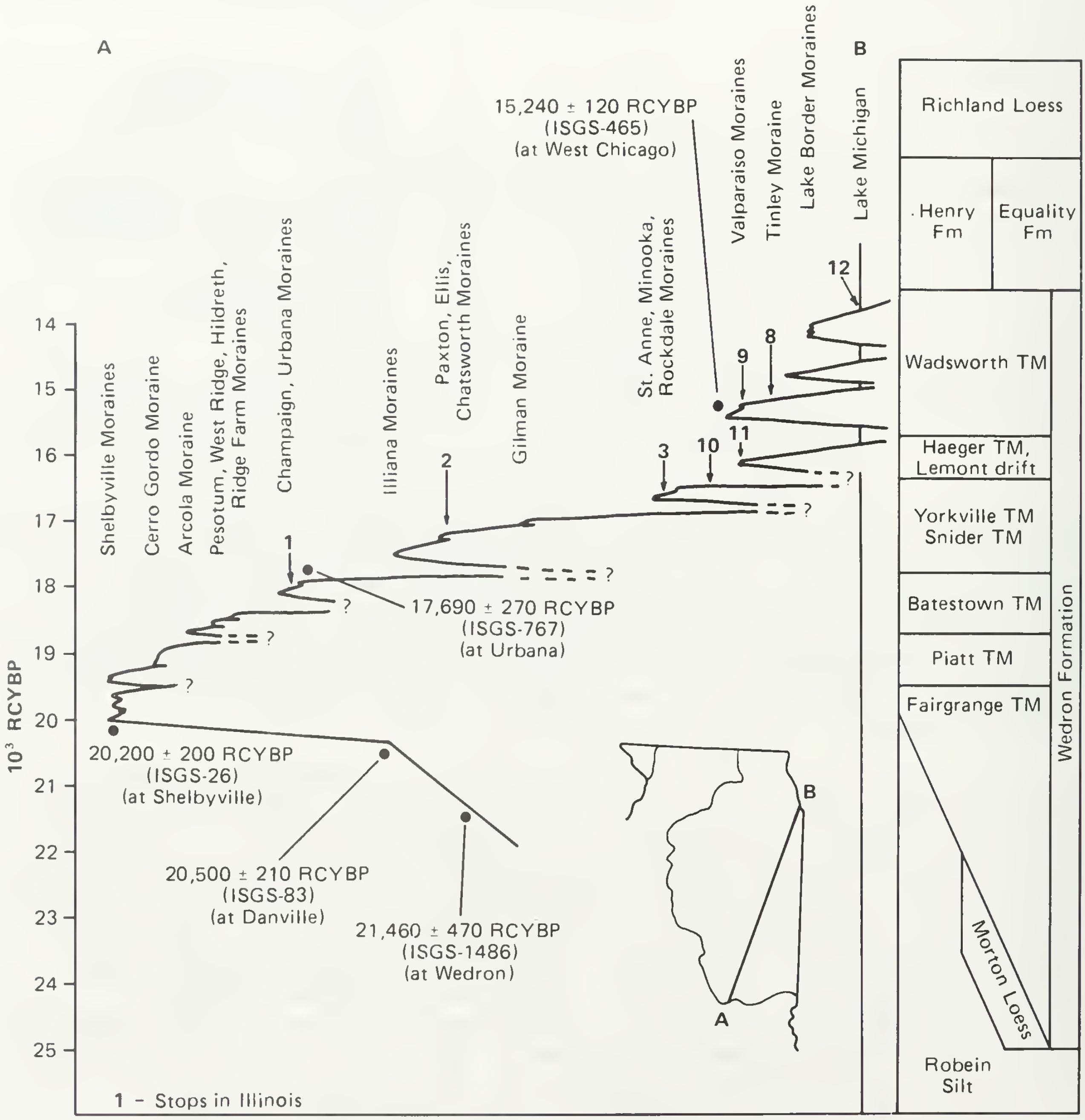

Figure I-5. Time-space diagram illustrating relationships of ice-margin fluctuations of the Decatur and Joliet Sublobes of the Lake Michigan Lobe to selected lithostratigraphic units and radiocarbon dates (date from Wedron is projected into Decatur Sublobe).

processes in the periglacial environment, and masking of relief as a result of local variations in loess thickness. Small-scale disintegration features, such as hummocks, kettles, ice-walled lakes, and kames, locally are common but generally are not conspicuous on the landscape. End moraines in northern Illinois are more prominent, particularly in the Valparaiso Morainic System (fig. I-2). Hummocky topography and kettles characterize these larger moraines. They occur over Silurian dolomite and locally are composed of glacial deposits from two glacial events.

The northern Illinois landscape is dominated not only by end moraines but by features that are the result of meltwater drainage, lake, and eolian events that occurred during deglaciation. The major lake plains are those of glacial Lakes Watseka, Pontiac, Ottawa, Wauponsee, and Chicago. The latter is discussed in the following section; the first four generally have been considered to be flood lakes that formed during the Kankakee Flood (Ekblaw and Athy, 1925; Willman and Frye, 1970). Study of the deposits in the Lake Watseka basin indicates that the lake formed between end moraine dams and a fluctuating ice margin; deposits directly related to the Kankakee flood event could not be identified (Moore, 1981). Similar relationships probably also pertain to Lakes Pontiac, Ottawa, and Wauponsee. The most important morainic dams were the Chatsworth Moraine and the Marseilles Morainic System.

The Kankakee flood has been related to the discharge of meltwaters from the east side of the Lake Michigan Lobe, the Saginaw Lobe, and the north side of the Huron-Erie Lobe when the Lake Michigan Lobe ice-margin was at the position of the Valparaiso Morainic System (Willman and Frye, 1970). The flood event affected the Kankakee Valley in Indiana and Illinois and eventually the Illinois Valley. Current interpretations of the Kankakee Valley and its drainage history are discussed by Nelson (Stop 4). In Illinois, we recognize two glacial events in the formation of the West Chicago Moraine of the Valparaiso Morainic System--the Haeger-Lemont and Wadsworth. Timing of the Kankakee flood event relative to these glacial events currently is under investigation.

Fluvial and beach sands were reworked by the wind; today extensive dune sands blanket portions of the Kankakee Valley and abandoned lake plains. A variety of well-developed dune forms are found on these surfaces. A soil developed in alluvial sediment and buried by eolian sand 10 km east of St. Anne was dated 12,900 ± 120 RCYBP (ISGS-271). Eolian activity probably was most active in the late Woodfordian, but locally, dunes have been active in the Holocene (see discussion, Stop 3).

Lake Michigan Basin History

Whenever the Lake Michigan Lobe wasted back into the Lake Michigan basin, a proglacial lake formed at its margin. This lake, named Lake Chicago by Leverett (1897), was impounded by moraines, first the Valparaiso and later the Tinley, which form a U-shaped belt around the south end of the basin. As the ice-margin retreated the proglacial lake extended northward. Evidence for Lake Chicago includes three abandoned beaches (Glenwood, Calumet, and Toleston) and an abandoned outlet (Chicago outlet) at the south end of the lake basin (fig. I-6) and lacustrine sediment (Equality and Lake Michigan Formation) in the lake basin.

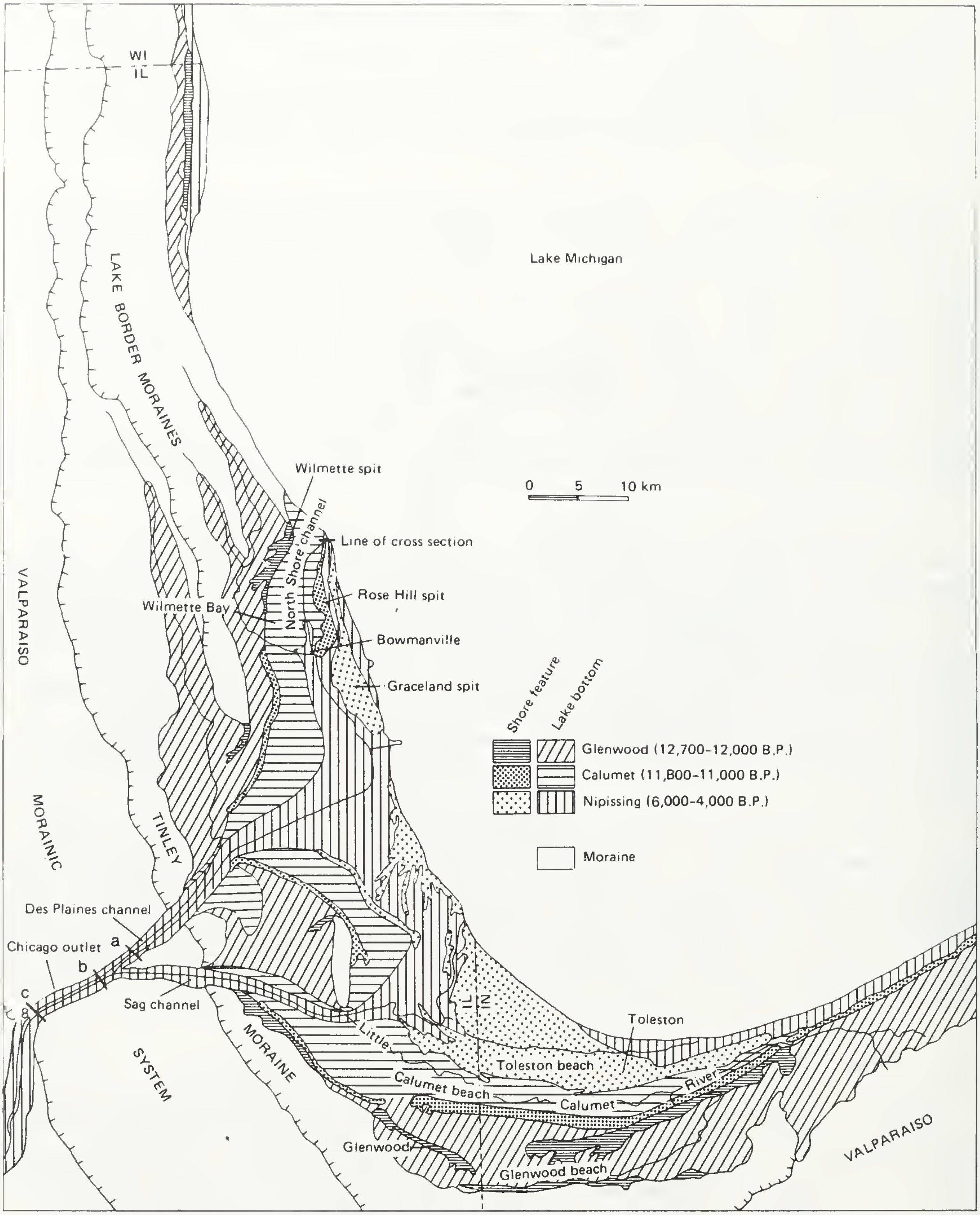

Figure I-6. Type area for Lake Chicago and Glenwood, Calumet, and Toleston beaches. Modified from Alden (1902), Schneider and Keller (1970), and Willman (1971).

Figure I-7 is a time-distance diagram that illustrates the relationship between glacial and lake phases in the Lake Michigan basin from 16,000 years BP to present; it shows the time transgressive nature of the phases relative to the Straits of Mackinac at the north end of the basin and the Chicago outlet at the south end. The radiocarbon age assignments of the lake phases represent estimates based on interpretation of the radiocarbon evidence for events in the Lake Michigan basin area (Stop 8, fig. 8-3).

Three main episodes of lake history are apparent in the Lake Michigan chronology: the Chicago episode, the Fenelon Falls-North Bay episode, and the St. Clair episode (fig. I-8; Hansel and Mickelson, in review). The Chicago episode represents the time during which overflow of proglacial lakes drained through the Chicago outlet. The Fenelon Falls-North Bay episode represents the time during which lake level fell well below the present level because the lakes were draining through the Straits of Mackinac to isostatically-depressed

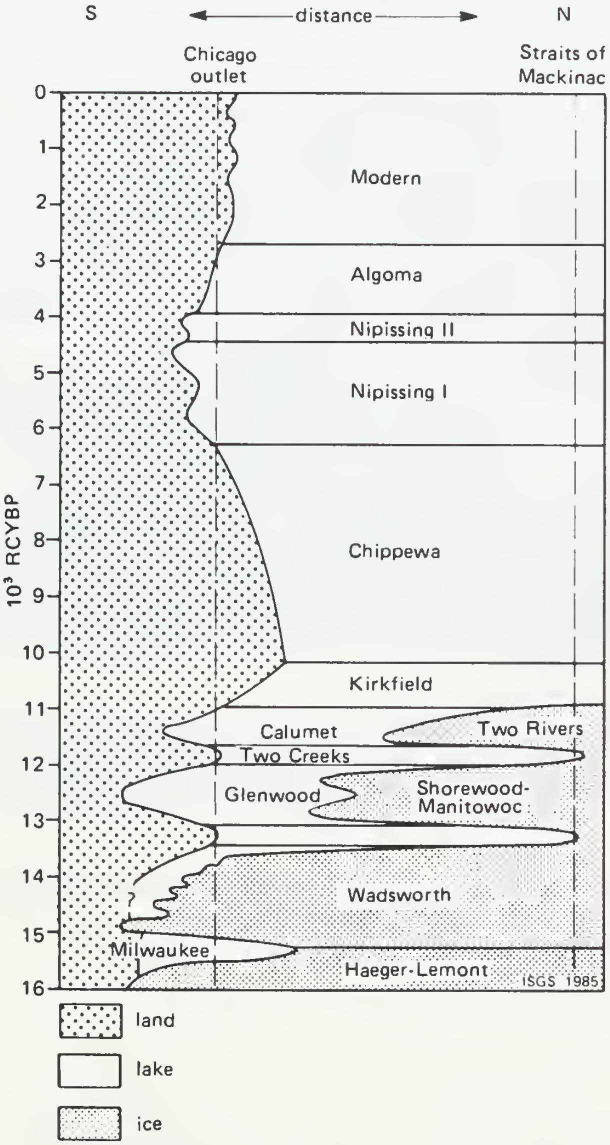

Figure I-7. Time-distance diagram illustrating relationships of glacial and lake phases in the Lake Michigan basin and areal extent of the lake to the Straits of Mackinac (at the north end of the basin) and the Chicago outlet (at the south end).

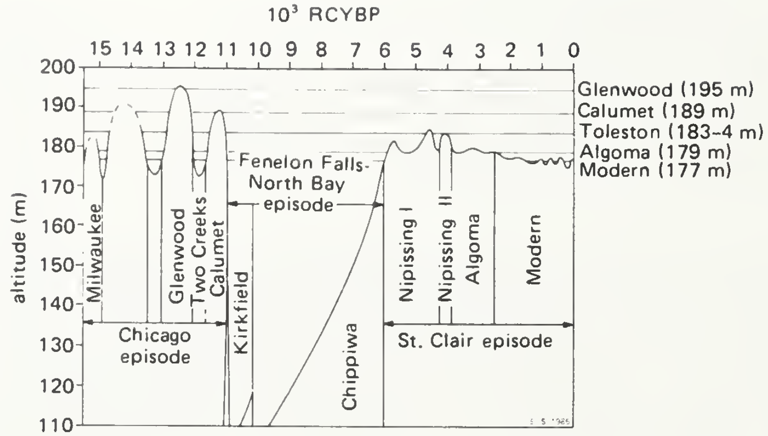

Figure I-8. Lake Michigan lake level chronology, 15,500 BP to present. Lake phases comprise three lake episodes: Chicago, Fenelon Falls-North Bay, and St. Clair.

northern outlets near Fenelon Falls and, later, North Bay. The St. Clair episode represents the time during which drainage was again by way of the southern outlets because differential isostatic rebound had uplifted the northern outlets relative to those at Chicago and Port Huron.

ACKNOWLEDGMENTS

Many individual landowners and quarry and pit operators allowed us access to their property both prior to and during the field trip. We appreciate their cooperation.

Lisa Smith and Brandon Curry assisted us with field work and field trip preparations and arrangements. Brandon Curry and Herbert Glass provided clay mineral data for the Land and Lakes and Beverly sections, respectively. We have benefitted from laboratory and field discussions with them and Leon Follmer. Grain size analyses were made by Rebecca Roper and Bill Westcott under the supervision of Michael Miller.

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We also want to thank our fellow contributors for providing papers for the guidebook and assisting us as field trip leaders.

ANDERSON SITE NEAR FOOSLAND

W. Hilton Johnson

STOP 1. Anderson site near Foosland
NW NW NW, Sec. 5, T22N, R7E, Champaign County, IL

At this stop we will examine and discuss ice-wedge casts exposed in a cutbank of the Sangamon River. The host material is diamicton of the Batestown Till Member, Wedron Formation.

INTRODUCTION

The Anderson site is an actively eroding cutbank of the Sangamon River in extreme northwestern Champaign County. When the exposure was first observed in 1978, three vertical wedge-shaped bodies were exposed. Since then the river has eroded laterally about 2 m and in 1985, four wedges were exposed, two of which were lateral continuations of the original wedges. The site is near areas of patterned ground that are evident on the location aerial photograph on the preceding page.

The wedges are in diamicton of the Batestown Till Member, Wedron Formation, and are overlain by Richland Loess. They are interpreted to be ice-wedge casts, which are the basis for interpreting the development of permafrost in this area following deglaciation and prior to significant loess accumulation (Johnson, 1986). Deglaciation is estimated to have taken place approximately 18,000 BP. Wedges are numbered from 1 (north) to 5 (south) for discussion purposes.

DESCRIPTION AND DATA

The 3-m high cutbank, which is in an upland sediment succession, exposes 1 m of Richland Loess over Batestown Till. The contact between the Richland and Batestown is gradual and locally marked by stones; the lower part of the Richland is sandy and pebbly. Elliott silt loam, an Aquic Argiudoll, has

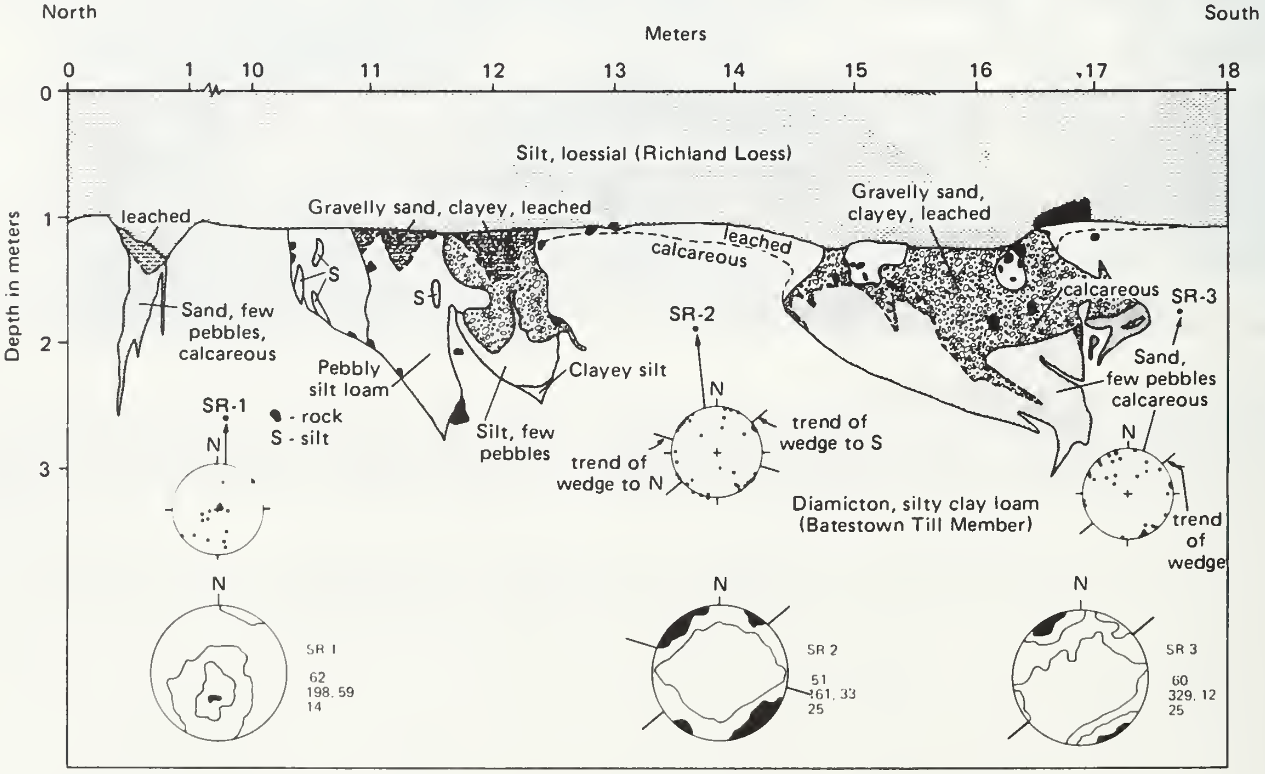

Figure 1-1. Sketch of ice-wedge casts 1, 2, and 3 in 1980. Pebble fabric diagrams based on azimuth and plunge of poles to plane of disk-shaped pebbles. (See fig. 11-1 for explanation of fabric data.)

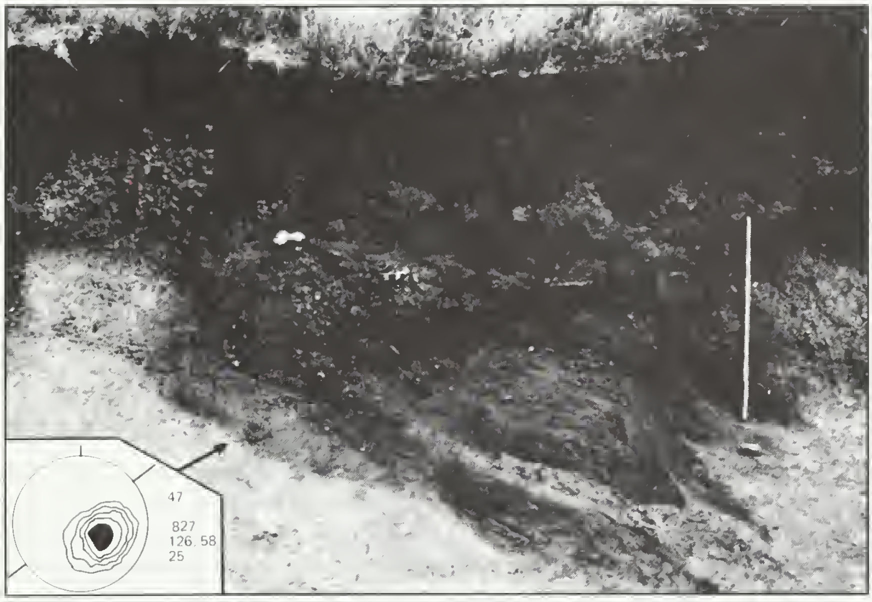

Figure 1-2. Ice-wedge cast 3 and bones of historic horse burial, July 1985. Pebble fabric diagram based on azimuth and plunge of long axis of prolate pebbles. (Fabric data courtesy of A. K. Hansel.)

developed in the sediment succession. The soil is better drained and the loess is thicker than typical Elliott.

Diamicton of the Batestown is a pebbly, silty clay loam (< 2 mm fraction of 4 samples of host diamicton averages 18% sand, 43% silt, and 39% clay) and is finer than diamicton typical of Batestown in east-central Illinois. The clay fraction of the Batestown generally contains 75-80% illite and the remainder mostly is chlorite (table I-1; Johnson et al., 1972). Disk-shaped pebbles in diamicton at the base of the cut and midway between wedges 1 and 2 dip to the northeast (poles to ab plane have a mean plunge of 59° to the southwest, azimuth of 198°. Pebbles of similar shape in diamicton near wedge margins have much steeper dips and orientations subparallel to the trend of wedges (fig. 1-1). Prolate pebbles also have a steep plunge parallel to the wedge margin (fig. 1-2).

Wedges 1, 4, and 5 are small, with maximum widths less than 0.5 m; wedges 3 and 4 are larger (fig. 1-1), but the section cuts both wedges at oblique angles and wedge widths are approximately 0.8 and 1.5 m, respectively. Wedge depths are from 1.5 to 2 m. Several of the wedges have small secondary wedges along the margins of the main wedge. Wedge 2 trends to the southeast and wedge 3 trends to the northeast. In 1980, the two wedges were 2 m apart (fig. 1); in 1983, they were about 1 m apart, and wedge 2 configuation and cast filling was less complex; in 1985, wedge 2 was not evident. Wedge 4, a small wedge 6 m south of wedge 3, and wedge 5 (fig. 1-3) were not exposed prior to 1985.

Except for wedge 2, cast material primarily is sand and gravelly sand with irregular masses of diamicton (fig. 1-1). The upper parts of cast fillings commonly are Beta horizon soil pendants, which are leached and clay-enriched. These upper zones contain more and larger pebbles than the lower cast filling does, and the pebbles locally have a steep to near-vertical orientation (fig. 1-2). Four samples of cast filling from the lower part of wedge 3 average 2% gravel, 83% sand, and 15% silt and clay. All sand fractions contain more than 10%; the medium, fine, and very fine fractions each contain about 20%. Diamicton in the cast filling is similar to the host diamicton except that in some instances it contains more stones.

The cast filling of wedge 2 consists of diamicton similar in texture to host diamicton (two samples average 21% sand, 43% silt, and 36% clay), relatively coarse gravelly sand, and pebbly silt loam (two samples average 9% sand, 63% silt, and 28% clay) or silt. Its boundaries were indistinct except where marked by pebbly silt, gravelly sand, or isolated silt bodies (fig. 1-1). It no longer is evident in the section.

INTERPRETATIONS AND DISCUSSION

The wedges are interpreted to be ice-wedge casts because they have characteristics that support such an origin and because other alternative interpretations have been rejected. An ice-wedge cast origin is supported by: 1) evidence of compression of host materials as indicated by pebble orientations in diamicton adjacent to wedge margins (fig. 1-1); 2) shape and size of wedges with narrow, tapering lower terminations; 3) evidence of filling from above (e.g., gravelly sand over sand in wedge 3 and gravelly sand over pebbly silt loam in wedge 2); 4) evidence of host diamicton flowing and/or slumping into and over cast filling (wedges 2 and 3, fig. 1-1); 5) linear character of wedges and probable polygonal pattern, as suggested by apparent junction of wedges 2 and 3; and 6) small, secondary wedges that suggest occasional cracking off center from the main wedge.

Alternative hypotheses that have been rejected include: 1) crevasse fillings--they would not be preserved as wedges because walls are ice; 2) stream-cut channels--shapes of wedges are not correct; 3) desiccation cracking or other expansion-contraction processes--climatic conditions

Figure 1-3. Ice-wedge cast 5, July 1985.

following deglaciation would not be appropriate; if cracking occurred later during the Holocene, wedge fillings should consist of loessal material, and host material does not contain expanding type of clay minerals; 4) slope-related tension cracks--no major slopes known at time of formation (on upland flat); and wedge orientations not consistent with slope-related stress system; and 5) seasonal frost cracking--cast fillings do not suggest filling along a narrow fracture (e.g., gravelly sand over sand and large masses of diamicton), and most wedges do not have a vertical structure as would seasonal frost wedges.

The following sequence of formative events is suggested. Permafrost developed about 18,000 BP, soon after deglaciation. Ice wedges formed, grew, and decayed prior to significant loess accumulation. Ice-wedge casts formed during decay. The source of the cast filling is not clear, as sand does not occur between diamicton and loess at the site. Some of the sand probably was wind blown (e.g., the less pebbly and better sorted zone in the lower part of wedge 3 and some of the smaller wedges). The coarser sand in the upper parts of wedges 2 and 3 probably was transported into the wedge by water. Diamicton from the host walls and possible rims moved into the wedge via mass wasting processes; most of the cast filling in wedge 2 formed in this fashion.

As the landscape stabilized in the wedge area, loess accumulated and eventually buried the ice-wedge casts. Drainageways formed during deglaciation and eventually the Sangamon River developed as the trunk stream of the drainage basin (observe the abandoned meandering channel south of the site on the location aerial photograph). Solution of carbonates during formation of Beta horizons in the wedges probably contributed to the development of the near-vertical pebble orientation in wedge 3. Subsequent downcutting and valley widening by the Sangamon River exposed the wedges at the Anderson site. During recent floods, the river eroded the cutbank laterally into the side of wedge 5 (fig. 1-3), which has an azimuth approximately parallel to the river at this point. Slope exposure improved soil drainage, hence the better-drained Elliott soil.

The horse burial was first observed in 1985. It is immediately above and centered over wedge 3. A marked depression that exists over the burial (fig. 1-2) was not evident earlier above this wedge (fig. 1-1). The A horizon of the soil in the burial spoil is well developed, but the B horizon is a blend of A and B horizon material. On the basis of the development of the A horizon, the burial probably took place from 50 to 100 years ago. (The land owner does not know the history of the burial.) It seems unlikely that the burial location decision was random and coincidentally occurred over a wedge. There must have been some surface indication, probably a slight depression over the subsurface wedge. The surface depression may have originated during ice wedge formation and been preserved during loess accumulation, or it may have developed as a result of soil pendant formation (solution of carbonates). Compaction of the burial spoil has resulted in the current depression over the wedge (fig. I-2).

TAPHONOMIC OBSERVATIONS ON THE RECENT FOOSLAND HORSE BURIAL

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In June 1985, W. H. Johnson collected a bleached and badly weathered horse (Equus sp.) mandible from the river margins at this locality. At the same location he observed other bones eroding from the bank and invited Illinois State Museum paleontologists (R. W. Graham, J. J. Saunders, and J. S. Oliver) to examine the site. Except for a few bones at the river margin, the horse skeleton was fully articulated, indicating that the entire carcass had been interred. It lay on its left side with its ventral portion exposed in the eroding bank. After the profile was cleaned, it was apparent that the horse was buried in an intrusive pit that terminated at the upper contact of the Batestown Till. The pit is defined by a) an abrupt termination of the B horizon of the modern soil at the sides of the pit above the skeleton, b) mottling of black and tan sediments indicating a mixing of soil horizons, and c) the slight depression of the land surface above the skeleton. Though the exact burial date is unknown, pedogenic development of the A horizon within the outlines of the pit suggests an age of less than 100 years.

Observations of the Foosland horse bone weathering patterns have a number of significant taphonomic implications. Bone weathering refers to mechanical and chemical degradation of bone that occurs mainly in response to sub-aerial temperature and moisture fluctuations and acidic waters. Behrensmeyer's initial study (1978) of bone weathering in the Amboseli Basin, Kenya demonstrated that bones pass through five weathering stages in which specific weathering damages occur within definable time periods. Stage 1 is defined by the presence of small cracks oriented parallel to the bone's fiber structure. At Stage 2, outer concentric bone lamellae begin to flake as cracking progresses. By Stage 3 flaking has exposed the interior of compact bone that has begun to weather, displays a rough fibrous texture; bone fibers remain attached to one another and weathering is restricted to 1.0-1.5 mm below the concentric lamellae. In Stage 4 concentric lamellae are largely absent and broad areas of bone display a coarse fibrous texture; bone fibers are fragile and easily removed and weathering may have progressed to expose cancellous bone. By Stage 5 the bone is very fragile, and large areas of cancellous bone are exposed; original bone shape is often difficult to determine. It was determined that weathering Stages 1, 2, 3, 4, and 5 take 0-3, 2-6, 4-15+, 6-15+, and 6-15+ years to develop, respectively. On the basis of this data it was suggested that bone weathering stages may be used to define attritional assemblages (Behrensmeyer, 1978) and help estimate the amount of time represented by most fluvial assemblages (Behrensmeyer, 1982).

Horse bones found in the Foosland locality stream bank were red-brown in color and unweathered; those that had eroded from the bank were bleached and displayed weathering Stages 2 through 5. Bones that were only partially buried exhibited two distinctly different weathering patterns; buried bone portions were unweathered, whereas many bones that projected from the bank presented slightly to highly weathered surfaces (weathering Stages 1-4). That several bones attained intense weathering damages in less than one year of sub-aerial exposure suggests that in less than 100 years of burial the bones had undergone significant chemical degradation. When bone became exposed in the river bank, sub-aerial weathering could proceed very rapidly because chemical degradation was already in progress. Although Behrensmeyer (1978) suggests that the weathering stages are broadly applicable to climatic regimes different from that of the semi-arid Amboseli Basin, it is likely that the frequent moisture and temperature fluctuations characteristic of midwestern temperate climates also increase bone weathering rates.

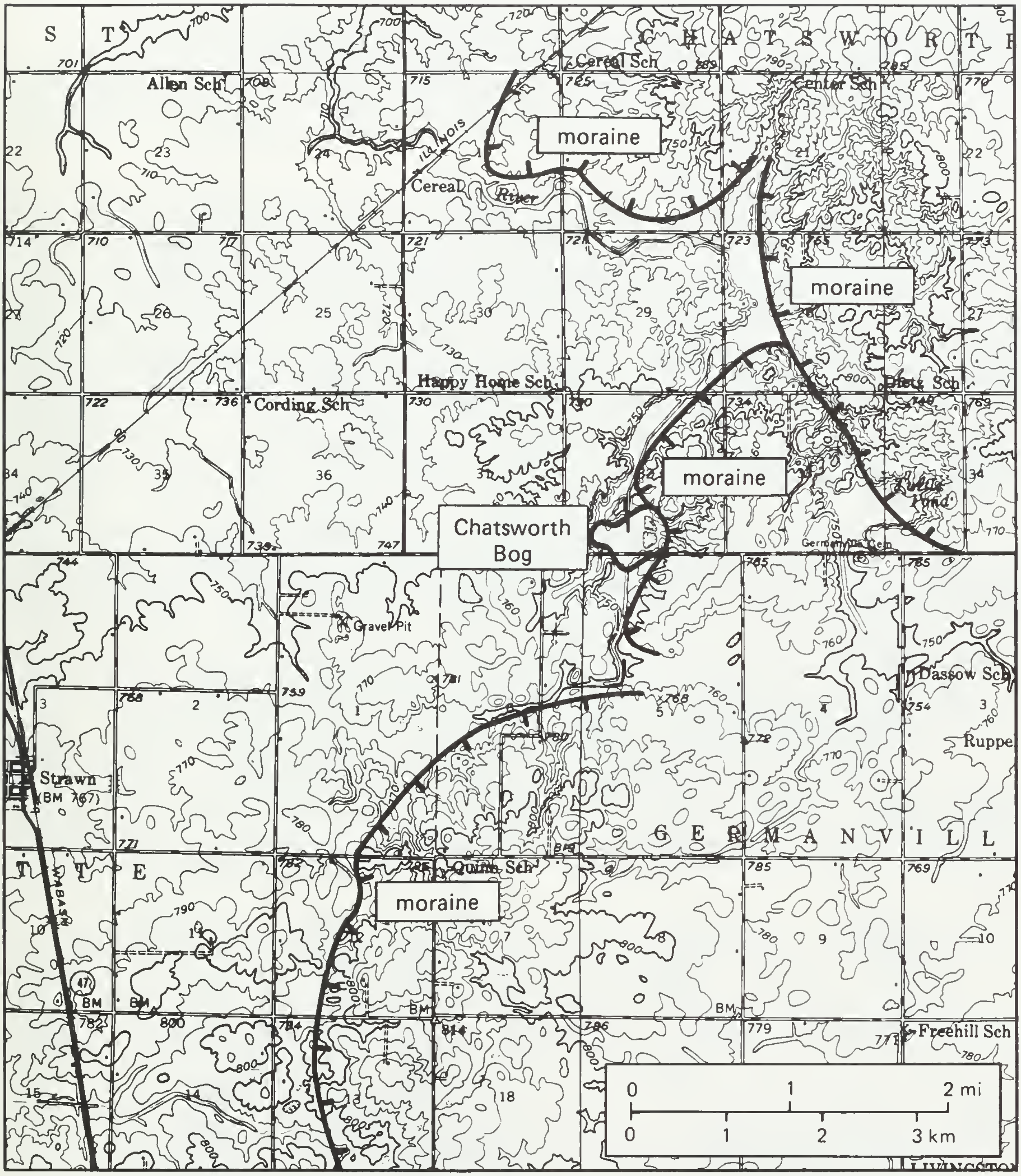
The observation that post-burial chemical changes radically reduce the capacity of bone to withstand sub-aerial weathering has a number of significant implications for the formation and interpretation of fossil assemblages. First, accelerated weathering rates for chemically degraded bone recently eroded from floodplain deposits may result in confusion about the taphonomic pathways of various bone specimens. Erosion of skeletons with similar taphonomic histories from floodplain deposits may result in fluvial assemblages with both weathered and unweathered bones. Alternatively, unburied bones that became weathered after long term sub-aerial exposure could be deposited with recently eroded bones that display similar weathering damages.

Thus, the presence of different weathering stages in an assemblage does not always indicate that the assemblage is attritional, and the presence of bones with similar weathering damage does not guarantee that the bones share similar weathering and taphonomic histories (contra Behrensmeyer, 1978). Moreover, the recycling of bone into the "pre-burial" taphonomic stage should be highly destructive and the survival rate for bones subjected to pre-fossilization recycling may be particularly low. This interpretation is at odds with that of Behrensmeyer (1982), who suggested that because bones eroding from banks of the East Fork River, Wyoming were "in a good state of preservation," they would survive recycling in the fluvial system. On the basis of this observation and estimates of fossil accumulation rates on floodplains, it was estimated that the temporal span represented by fluvial assemblages was 10^3 - 10^4 years (Behrensmeyer, 1982). Rapid and intense weathering of recently eroded Foosland horse bones suggest that many bones would not be able to survive this recycling and that many fluvial fossil assemblages may have accumulated over less amounts of time (i.e., 10^2 years). Finally, weathering stages defined on the basis of carcasses in East Africa may not apply to present Midwestern temperate climates or Quaternary glacial and periglacial environments.

Observations of Foosland horse bones illustrate the complexities of the weathering process and the difficulties in interpreting site formation processes based on bone weathering patterns. More intensive study is required before accurate and detailed taphonomic and ecologic information can be derived from bone weathering analyses.

CHATSWORTH BOG: A WOODFORDIAN KETTLE

James E. King



STOP 2. Chatsworth Bog

SW Sec. 32, T26N, R8E, Livingston County, IL

This bog, a rare occurrence here in central Illinois, provides significant information on the floral history from about 14,000 years ago to the present.

THE CHATSWORTH BOG

Chatsworth Bog is a marl bog situated within a roughly circular, 25-hectare depression dissected by an outwash channel that originated in the late Wisconsinan Chatsworth Moraine (Willman and Frye 1970) 4 km to the north. A small, permanent stream flows in the channel and through the bog. In the 1930s the organic-rich marl was commercially mined from the east half of the bog for agricultural lime, producing a pit that is now occupied by a small lake. Although the bog was probably surrounded by forest in the 19th century, the primary vegetation on the rolling morainic topography was tall-grass prairie (Anderson 1970).

Fossil pollen in Chastworth Bog was first investigated by John Voss (1937) who sampled the vertical walls of the open pit during the period of active mining at the site. He reported 60% spruce pollen at a depth of 11.2 m. This analysis included only the arboreal pollen types and was completed only on sediments below 6.5 m depth. Leonard (1974), who referred to the site as Strawn Northeast, studied the snails recovered from the fossiliferous marls at the edge of the basin in sediments dated younger than 9000 RCYBP and reported no evidence of climatic change. The snails indicated a uniform environment with some fluctuations in water levels. A pollen study of Turtle Pond, 3 km east of Chatworth Bog (Griffin 1951), did not include herbaceous pollen types.

A 5-cm diameter continuous core, 1275 cm long, was collected from the southwestern side of the Chatsworth basin in the remaining unmined area. The stratigraphy is shown in figure 2-1. Volumetric pollen samples were recovered

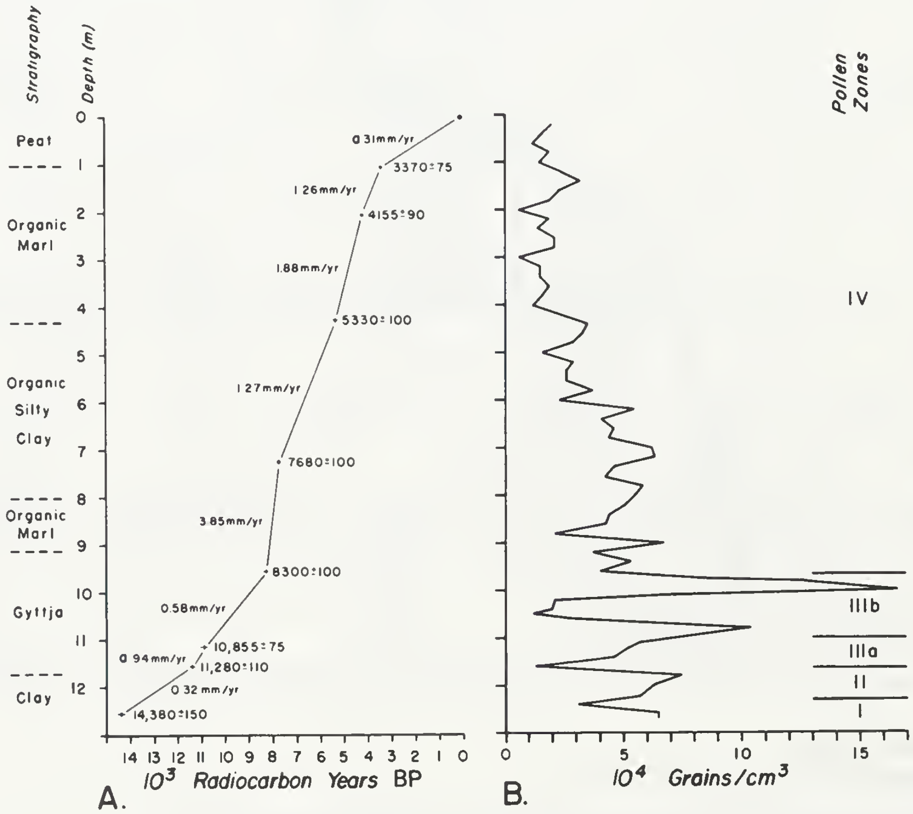


Figure 2-1. Stratigraphy, sedimentation rates, and pollen concentration for the Chatsworth Bog core. (A) Sedimentation rates are calculated from adjacent pairs of dates and the bog surface. (B) Pollen concentration (grains/cubic cm).

from the core at 20-cm intervals. Additional samples were later analyzed from selected parts of the core at 5- and 10-cm intervals in areas of rapid changes in pollen frequency and/or influx. The extraction methods and a detailed discussion of this and other Illinois pollen sites are described by King (1981).

Radiocarbon dates from the core are shown in figure 2-1 along with a plot of sedimentation rates throughout the sequence. The radiocarbon dates of 3370 ± 75 RCYBP from the top of the marl and 2640 ± 75 RCYBP (Leonard 1974) from near the base of the overlying surface peat bracket the stratigraphic contact between the organic marl and the surface peat.

Pollen concentration (fig. 2-1) fluctuates widely below 1000-cm depth, then slowly declines in the upper portion. There is no appreciable change across the marl/peat stratigraphic boundary at 100 cm. Total pollen influx remains relatively low (about 2000 grains/sq cm/yr) between 14,300 BP and 11,000 BP, when it increases to 5000 grains/sq cm/yr. Between 10,200 and 9100 BP, it again declines to about 1000 grains/sq cm/yr. At 9100 BP the pollen influx begins a rapid increase to 28,000 grains/sq cm/yr, remains high until about 7500 BP, when it declines to about 7000 grains/sq cm/yr, and then continues to decline to the top of the marl at 100 cm depth, about 3400 BP.

The pollen record from Chatsworth Bog (fig. 2-2) is dominated by spruce (Picea) in the lower Pleistocene levels and oak (Quercus) in the upper Holocene sections. The influx pollen diagram is presented in figure 2-3. The pollen record is divided into 4 assemblage zones.

ZONE I. Zone I is dominated by spruce (up to 76%), with lesser amounts of fir, larch, alder, birch and oak. Also present are grass and sage. Pollen influx values range from 1000 to 2100 grains/sq cm/yr. On the basis of the sedimentation rate curve (fig. 2-1), Zone I from the base of the core dates about 14,700 BP to 13,800 BP. Although oak accounts for up to 17% of the total pollen in Zone I, its influx ranges from only 80 to 400 grains/sq cm/yr. This is considerably less than the 2,000 to 12,000 grains/sq cm/yr in areas where oak trees presently occur, and indicates that the late Pleistocene oak component was from long-distance wind transport, not from the presence of significant quantities of local oak trees. Zone I is interpreted as reflecting a mosaic of open spruce woodland and tundra, perhaps similar to the modern forest-trundra transition.

ZONE II. In this zone, the percentage of spruce pollen decreases markedly, while pollen of ironwood, elm, oak, and ash (particularly black ash) increases. There is little pine pollen present (less than 2%). Pine is poorly represented at Chatsworth Bog, suggesting that pine did not occupy an important place in the late-glacial vegetation of central Illinois as it did in areas to the north. Total pollen influx increases slightly to a maximum of 2400 grains/sq cm/yr. Most of this increase is due to an increase in ash pollen; oak remains about 500 grains/sq cm/yr. Zone II dates between 13,800 and 11,600 BP. This zone is interpreted as a rapid expansion of black ash in the wet lowlands in the vicinity of the bog while the surrounding uplands remained open and treeless. Spruce had been displaced by the ash with climatic warming.

ZONE III. This double zone is dominated by tree taxa. Zone IIIa, dominated by cool temperate species, contains a sharp decline in ash and increases

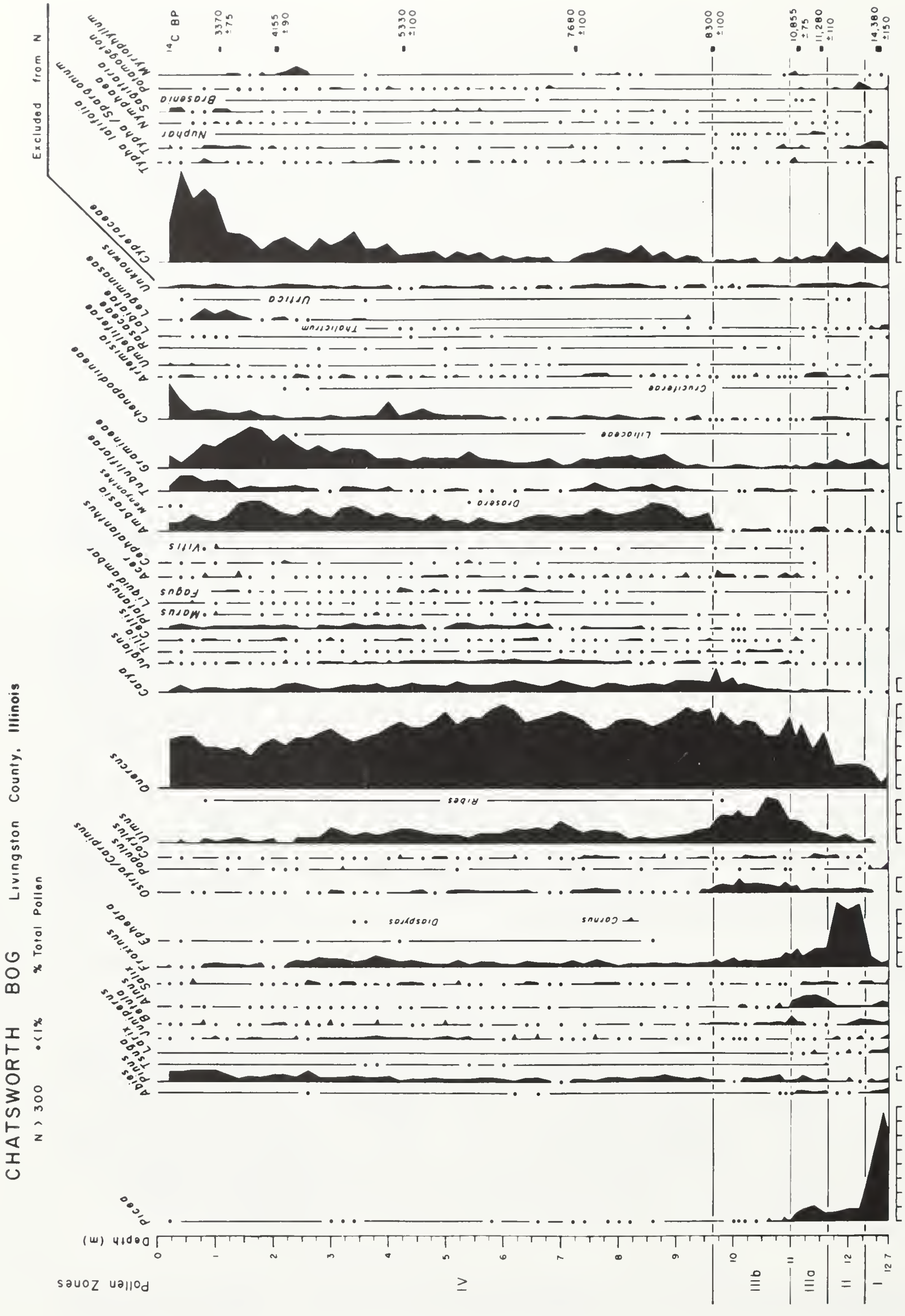


Figure 2-2. Percentage pollen diagram for Chatsworth Bog.

in alder, elm, and oak. IIIa also contains the last major occurrence of spruce and fir; it is dated between 11,600 and 10,600 BP. In Zone IIIb the cool-temperate taxa are replaced by warm-temperate trees. Ash, fir, spruce, larch, and alder decline further or disappear from the pollen record while elm, ironwood, hickory, and oak increase to maximums. Zone IIIb dates from 10,600 to 8300 BP and is interpreted as the culmination of the transition from tundra and boreal woodland to oak dominated deciduous forest. By the top of Zone IIIb, the dominant vegetation in the area was oak-hickory forest. The climate in central Illinois at this time was wetter than at present.

ZONE IV. At 8300 BP there was an abrupt increase in ragweed (*Ambrosia*) and shortly after, grass, Chenopods, and the sunflower group (*Tubluliflorae*) increased. The pollen of the deciduous trees declined at the same time. Between 970 and 860 cm depth the percentage of NAP (non-arboreal pollen) increases from 3% to 37%. The percentage increase in NAP is also apparent in the influx values. This increase in herb and grass pollen is interpreted as the first appearance of prairie in the Holocene on the broad upland of central Illinois. Oak pollen continues to dominate the pollen record, however, as small remnants of forest persisted along river and streams. Prairie produces small amounts of pollen because most of its constituent species, with the exception of grass and ragweed, are insect pollinated. Because of the disproportionally large production of pollen by trees, small NAP increases are more significant than overriding percentages of trees. The shift from forest to grasslands in central Illinois 8300 years ago suggests that climatic conditions were becoming increasingly dry. The Chatsworth Bog pollen record indicates little vegetation change after 8300 BP, when prairie vegetation was established.

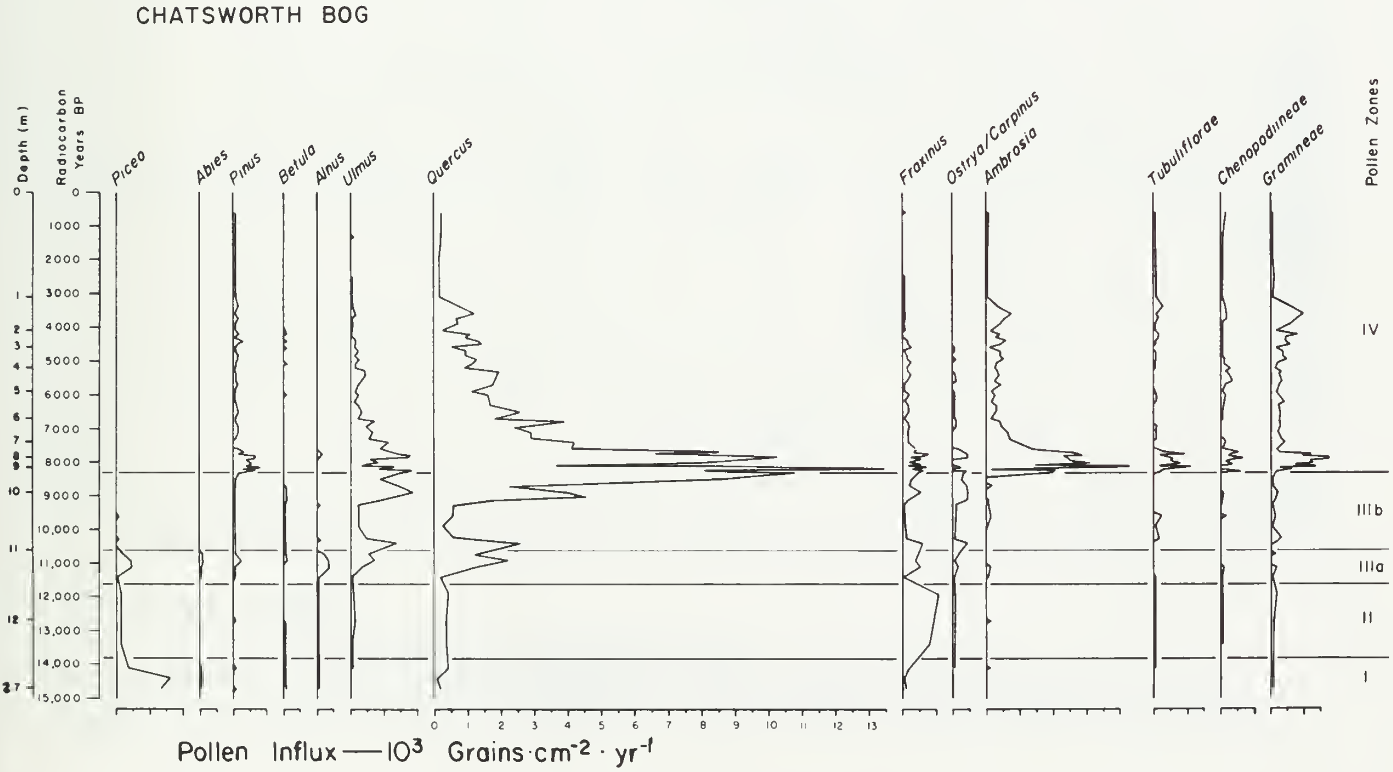
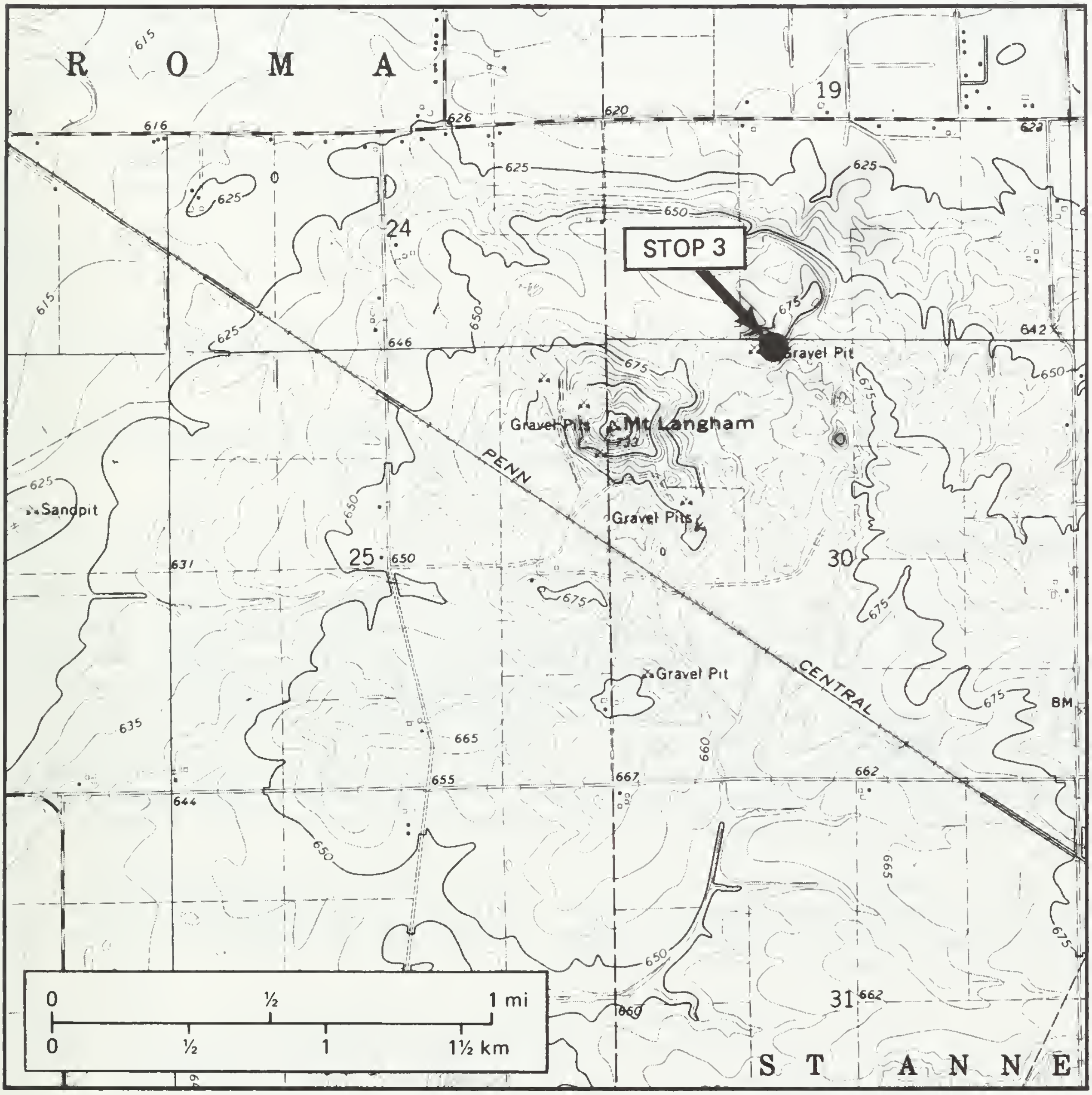


Figure 2-3. Pollen influx of selected taxa for Chatsworth Bog plotted as a function of years BP.

A LATE WOODLAND ARCHAEOLOGICAL SITE IN ASSOCIATION WITH AN ICE-CONTACT KAME

Robert D. Gergen



STOP 3. Mt. Langham

NW NE NW,Sec. 30, T30N, R12W, Kankakee County, IL

Several archaeological sites are located near Mt. Langham, one of the largest ice-contact kames in Illinois. The geological setting provides an important background for a unique microcosm of human habitation in northeastern Illinois.

INTRODUCTION

Until the mid 1970s, Illinois upland prairies had received scant attention from archaeologists. This lack of interest can be largely attributed to two factors. First, investigations traditionally have focused on architectural sites in riverine environments, and second, work has been influenced increasingly by salvage projects (Carmichael, 1976). However, because of the recent rapid expansion of archaeological awareness, locally significant sites are being included in the ever-increasing archaeological data base.

Because the scope of archaeology has expanded, the number of research questions has also greatly increased. The investigation focusing on the Mt. Langham site attempts to address the following questions:

- What are the geological factors that contribute to the structure of the area?
- What is the significance of the geological setting in relation to human occupation?
- What is the correlation between the Mt. Langham site and other similar or dissimilar sites in Illinois, if any?

GEOLOGIC SETTING

Mt. Langham, a large kame, is one of the more prominent features in this area. It rises about 100 ft above the Woodfordian drift plain to the south and 120 ft above the Kankakee River floodplain to the north. Willman and Frye (1970) map it as part of the St. Anne Moraine (fig I-1), but prominent kames, such as Mt. Langham, are not commonly associated with end moraines in this part of the Woodfordian drift plain. The kame is northeast of an interlobate position between the Marseilles Morainic System of the Peoria Sublobe and the Gilman Moraine of the Decatur Sublobe (fig. I-3), and it may have formed in an interlobate position. Several gravel pits have been opened in Mt. Langham.

The archaeological site is located on the north rim of a large kettle immediately east of Mt. Langham and west of the St. Anne Moraine. The kettle opens to the south, and drainage appears to have been to the south prior to final melting of buried ice in the kettle.

Drift is thin in the Kankakee area and the Silurian dolomite occurs near land surface. The overlying drift is late Wisconsinan, and consists of loess, eolian sand, till, outwash, and lacustrine deposits. The area around Mt. Langham has been extensively modified by meltwater floods draining west and north down the Kankakee Valley.

Soil at the site is Oakville fine sand, a Typic Udipsamment, developed in eolian sand. The C horizon typically is yellowish brown (10YR 5/6) fine sand, single grained, loose, and very strongly acid (Paschke, 1979). As a result of the acid conditions, preservation of flora and faunal remains at the site is poor.

DAILEY ARCHAEOLOGICAL SITE

The site area includes three well-defined terraces (fig. 3-1). Because the lithic scatter on the second terrace was abundant, the excavation plan was to put a 2- by 2-m test square on the second terrace and to dig a 2-m wide trench into the third terrace. Testing of the second terrace revealed undisturbed laminated sand at a depth of 5 cm, and no further testing was done on the second terrace.

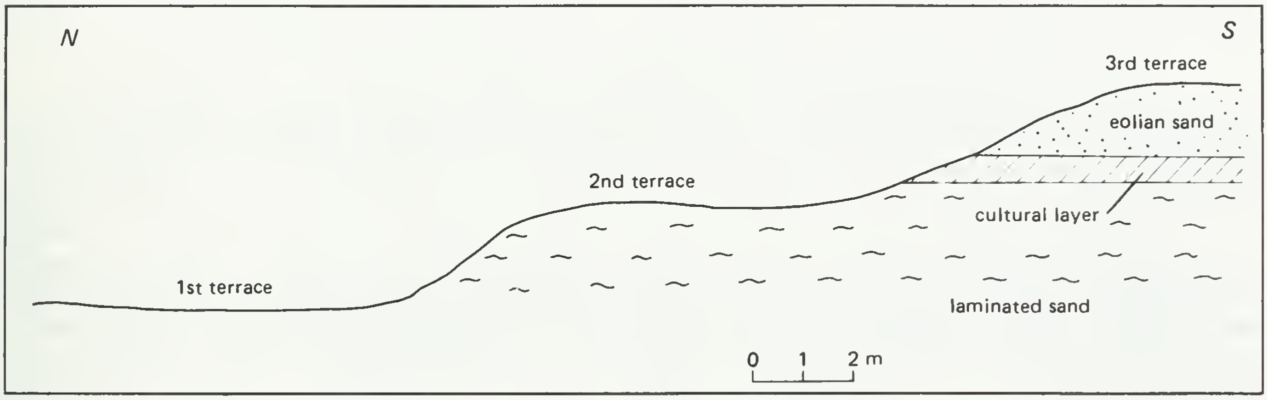


Figure 3-1. Terrace topography at the Dailey archaeological site, Mt. Langham.

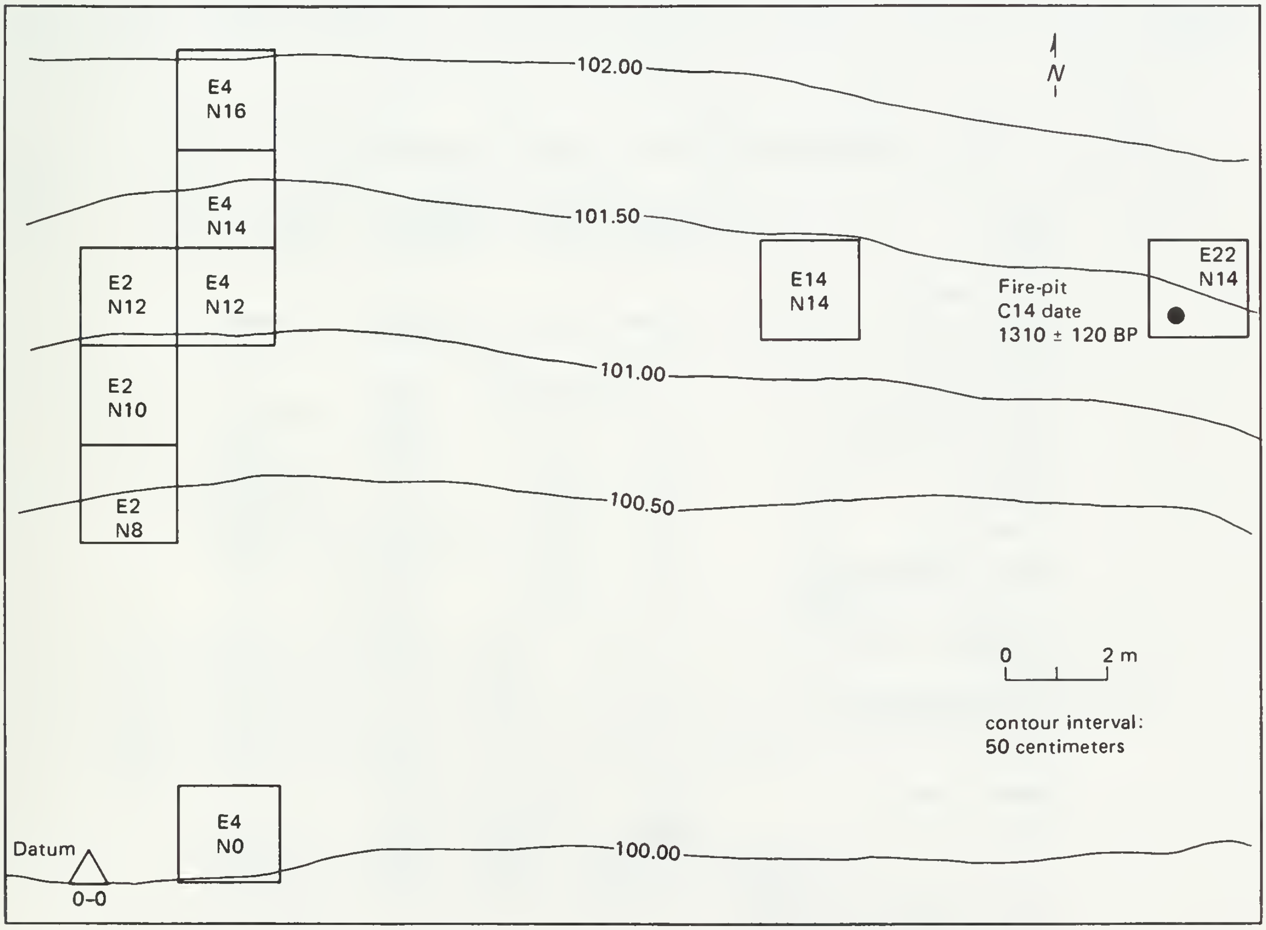


Figure 3-2. Excavation units at the Dailey archaeological site. Units established at 2-x 2-m grids on a north-south, east-west axis. Grid unit numbers indicate the number of meters north and east of the datum 0-0; datum line given arbitrary number of 100 m.

The trench in the third terrace revealed the location of the cultural layer. The layer was exposed at the base of the southern edge of the slope of the third terrace, which explains the large amount of lithic scatter on the second terrace. The cultural layer is deeply buried under 2 m of eolian sand at the top of the third terrace (fig. 3-1). A total of nine grid units, 2 m by 2 m, were excavated (fig. 3-2) through the cultural layer.

RESULTS

Excavation determined that the cultural layer extends 30 cm above the laminated sand. The cultural layer consists of light brownish yellow (10YR 6/4) fine-grained sand. Virtually all the lithic material collected from the grid areas was transported to the site by man and has archaeological significance.

Table 3-1 is a compilation of lithic materials. In terms of weight and size, the amount of weathered dolomite fragments suggests that the inhabitants would seek certain nodules with a somewhat uniform cortex (outer layer) and transport them to the site before cracking. Many fragments had cherty cores, but some did not.

Several siliceous flakes were also found. The material, when viewed under a 10x microscope, revealed fine-grained consolidated sand infused with quartz grains. The material is unlike any of the Silurian cherts. The flakes

Table 3-1. Debitage material types at the Dailey archaeological site.

Material	Number	% of total	Weight (grams)	% of total
Fire-cracked igneous rock	243	5.1	3537.4	31.6
Heat-treated igneous rock	71	1.5	335.2	3.0
Rough igneous rock	54	1.1	309.4	2.8
Raw chert	35	0.7	72.6	0.6
Worked chert*	3654	76.6	3717.5	33.2
Heat-treated dolomite	32	0.7	152.0	1.3
Sedimentary rough rock	314	6.6	731.0	6.5
Sandstone	13	0.3	306.8	2.7
Weathered dolomite	318	6.7	1711.1	15.3
Chert cores	4	0.1	157.8	1.4
Siliceous flakes**	30	0.6	182.0	1.6
TOTAL	4768	99.9	11212.8	100.00

*includes flakes and shatter

**low grade metamorphic material

have very friable edges and would not be useful in producing tools commonly associated with chert. No artifacts were found made of this material.

Several fire-cracked igneous rocks were found, as well as a large amount of heat-treated, very friable igneous rock. The application of heat to rough rock prior to artifact manufacture was apparently an important aspect of lithic technology in view of the large amount of dolomite as well as igneous rock. The heat-treated dolomite was fractured into rectangular blocks of various sizes ranging in length of from 1 to 10 cm. The heat-treated dolomite did not have the well-weathered cortex characteristic of the nodules.

Table 3-2 is an analysis of the worked chert debitage. Chert quality was judged on the following characteristics: pitting, fossil inclusions, and grain texture. Most flakes were of high quality chert (47%) but a significant number of low quality (22%) and medium quality (31%) were found. The number of heat-treated flakes is fairly consistent with the findings of Wiant's research in the Will-Kankakee county line area. Wiant concluded that 18% of the chert debitage was heat treated (Knight, 1983). The percentage of heat-treated flakes at the Daily site was 13 %. The colors of chert show a wide range: white, buff, red/yellow, black, gray/white, red, blue/gray, gray, mottled white/gray, banded gray/blue, banded red/yellow.

The chert-bearing bedrock of the Silurian dolomite in Kankakee County is a dense white chert in layers 4 in. thick (Willman and Frye, 1970). Although a complete analysis of the number of flakes belonging to each color type has not been done, a small fraction of less than 3 % has the color characteristic of locally embedded Silurian chert. I conclude that even though Silurian chert was readily available, very little of it was used. The Indians relied almost entirely on chert from the glacial gravels in Mt. Langham even though more than half of it was of low to medium quality and higher quality cherts could be found within a short distance of the site.

Table 3-2. Worked chert debitage at the Dailey archaeological site.

Type	Chipped Stone Number	Percentage of total
primary	1013	28
secondary	909	25
tertiary	767	21
bifacial thinning flake	206	06
shatter	759	20
TOTAL	3654	100.00

1. Primary flake: lacks dorsal scars; created by the prior removal of other flakes; may or may not posses cortex
2. Secondary flake: one or more dorsal ridges; tends to have a blocky dorsal aspect
3. Tertiary flake: one or more dorsal ridges; tends to have a smooth dorsal surface
4. Bifacial thinning flake: striking platform is bifacial edge
5. Shatter: piece of stone with no flake characteristics

Chert quality of flakes

	low	fair	high	heat-treated
number	644	908	1343	369
percent	22	31	47	13

SUMMARY

Prehistoric people were for the most part dependent on a lithics-based technology. Four primary methods of obtaining raw materials were utilized:

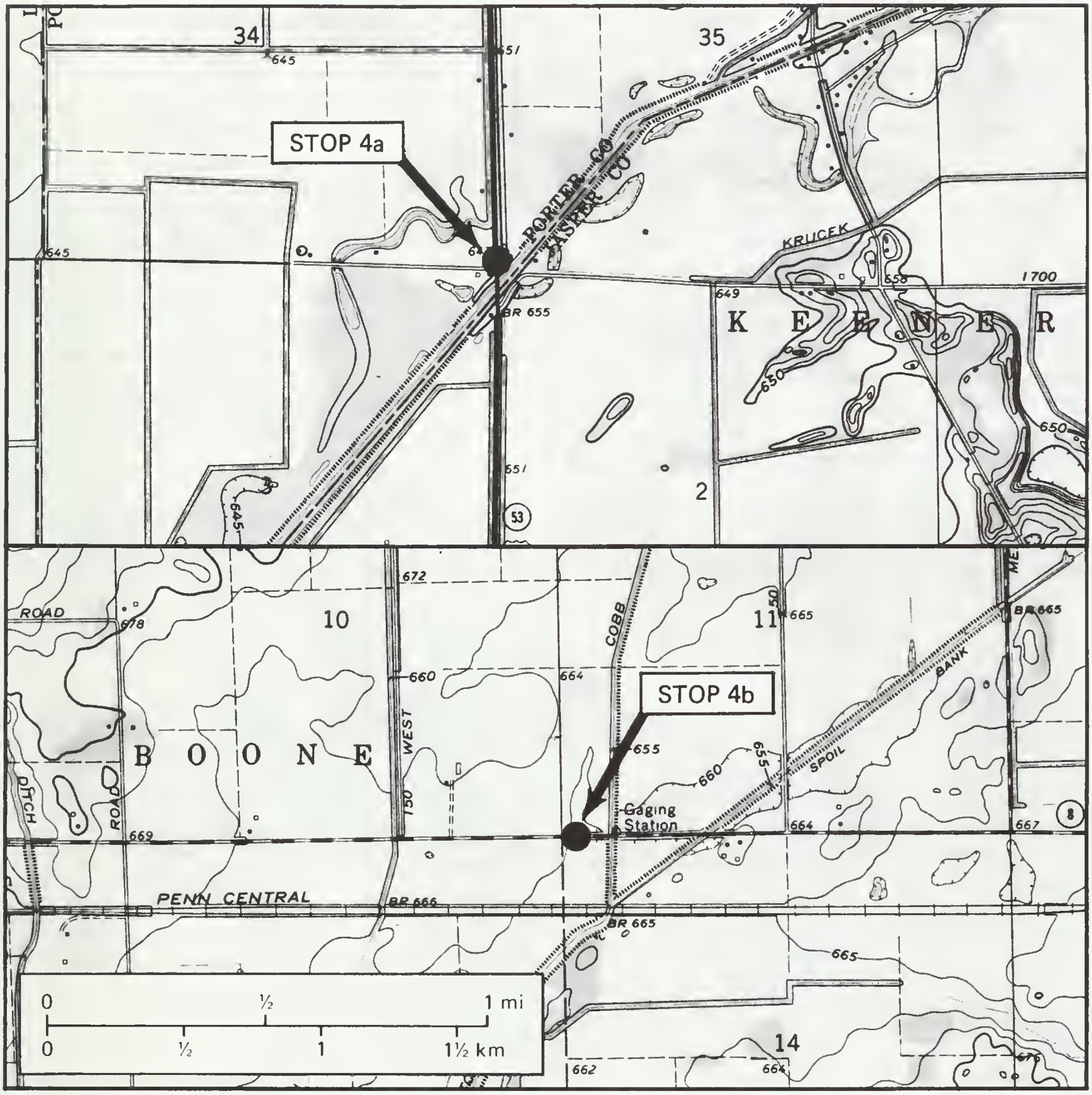
- Quarrying in situ material from its bed
- Gathering eroded material from stream beds or talus slopes
- Gathering material deposited by glacial ice or its meltwaters
- Obtaining material through a trading network

Along with floral and faunal resources, the availability and accessibility of lithic materials were primary factors in determining whether or not a prehistoric group of people could establish a permanent or semi-permanent settlement.

Ice-contact hills such as Mt. Langham contain some of the largest and most easily accessible supplies of lithic material in Illinois. The prehistoric people who established themselves around Mt. Langham were able to do so because the geological factors necessary for human habitation were present. Until now, kame deposits in Illinois have been ignored by archaeologists; this study indicates that additional research is warranted. Archaeology, coupled with geology, can provide important information as to man's relationship to his natural environment.

GLACIGENIC SEDIMENTS OF THE KANKAKEE OUTWASH PLAIN AND VALPARAISO MORAINIC SYSTEM, NORTHERN INDIANA

Kim A. Nelson



STOP 4. Kankakee Valley
4a: SE Corner, Sec. 34, T33N, R7W, Porter County, IN
4b: SW Corner, Sec. 11, T33N, R6W, Porter County, IN

At stop 4a we will discuss the genesis of glacigenic sediments in the Kankakee Valley. The discussion at stop 4b will focus on the sedimentation of the Valparaiso Morainic System Complex.

REGIONAL SETTING

The Kankakee River drainage basin encompasses an area of 13,400 sq km (5,165 sq mi) in Michigan, Indiana, and Illinois (Gross and Berg, 1981), with well over half the area (7770 sq km) in Indiana (fig. 4-1). The river flows southwestward across northern Indiana and bends northward to join the Des Plaines River at Wilmington, Illinois, where the combined streams form the Illinois River. The drainage basin area includes the Iroquois Moraine, most of the Valparaiso and Maxinkuckee Moraines, and the Kankakee Outwash Plain. The Kankakee Outwash Plain is an elongate body of fluvio-lacustrine and ice-stagnation sediments deposited during the late Wisconsinan (Nelson and Fraser, 1984).

The river has a meandering length of approximately 320 km (200 mi) and a gradient of 8 cm/km (5 in/mi) (Leverett, 1899). The river valley is flat and broad, ranging in width from 3 km (2 mi) near South Bend to around 8 km (5 mi) at the Indiana-Illinois state line (Bushnell, 1927). The valley is bounded on three sides by moraines; on the north by the Valparaiso Moraine (Lake Michigan Lobe), on the south by the Iroquois Moraine (Huron-Erie Lobe), and on the east by part of the Maxinkuckee Moraine (Saginaw Lobe). The moraine fronts are rather subdued, rising 3 to 10 m (10-25 ft) from the outwash floor (Leverett, 1899), although elevations away from the Valparaiso Moraine front reach more than 60 m above the outwash plain.

The moraines are the physiographic borders for the Kankakee Outwash Plain (fig. 4-1). The Valparaiso Moraine is a thick accumulation of sand and till flanked by coalesced outwash fan lobes along much of its southern border. The

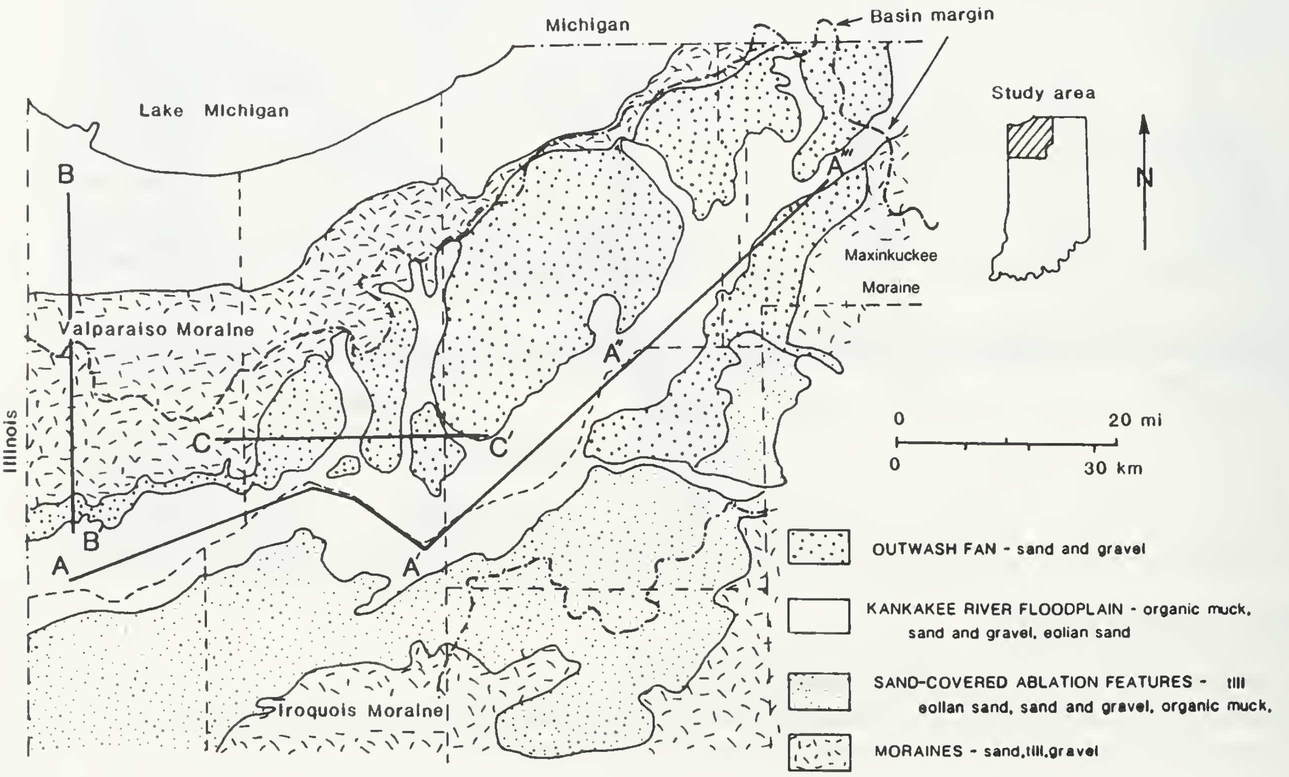


Figure 4-1. Surficial deposits of the Kankakee basin, northern Indiana, showing drainage basin margins and lines of cross section.

outwash surface is relatively smooth near the Indiana-Illinois line, but to the northeast it becomes pitted with numerous organic-filled depressions. This upper outwash plain gently slopes away from the moraine front and grades into the present Kankakee River floodplain along its southern margin.

The floodplain is a level, poorly-drained region characterized by sandy outwash with a veneer of organic mucks and isolated sand knolls. Much of the outwash plain was once covered by an extensive wetland known as the Kankakee Marsh (Meyer, 1936). The marsh was a nationally known hunting and fishing locale until it was ditched and drained for use as ranch and farmland in the early 20th century. The ditching project included straightening of the Kankakee River itself, from the Indiana-Illinois state line eastward. The isolated, forested sand knolls dotting the floodplain today are probably modified dunes that stood as islands in the marsh (Meyer, 1936).

A region of ablation tills, outwash sands and gravels, and valley train sands occurs along the southern flank of the floodplain, and along with the floodplain forms a lower outwash plain surface (fig. 4-1). Eolian dunes and cover sands drape this entire region. The dunes are concentrated in a band 30 to 50 km (20-30 mi) wide just south of the river (Gross and Berg, 1981) and are generally 3 to 10 m (10-25 ft) high with some up to 15 m (50 ft) in height (Ehrlinger et al., 1969). This sand cover laps up onto the Iroquois Moraine at the southern boundary of the drainage basin in the western part of the valley, and abuts outwash fan deposits and the Maxinkuckee Moraine to the east, in Marshall County, Indiana.

STOP 4a: KANKAKEE OUTWASH PLAIN

The thickness of the surficial cover in the Kankakee Valley increases from a thin veneer, primarily of Holocene alluvium, in Illinois to nearly 100 m of glacigenic sediments near South Bend. Broad facies tracts and a simple vertical sequence characterizes much of the material in the southwestern part of the basin and along the valley axis to the northeast. Along the margin of the valley and to the northeast toward the head of the valley, however, the vertical sequence and the lateral facies distribution are more complex.

In the southwest the sequence consists of bedrock or till (at the base) overlain progressively by lacustrine muds, valley train outwash, and eolian sands or organic-rich sediments (fig. 4-2). The lacustrine muds are blue gray to olive gray and consist almost entirely of silt and clay. They fill in the irregularities at the base of the sequence but have a nearly horizontal upper surface at an elevation of approximately 190 m (640 ft) msl. They are the most widespread of the facies and are found along nearly the entire length of the outwash plain (fig. 4-2).

The overlying valley train sediments consist of medium- to fine-grained, moderately sorted, gray to tan sands. They are the dominant facies in the western part of the outwash plain, but in the eastern, upstream part of the plain, valley train deposits are either absent or are restricted to a narrow zone along the valley axis (fig. 4-2).

Valley train sands are, in general, overlain by eolian sands or by organic-rich sediments including sand, muck, and peat. The organic material probably represents late Pleistocene/Holocene deposition in the Great Marsh of the Kankakee or more recent floodplain deposits that accumulated after drainage of the marsh.

Eolian sands are fine- to medium-grained, well-sorted, and mud-free. They occur either as cover sands or dunes overlying till, outwash, or valley train sediments. The dunes occur as complex transverse and linear forms and are concentrated in an extensive dune field south of the river in the western part of the plain. The dunes are largely inactive, although blowouts are presently forming in some areas.

Variations in the basic motif occur in the upstream part of the Kankakee Plain and along the northern and southern margins. Dune sands, for instance, overlie outwash in the valley axis but along the southern margin they overlie ice-disintegration sediments of the Iroquois Moraine. Dune sands are not common along the northern margin of the plain, and there the valley train sands may be overlain by or interfingered with outwash sand and gravel, or cut by outwash channels. The source of this outwash lies either in the fan apron extending south from the Valparaiso Moraine along the eastern part of the Kankakee Plain or from channels cutting across both the outwash plain and the outwash apron (fig. 4-1). Some of these channel fills are quite large and are responsible for introducing coarse-grained sediment into the valley train sands. There the latter deposits occur as discrete, commonly stacked lenses of coarser material enclosed by finer-grained valley train sands of the Kankakee Plain (fig. 4-3).

The upstream part of the Kankakee Outwash Plain is particularly complex because the sources of lateral input into the valley were close to the valley axis. Till units and outwash sand and gravel are the dominant sediment types, and these interfinger with units of relatively finer-grained valley train outwash (fig. 4-2). The surface of the plain is marked with collapse basins

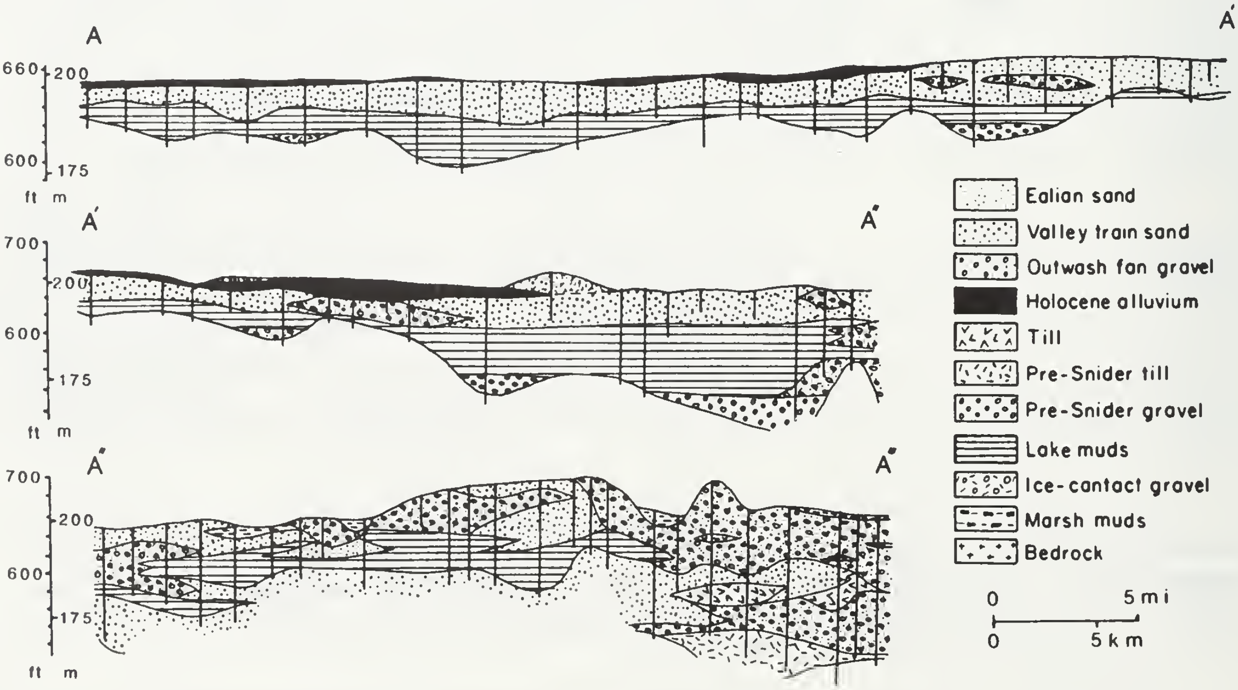


Figure 4-2. Longitudinal profile of the Kankakee River valley, northern Indiana, showing increasing thickness of glacigenic sediments to the east. (Location of lines of cross section shown in fig. 4-1).

filled with marl, muck, and peat. These features suggest that ice-stagnation was an important control on facies distribution during active valley train sedimentation, and the complex interrelationship between valley train sands and facies of the Valparaiso and Iroquois Morainic complexes suggests that active sedimentation was occurring along both margins of the plain as well.

STOP 4b: VALPARAISO MORAINIC COMPLEX

The Valparaiso Morainic Complex in Indiana may best be described as a linear pile of sand with a thin veneer of till. No definitive comparison between the sand of the complex and that of the Kankakee Outwash Plain has been made because of the lack of surface exposures, but from the outcrops that are available and from stratigraphic relationships established from subsurface information, the two sand bodies may, in fact, be the same.

The subsurface expression of the sand in the moraine also suggests that the sand was deposited prior to the formation of the complex and was pushed up to form the core of the moraine (fig. 4-4). This interpretation is

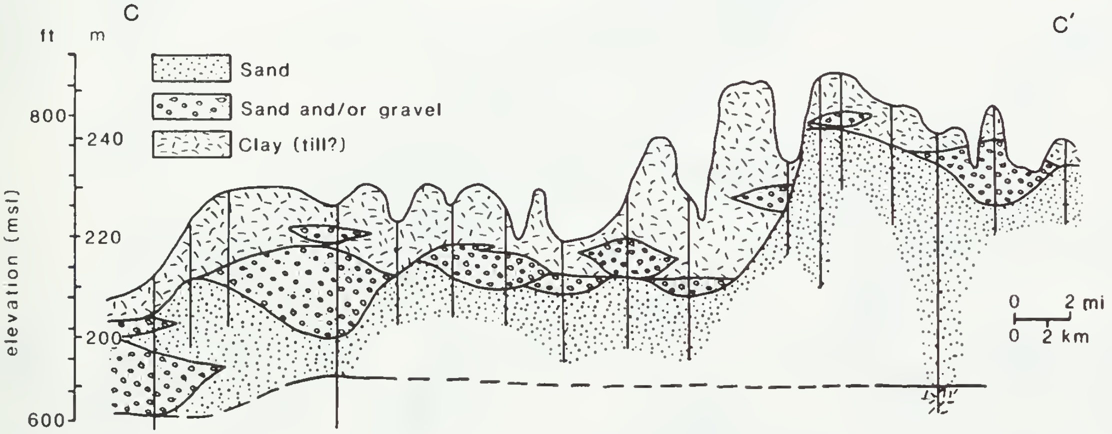


Figure 4-3. Transverse profile of outwash channels cutting Valparaiso Morainic Complex and outwash apron of the Kankakee Plain. The stacked outwash sand and gravel lenses are underlain by finer-grained valley-train sands and capped by till. The till unit is thicker within the channel than on the interchannel surface. (Location of line of cross section shown in fig. 4-1).

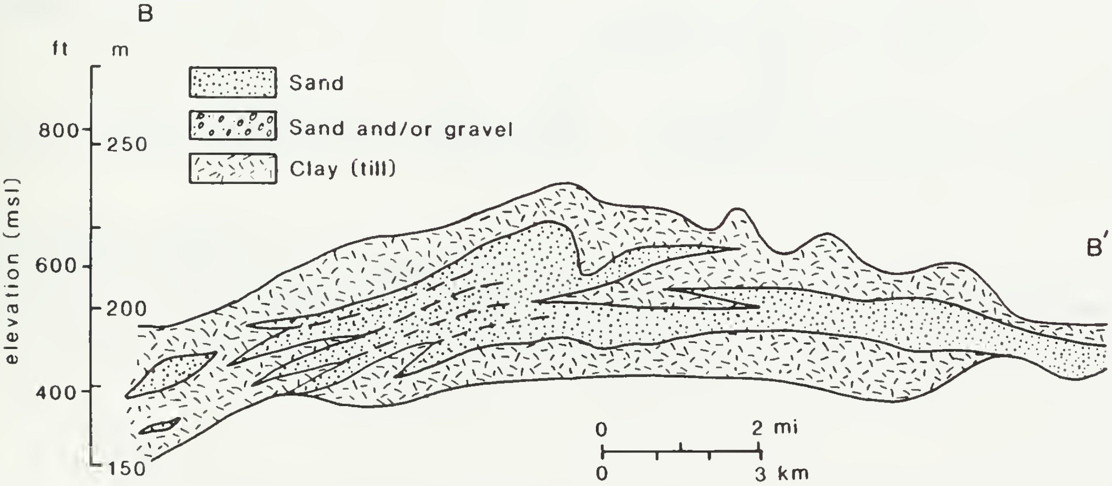


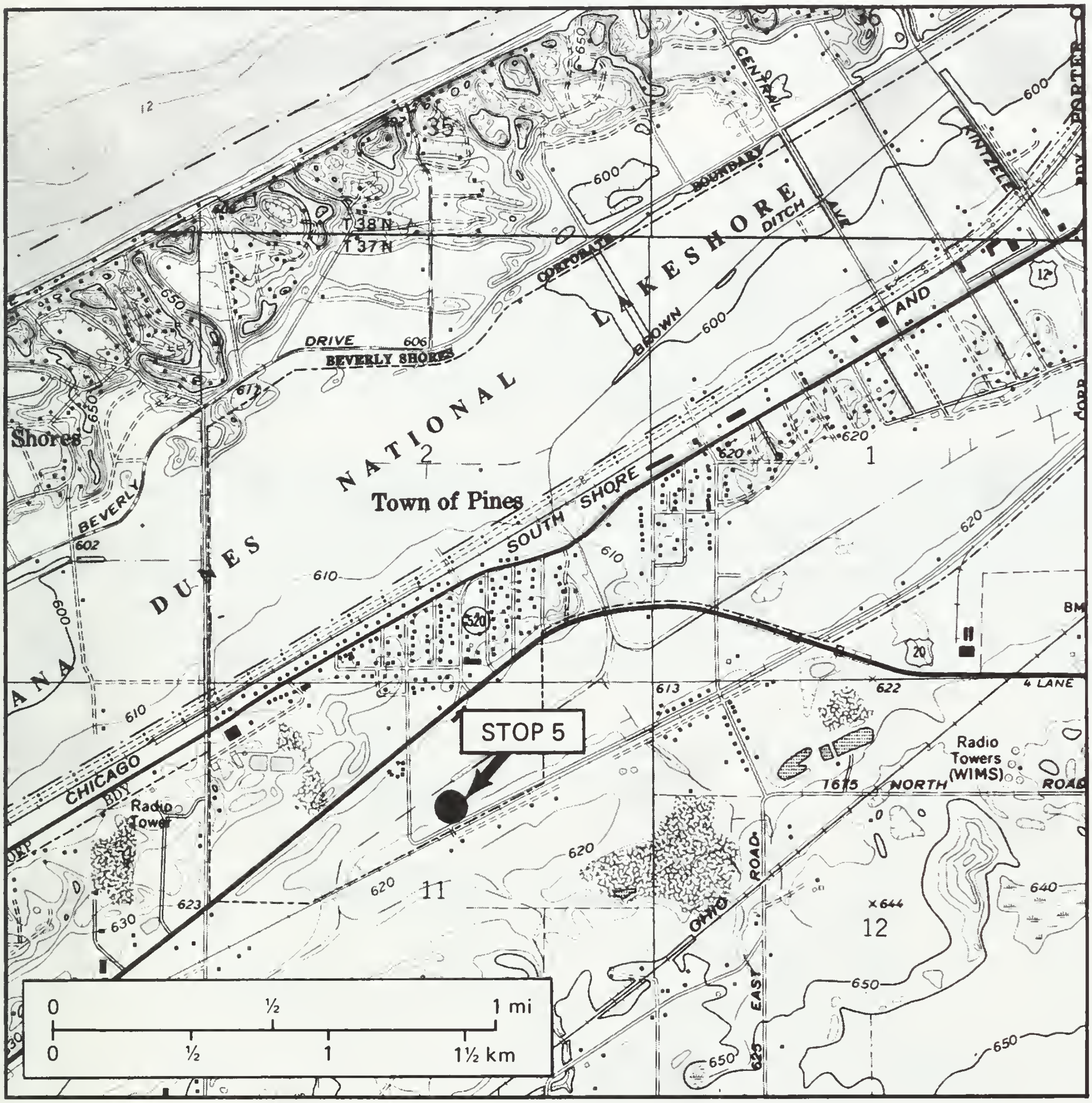
Figure 4-4. Transverse profile through the Valparaiso Morainic Complex, northwestern Indiana. Note sand core encased in till. (Location of line of cross section shown in fig. 1.)

substantiated by the occurrence of channels cutting across both the moraine and the outwash apron that occurs along the southeastern edge of the moraine (fig 4-1). Sediments filling these channels consist of poorly-sorted sand and gravel far different in character not only from the the tills capping the moraine, but also from the sand in the core of the moraine and the outwash apron.

These channels appear to have acted as the drainage path carrying meltwater and debris away from the moraine during its construction. Later they may also have funneled debris flows away from the ice, as indicated by the greater thickness of till in the channels in comparison to thicknesses on the interchannel surfaces (fig. 4-3).

A TWOCREEKAN SPRUCE FOREST AT THE SOUTH END OF LAKE MICHIGAN

Kenneth L. Cole



STOP 5. Brown's Sand Pit

SW SE NW Sec. 11, T35N, R5W, Porter County, IN

At this stop we will examine a layer of logs of Two Creeks age buried by lacustrine and eolian sands and discuss plant macrofossils and the sedimentation and age of the overlying sand.

BROWN'S SAND PIT

Recent excavation at the Brown's sand pit site, 5 km southwest of Michigan City, Indiana, was halted when a layer of logs within the sand prevented deeper mining. Todd Thompson called my attention to the deposit and mentioned that the location of the logs suggested a Two Creeks age. Closer inspection revealed abundant spruce cones, further indicating the antiquity of the deposit.

A radiocarbon date of 11,850 ± 150 RCYBP (ISGS-1454) on wood from the log layer confirms that the forest grew during the Two Creeks low-water phase (12,000 to 11,800 BP) (Hansel et al., 1985). The forest was inundated during the Calumet high-water phase of glacial Lake Chicago, which began about 11,800 BP. Scattered rounded pebbles are present in the sand at and below 186.5 m (612 ft), as are lenses of peat and clay-rich material (fig. 5-1). The site is situated between the Calumet and the earlier (12,700 to 12,000 BP) Glenwood beach ridges (fig. 5-2). The environment of deposition is interpreted as an interdunal wetland that was at times subjected to swash and washover. Sand above 186.5 m appears to be eolian.

Several peats and fossiliferous layers run discontinuously along the 150 m of exposed outcrop. Well-preserved plant macrofossils are present in pockets scattered throughout the deposit, but are most common on an intermediate surface where they are concentrated by wind deflation of the overlying sand. The plant macrofossils represent lowland spruce forest and wetland environments. All wood fragments identified thus far are spruce. Cones, needles, and twigs of both white spruce (Picea glauca) and black spruce (Picea mariana) are present. Wetland habitats are represented by wetland herbaceous

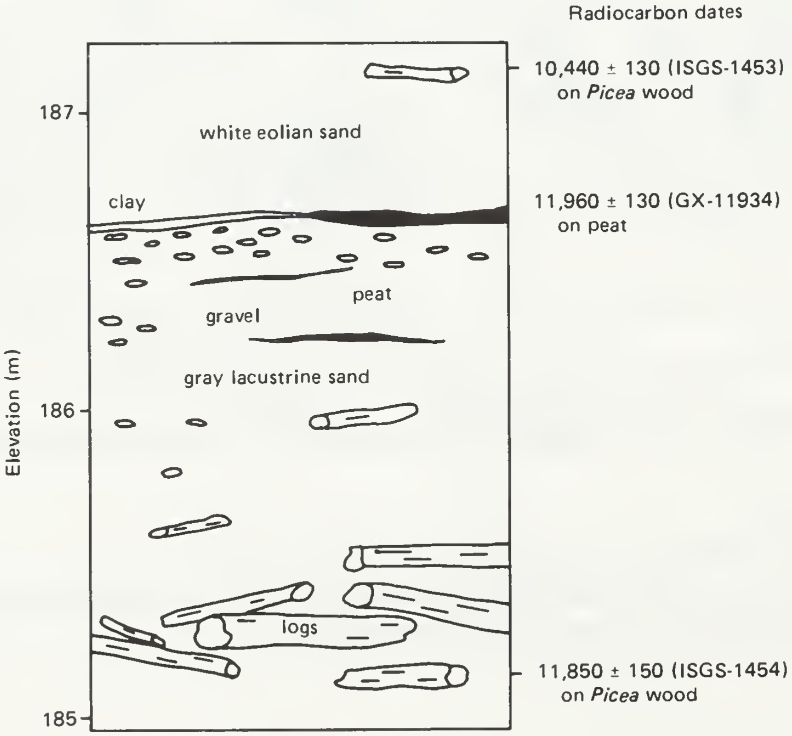


Figure 5-1. Generalized diagram of stratigraphy at Brown sand pit, showing approximate elevations of strata and radiocarbon samples.

taxa such as bulrush (*Scirpus* sp), pondweed (*Potomogeton spirillus* and *P. vaseyi*), and naiad (*Najas flexilis*).

Cones and needles of tamarack (*Larix laricina*) and needles of balsam fir (*Abies balsamea*), both typical conifers of swampy spruce forest, are also present. The deposit is remarkable for its remains of upland woody plants such as seeds of silverberry (*Eleagnus commutata*), dogwood (*Cornus sp*), and sand cherry (Prunus pumila).

The largest spruce logs are concentrated at an elevation between 185 m and 186 m at the western end of the sand pit. Surficial springs are present in this area. These springs are probably located above breaks in the clay layers of the Wadsworth diamicton and may be similar to others found in the interdunal wetlands (Wilcox et al., in press). If this is the case, the springs were probably present during Two Creeks time and may have been responsible for the dense local growth of spruce. A dense stand of another conifer, white pine (*Pinus strobus*) grew at this site prior to settlement and logging early in this century (Pavlovic, unpublished map; Harry Frey, verbal communication).

This record suggests that spruce forest remained dominant along the dunes of the southern shore of glacial Lake Chicago at least until 11,800 BP, a time when pine and ash were beginning to invade bogs farther inland such as the Pinhook Bog (Futyma, 1985), 10 km to the southeast. Further analysis of the upper strata will demonstrate whether spruce communities persisted to even later dates in the cool-moist habitats along the lake.

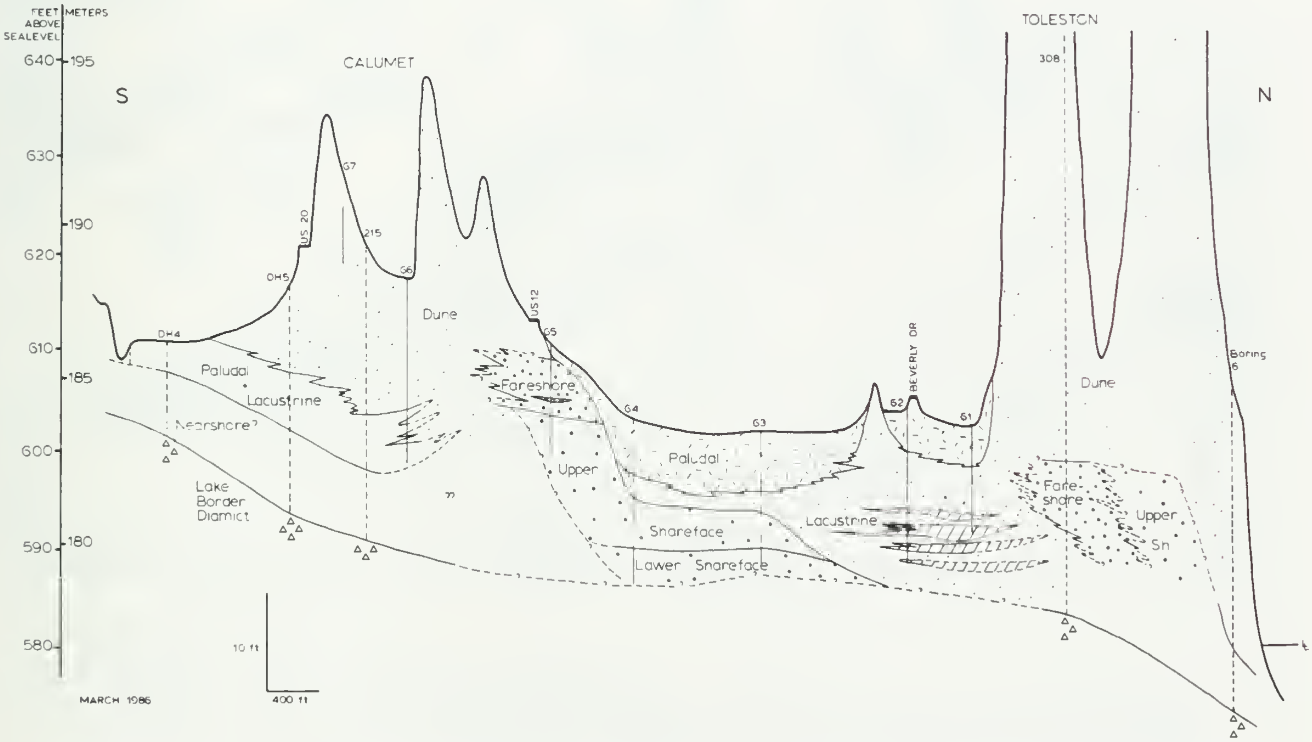
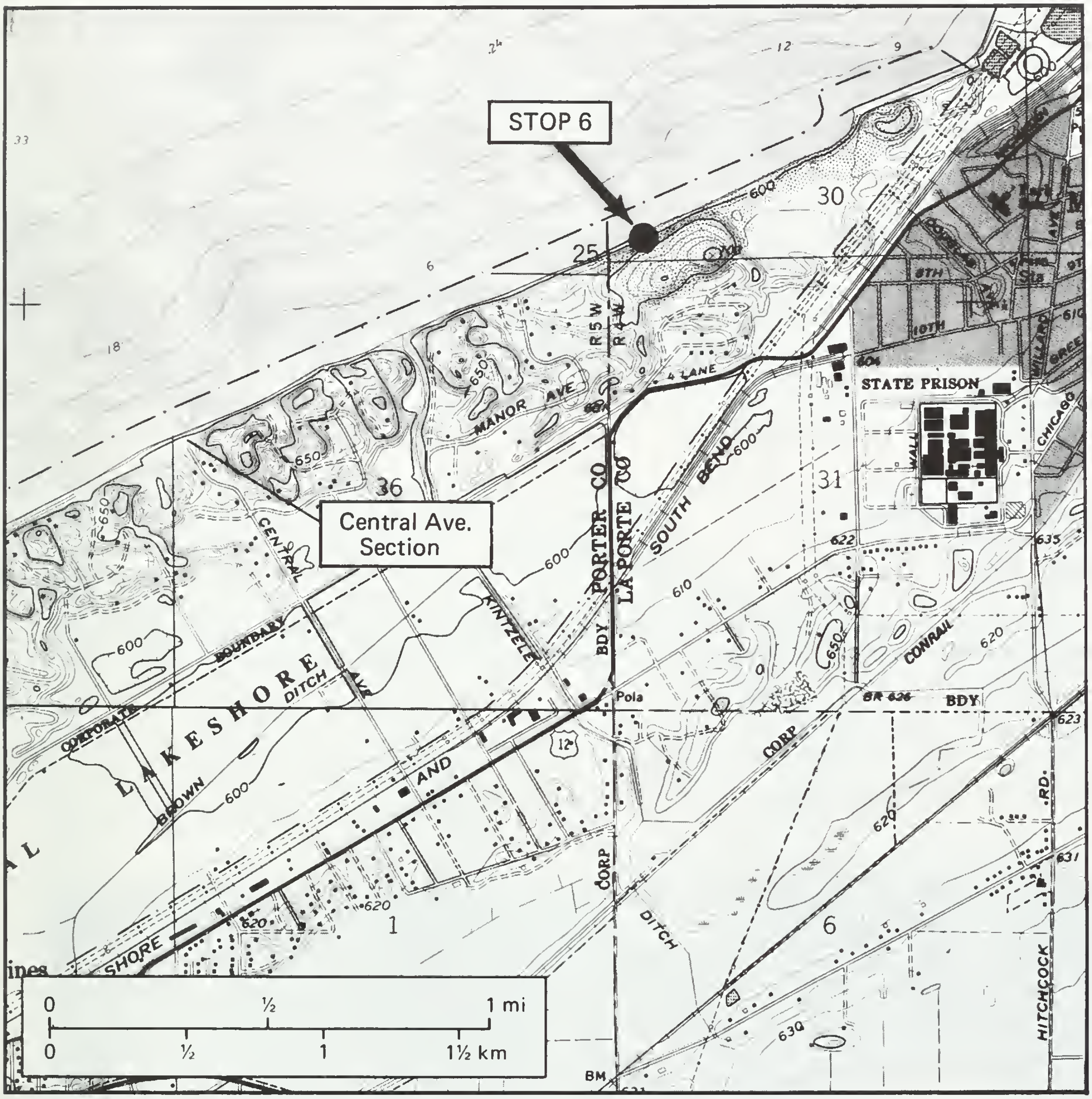


Figure 5-2. North-south cross section of sedimentary facies along Lakeshore County Road from Lake Michigan to near Brown's sand pit. The pit is located near the ditch shown at extreme left of diagram. Section courtesy of Todd Thompson (dissertation in progress).

POST LAKE CHIPPEWA TRANSGRESSION DEPOSITS IN THE INDIANA DUNES NATIONAL LAKESHORE

Todd A. Thompson



STOP 6. Mt. Baldy Section

S½ SW SW Sec. 30, T38N, R4W, Porter County, IN

The Mt. Baldy Section is one of the few exposures of sediments in the southern part of the Lake Michigan basin that were deposited in Lake Nipissing. The sedimentary sequence here records a transgression from the Chippewa low phase to the Nipissing I phase.

INTRODUCTION

Mt. Baldy is a bicrested domal dune on the east end of the Indiana Dunes National Lakeshore. The dune is actively migrating landward at a rate of 4 to 5 ft per year in response to strong northwesterly winds. In late fall and early spring, storm waves erode the lakeward margin of the dune. They expose a sequence of back-barrier lacustrine sands and clays that rest on till and are overlain by nearshore sands and pebbly sands (fig. 6-1). The entire sequence is capped by eolian deposits. Radiocarbon dates indicate that the paralic deposits below the dune sands are early Lake Nipissing in age (Larsen, 1985b; Hansel and others, 1985b).

At this stop we will examine the types of sedimentary deposits exposed below the eolian sands, giving special attention to their vertical and lateral arrangement along the shoreline and mode of formation. This report briefly describes the characteristics of these deposits and suggests environments of deposition. Because I do not intend to replace the work of Gutschick and Gonsiewski (1976) with this report, I will heavily rely on their descriptions and stratigraphic framework throughout this discussion. I will attempt, however, to enhance their environmental interpretation in the light of modern studies of coastal sedimentation.

SEDIMENTARY DEPOSITS

Pebbly Clay

Present high lake levels do not permit examination of the lower part of the Mt. Baldy section. Winkler (1962), however, reported that the base

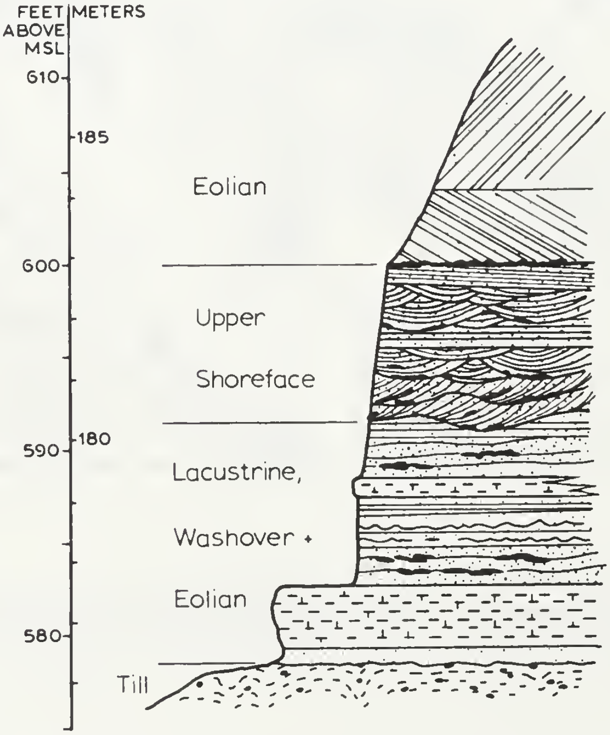


Figure 6-1. Stratigraphic section at Mt. Baldy. Modified from Gutschick and Gonsiewski (1976).

consists of foldlike-contorted pebbly clay. Vertical cracks in the clay form polygons of the surface of the bed. Compressed wood from the top of the pebbly clay has been dated at 6,350 ± 200 RCYBP (Winkler, 1962).

Fossiliferous Silty Clays

The basal pebbly clay is overlain by a calcareous and carbonaceous blue-black silty clay. A second silty clay occurs upsection, and it is separated from the basal clay by 0 to 3 ft of fine-grained sand. The silty clays are highly fossiliferous and contain disseminated and compacted plant debris and a fauna of gastropods, pelecypods, ostracods, turtles, and fish (Gutschick and Gonsiewski, 1976). The basal clay is exposed along the shoreline for 2 mi. It has also been traced landward by examining vibracores and ditches to just north of Beverly Drive. The top of the basal clay has been dated at 4,690 ± 200 RCYBP (Gutschick and Gonsiewski, 1976). The upper clay cannot be traced landward; it pinches out westward into the sands described below. This clay has been dated at 5,475 ± 250 RCYBP (Winkler, 1962).

Planar Cross-Stratified Sands

The fossiliferous silty clays are overlain and interbedded with 6 to 8 ft of planar cross-stratified medium-grained sand. Foresets are 20 to 25 ft long and concave upward (fig. 6-2). Low-angle truncation, as well as discontinuous layers of pebbles along the foresets, are common. The medium-grained sand grades laterally (eastward) and upsection into planar cross-stratified fine-grained sand (fig. 6-2). Foresets can be traced downdip into the clay, where they become intercalated with organic-rich clay and peat layers. Micro-trough cross-stratification and wavy, ripple, and flaser bedding occur along the foresets. The sequence from medium-grained sand with pebbly horizons to fine-grained sand with mud layers is repeated at least three times along the length of the Mt. Baldy exposure (west to east). On the third cycle, the foresets of the fine-grained sand do not extend into the silty clay, but they flatten and become intercalated with wavy organic-rich clay layers (fig. 6-3).

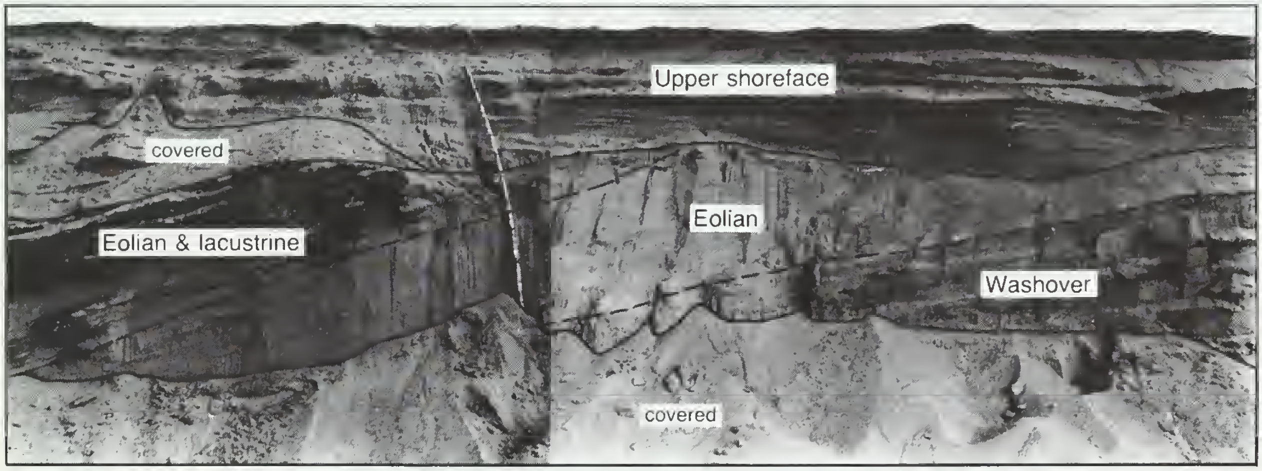


Figure 6-2. Composite photograph showing a washover to eolian and lacustrine cycle at the Mt. Baldy section. The planar cross-stratified washover and eolian deposits are overlain by subhorizontal, parallel-laminated upper shoreface deposits. View is to the southeast; scale is 6 ft long.

Parallel-Laminated and Trough Cross-Stratified Sands

Foresets of the planar cross-stratified sands are truncated upward by a very irregular and erosional contact at the base of 3 to 6 ft of horizontal to subhorizontal parallel-laminated and trough cross-stratified medium- and coarse-grained sand (figs. 6-2 and 6-3). The parallel-laminated sand is common in the upper part of the sequence and decreases in abundance eastward along the shoreline. Dip directions in the trough cross-stratified beds indicate both alongshore and offshore sediment dispersal. Offshore-dipping troughs are larger and coarser than shore parallel-dipping troughs and make up most of the basal past of the unit (fig. 6-3). The shore-parallel dipping troughs are interbedded with the parallel-laminated sand in the upper part of the sequence and are slightly coarser than the parallel-laminated sand.

DISCUSSION

The basal pebbly clay at the Mt. Baldy section can be traced landward in vibracores and water wells to where it crops out as part of the Lake Border Moraine. This unit has also been traced under Lake Michigan as the Wadsworth

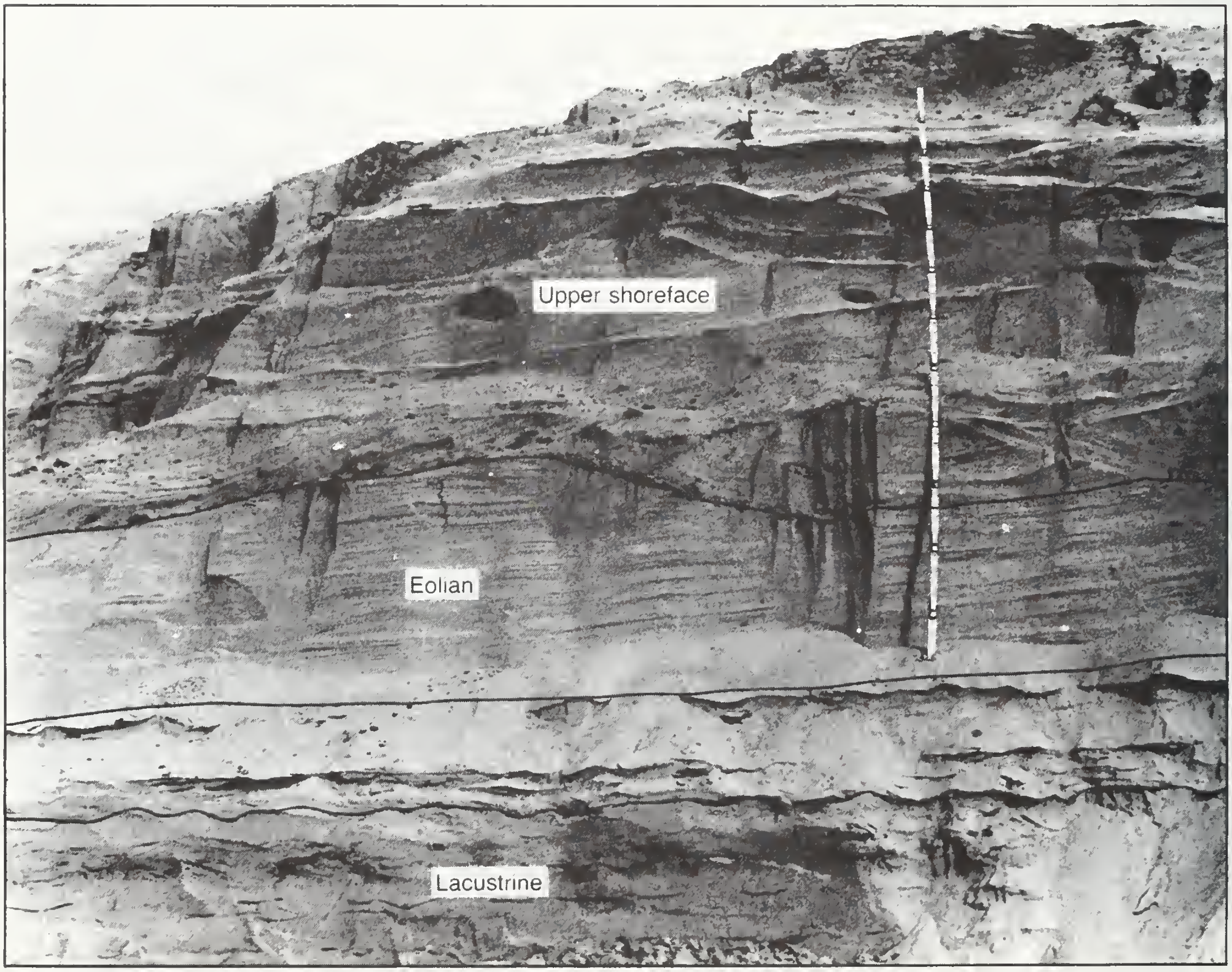


Figure 6-3. Eastern part of the Mt. Baldy section. Note the coarser grained trough cross-stratified sands in the basal part of the upper shoreface deposits and the nearly horizontal eolian sands. View is to the southeast; scale is 6 ft long.

Till Member of the Wedron Formation (Lineback and others, 1974). The date of 6,350 ± 200 RCYBP on the compressed wood above the pebbly clay indicates that the till was exposed during the Chippewa low phase.

The silty clays are interpreted as having formed in a lacustrine to paludal environment (Winkler, 1962; Gutschick and Gonsiewski, 1976). Because no topographic low of sufficient magnitude to permit widespread ponding exists in the underlying till, I suggest that a barrier beach existed lakeward of the Mt. Baldy area during the development of the lower and upper silty clays. On the basis of the available dates (although they are not sequential), the beach was in existence for about 1,500 years. This temporary high stage following the Lake Chippewa low phase has been suggested by Larsen (1985b).

Landward migration of the barrier beach and the establishment of the Nipissing I phase are recorded in the planar cross-stratified sands overlying the lower silty clay and interbedded with the upper silty clay. The medium-grained planar cross-stratified sand is interpreted as a washover deposit (cf. Schwartz, 1982) that entered the back-barrier basin during storm conditions. Washover is enhanced by accelerated periods of lake-level rise. Stable conditions are recorded by the fine-grained and planar cross-stratified eolian sands and by reestablishment of lacustrine and paludal conditions landward of the barrier. During the third cycle of washover to eolian deposition, the back-barrier basin was filled, and the development of lacustrine and paludal conditions was prohibited.

The overlying parallel-laminated and trough cross-stratified sand is upper shoreface deposit of the Nipissing I phase. The shore parallel-oriented trough cross-stratified sand is interpreted as long-shore trough deposits, and the coarser, offshore-oriented troughs were probably formed by rip currents (cf. Davidson-Arnott and Greenwood, 1974, 1976; Hunter and others, 1979; Greenwood and Davidson-Arnott, 1979). The parallel-laminated sand is interpreted as seaward-slope bar deposits (cf. Fraser and Hester, 1977). The exposure at Mt. Baldy is slightly oblique (5° to 10°) to the paleoshoreline of the Nipissing I phase beach. The decrease in abundance to the east of the parallel-laminated deposits is due to the more landward view of the shoreline in an easterly direction. I have followed the exposure at Mt. Baldy into Michigan City, but no foreshore deposits have been observed. Vibracores from the west end of the Indiana Dunes National Lakeshore have recovered foreshore deposits, and water wells through the Tolleston dune/beach complex at Beverely Shores also have encountered gravels of a probable beach origin. The maximum elevation for the foreshore deposits is 603 ft above msl.

A sequence similar to that at the Mt. Baldy section is exposed at the Central Avenue beach (fig. 6-4). The upper silty clay and washover deposits, however, are not present. Larsen (1985b) reported beach gravels at the Central Avenue exposure. I have not observed foreshore deposits at this section.

SUMMARY

The sequence of sedimentary deposits exposed along the shoreline on the east end of the Indiana Dunes National Lakeshore records the transgression from the Lake Chippewa low-water phase to the Nipissing I high-water phase.

The landward translation of a barrier beach is indicated by an interbedding of washover, eolian, and lacustrine/paludal deposits. Overlying upper shoreface sediments were formed during the Nipissing I phase. Vibracoring and drilling within the Lakeshore establishes the maximum elevation for the Nipissing I phase on the southern shore of Lake Michigan at 603 ft above msl.

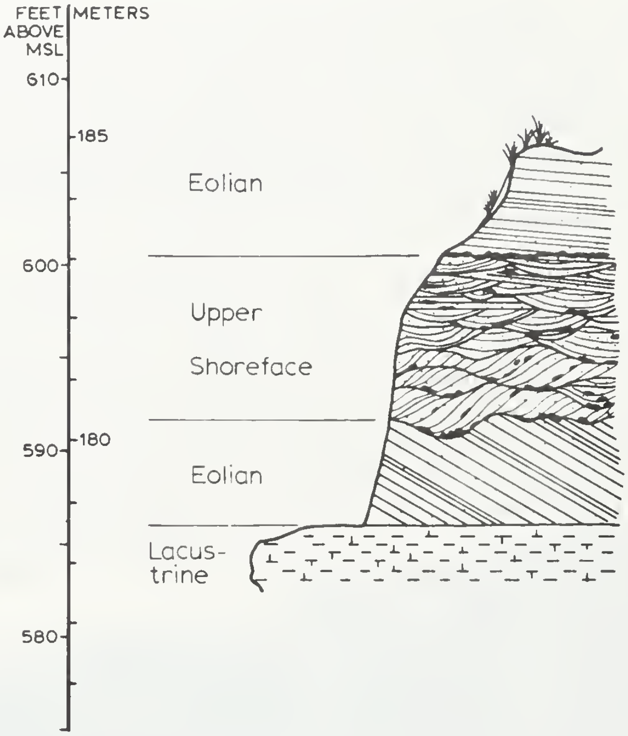
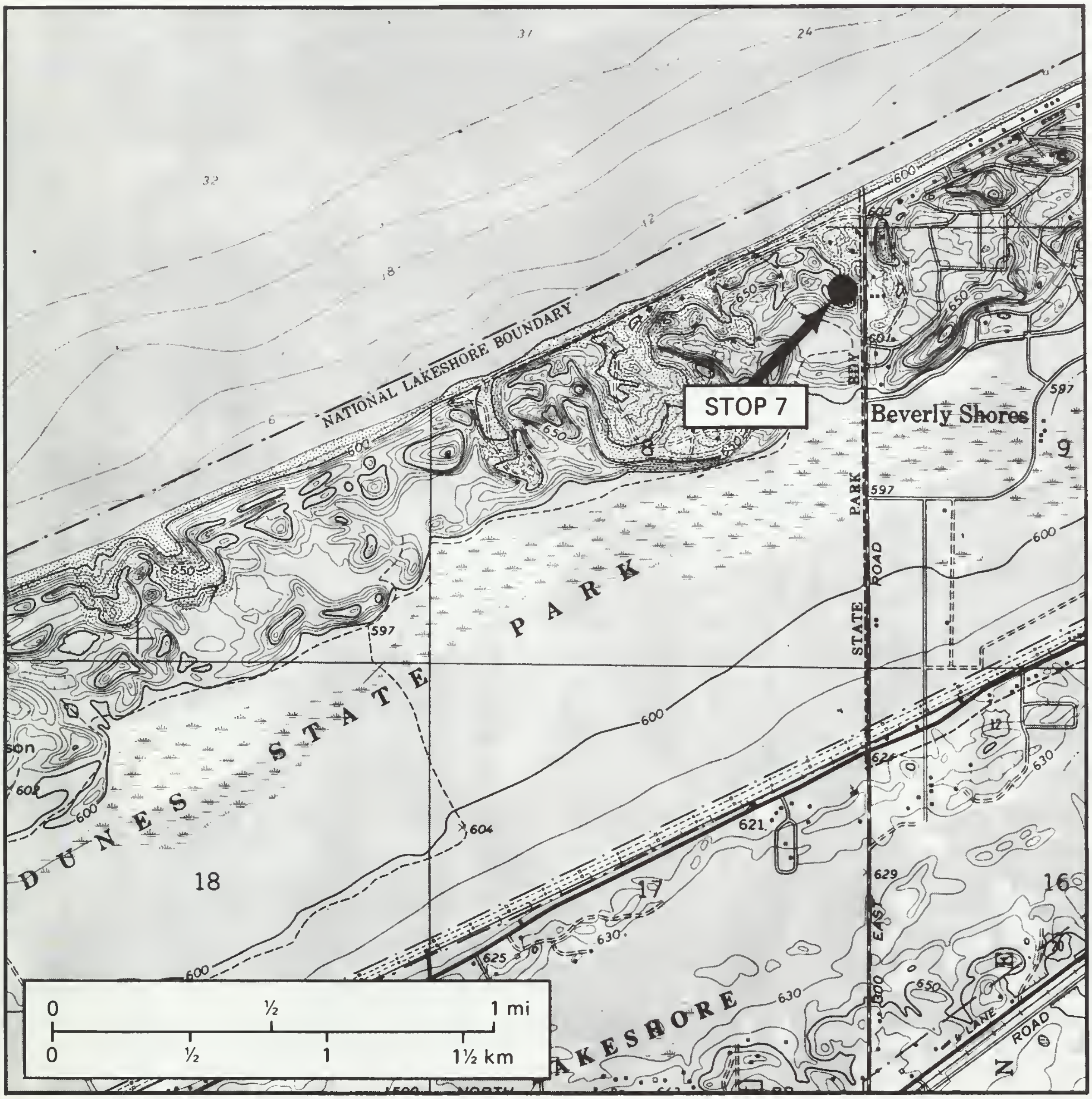


Figure 6-4. Stratigraphic section at the Central Avenue beach.

LATE HOLOCENE DUNE FORMATION, EROSION, AND VEGETATIONAL DEVELOPMENT ALONG THE SOUTHERN SHORE OF LAKE MICHIGAN

Kenneth L. Cole



STOP 7. Indiana Dunes State Park, Kemil Road

NE NE Sec. 8, T37N, R5W, Porter County, IN

In this classic area the theory of plant succession was first applied to vegetational types along a series of dunes of different ages. We will examine a vegetational transect and discuss the possible effects of additional factors on the successional sequence. Other discussion topics: "ghost forests," modern shore erosion, and the pollen and heavy metal record of Cowles Bog, a calcareous fen with a history that spans most of the Holocene.

INTRODUCTION

Kemil Road runs along the eastern boundary of Indiana Dunes State Park, transecting a variety of substrate and habitat types between Lake Michigan and U.S. 12. This stop provides several topics of interest for Quaternary scientists: 1) a transect through dunes of differing ages demonstrating vegetational succession, 2) recent and imminent erosion of the lakeshore, and 3) stratigraphic, palynological, and heavy metal depositional history within the last 8,000 years.

Transect of Vegetational Succession

Kemil Road runs south of Lake Michigan for about 1 km to U.S. 12, cutting through several habitat types from open beach, stabilized foredune, forested dune, backdune, interdunal wetland (Great Marsh), to the Calumet dune. The series of vegetational types found south of Lake Michigan were used as evidence of primary plant succession when Henry Cowles first introduced successional theory to North America (Cowles, 1899). This series of dunes of differing ages creates a natural laboratory for the analysis of long-term soil development and plant succession (Olson, 1958).

The dunes transected along Kemil Road range in age from modern (active today) at the shoreline to greater than 12,000 years north of the Calumet dune. The stratigraphy is similar to that shown in figure 5-2 from Lakeshore County Road (2 km to the east). The massive dunes close to the lake belong to the Tolleston dune complex. The Tolleston dunes were deposited within the last 6000 years, but the age of the surface may date from any time within the late Holocene because blowouts have exposed fresh surfaces within the shifting sands. An interdunal wetland, "The Great Marsh," lies between the Tolleston and the Calumet dunes. U.S. 12 runs along the northern face of the Calumet dunes, which were deposited during or after the Calumet high-water phase of glacial Lake Chicago, 11,800 to 11,200 BP (Hansel et al., 1985b).

The plant successional series begins with freshly exposed sand at the beach. Pioneer herbs such as sea rocket (*Cakile edentula*) and common bugseed (*Corispermum hyssopifolium*) will grow even on freshly disturbed sand within the swash zone. At slightly higher elevations, marram grass (*Ammophila breviligulata*) and sand reed grass (*Calamovilfa longifolia*) grow and stabilize the blowing sand. These grasses reproduce through stolons running beneath the sand and can grow quickly to keep pace with sand deposition. Shrubs and small trees such as sand cherry (*Prunus pumila*), cottonwood (*Populus deltoides*), and jack pine (*Pinus banksiana*) are supported above the swash zone on partially stabilized dunes (foredune).

On dunes that have been stabilized for longer periods, little bluestem (*Andropogon scoparious*) becomes the important grass species. White pine (*Pinus strobus*) and basswood (*Tilia americana*) are important trees along the top and windward side of the foredunes. Basswood has the ability to grow quickly and stay alive even while being buried in blowing sand. White pine cannot tolerate burial, but the abundant "ghost forests" of buried, and subsequently uncovered, white pine testify to the fact that it was abundant on the foredunes in the recent past. Two ghost forests near Kemil Road have been dated at 200 ± 70 (GX-11588) and 420 ± 70 RCYBP (GX-11590). This Kemil Road site supports one of the few remaining stands of white pine existing along the

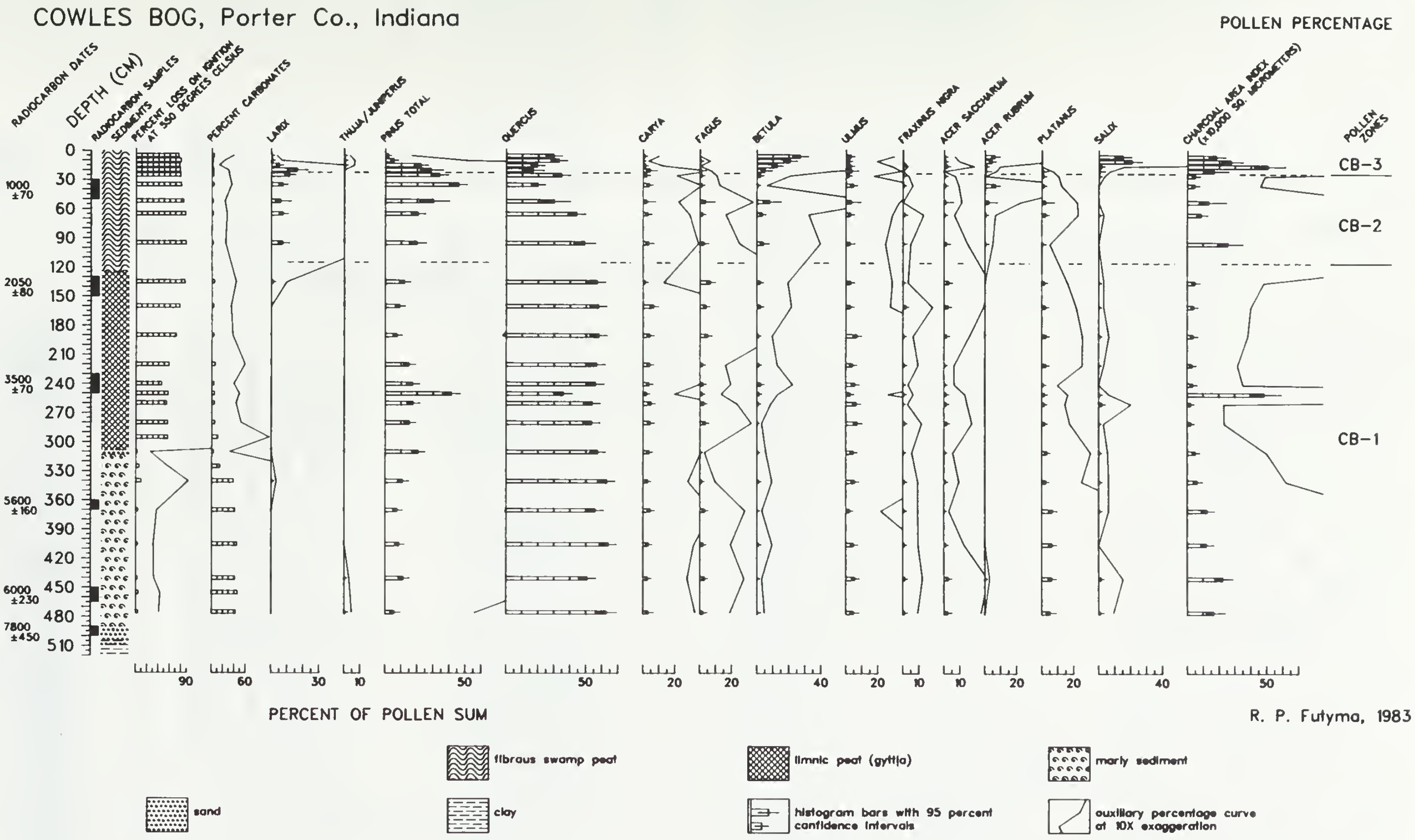


Figure 7-1a. Pollen percentage diagram from a red maple swamp, Cowles Bog, in the Great Marsh, 6 km west of Kemil Road. Selected taxa are shown from Futyma, 1985.

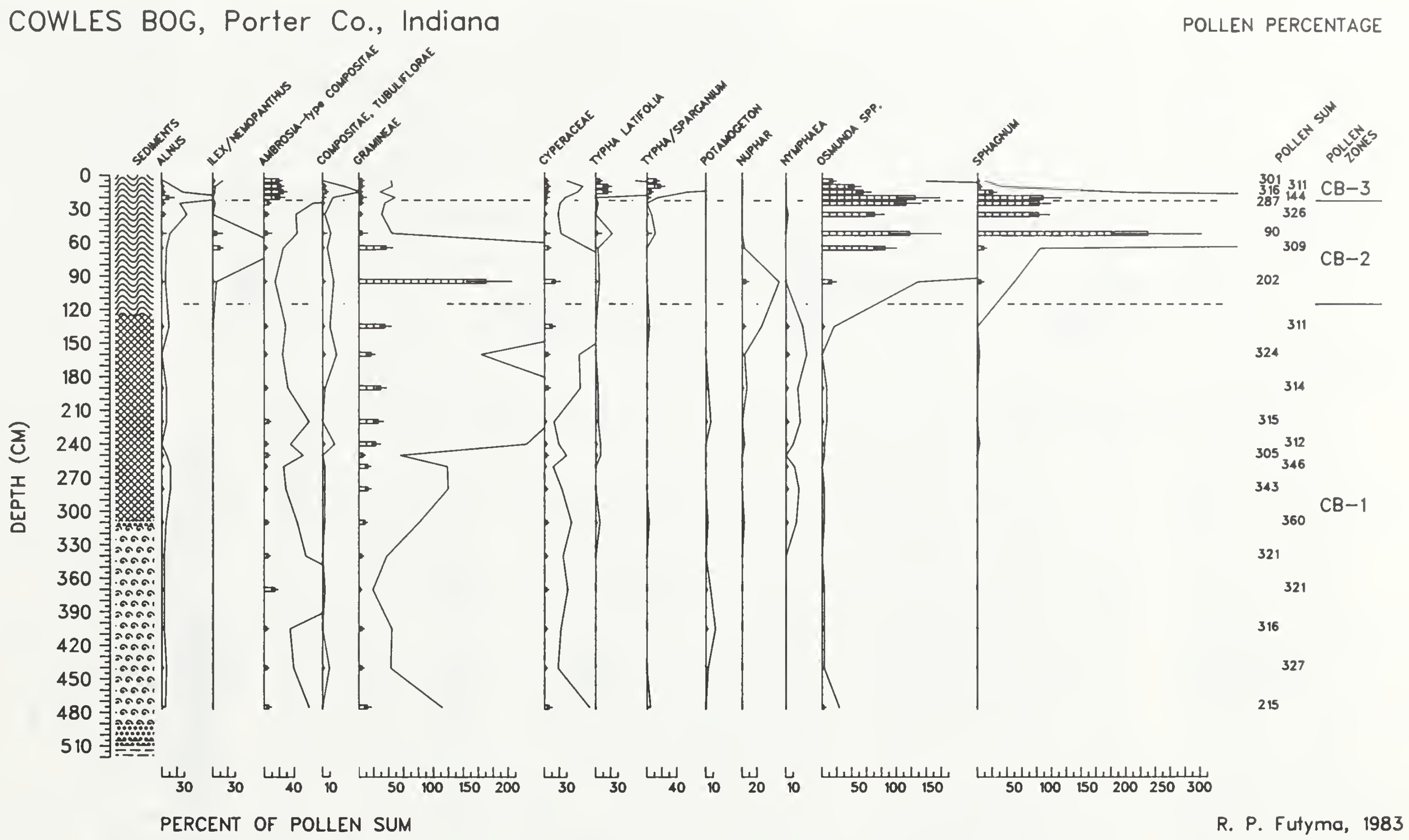


Figure 7-1b. Pollen percentage diagram from a red maple swamp, Cowles Bog, in the Great Marsh, 6 km west of Kemil Road. Selected taxa are shown from Futyma, 1985.

shoreline in Indiana. Historical photographs, fossil pollen records, land survey descriptions, and accounts of loggers indicate that most of the white pine disappeared just prior to this century because of logging. Wildfire suppression and air pollution have also been detrimental to the white pines.

The predominant tree on the forested dunes is black oak (*Quercus uelutina*), although white oak (*Quercus alba*) and sassafras (*Sassafras albidum*) are also abundant in the oak forest covering the majority of the Tolleston dunes today. The oak communities on the Calumet dunes are similar to those of the older portions of the Tolleston dunes but have several more mesophytic species such as hickory (*Carya ovata*) and greater predominance of white oak and black cherry (*Prunus serotina*).

Although successional relationships are not as clearly illustrated along Kemil Road as they were in Gary before industrialization, the successional sequence present along Kemil Road is probably the least disturbed remaining transect south of Lake Michigan. However, the effect of several additional variables on the successional sequence has yet to be properly evaluated. Many fire ecologists (e.g., Henderson and Long, 1984) are of the opinion that successional patterns observed during the last century are more strongly correlated to fire suppression than to succession. Also, the effect of climatic variability along the vegetational transect south of the lake has never been evaluated. Wind, temperature, and humidity vary greatly from the lakeshore to the lee side of the foredunes over a distance of only several hundred meters.

Erosion Along Lakefront Drive

During the summer and fall of 1985, Lakefront Drive near Kemil Road began to be undermined by wave action from the rising lake level. This beach, directly downdrift from protected structures in western Beverly Shores, was showing high rates of erosion. An emergency rock revetment was installed here in the winter of 1985-86 by the Army Corps of Engineers. Erosion has since greatly increased downdrift from the revetment.

Great Marsh Stratigraphy

The interdunal wetland between the Tolleston and Calumet dunes has been called the Great Marsh. It extends from Cowles Bog to near Mount Baldy. Along Kemil Road this wetland is mostly forested with a red maple (*Acer rubrum*) swamp, although some cattail (*Typha spp*) marshes are visible as well. Historical photographs and pollen stratigraphy demonstrate that both of these communities are recent invaders of this century.

Cowles Bog, a calcareous fen in the Great Marsh named for Henry Cowles, is 5 km to the west of Kemil Road. This portion of the Great Marsh has been the site of several paleocological studies. Figure 7-1 shows the results of a palynological analysis completed by Richard Futyma (Futyma, 1985). This pollen record, taken from what is now a red maple swamp, spans most of the Holocene. Interesting changes in the pollen sequence included: 1) a decline in pine during the last 150 years, probably due to lumbering, 2) a decline in Tamarack (*Larix*) within the last 100 years, probably caused by ditching and artificial drainage of the wetlands, 3) a tremendous rise in ragweed (*Ambrosia*)

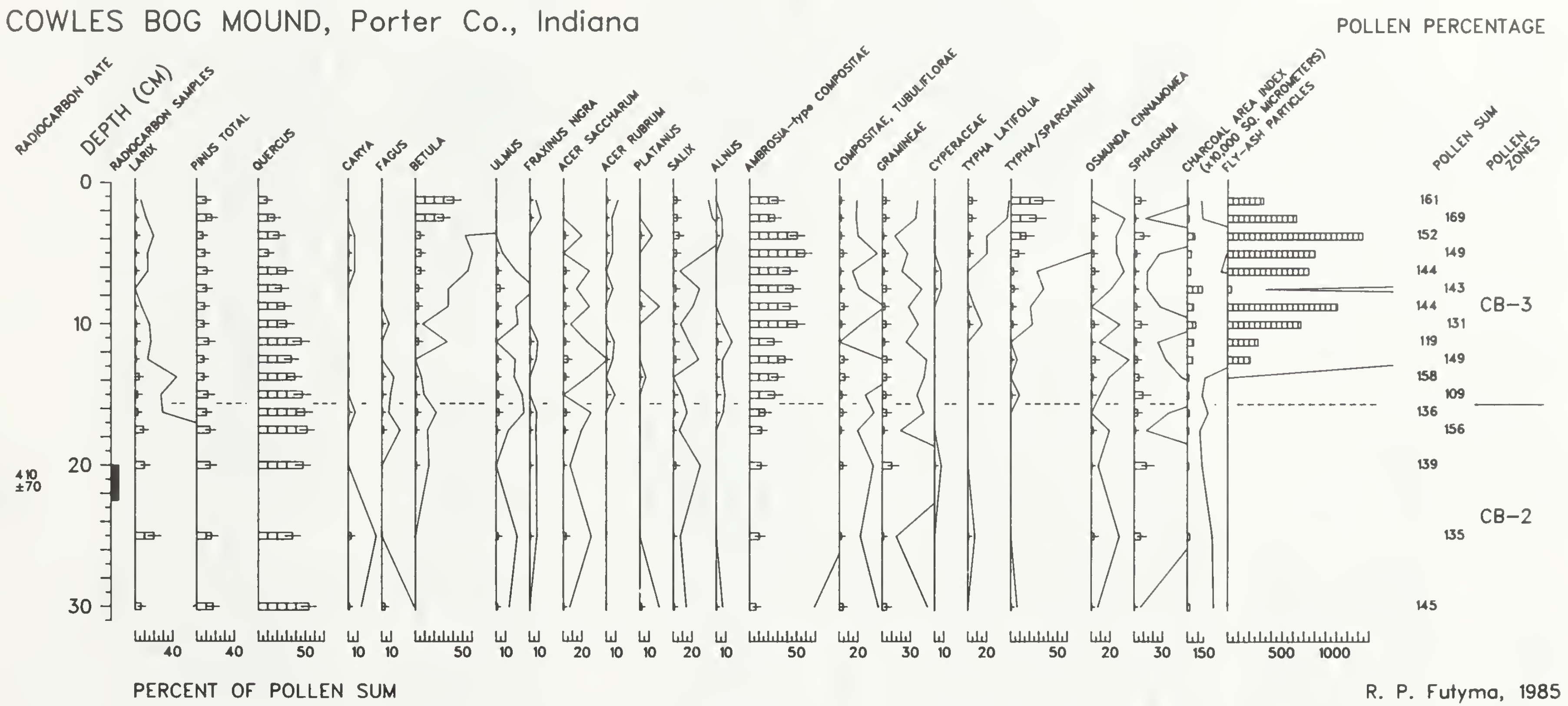
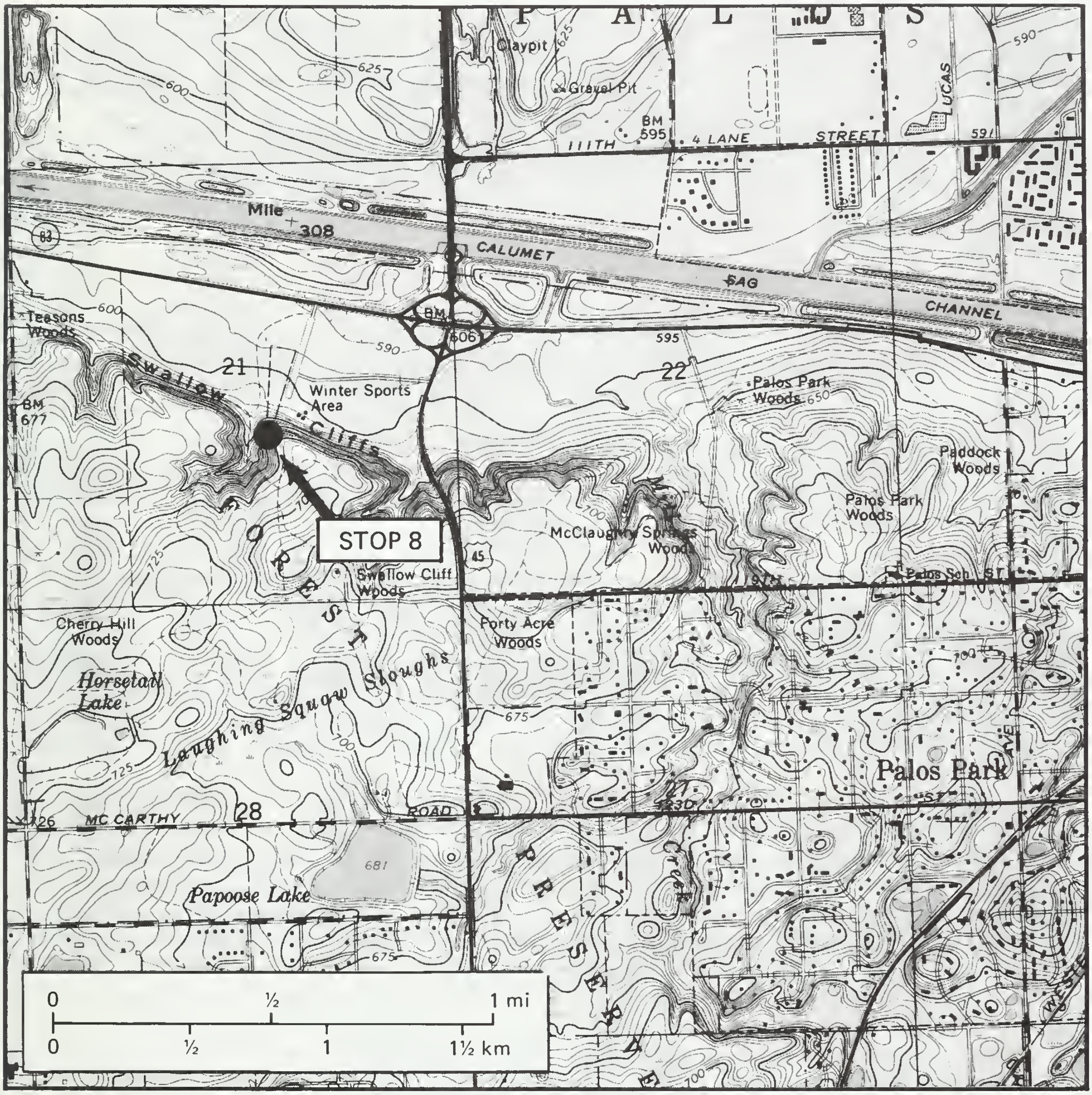


Figure 7-2. Pollen percentage diagram emphasizing the last 500 years from Cowles Bog. Selected taxa are shown from Futyma (unpublished report). The dashed line between zones CB2 and CB3 has been dated to about 1850 A.D. by D. Engstrom (unpublished report) using a lead-210 series.

associated with land clearance, and 4) the recent rise of red maple (Acer rubrum), birch (Betula), and cattail (Typha) in the wetland.

Another core (fig. 7-2), taken beneath a relict stand of pine and tamarack, provides information on the last 500 years. Most of the large changes seen within both cores have occurred within the last 130 years. The rise in ragweed (Ambrosia) is marked as the bottom of zone CB-3. This level has been inferred to be about 1850 A.D. from extrapolation of the sedimentation rates from radiocarbon and lead-120 chronologies (Englstrom, unpublished report). Change in the fire regime and pollution, and the introduction of exotic species may have also played roles in the rapid rates of change observed since 1850.

The sediment cores from Cowles Bog show heavy concentrations of fly-ash particles as the site is downwind of two steel mills and one coal-fired power plant. Heavy metal profiles of the last 500 years of deposition demonstrate large increases in heavy metal content. For example, lead increases from a background of 0.6 ppm to greater than 4.5 ppm within the last 150 years. These results will be shown along with a lead-210 profile completed by Dan Engstrom during the field trip.



STOP 8. Toboggan Slides Overlook

NW NW SE Sec. 21, T37N, R12E, Cook County, IL

This site overlooks the southern arm (Sag channel) of the Chicago outlet, an overflow channel for high-level lakes in the Lake Michigan basin during the Glenwood, Calumet, and Nipissing lake phases. At this stop we will discuss the evolution of the Chicago outlet and causes of lake level stabilization.

INTRODUCTION

The Glenwood, Calumet, and Toleston beaches occur at progressively lower elevations at the south end of Lake Michigan--635-640 ft (194-195 m), 615-620 ft (188-189 m), and 600-605 ft (183-184 m), respectively (fig. I-6). Their formation has generally been attributed to glacial Lake Chicago, the proglacial lake that existed in the Lake Michigan basin during retreat of the late Wisconsinan ice sheet. Lake Chicago drained by way of the Chicago outlet, an overflow channel that formed a spillway through the Tinley and Valparaiso Moraines at the southwest end of the lake basin (fig. I-6) At this stop we will discuss the timing and possible causes of lake level stabilization and the evolution and role of the Chicago outlet in lake history.

DESCRIPTION OF THE CHICAGO OUTLET AREA

The Chicago outlet is a steep-sided, flat-floored valley through the 12-mi upland belt of the Tinley and Valparaiso Moraines at the southwest end of Lake Michigan (fig. I-6). The valley is trench-shaped in cross-section and Y-shaped with straight sides in plan. It consists of a northern arm (Des Plaines channel) and a southern arm (Sag channel) that converge to form a westward-pointing Y. East of their confluence, the Des Plaines and Sag channels are less than 1 mi wide, and 6 mi and 5 mi long, respectively. The confluent portion of the valley is 6 mi long and 1 mi wide. The valley averages about 75 ft deep. The floor of the valley of the Chicago outlet has been disturbed by the dredging of three canals (the Illinois and Michigan Canal, the Sanitary and Ship Canal, and the Calumet Sag Channel) and a diversion channel for the Des Plaines River, which flowed through the Des Plaines channel. The gradient of the valley is low--so low, in fact, that it has been referred to as the "12 mile level" (Goldthwait, 1909). The low gradient of the valley is reflected in the low bottom gradient of the canals, 1 ft in 7 mi in the Des Plaines channel and 1 ft in 7.5 mi in the Sag channel (Bretz, 1955).

East of the outlet is the low drainage divide between St. Lawrence and Mississippi drainage; it is only about 10-12 ft above modern Lake Michigan (580 ft) and consists of a poorly drained slough on the Chicago lake plain. The Chicago outlet valley is cut into glacial drift and bedrock (Silurian dolomite); a bedrock sill is encountered at 590 ft. Goldthwait (1909) observed at least 85 ft of relief on the bedrock surface in the outlet. Rock crops out 50 ft above the valley floor at Lemont, descends to the valley floor about 2 mi east of Lemont and to near that level 1 mile south of Lemont. Leverett (1897) reported glacial striae and polish on the bedrock surface in the valley floor near Willow Springs (Des Plaines channel) and at the base of the bluffs near Lemont, where Goldthwait (1909) also observed such features. The gradient of the Des Plaines River steepens markedly west of the Valparaiso front where the valley curves southward; between Romeo and Joliet it descends 80 ft in 10 mi.

The morainic upland of the Valparaiso and Tinley Moraines forms a U-shaped belt around the south end of the Lake Michigan basin. The topography is hummocky. This is especially true in the triangular-shaped portion between the two arms of the outlet valley; it contains large kettles with lakes and sloughs. Most of the valley walls of the outlet are composed of glacial drift. Two drifts have been recognized, the upper clayey Wadsworth Till

Member and the lower bouldery, silty Lemont drift. Bretz (1955) observed that the two drifts drape down into the valley (e.g., eskers and kames extend from the upland to an elevation of 610 ft in the valley). Outwash terraces, fields of dolomite boulders, and peat beds have been reported near the heads of the outlet channels.

MODELS OF LAKE LEVEL STABILIZATION

With two exceptions (Wright, 1918; Mickelson et al., 1985), previous geologists (e.g., Leverett, 1897; Alden, 1902; Goldthwait, 1908; Bretz, 1951; Hough, 1958; Willman, 1971) have related the level of Lake Chicago to the threshold altitude of the Chicago outlet. The three abandoned beaches at the south end of the Lake Michigan basin are at about 60 ft, 40 ft, and 20 ft above present lake level; the abandoned lake outlet is cut to bedrock at about 10 ft above present lake level. On the basis of these relationships the progressive lowering of Lake Chicago from the highest to the middle to the lowest beach generally has been attributed to outlet downcutting. Because no intermediate beaches were observed between the three prominent ones, it was assumed that outlet downcutting was rapid and episodic rather than gradual. This outlet-control model of lake level stabilization was extensively developed by Bretz (1951, 1955), who offered explanations for the causes of lake level stabilization and outlet downcutting and correlated these events with other glacial and postglacial events in the region.

On the basis of field evidence, Bretz (1951) maintained that the dam for Lake Chicago was not the Valparaiso Moraine, but rather the younger Tinley Moraine and its valley train, which extended for several miles down valley. He observed that the elevation of the surface of this outwash was at least as high as 630 ft and its base was at 610 ft. He concluded that the pre-Tinley valley was eroded at least to that elevation and that it was the Tinley drift dam that "controlled" the level of Lake Chicago.

Bretz speculated that lake level stabilized during the Glenwood and Calumet phases because erosion-resistant boulder lags formed in the head of the outlet channel and retarded incision. He asserted that the boulder lags formed when discharge came solely from Lake Chicago and that they were swept away when discharge increased greatly with the addition of drainage from glacial lakes in the Huron/Erie basins via the glacial Grand Valley across Michigan. Supposedly, after the Chicago outlet had been cut to bedrock, the lake was stabilized at the Toleston level. Bretz correlated the first episode of downcutting and the lowering to the Calumet level to an influx of Huron/Erie discharge (Lakes Maumee, Arkona, and Whittlesey) during the Port Huron advance, and the second episode of downcutting (which exposed the bedrock sill) and the lowering to the Toleston level to an influx of Huron/Erie discharge (Lake Warren) during post-Two Creeks time (equivalent to Two Rivers glacial phase).

An alternative to the outlet-control model of lake level stabilization is a discharge-control model. Wright (1918) was the first to suggest a relationship between lake level and the amount of water coming into the lake; he called for an influx of water from the east to account for a rise to the Calumet level after the outlet had already been cut to bedrock.

More recently, Larsen (1985), Hansel et al. (1985b), and Mickelson et al. (1985) have questioned the outlet-control model. Larsen concluded that during late Holocene lake level fluctuations, downcutting of the St. Clair River kept pace with uplift of the outlet, causing the threshold altitude of the outlet river at Port Huron to remain constant during this time. Hansel et al. (1985b) showed that new radiocarbon age control on the Glenwood, Calumet, and Toleston beaches makes the timing of events in Bretz' model of outlet downcutting untenable. Mickelson et al. (1985) argued that the changes of lake level between the Glenwood, Calumet, and Nipissing phases can be explained by changes in the amount of water coming into the lake from glacial melting and precipitation. These arguments will be further developed after radiocarbon evidence for the timing of lake phases and outlet downcutting is discussed.

TIMING AND CORRELATION OF HIGH LAKE PHASES

Recent work on lake history in the southern Lake Michigan area has concentrated on establishing radiocarbon age control on the type Glenwood, Calumet, and Toleston deposits and the deposits preserved in the Chicago outlet (Hansel et al., 1985b; Hansel, 1985; Larsen, 1985a, 1985b; Schneider et al., 1979). A summary of the radiocarbon age control on high lake phases and drainage through the Chicago outlet is included here. A more complete discussion can be found in Hansel et al., 1985b.

Shoreline Record

Only three of the high lake phases proposed by Bretz (1951) and Willman (1971) (fig. 8-2) are confirmed by radiocarbon dates. These include a pre-Two Creeks Glenwood phase during which the Glenwood beach formed (between 12,700 and 12,000 BP), a post-Two Creeks Calumet phase during which the Calumet beach formed (between 11,800 and 11,000 BP), and a middle Holocene Nipissing phase during which the Toleston beach formed (between 6000 and 4000 BP).

There is no evidence, however, for any pre-Port Huron Glenwood level or pre-Two Creeks Calumet level Lake Chicago events nor for any pre-Chippewa Toleston level Lake Chicago or Lake Algonquin events, each of which was proposed by one or more earlier geologists (e.g., Leverett and Taylor, 1915; Bretz, 1955; Hough, 1966; Willman, 1971; Eschman and Farrand, 1970; Evenson, 1973) (fig. 8-2). Larsen (1985b) has suggested that the abandoned Algonquin beaches and terraces at the north end of the basin, which have been interpreted as uplifted Toleston level landforms (Goldthwait, 1908), actually plunge beneath the Toleston level (Nipissing) features in the area of the Algonquin "hingeline." By this interpretation, these Algonquin landforms would reflect a low-water phase (Kirkfield, fig. I-7) in the Lake Michigan basin.

Figure 8-3 summarizes the radiocarbon age control on the three high lake phases in the Lake Michigan basin. Four dates on wood from Glenwood level deposits ranged between 12,660 and 12,220 BP, indicating a pre-Two Creeks Glenwood lake phase. Eleven dates on wood from Calumet level deposits ranged between 11,870 and 11,000 BP, indicating a post-Two Creeks Calumet lake phase. Eleven dates on wood from Toleston level deposits ranged between 6350 and 4030 BP. Five dates on wood or shell from the Bowmanville deposits (Baker,

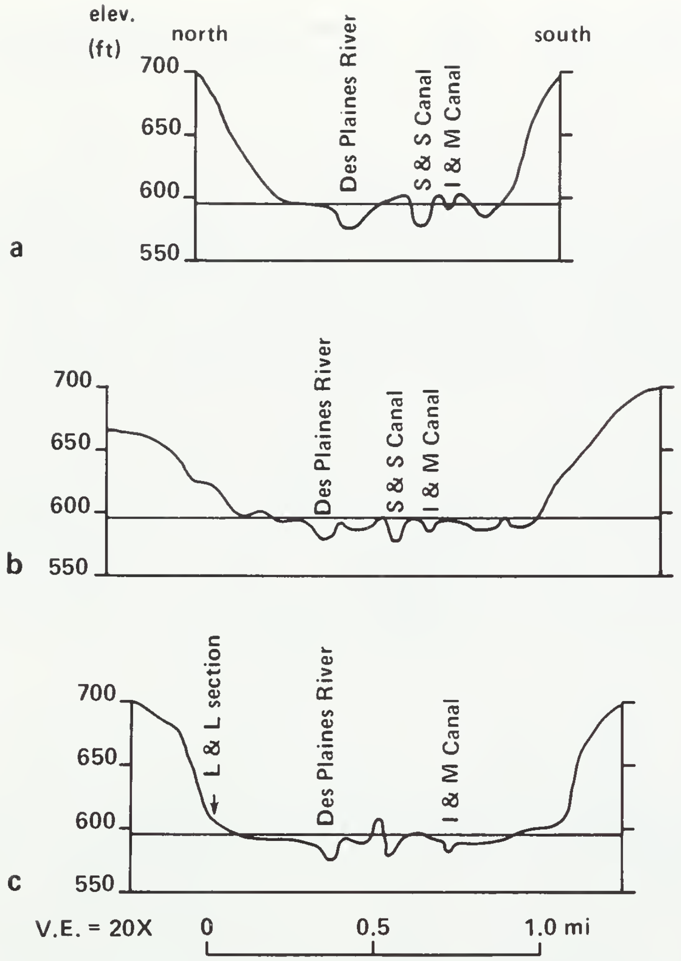


Figure 8-1. Valley cross sections in the Chicago outlet spillway of the Des Plaines Valley. Cross section locations shown on figure I-6.

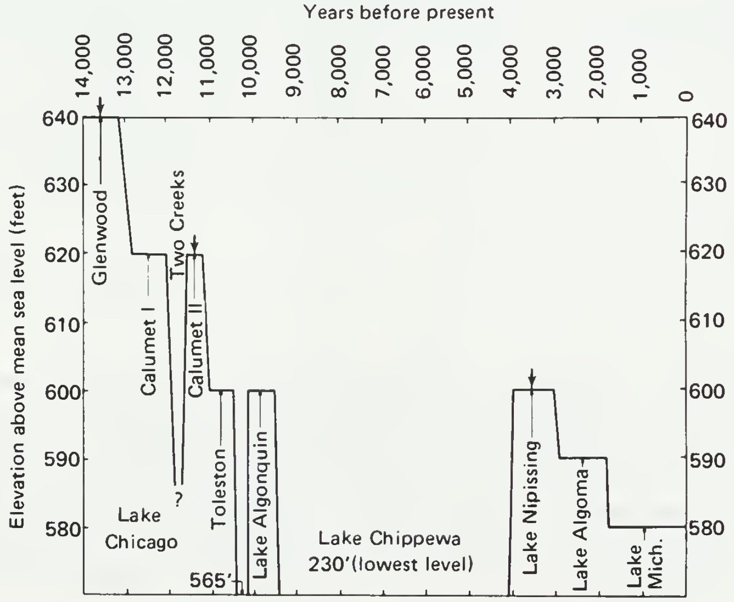


Figure 8-2. Altitudes and ages of lakes in the southern part of the Lake Michigan basin (Willman, 1971). Arrows indicate lake phases confirmed by radiocarbon dates in Hansel et al. (1985b).

1920) also fall within this range. These data record a postglacial Nipissing phase.

Outlet Record

Peat and wood dates from the outlet are also plotted in figure 8-3. Peat from a core near the eastern edge of the Nipissing Sag channel (fig. I-6) was dated at 6280 ±70 RCYBP. Silt units above and below the peat probably represent Nipissing and Calumet lacustrine deposits, respectively. About a mile to the west along the south side of the Sag channel (fig. I-6), peat units above and below silty clay were dated at 3390 ±70 B.P. and 8690 ±80 RCYBP, respectively; these data provide limiting dates for Nipissing drainage through the outlet. Wood dates from the Land and Lakes section (fig. I-4, Stop 9) along the north side of the channel at the western edge of the Chicago outlet (fig. 9-3) suggest that the channel was cut to bedrock before the Two Creeks low-water phase, which began about 12,000 BP. If this interpretation is correct, the outlet channel at that site was cut to the level of the bedrock sill early in the history of Lake Chicago, i.e., during the Glenwood phase. This interpretation will be discussed at Stop 9.

Summary

The time-distance diagram for the Lake Michigan basin (fig. I-7) summarizes the relationships between lake phases and glacial phases and illustrates how the areal extent of the lake changed through time relative to the Straits of Mackinac at the north end of the basin and the Chicago outlet at the south. The lateral extent, level, and duration of proglacial lakes associated with the Haeger-Lemont and Wadsworth glacial phases are not known, but the existence of lake sediment between till units indicates their existence. During the Glenwood, Calumet, and Nipissing phases, the lake transgressed the present shoreline at the south end of the Lake Michigan basin. The Glenwood lake phase corresponded in time with the pre-Two Creeks Shorewood-Manitowoc (Port Huron) glacial phase, and the Calumet lake phase with the post-Two Creeks Two Rivers glacial phase. The postglacial Nipissing lake phase began when differential uplift of the North Bay outlet caused southward transgression of the lake, and it ended when Holocene climate changes (Larsen, 1985b) and/or incision of the St. Clair River at Port Huron resulted in the lowering of the lake to its present level.

DISCUSSION

The transmorainic portion of the Chicago outlet has a uniform, trenchlike shape that is fairly constant in width at top and bottom, in slope angle of valley sides, and in cross-sectional symmetry (fig. 8-1). Such morphology is indicative of a spillway channel rather than of a river valley (Kehew and Lord, 1986). The absence of terraces in the 12 mi length of the outlet suggests that even during the last phase (Nipissing), the volume of water flowing through the outlet was sufficient to cover the entire floor.

The outlet clearly is located in what once must have been a sag or low place in the moraine. The bedrock walls and striated floor along the channel sides near Lemont and kames and eskers that grade into the channel indicate that the channel predates the Wadsworth glaciation (Bretz, 1955). Bedrock valleys in the area (including this part of the Des Plaines) are filled with Lemont sand and gravel and pre-Lemont diamicton (Horberg and Emery, 1943; Bretz, 1955); thus, a bedrock valley wider than the channel predates the Lemont glaciation as well. The channel may have originated as a subglacial (tunnel) valley during the Lemont-Haeger glaciation but after proglacial Lemont outwash filled preexisting valleys. Drainage in the channel initially was to the west through a valley in the Rockdale Moraine to the Du Page River. Meltwater from the Wadsworth ice sheet and drainage from proglacial lakes subsequently deepened the channel, and at some point in time drainage was diverted to the southwest down the Des Plaines River valley toward Joliet.

If, as the radiocarbon evidence suggests, the outlet was cut (through the drift fill) to bedrock by at least 12,000 years BP, then the threshold altitude of the outlet (about 590 ft) cannot be used as an explanation for the post-Two Creeks transgression of the lake to the Calumet level (615-620 ft). Even without the radiocarbon evidence, it is difficult to explain the lake level sequence envisioned by Bretz (1951) and Willman (1971). For example, they had to argue that there had to have been a pre-Two Creeks Calumet phase because there was no evidence that the lake rose higher than the Calumet level in post-Two Creeks time. Because of this, they reasoned, the outlet must have been cut below the Calumet level in pre-Two Creeks time. Similarly, a second episode of outlet downcutting and a Toleston level lake had to precede the Chippewa low lake phase (fig. 8-2); otherwise the outlet would have remained above the Toleston level during the middle Holocene Nipissing transgression. In addition, inconsistencies exist between the radiocarbon chronology presented in figure 8-3 and the timing of events proposed by Bretz. For example, Bretz called for an influx of water (Lake Warren) from the Huron/Erie basin to cut the outlet and cause a drop to the Toleston level in post-Two Creeks time. However, radiocarbon evidence indicates that a lower eastern outlet (Mohawk) was open for the eastern lakes prior to Two Creeks (MacClintock and Terasmae, 1960; Dreimanis, 1964), so there would have been no influx of water from the Huron/Erie basin to do the required downcutting in post-Two Creeks time.

CONCLUSION

The coincidence in time of the Glenwood phase with the time when discharge from the eastern lakes also drained into Lake Chicago (Port Huron glacial phase), the Calumet phase with the time when drainage was from Lake Chicago alone (Two Rivers glacial phase), and the Nipissing phase with the postglacial middle Holocene transgression that resulted from differential uplift in the basin (fig. I-7) is strong evidence that the changes in lake level may relate to differences in discharge. Furthermore, calculations by Mickelson et al. (1985) indicate that the relative differences in water level at the outlet head can be explained by relative differences in the amount of meltwater runoff plus precipitation being supplied to the Lake Michigan basin during the Glenwood, Calumet, and Nipissing phases. Clearly the Glenwood and Calumet phases occurred when glaciers were in the Lake Michigan and Lake Huron basins. About 2.5 times as much discharge would have been supplied to the Chicago outlet during the Glenwood phase, when drainage from Huron and Erie basins entered Lake Chicago, than during the Calumet phase, when it was supplied

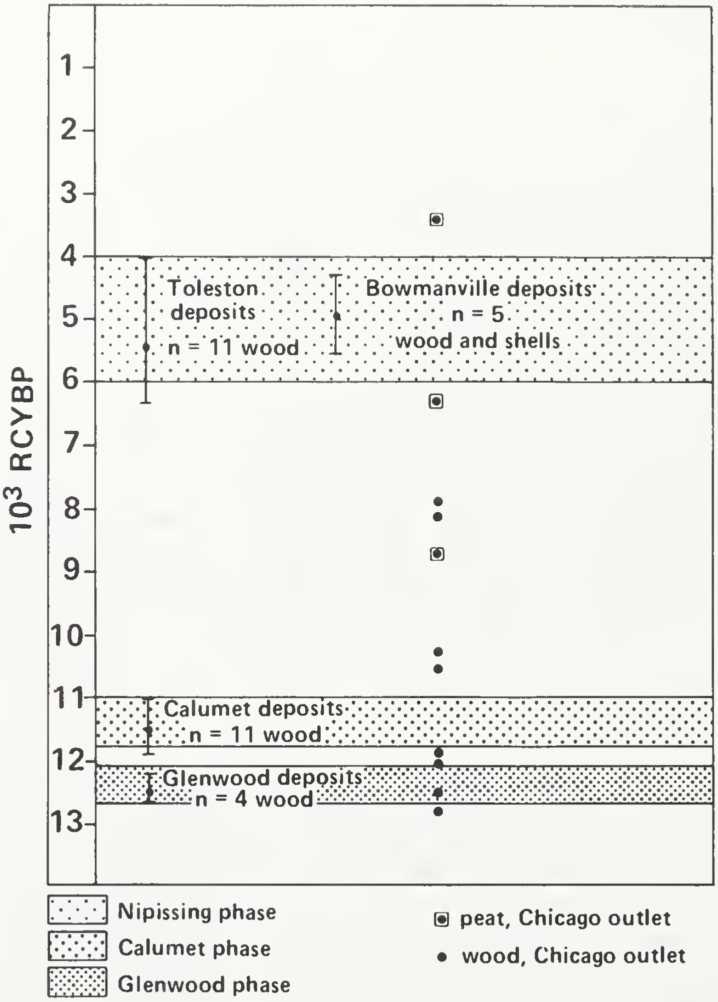
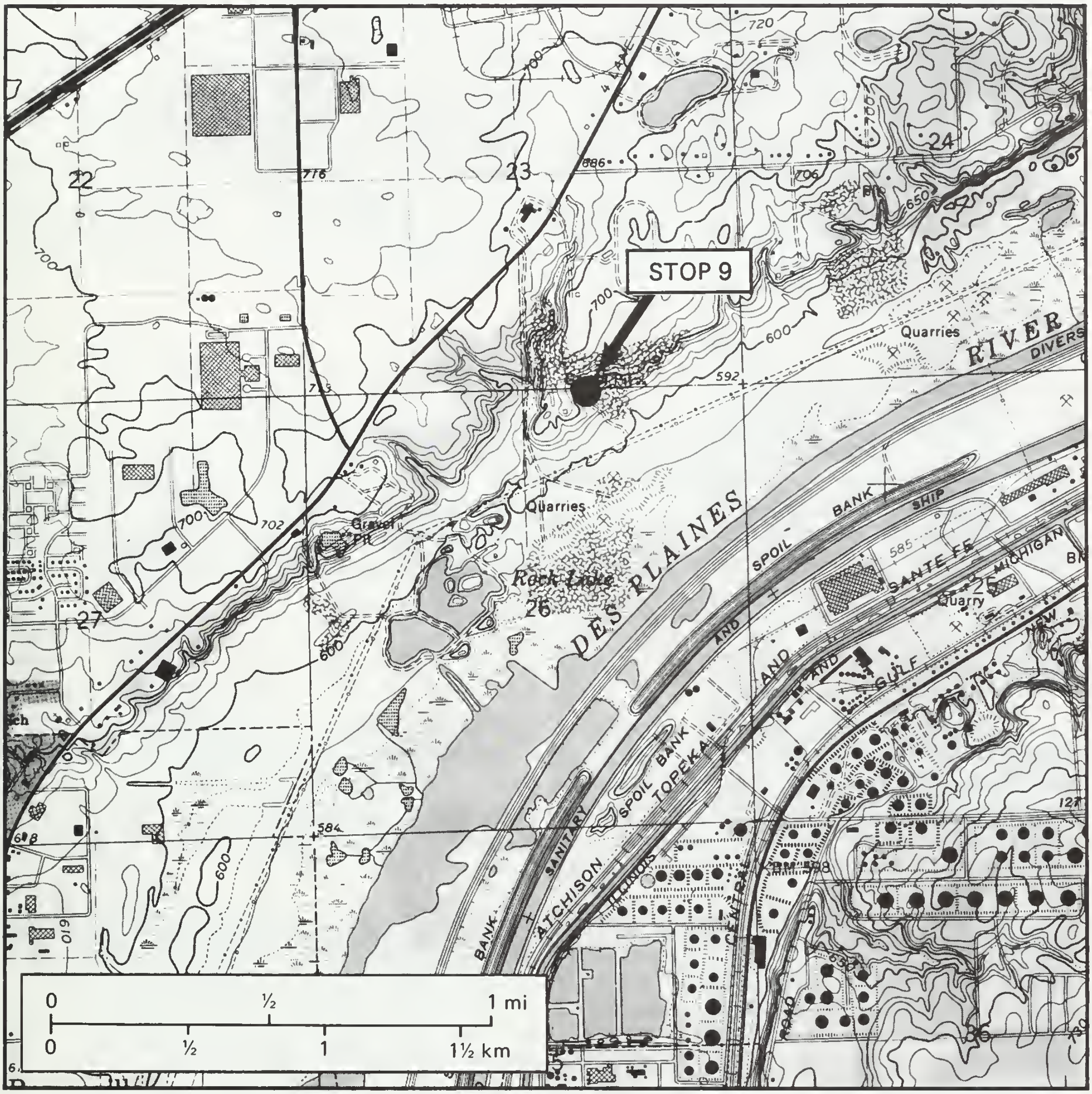


Figure 8-3. Radiocarbon-dated high lake phases, southern Lake Michigan basin. Dots indicate dates from the Chicago outlet.

from Lake Chicago alone; about a third as much would have been supplied during the Nipissing phase when ice had retreated from the area (Hansel and Mickelson, in review). When this evidence is combined with radiocarbon evidence suggesting that the outlet was cut during the Glenwood phase, it presents a strong argument against the downcutting hypothesis that has been used to explain 6 m changes in lake level in the Lake Michigan basin.



STOP 9. Land and Lakes Landfill Section

SW SE Sec. 23, and NE NW NE Sec. 26, T37N, R11E, Will County, IL

The late Quaternary record of the Chicago area is exposed in the walls and in the bottom of the Chicago outlet channel. At this landfill we will examine a bluff exposure of Wadsworth Till Member over Lemont drift, and a bottomland exposure of colluvial and organic sediments in the Chicago outlet.

INTRODUCTION

The Land and Lakes Landfill section is located in the Valparaiso Morainic System along the north valley wall of the Des Plaines River (fig. I-6). The site is about 1 mi east of the front of the West Chicago Moraine, the outermost moraine of the Valparaiso System (fig. I-2). This part of the Des Plaines Valley, known as the Chicago outlet, served as an overflow channel or spillway for high-level lakes in the Lake Michigan basin. At this stop two sections will be examined. One, a bluff section, exposes a glacial succession of Wadsworth Till Member overlying Lemont drift; the other, a bottomland section, exposes postglacial colluvium that grades to a thin gravel lag on bedrock and is overlapped by organic sediments. Discussions will center on the age, correlation, and sedimentary sequence of the Lemont drift, and on the age and drainage history of the Chicago outlet.

GLACIAL SECTION

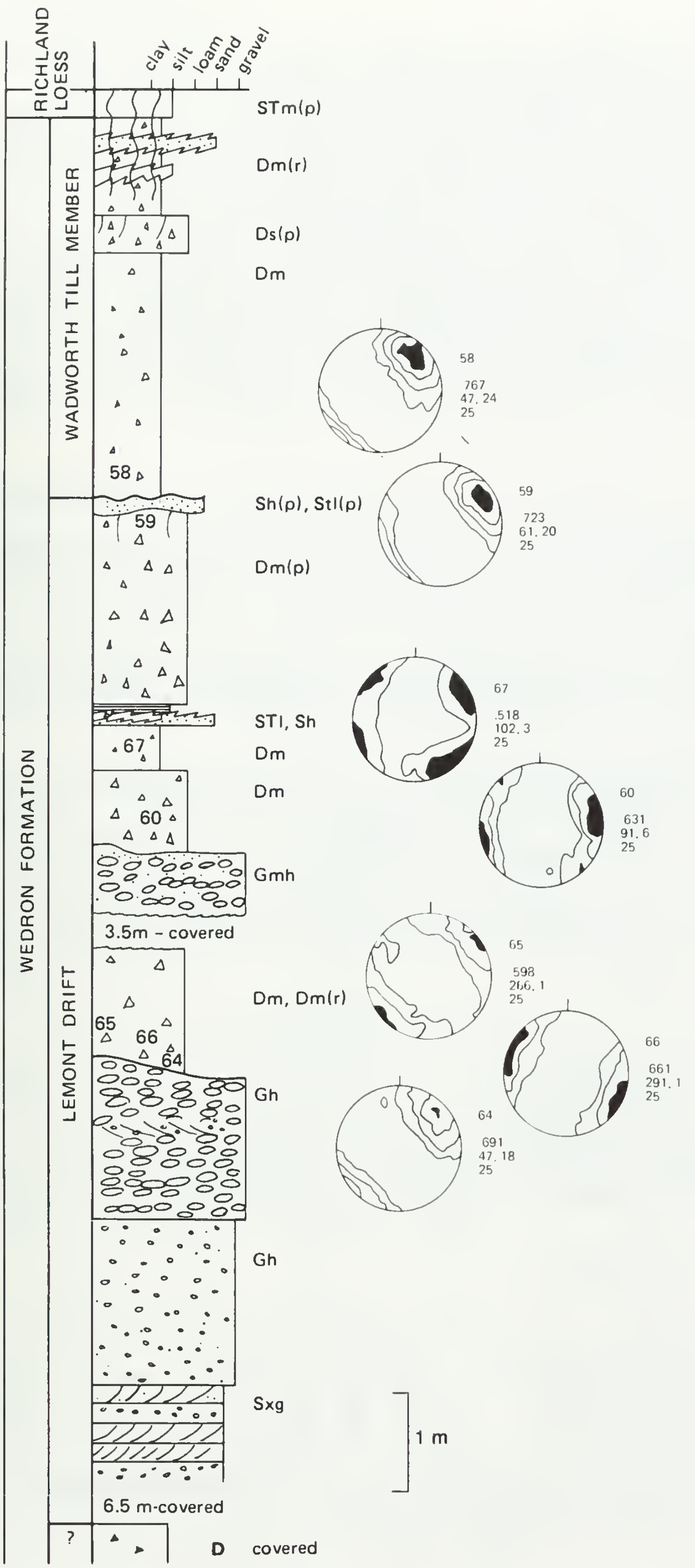
The Land and Lakes Landfill is located about 1.5 mi northeast of the type section of the Lemont drift. The sediment sequence here is similar to that at the type section. The Lemont was named by Bretz (1939) and was described in considerable detail by Bretz (1955) and Horberg and Potter (1955), and more recently by Bogner (1973). A more comprehensive discussion of the Lemont is in Johnson et al. (1985); portions of the following discussion are from that source.

Description

The 29-m bluff section exposes 7 m of diamicton of the Wadsworth Till Member, Wedron Formation over diamicton and a coarsening upward succession of sand and gravel of the Lemont drift. Less than .5 m of Richland Loess is present on the upland surface. Gray silt loam diamicton has been excavated from beneath the sand and gravel at the base of the pit for use as a liner in the landfill operation.

Figure 9-1 is a composite section for the glacial succession at Land and Lakes Landfill. Lithofacies, descriptions, and pebble fabrics are shown. Grain size and composition of selected units are shown in table 9-I. The Modern Soil is developed in massive silt of the Richland Loess and the upper 2 m of Wadsworth diamicton, a silty clay loam that contains interbeds of silt and sand. The lower 15 cm of this diamicton is weakly calcareous, it is underlain by 15-20 cm of stratified diamicton that consists of a leached gravelly loam to silt loam. The remaining 4.5 m of Wadsworth is a fairly uniform silty clay loam diamicton. It exhibits clay skins and leaching along joints and contains abundant illite (80%) in the clay size fraction. A pebble fabric (fig. 9-1, #58) in this unit shows a preferred orientation of prolate pebbles dipping to the northeast. The lower contact is abrupt and erosional.

The upper 2 m of Lemont drift in the bluff exposure consists of silt loam diamicton containing abundant dolomite clasts. In places stratified fine sand and silt are present at the upper contact. These stratified zones locally are leached and clay enriched, as are the uppermost 20-50 cm of diamicton. A pebble fabric (fig. 9-1, #59) measured in the upper Lemont diamicton shows a



STm(p) silt loam to silty clay loam; oxidized; leached, part of Modern Soil (loess)

Dm(r) silty clay loam; oxidized; leached, lower 15 cm weakly calcareous; interbeds of sand and silt (supraglacial deposits)

Ds(p) silt loam to loam, gravelly; oxidized; crudely stratified; leached (Beta horizon in supraglacial deposits)

Dm silty clay loam with shale pebbles; oxidized (10YR to 2.5Y 5/4); small to medium subangular blocky with larger structure at depth; Fe stains and clay films along joints, leached along joints (till)

Sh(p), Stl(p) fine sand and silt, stratified with thin diamicton interbeds; oxidized (10YR 5/6); leached; thick clay accumulation along joints; abrupt upper and lower contacts (lateral Beta development)

Dm(p) silt loam with abundant dolomite clasts; oxidized (10YR 5/6 - 5/5); locally leached up to 4 m (lateral Beta development in till)

STl, Sh silt and fine sand interbedded with gravelly sand and lenticular diamicton beds up to 2 cm thick; abrupt upper and lower contacts (sheetwash)

Dm silty clay; oxidized (2.5Y 4.5/4); lower contact abrupt but wavy (soft sediment deformation?) (lake sediment)

Dm silt loam; oxidized (2.5Y 6/6); few lenses of sorted sediment; fairly uniform with few lenses of sorted sediment (till)

Gmh gravel, coarse, rounded, sandy; lenticular zones of fine sand and silt (outwash)

Dm, Dm(r) silt loam with abundant dolomite clasts; gray oxidized (2.5Y 4/1 - 6/6) in upper part locally; contains silt and sand lenses and gravel concentrations locally; abrupt lower contact, unit thickens to east (till and sediment flow deposits)

Gh gravel, bouldery, horizontal bedded; beds from 5 to 75 cm thick; some coarse sand and granule zones; some cross-bedded zones; some open framework; imbricated clasts (outwash)

Gh granules and small pebbles, interbeds of coarse sand and granules and silt and sand; generally planar bedded and crudely stratified; some planar crossbeds (outwash)

Sxg sand with some granules and fine gravel; trough cross-bedded (outwash)

D silt loam with dolomite clasts; gray (2.5Y 4/1); excavated from base of pit

Figure 9-1. Composite section, lithofacies, descriptions, and pebble fabrics at the Land and Lakes Landfill bluff exposure. (Fabric and symbols explained in fig. 11-1.)

preferred orientation of prolate pebbles dipping to the northeast. The remaining 9 m of Lemont above the coarsening upward sand and gravel succession contains several distinct units including from top to bottom, 15-20 cm of interbedded silt and fine sand, 40-90 cm of fairly uniform silty clay diamicton with few pebbles, 1.25 m of fairly uniform silt loam diamicton with few lenses of sorted sediment, 60 cm of crudely-bedded coarse gravel with a sand matrix, 3.5 m of covered section, and up to 2 m of silt loam diamicton containing abundant dolomite clasts, lenses of sand and silt, and gravel concentrations. The lower diamicton unit, which has an abrupt, erosional lower contact, thickens to the east at the expense of the underlying gravel. Fabrics in diamicton of the lower 9 m are generally weaker and more variable than the fabrics (#58 and #59) measured near the Wadsworth-Lemont contact. Lemont diamicton, like that of the Wadsworth, contains abundant illite (75%) in the clay fraction.

A 10-m coarsening-upward succession of sand and gravel is present below Lemont diamicton. The upper 3 m consists of clast-supported, horizontal-bedded cobble gravel with a matrix of coarse sand; it is underlain by 1.5 m of finer gravel (pebbles and granules) that is planar bedded and crudely stratified. The gravel is underlain by trough cross-bedded sand, granules, and fine gravel. The lower 6 m of the section is covered.

Silt loam diamicton containing abundant dolomite clasts has been excavated from the base of the pit; it is underlain by bedrock.

Table 9-1. Grain size and clay mineral composition of selected units at Land and Lakes Landfill section.

Stratigraphic unit	Lithofacies[1]	Genetic interpretation	Grain-size matrix[2]			Clay mineral composition[3]		
			% S	% St	% C	% Exp	% Ill	% C-K
Wadsworth T.M.	Dm(r)	Supraglacial deposits	16	49	35	*10	80	10
			17	50	33	* 9	79	12
			19	43	38			
			19	40	41	*12	74	13
			17	45	38	* 8	81	11
	Ds(p)	Beta development in stratified drift	33	47	20	* 9	80	11
Lemont drift	Dm(p)	Beta development in till	23	42	35	*23	67	10
			35	20	45	*11	73	11
	Dm	lake sediment	10	49	41	* 6	84	10
	Dm	till	20	41	39			
			23	58	19	* 9	78	13
	Dm,Dm(r)	till and sediment flow deposits	28	55	17	9	74	17
			29	55	16			
			32	53	15	* 8	78	14

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*oxidized sample

[1] Data are tablulated by lithofacies within each stratigraphic unit

[2] Percent of < 2-mm fraction

[3] Percent of < 2 μm fraction

Interpretation

We interpret the coarsening-upward sand and gravel succession of the Lemont drift as proglacial fluvial sediment, and some of the overlying Lemont diamicton as proglacial sediment flow and lacustrine deposits. The uppermost clast-supported cobble gravel and some of the diamicton represent proximal proglacial fluvial and sediment flow facies that were eventually overridden by the advancing ice margin before Lemont till was deposited. The overlying Wadsworth diamicton is interpreted as basal till overlain by supraglacial sediment. The silt in which the Modern Soil is developed is interpreted as loess that accumulated on the landscape during the late Wisconsinan deglaciation. Leached, clay-enriched zones in sorted and coarse-textured units in the Wadsworth and Lemont are interpreted as Beta horizons. Interpretations of individual units are shown in parenthesis in figure 9-1.

DISCUSSION

Composition and Character of Lemont and Wadsworth Diamictons

The strongly contrasting character and composition of the two diamictons is obvious, yet both occur in the same general area. Researchers previously related these differences to both the bedrock geology of the Lake Michigan basin and the Woodfordian deglaciation history.

The dolomitic character of the Lemont diamicton--all fractions coarser than 0.5 mm contain more than 90% dolomite--clearly is the result of "local loading" of the ice sheet by erosion of Silurian dolomite (Horberg and Potter, 1955). The ice margin advanced up the backslope of a regional cuesta in an erosive regime. The particle size distribution in the Lemont diamicton suggests a relatively short transport distance with a dominance of dolomite in the gravel fraction but also significant quantities in the matrix fraction (Bogner, 1973).

The lack of appreciable amounts of clay and the presence of only moderate amounts of nondolomitic silt in Lemont diamicton suggest that significant lake deposits were not present in the Lake Michigan basin immediately prior to the ice margin advance that resulted in deposition of the Lemont. Assuming that the Lemont is Woodfordian (see following discussion), previous ice margin retreats in the Woodfordian probably did not extend back into the basin. Proglacial lake deposits are present, however, below Lemont outwash along the flank of the basin (Bogner, 1973).

The silty and clayey character of Wadsworth diamicton and other fine-grained units in Illinois has been attributed to the incorporation of proglacial lake sediment deposited in one or more early lakes in the Lake Michigan basin (Krumbein, 1933). Schneider (1983) inferred the existence of a lake in the basin prior to formation of the Valparaiso Morainic System, and named it Lake Milwaukee (fig. I-7). In addition, the fine-grained texture of the Wadsworth is in part the result of incorporation and comminution of Devonian shale eroded from the Lake Michigan basin (Willman and Frye, 1970). The incorporation of lake sediment, however, is thought to be most responsible for the fine-grained texture of the unit.

Age of the Lemont Drift

Observations and interpretations of weathered materials in the upper part of the Lemont have raised questions about its age. These materials were described first by Horberg and Potter (1955) at three localities. The described materials were clayey, leached of carbonate, red-brown to yellow-brown, and at one locality, 78 in. thick. The weathered materials were either stratified sand and gravel, or silt. Horberg and Potter (1955) interpreted the materials to be part of a buried soil that probably correlated with the Sangamon Soil, and they suggested that the Lemont drift was Illinoian. Bretz (1955) thought the Lemont probably was Illinoian or possibly late Wisconsinan; Frye and Willman (1960) suggested that the buried soil might correlate with the Farmdale Soil and, if so, that the drift might be early Wisconsinan (Altonian).

Bogner (1973) interpreted the weathered material to be the result of modern weathering processes rather than part of a buried soil. She reported that weathered materials were present not only at the top of the Lemont, but also within the Lemont and the Wadsworth, and that they were always associated with stratified drift. Pedogenic weathering of stratified drift can occur beneath calcareous diamicton when the diamicton is jointed, or when the stratified drift has a lateral connection with the surface, allowing modern weathering processes avenues of penetration. Weathering zones of this type have been termed Beta horizons (Bartelli and Odell, 1960); they commonly form in coarse, stratified deposits that are relatively more permeable than the overlying deposit.

At the Land and Lakes Landfill section, weathered materials below the normal B horizon of the Modern Soil occur in sorted deposits in the upper part of the Wadsworth, in sorted deposits at the Wadsworth-Lemont contact, and locally lower in the Lemont. These are all interpreted to be Beta horizons, not buried soils. Thus, we believe the Lemont is Woodfordian, as did Bogner (1973).

Stratigraphic Position and Correlation of the Lemont Drift

The Lemont drift lies stratigraphically below the Wadsworth Till Member. Its relationship to other till members of the Wedron Formation, however, is problematic. Correlation has been suggested with the Malden Till Member (Landon and Kempton, 1971; Bogner, 1973), and Willman and Frye (1970) observed that lithologically it is most similar to the Haeger Till Member. We advocate the latter correlation on the basis of lithology, lithologic sequence, stratigraphic position, and spatial relationships.

Correlation of the Lemont drift with the Malden Till Member has been based on the following observations and interpretations:

- Landon and Kempton (1971) and Bogner (1973), on the basis of subsurface studies, suggested that the stratigraphic succession near Lemont (Wadsworth Till over Lemont drift) can be traced both northwest (toward the area of Haeger Till) and to the west beyond the area of Wadsworth Till (the West Chicago Moraine). In the latter area the clayey surface diamicton is mapped as Yorkville (fig. I-4) and the subjacent loam till is considered to be Malden. Thus, they concluded that Wadsworth correlates with Yorkville and Lemont with Malden. The correlations were based on similar lithologic successions and generally similar diamicton textures and clay mineral compositions.

- Samples of the fine-grained diamicton (upper unit) at the Land and Lakes and Lemont sections contain large proportions of illite (about 80%), and have the same clay mineral composition as Yorkville diamicton in the Marseilles Morainic System to the west. H. D. Glass (personal communication) believes that the upper diamicton at Lemont is Yorkville and that sediment with that clay mineral composition can be traced westward in the subsurface below diamicton with less illite (about 75%) that he considers to be Wadsworth. Thus, Glass interprets the Lemont to be older than Yorkville and, if so, conceivably it could correlate with the Malden.

We believe that the basal outwash sequence in the Lemont can be traced in the subsurface to the southeast toward the Kankakee Valley and to the east into Indiana. In these areas, it is overlain by Lemont diamicton and variable fine-grained diamictons of the Wadsworth. In Indiana, the outwash deposit extends beyond the margin of the Wadsworth and forms the high-level outwash plain south of the Valparaiso Moraine on the north side of the Kankakee Valley (fig. I-2). Because the outwash surface has not been overridden by glacier ice, it must be younger than Snider (Yorkville-equivalent) diamicton, which occurs to the south in western Indiana (Bleuer et al., 1983). If the subsurface correlations are correct, the Lemont must be younger than the Malden and Yorkville. Stratigraphic relationships discussed at Stop 10 also suggest that the Lemont is younger than the Yorkville. The outwash plain in Indiana generally has been related to the "Valparaiso" till (Wadsworth-equivalent); we relate the outwash deposit to an earlier event, the Haeger-Lemont, and believe that it was deposited at the same time that thick and extensive outwash was deposited along the west flank of the Lake Michigan Lobe in Illinois.

The silt loam diamicton containing abundant dolomite clasts that was excavated from beneath Lemont sand and gravel in the base of the pit is similar to the Lemont in composition and texture. However, its occurrence beneath the coarsening-upward proglacial Lemont outwash succession suggests that it reflects a pre-Lemont event. It is similar to the silt loam diamicton (Malden?) encountered beneath clayey diamicton (Yorkville) in test holes west of the West Chicago Moraine and to the diamicton overlying bedrock at the Boughton pit, 1 mi south of the Avery pit (Stop 10) in Du Page County.

Correlation of the Lemont drift and Haeger Till Member will be discussed further at Stop 11. We place strong emphasis on the proglacial coarsening-upward outwash succession and continuity of the lithologic sequence between Lemont and the area in which Haeger is the surficial till unit (fig. I-4). Meltwater drainage was generally westward and then to the south via the Du Page and Fox River valleys, as indicated by the decrease in elevation of the outwash to the southwest (fig. 9-2).

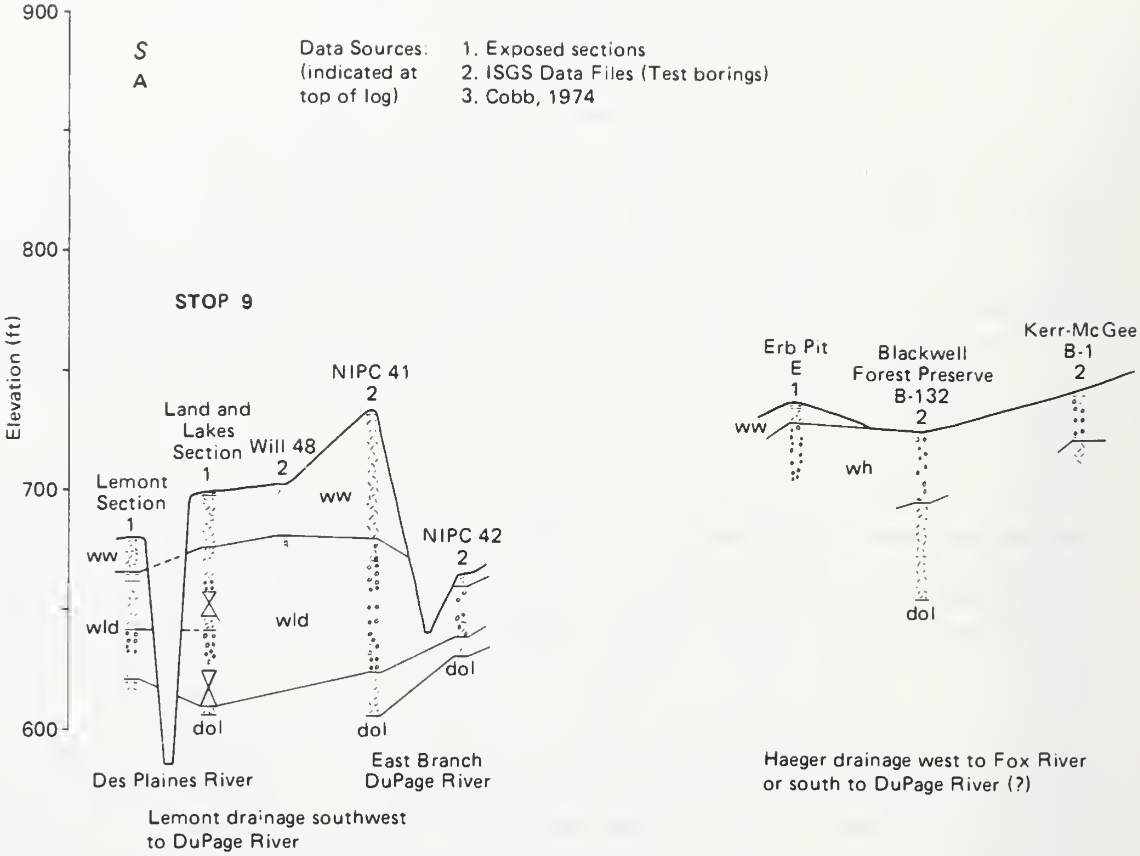


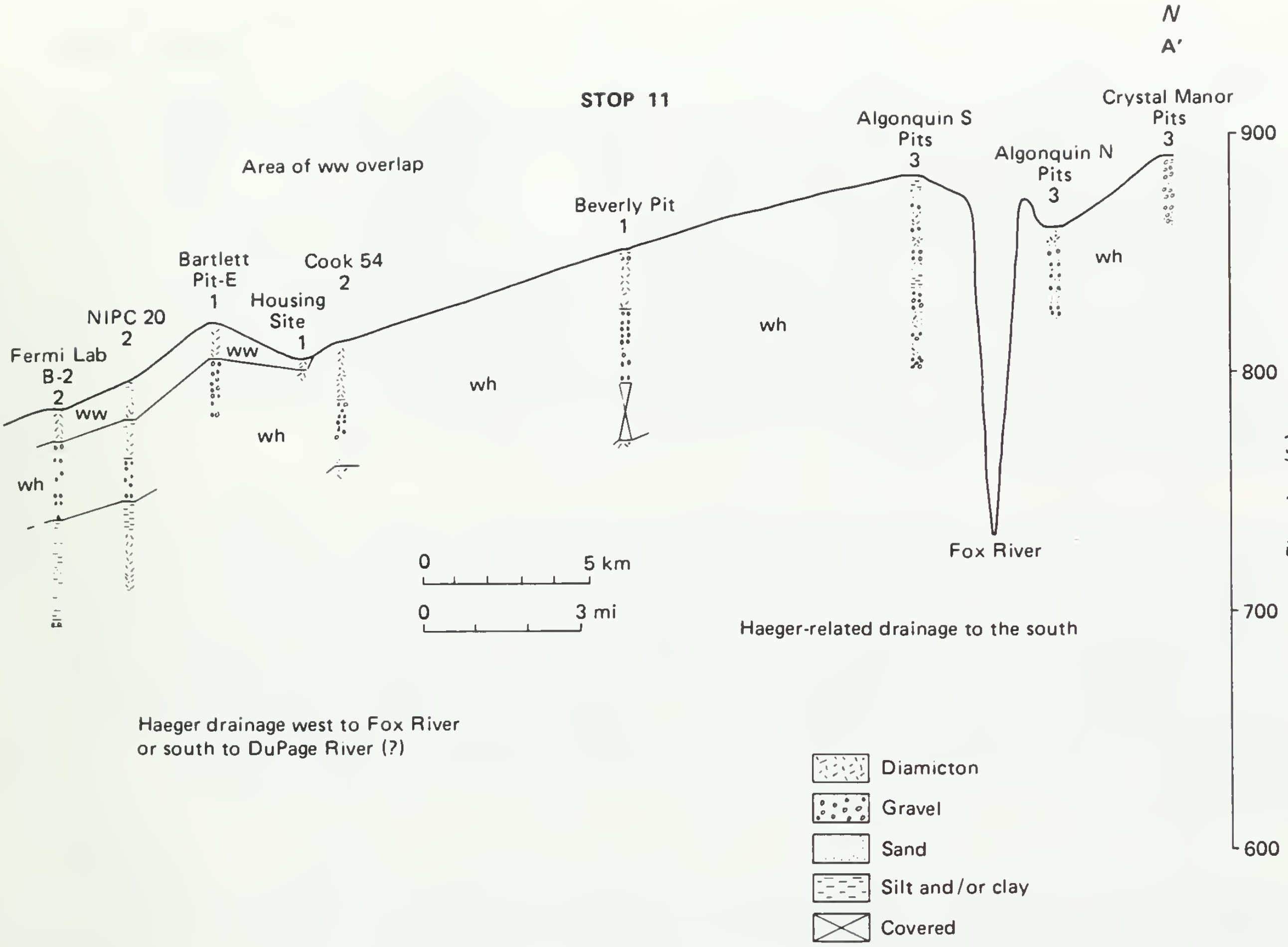
Figure 9-2. Cross section (including Stops 9 and 11) along the margin of the West Chicago and Woodstock Moraines showing stratigraphic relationships between the Lemont drift (wld), Haeger Till Member

POSTGLACIAL SECTION

An important record of the Chicago outlet drainage history was exposed here in 1984 and 1985 (fig. 9-3) in a drainage ditch that cut through the colluviated slope at the base of the outlet channel wall and floor at an elevation of more than 600 ft. Unfortunately, most or all of that exposure has since been destroyed. At this stop we will discuss evidence that suggests the Chicago outlet, which is about 1 mi wide and 100 ft deep at this site (fig. 8-1c) near its west end, was downcut to the level of the bedrock sill early in the history of Lake Chicago (i.e., during the Glenwood phase, 12,700 to 12,000 BP).

Description

Figure 9-3 shows a north-south section exposed in a drainage ditch cut in the lower part of the landfill in 1985. A similar exposure was also studied in 1984. The 2.5- to 3-m succession of deposits consisted of an upper (up to 1.5 m thick) unit of fossiliferous muck interbedded with fossiliferous marl; a middle (up to 1.5 m thick) unit of fossilferous marl interbedded with carbonaceous silt loam and muck and wood; and a lower unit (up to 2 m thick) of gravelly loam diamicton. The diamicton unit was underlain by stratified sand



(wh), and Wadsworth Till Member (ww), and the north-to-south decrease in elevation of proglacial outwash in the Haeger and Lemont units. (Location of section shown on fig. I-2.)

and gravel in the north part of the exposure and by dolomite bedrock in the middle and south parts. Excavation in the landfill in 1985 suggested that the stratified sand and fine gravel could be traced to the Lemont sand and gravel at the base of the bluff section in the north part of the pit. The bedrock surface, which slopes toward the middle of the channel, is approximately 20 ft lower in the south part of the pit than in the north.

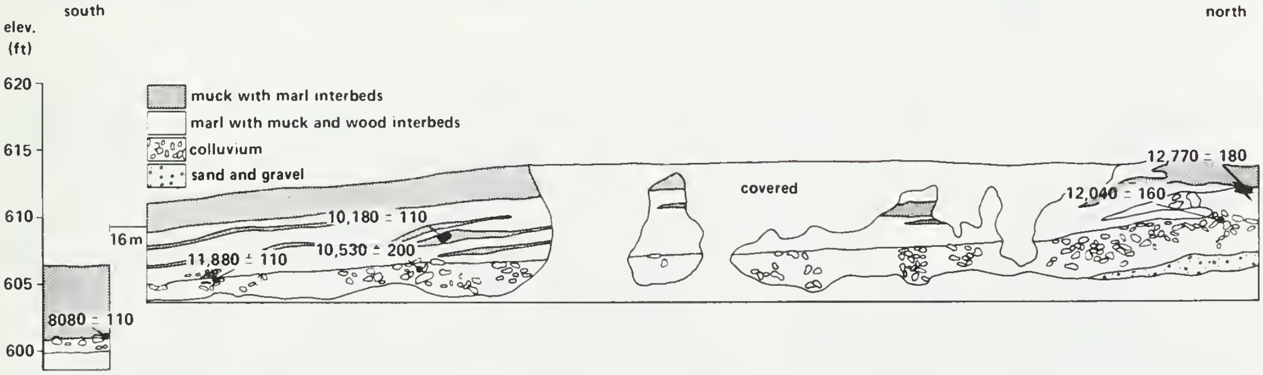


Figure 9-3. Sketch of 1985 north-south bottomland exposure at Land and Lakes Landfill showing stratigraphy and radiocarbon dates.

The lower gravelly loam diamicton ranges from matrix to clast supported. Clasts are predominantly subangular to subrounded dolomite cobbles that range from 10 to 35 cm in diameter; many are 20 to 25 cm in diameter. The diamicton matrix ranges in texture from loam to silt loam and sandy loam and contains carbonaceous silt and wood. The carbonaceous silt is most common in the middle and south parts of the exposure. The gravelly loam diamicton is traceable across the exposure; its surface dips about 4° to the south toward the valley, but locally the dip is steeper, especially in the north part of the exposure where the contact between the diamicton and the middle marl unit is irregular. The diamicton forms a wedge-shaped unit that thins to a gravel lag on bedrock in the south part of the pit, where some cobbles in the unit are more rounded. More rounded cobbles are also present at the top of the exposure, in the middle part of the unit, where 15-20 cm of silty clay was present at the upper contact.

The middle unit consists of fossiliferous marly loam interbedded with layers of carbonaceous marly silt loam and muck, and lenses of muck containing wood. Some contacts are abrupt, but most are gradational. Lenses of muck containing wood are up to 30 cm thick and up to 10 m in length. Layers and lenses in this unit generally dip at a low angle toward the valley; dips are conformable with the underlying diamicton surface. Gastropods identified in the marl and muck were terrestial (e.g., *Helicodiscus parallelus*, *Carychium exiguum*, *Vertigo milium*, *Strobilops* sp., *Derocera laeve*, *Gastrocopta farmifera*, and *Bakerlymnaea dalli*, *Nesovitrea electrina*, *Vertigo ovata*, *Succinea ovalis*, and *Euconulus fulvus*) (B. B. Miller, written communication).

The upper unit consists of fossiliferous muck that contains up to 25-cm thick interbeds of marly loam and carbonaceous marl. Contacts are generally gradational. This unit, which contains abundant gastropods and some wood, thickens to the south toward the valley, where it is more than 1.5 m thick and overlies a cobbly lag on bedrock.

Eight samples of wood from the 1984 and 1985 exposures were radiocarbon dated by the ISGS Radiocarbon Lab. Wood from the gravelly loam diamicton yielded ages of 12,770 ± 180 (ISGS-1418), 12,500 ± 110 (ISGS-1332), 12,040 ± 160 (ISGS-1433), 11,880 ± 110 (ISGS-1413), and 10,530 ± 200 (ISGS-1417) RCYBP. A log from a relatively mineral-free lens of wood and muck in the middle unit yielded an age of 10,180 ± 110 (ISGS-1455) RCYBP. Wood from the base of the fossiliferous muck unit yielded ages of 8080 ± 110 (ISGS-1425) and 7900 ± 90 (ISGS-1300) RCYBP. The oldest wood dated was identified as a spruce log. A piece of wood from the same stratum where the youngest dated wood was found was identified as a cottonwood root.

Soils at this site are Rodman gravelly loam, Lena muck, and Harpster silty clay loam. These soils are calcareous in this locality. The existence of a steep slope (outlet valley wall), the lower part of which consists of Lemont sand and gravel, has created a groundwater discharge zone along the colluviated footslope of the valley wall. The Rodman gravelly loam soil has developed in gravelly Lemont and colluviated gravel along the steep slope; the Lena muck and Harpster silty clay loam soils have developed in fine organic-rich sediment along the lower colluviated footslope. The latter two soils are Medisaprists and Calciaquolls, respectively; they developed in a wetland environment that provided a favorable habitat for the snails characteristic of both soils.

Interpretation

We interpret the gravelly loam diamicton as colluvium derived from the Lemont drift exposed in the valley wall. It is similar to the Lemont in texture and gravel lithology. Some of the carbonaceous silt in the south and middle parts of the exposure may have accumulated during the Two Creeks phase when the site was emergent. In the south and middle parts of the exposure the cobbles are more rounded, and they may have been partly reworked by fluvial processes during the Calumet phase. Likewise, the silty clay at the upper contact may have been deposited during the Calumet phase. The sand and fine gravel underlying the gravelly loam diamicton in the north part of the exposure is interpreted as Lemont drift. The wedge-shaped form and stratigraphic position of the diamicton unit, which overlaps Lemont drift and is overlapped by (and in part interfingered with) marl and muck, is also consistent with a colluvial origin.

The overlying marl and muck succession probably represents accretion in a spring-fed wetland on the colluvial deposits at the edge of the valley. The 10,180 ± 110 RCYBP date on a log from a muck and wood lens in the marl indicates that the succession is post-Calumet. The presence of terrestial rather than aquatic gastropods and the calcareous soils that developed in the marl and muck succession suggest deposition in an alkaline wetland, probably a valley-side fen.

Discussion

The bottomland succession at Land and Lakes Landfill occurs between the 598.5-ft and 613-ft elevation. Because the gradient of the Des Plaines channel of the Chicago outlet is low (1 ft in 7.5 mi according to Bretz, 1955), during times of lake overflow the elevation of water flowing through the channel would have been essentially the same as the elevation of the lake in the Lake Michigan basin. Overflow water from glacial Lake Chicago surely would have submerged this site during the Glenwood transgression (12,700 to 12,000 BP) when lake level reached 635-640 ft, and during the Calumet transgression (11,800 to 11,000 BP) when lake level reached 615-620 ft. The site was probably emergent during the Nipissing trangression (6000 to 4000 BP) when lake level reached 600 ft.

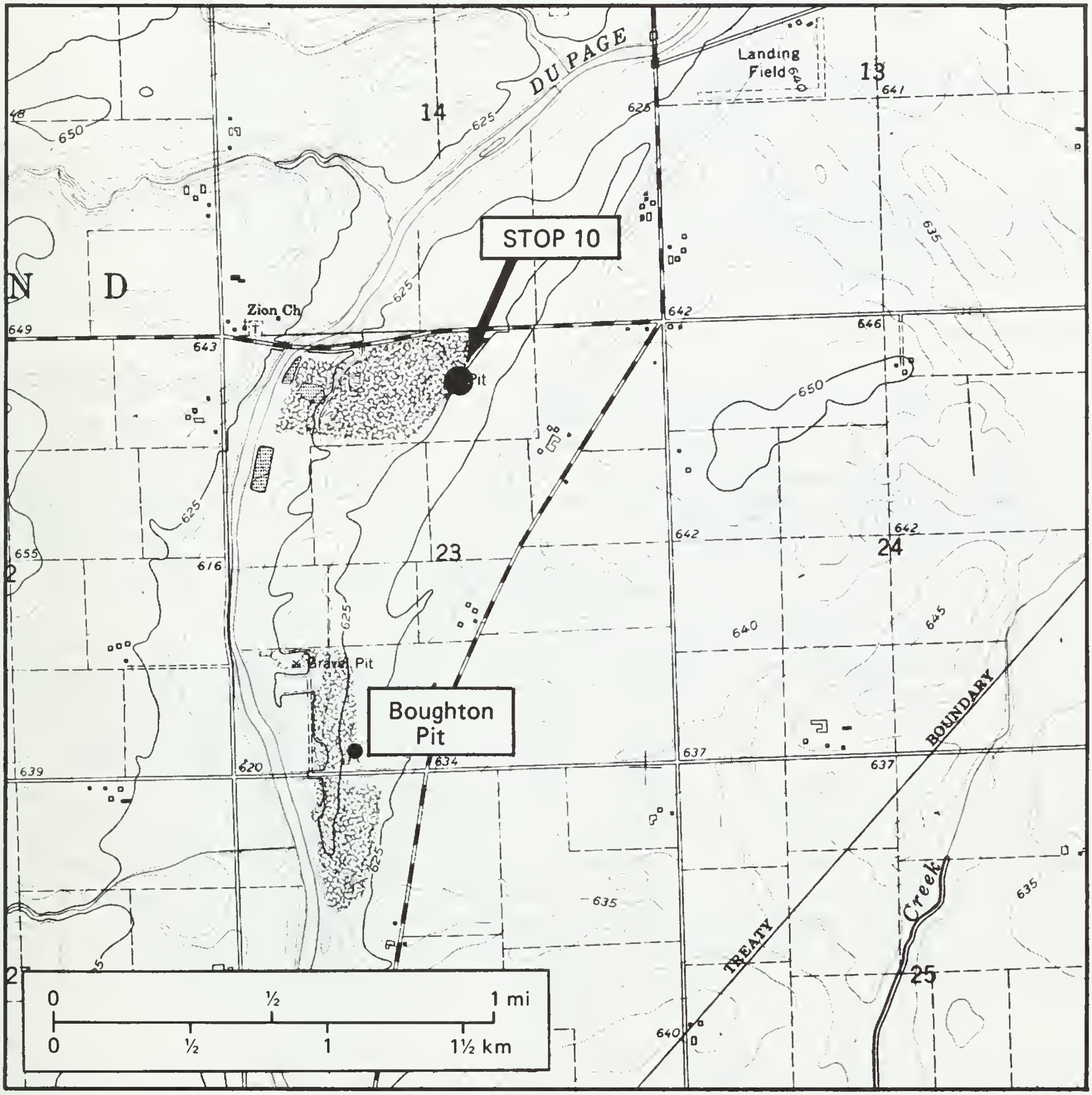
The radiocarbon dates on wood from the succession range from pre-Glenwood to pre-Nipissing (fig. 9-3). All but one date (12,500 ± 110 RCYBP) fall between the times of high lake phases or at the beginning or ending of high lake phases, when lake level was probably rising or falling, respectively (fig. 8-3). These observations suggest to us that these dates from the outlet succession are meaningful (i.e., they are consistent with the rest of the radiocarbon record from the Lake Michigan basin). The stratigraphic order of some of the dates is harder to explain. We suggest that the most useful date is the 10,180 + 110 RCYBP date on a log from a muck lens in the middle marl unit; it probably represents an in situ deposit. On the other hand, the wood from the colluvial deposit is probably partly detrital. With one exception (ISGS-1417, 10,530 ± 200), the dates (12,770 ± 180, 12,500 ± 110, 12,040 ± 160, and 11,880 ± 110 RCYBP) on wood from the colluvial deposit correspond in time with the Glenwood and Two Creeks lake phases and suggest to us that colluviation was probably a response to slope instability that resulted from downcutting of the outlet channel during the Glenwood high-water phase. A Twocreekan date of 11,740 ± 90 RCYBP (ISGS-120) on wood in fill from the base of the bedrock channel near Ottawa, Illinois, is further evidence that incision of the channel of the Chicago Outlet River probably pre-dates the Two Creeks low-water phase. The 10,530 ± 200 date from wood in the colluvial deposit is apparently too young; the wood dated may be a root from a tree that grew on a younger surface; modern roots penetrate the succession today. Wood from the base of the upper fossiliferous muck unit yielded ages of 8080 ± 110 and 7900 ± 90 RCYBP and the muck yielded an age of 7300 ± 90 RCYBP, indicating that the muck succession accumulated during the Chippewa low-water phase (fig. I-7).

Age of Downcutting of the Chicago Outlet

Clearly, the steep-walled valley at this locality is the channel cut by the Chicago Outlet River. The channel is floored in bedrock below about 600 ft. This elevation is at least 30 ft below the surface of the Tinley drift dam in the outlet head, which, according to Bretz (1951, 1955), controlled lake level during the Glenwood phase. It is about 10 ft below the dam that supposedly controlled lake level during the Calumet phase. The elevations, dates, and stratigraphic relationships of the units in the postglacial succession suggest to us that at this locality the channel of the Chicago outlet was cut to bedrock before the Two Creeks low-water phase (12,000 to 11,800 BP) and that the colluvial deposit is pre-Calumet (>11,800 BP) in age. During the Calumet high-water phase, the upper part of the colluvial deposit may have been scoured, with the most reworking of material occurring at the lowest elevations. The Glenwood age wood in the colluvium probably is detrital wood that was moved to the site by mass wasting processes; the Twocreekan wood probably is from trees that grew at the footslope site. The carbonaceous zones prevalent in the lower and middle parts of the colluvium likewise probably represent in situ organic accumulation during the Two Creeks low-water phase. The Twocreekan date (11,740 ± 90 RCYBP) on wood from muddy gravel near the base of the bedrock channel approximately 60 mi downstream at Ottawa provides additional evidence for pre-Two Creeks incision of the channel of the Chicago Outlet River. It was probably during the pre-Two Creeks Glenwood high-water phase that the largest volume of water discharged from glacial Lake Chicago (see discussion, Stop 8), and we believe that the Quaternary record at this site is most consistent with downcutting of the outlet to bedrock during the Glenwood high-water phase.

DOLOMITE BLOCKS IN THE DU PAGE RIVER VALLEY

W. Hilton Johnson and Ardith K. Hansel



STOP 10. Avery Quarry

NW NE Sec. 23, T37N, R9E, Will County, IL

At this stop we will examine glaciofluvial sand and gravel, diamicton of sediment flow origin, and "large" blocks of dolomite in a bedrock valley. Our discussion will focus on problems of correlating deposits with glacial events and on the mode of emplacement of the dolomite blocks.

INTRODUCTION

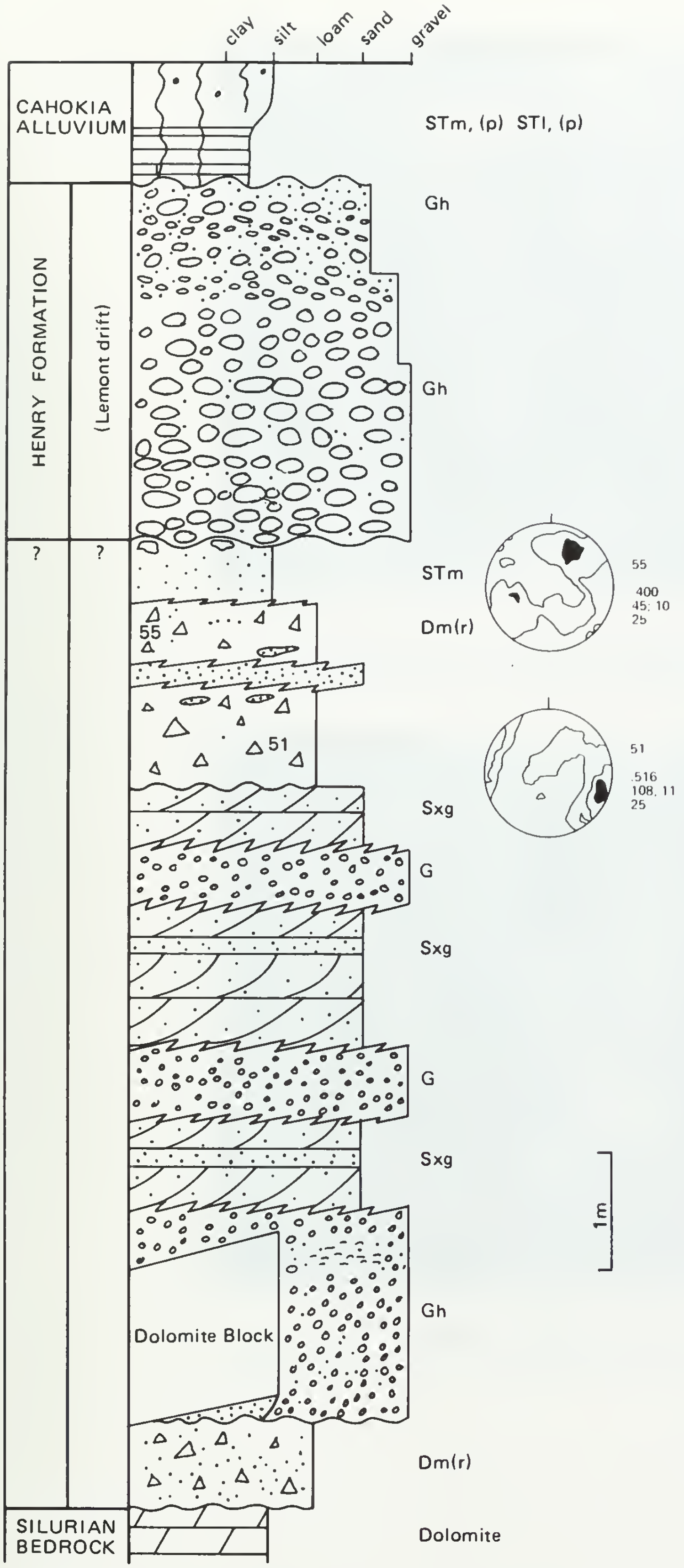
Avery Quarry is in the Du Page River valley about 7 km downstream from the frontal margin of the West Chicago Moraine and due west of Stop 9 (fig. I-2). Our first observations in the quarry were made in 1985 and our understanding of the deposits is in the development stage. The stop is located between the Minooka Moraine to the west and the Rockdale and West Chicago Moraines to the east. The surficial deposit in the uplands bordering the Du Page River valley is fine-grained diamicton that has been included in the Yorkville Till Member (Willman and Frye, 1970). It is mapped in both the Minooka and Rockdale Moraines, and is similar in texture and composition to Wadsworth diamicton that is mapped as the surface unit of the West Chicago Moraine, as at Stop 9.

DESCRIPTION

The succession along the east side of Avery Quarry consists of about 1 m of Cahokia Alluvium (on the terrace surface to the southwest, the upper silt is probably mostly Richland Loess) overlying up to 6 m of gravel and sand of the Henry Formation. The latter is underlain by a thin but variable unit of loam diamicton and/or silt that in turn overlies another thick deposit of sand and pebble gravel. Large dolomite blocks are embedded in the latter unit near the bedrock surface. A composite section of the units exposed in the Avery Quarry is represented in figure 10-1. Lithofacies descriptions, pebble fabrics, and summary data are also shown.

Of most interest are large dolomite blocks that appear "embedded" within the lower sand and pebbly gravel unit, and occur only along the west side of the bedrock valley. The blocks are composed of massively bedded (about 50 cm thick) dolomite and are not from the same rock unit as the more thin-bedded dolomite in the quarry (fig. 10-2a). The blocks vary in size from small boulders (<1 m^3) to some as large as 120 m^3. They generally are rectangular in shape and are outlined by bedding planes and joint surfaces. Most blocks have one or more sides that are smooth, solution weathered, and fluted; other surfaces are more irregular but are not fresh fractures. Abrasion features are not present on the blocks. Solution weathered surfaces occasionally contain a thin crust of travertine that locally is broken or cracked. The orientation of blocks is variable and somewhat chaotic; several blocks dip to the northeast.

One large block is shown in figure 10-2b. On the northeast and southeast sides, beds of sand and muddy gravel abruptly terminate against the block with essentially no deformation (fig. 10-2c). Similar deposits continue over and bury the blocks, also with little or no deformation. On the southwest side of the block, slightly inclined tabular slabs of dolomite set in a sandy matrix and a mixture of sand and wood fragments occur immediately adjacent to the block (fig. 10-2d). This same block rests on lenticular fine sand and silt containing clay laminae that are restricted to the area under the block. The lens is up to 24 cm thick. The sediment is deformed but not excessively so. The block and the fine-grained sediment overlie a chaotic rubble of dolomite slabs, irregular rock fragments, and wood with a matrix of loam texture or clean sand (fig. 10-2e). Large tabular clasts have no preferred orientation and have angular to subangular edges. Wood fragments are spruce and one piece



STm(p), STl(p) silt loam to silty clay loam; upper part massive with disseminated pebbles, lower part finer-grained and faintly bedded, abrupt lower contact; up to 2 m thick; leached, part of Modern Soil colluvium, locally loess

Gh pebbles to cobbles; clasts up to 15 cm in lower part, finer toward top, well rounded; matrix to clast supported, matrix loam textured; planar bedding, some planar cross-bedding

Gh coarse cobbles, clast up to 20 cm in diameter, well rounded; clast supported; crude planar bedding, some planar cross-bedding; clasts imbricated with dips to SE; mostly dolomite; entire gravel unit up to 5 m under highest part of terrace surface

STm silt loam, dark gray, massive; discontinuous; associated with Dm(r) below

Dm(r) loam, bouldery; clasts subangular to rounded, most clasts dolomite; contains silt and sand layers, lenses and stringers; clasts locally concentrated near base of individual diamicton layers, coarse lag with boulders up to 0.5 m at upper contact; unit restricted to upper part of fill in bedrock valley

Sxg, G sand with granules and pebbles; mostly trough cross-bedding with dips to SW; some sets with rhythmic fining upward sequences, interbedded with gravel beds

Gh pebbly, most pebbles 1-3 cm; clast- to matrix-supported; matrix sandy loam to loam; crude planar bedding, cross-bedding to massive; sand and gravel fill lower part of bedrock valley

Dm(r) loam to sandy loam, contains tabular slabs of dolomite and wood; up to .25 m lens of fine sand and silt containing clay laminae beneath large dolomite block

Figure 10-1. Composite section, lithofacies, descriptions, and pebble fabrics at Avery Quarry. (See explanation of fabric and symbols in fig. 11-1.)

Figure 10-2a. Massively bedded dolomite block at Avery Quarry abutting thin-bedded dolomite bedrock along the west side of a bedrock valley.

Figure 10-2b. Large dolomite block embedded in gravel and sand.

Figure 10-2c. Beds of sand and muddy gravel terminating on southeast side of the large block shown in figure 10-2b.

Figure 10-2d. Slightly inclined tabular slabs of dolomite in sandy matrix containing wood, on southwest side of large block shown in figure 10-2b.

Figure 10-2e. Chaotic rubble of dolomite slabs, irregular rock fragments, and wood in a matrix of loam texture and sand beneath large block shown in figure 10-2b.

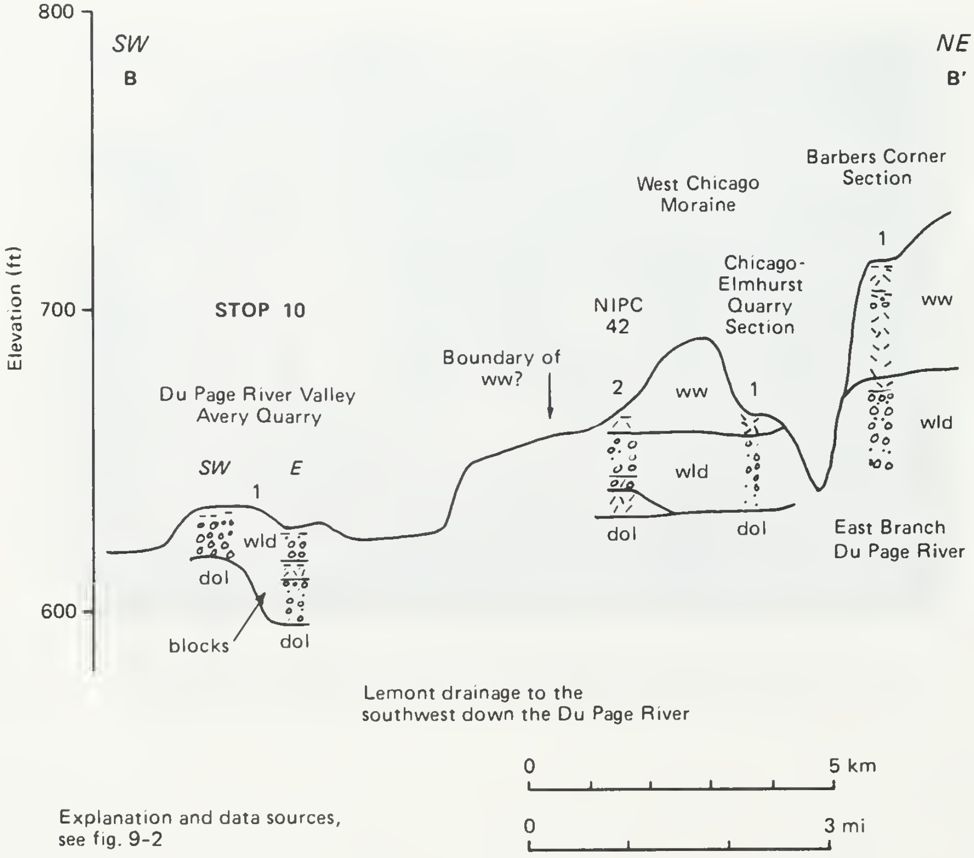


Figure 10-3. Cross section (including Stop 10) near the Du Page River showing Lemont outwash (wld) extending from beneath the Wadsworth Till Member (ww) and beyond the margin of the West Chicago Moraine. Section not to scale at Stop 10. Location of section shown on figure I-2.

from beneath the block dated > 45,880 RCYBP (ISGS-1473). This basal material is about 0.8 m thick and overlies a polished, undulating bedrock surface with no striae. Fragments of bedrock from this surface also are in the overlying rubble. Workers in the quarry report that at one time trees with trunks about 5 cm in diameter were exposed in growth position with their tops broken off. The site was in the area where blocks are present.

A few dolomite blocks also occur in Boughton Quarry, 1 km south of Avery. The blocks again are associated with the west wall of a bedrock valley, probably a tributary to the valley at Avery. In this valley the blocks occur either in dark gray silt or gray, bouldery, silt loam diamicton and silt. Silt beneath one block was leached and slightly carbonaceous but was overlain by stratified and calcareous silt. A block associated with diamicton was first exposed in 1986 and has not been studied in detail; some of the diamicton appears to be till.

INTERPRETATIONS AND DISCUSSION

Stratigraphy and Sedimentology

Stratigraphic interpretations at Avery are difficult because no till is present in the sequence and ties between the main units in the sequence and formal till units are not direct. Our tentative interpretations are that the upper cobble gravel relates to the Lemont glacial event, and that the bouldery loam diamicton and lower sand and pebbly gravel are related to one or more Woodfordian events, probably Lemont and/or Malden. Other stratigraphic interpretations are not precluded.

Upper cobble gravel. The coarse cobble gravel is interpreted to be valley train outwash that was deposited within the Du Page River valley. The coarse nature of the deposit suggests it is a proximal facies. Similar deposits occur in quarries immediately north and south of Avery, and extensive deposits have been removed from gravel pit operations 5 km south near Plainfield. These deposits in the Du Page River valley are continuous with sand and gravel that occurs in drainageways that extend east-west through Minooka ground moraine and Rockdale end moraine (fig. I-2). Relict braided channel patterns are evident on air photos of terrace surfaces in the valley and the east-west drainageways.

Previous interpretations considered these gravels to be younger than the Yorkville (inset relationships) and to be related to the Wadsworth glacial event and the West Chicago (Valparaiso) Moraine (Willman, 1971). We agree with the former but not the latter interpretation. The character of the deposit suggests to us that it probably is not Wadsworth-related outwash. Diamicton in the Wadsworth contains small amounts of sand and gravel, and we think it unlikely that a thick, extensive, and coarse outwash would be derived from such a fine-grained unit. More importantly, the deposit can be traced to northeast and east and appears to us to go beneath both Wadsworth and Lemont diamicton (fig. 10-3). Outwash in the lower Lemont drift is exposed in gravel pits and quarries near Barbers Corners, 10 km to the northeast, and in several test borings between Avery and Barbers Corners (fig. 10-3). Wadsworth diamicton is found in the upper part of these occurrences and Lemont diamicton occurs between Wadsworth diamicton and Lemont outwash at the Barbers Corners section. We believe that the upper outwash at Avery is continuous with the lower outwash unit in the Lemont drift and is part of the proglacial sequence that was not overridden by the Lemont ice margin.

Last year, we hypothesized that the Wadsworth ice margin advanced well beyond the West Chicago Moraine and extended to the Minooka Moraine (Johnson et al., 1985). That concept was based primarily on possible geomorphic and stratigraphic relationships north of this area. Preliminary investigations in this area indicate that this interpretation is unlikely. The outwash in this area that we correlate with the Lemont clearly appears to be inset into the upper fine-grained diamicton, and thus the diamicton must be Yorkville and not Wadsworth. The Wadsworth ice margin north of Joliet appears to correspond to the West Chicago Moraine, but locally may have extended west beyond the moraine proper.

Bouldery loam diamicton. This unit is interpreted to consist of sediment flow, lacustrine, and fluvial deposits. Locally where the unit is mostly diamicton, fabric data and sedimentary characteristics of the deposit indicate that it is not till. The fabrics measured are weak and show no preferred orientation (fig. 10-1). Individual flows, where distinguishable, are relatively thick (about 0.5 m) (fig. 10-4), and probably are similar to the Type II or Type III flows of Lawson (1982). Lacustrine silt probably accumulated in local ponded areas; fluvial deposits (silt and sand) are most likely of sheetwash and shallow flow origin. Erosional lags are not uncommon. The sediment assemblage is a marginal facies that appears to be confined to the Du Page River valley , but a more extensive distribution is not precluded.

The texture and composition of the diamicton suggest that it was derived from an ice sheet carrying abundant dolomite clasts of all sizes. It is lithologically similar to Lemont diamicton, and one possible interpretation is that it was derived from the Lemont ice margin some 7 km to the northeast or from a tongue of Lemont ice that extended down the Du Page River valley. The former interpretation is difficult because it seems a long distance down the

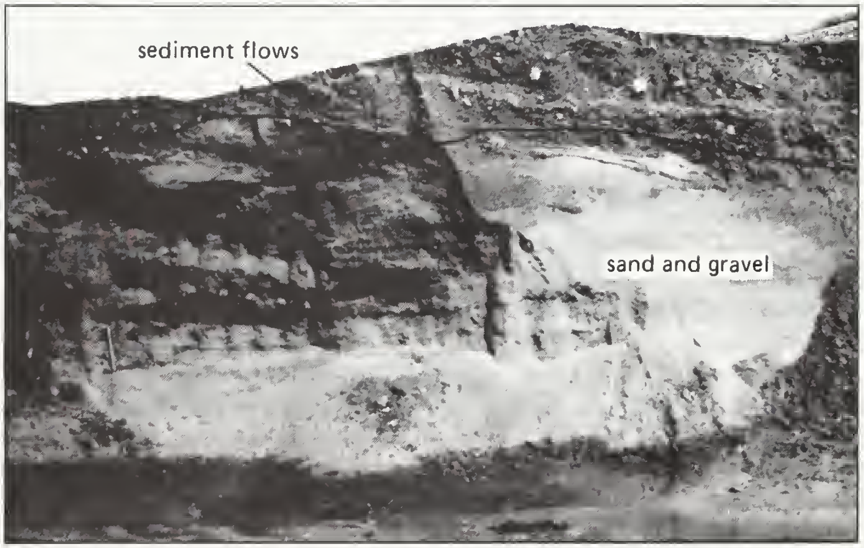


Figure 10-4. Bouldery loam diamicton containing silt and sand layers, lenses, and stringers above crossbedded sand at Avery Quarry. Diamicton is interpreted as sediment flow deposits.

meltwater valley for relatively viscous flows to maintain their integrity, and no evidence of an ice tongue extending down the valley is known.

A more likely interpretation is that the diamicton was associated with an earlier (pre-Lemont) ice sheet that also was dominated by locally derived dolomite. In terms of color, texture, and composition, it is most similar to diamicton in the Malden Till Member or in the lower part of the Tiskilwa Till Member. The former is more likely because the diamicton does not have a violet or pinkish tinge as is typical of Tiskilwa-related units.

Lower sand and pebbly gravel. The sorted and stratified unit filling the bedrock valley is interpreted to be outwash. It is a medial facies, and bedding and other characteristics suggest that it was deposited by a braided river. As with the overlying diamicton, it could be related to the Lemont, but that is not likely. The matrix in the pebble gravel is similar to the silt loam matrix of the overlying diamicton, but there are more nondolomite clasts in the gravel than is typical of the Lemont. The outwash probably is early Woodfordian or older.

The Blocks

The mode of transport and emplacement of the blocks is problematic. The character of the blocks suggests that they were transported with a minimum of mechanical wear and that they have not been modified significantly since their emplacement. We believe it most likely that the blocks in both Avery and Boughton Quarries were emplaced during the same event. We also believe that the blocks generally moved from an easterly direction toward the west, and that movement was terminated because of the northwest wall of the bedrock valley. The most likely origins are: 1) entrainment, transport, and lodgement by glacier ice, and 2) a large-scale block and debris avalanche down a valley side or off a glacier surface. Transport by glacial meltwaters, icebergs, or viscous debris flows does not seem physically possible in this setting.

The block and debris avalanche origin is supported by the chaotic nature of the blocks and the rubble beneath them at Avery, as well as the lack of till in and around them. We do not believe there is adequate relief on the bedrock surface to account for the avalanche by failure of a valley side. Thus, if mass wasting occurred, the blocks must have been incorporated in the ice sheet and concentrated in a supraglacial position prior to movement.

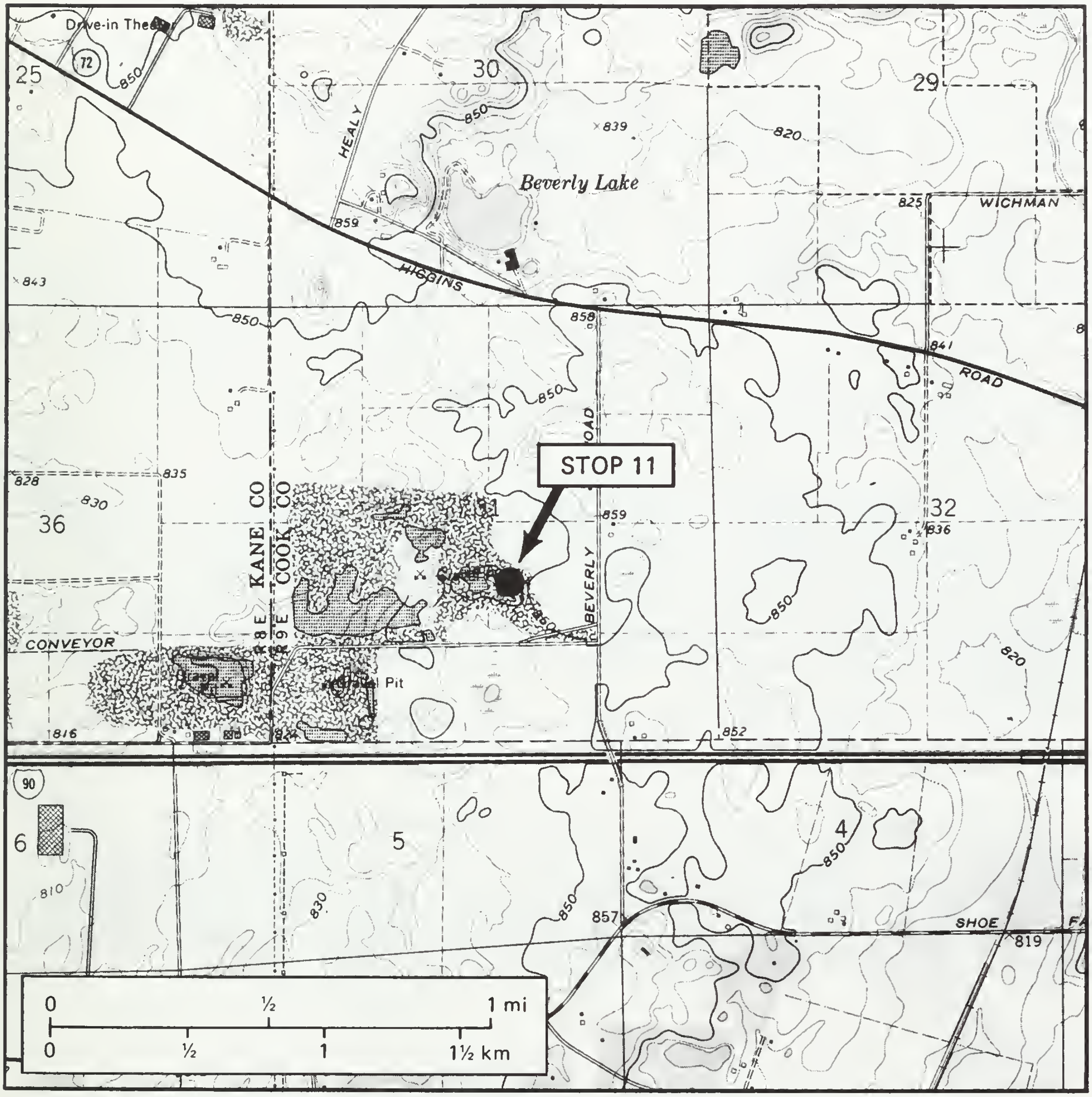
A basal lodgement origin is suggested by the association of one block with diamicton at Boughton. If so, the blocks probably were entrained by freeze-on, transported a short distance in basal ice but above the glacier bed, and then lodged against the west valley wall of the bedrock valley. If till was deposited with the blocks at Avery, it was subsequently eroded prior to being buried by glaciofluvial pebbly gravel and sand. The rubble beneath the one block (fig. 10-2c) at Avery may have been moved and deformed beneath the sole of the ice sheet. The slabs, rocks, sand, and wood on the southwest side of this block (fig. 10-2e) probably were pushed in front of the block as it was being lodged. The lens of silt and fine sand beneath one end of the block probably was deposited in a cavity sometime after the block came to rest. The lack of striae on any side of the block and the bedrock surface beneath the block is diddicult to explain by the basal lodyment origin.

The time of emplacement of the blocks also is unclear. The valley clearly was in existence prior to the late Wisconsinan, on the basis of the one wood date and the report of trees in growth position. We think that the blocks probably were emplaced in the Woodfordian, but they could have been moved to this site during the Illinoian.

Further study of the newly exposed blocks at Boughton, determination of their stratigraphic position relative to the bedrock in the quarry and of possible sites of entrainment, and further observations of blocks at Avery should help answer some of the questions concerning these blocks. We welcome suggestions from field trip participants.

STRATIGRAPHIC RELATIONSHIPS, SEDIMENTATION, AND CORRELATION OF THE HAEGER TILL MEMBER IN NORTHEASTERN ILLINOIS

Ardith K. Hansel and W. Hilton Johnson



STOP 11. Beverly Sand and Gravel Pit

Sec. 31, T42N, R9E, Cook County, IL

A typical succession of the sand and gravel and diamicton facies of the Haeger Till Member of the Wedron Formation is exposed in the Beverly sand and gravel pit. We will examine the stratigraphy and sedimentation of the Haeger Till Member and discuss the correlation of the Haeger with the Lemont drift.

INTRODUCTION

The Haeger Till Member of the Wedron Formation consists of a lower facies of sand and gravel and where present, an upper (generally thin) facies of loam to sandy loam diamicton that is yellowish brown to gray. It outcrops in the Harvard Sublobe area of McHenry County and adjacent parts of Lake, Cook, and Kane counties in northeastern Illinois (figs. I-3, I-4). The Haeger can be traced across the state line into Wisconsin, where it is mapped as New Berlin Formation from the Darien Moraine eastward to the front of the Valparaiso Morainic System (Schneider, 1983; Mickelson et al., 1984).

The Haeger Till Member overlaps gray, silty clay diamicton mapped as Yorkville Till Member in Kane and southern McHenry counties; farther north where the Yorkville pinches out, it overlaps the pink Tiskilwa Till Member (Lineback, 1979). Although Willman and Frye (1970) defined the upper boundary of the Haeger to be the contact with Wadsworth Till Member, they suggested that the Haeger graded into the adjacent clayey diamicton of the Wadsworth. Work by Hansel and Johnson (unpublished) indicates that in Lake and northern Cook counties the Haeger is overlapped by the gray, silty clay diamicton of the Wadsworth Till Member.

The stratigraphic problem presented by the Haeger Till Member, sandwiched between the clayey Yorkville and Wadsworth diamictons, involves its correlation with other units south and east of the Harvard Sublobe area. A slight reentrant is present near Elgin at the junction of the Harvard and Joliet Sublobes (fig. I-3). The main question is: Was the Haeger ice margin continuous across the Harvard and Joliet Sublobe areas, or was the Haeger ice margin confined to the Harvard Sublobe, which did not extend to the southern Lake Michigan area?

BEVERLY SAND AND GRAVEL PIT

The Beverly pit is located in the critical Harvard-Joliet Sublobe reentrant area, along the front of the Woodstock Moraine (formerly mapped as West Chicago Moraine, Johnson et al. (1985) (fig. I-2). It is near the southern margin of the area mapped as Haeger Till Member. At this stop we will examine the character and sedimentation of the Haeger Till Member in its type area and compare it to that of the Lemont drift examined at Stop 9.

Description

In the pit, up to 18 m of gravel and sand is overlain by up to 6 m of yellow brown to gray loam diamicton. This succession of deposits is typical of the Haeger Till Member in northeastern Illinois. The base of the pit (below groundwater level) is in gray, silty clay diamicton that probably correlates with the Yorkville Till Member, which is exposed in a roadcut 5 km to the west. The gravel is thickest in the northeastern part of the pit. Sorted sediment of the Henry Formation locally overlies the Haeger at the Beverly pit. Up to 2 m of silt, Richland Loess, is present at the surface. A composite section of the units exposed in the Beverly pit during the summer and fall of 1984 is represented in figure 11-1. Lithofacies descriptions, pebble fabrics, and summary data are also shown. A more complete description and discussion of the stratigraphy in the Beverly pit section is given in Johnson et al., (1985) (Stop 3). Figure 11-2 shows an east face of the Beverly pit.

Interpretation

The gravel lithofacies (Gmh) of the Haeger Till Member exposed at the Beverly pit is part of a complex of coalescing outwash fans up to 10 km wide that parallels the front of the Woodstock-West Chicago Moraine for 38 km in McHenry, Kane, and northern Cook counties (Masters, 1978) (fig. 9-2). The massive to crudely bedded, coarsening-upward cobble gravel at the Beverly pit is similar to the proximal assemblage in the outwash complex described by Fraser and Cobb (1982) in McHenry County. It is interpreted as proglacial fluvial sediment that was deposited in a prograding outwash plain complex adjacent to the advancing Haeger ice margin.

Lithofacies variability between the diamicton units described at the Beverly pit reflects different depositional environments. Many of the sedimentary features of the lower diamicton lithofacies (Dm(r)), including interbeds of sand and gravel, rafts of fine-textured laminae, silt stringers, coarse clast concentrations along bed boundaries, plugs of pebble- to cobble-size gravel enclosed by diamicton, pods of sand and fine gravel, and strata of variable texture, are characteristic of sediment flow deposits (Lawson and Kemmis, 1983; Eyles et al., 1983). The lack of a preferred orientation in pebble fabrics (fig. 11-1) is also consistent with a sediment flow origin. This lithofacies is interpreted to have originated in the Haeger ice-marginal environment. When the ice margin was located immediately east of the Beverly pit, some of the debris that had melted out in the supraglacial environment probably was mobilized by mass gravity processes and redeposited in the proglacial environment. Such processes could produce many of the sedimentary features observed in the lower diamicton lithofacies.

The overlying diamicton lithofacies (Dm) is interpreted as till. The pebble fabrics measured in this unit show a significant preferred orientation of prolate pebbles that parallels the direction of regional ice flow during the Haeger ice margin advance; the mean vector of the eight strongest pebble fabrics has an azimuth of 86° and a plunge of 13°. The Haeger ice margin overrode the proglacial gravel and sediment flow deposits in the eastern part of the Beverly pit and deposited till, probably by a combination of meltout and lodgement. The nonuniform texture, lenses of sorted sand and gravel, diffuse color and grain-size laminations, sorted layers draped around clasts, and strong preferred pebble orientations with up-ice plunges are consistent with a meltout origin for most of the till.

The sorted sediment (Henry Formation, fig. 11-1) of the overlying lithofacies, including sand and gravel (Sh, Gh) and laminated silt (STl(d)), is interpreted to have originated by glaciofluvial and lacustrine deposition in the supraglacial and proglacial environments at the Haeger ice margin. The massive silt (STm(p)) that blankets the landscape is interpreted as Richland Loess that accumulated on the landscape during the late Wisconsinan deglaciation. The Modern Soil is developed in this unit.

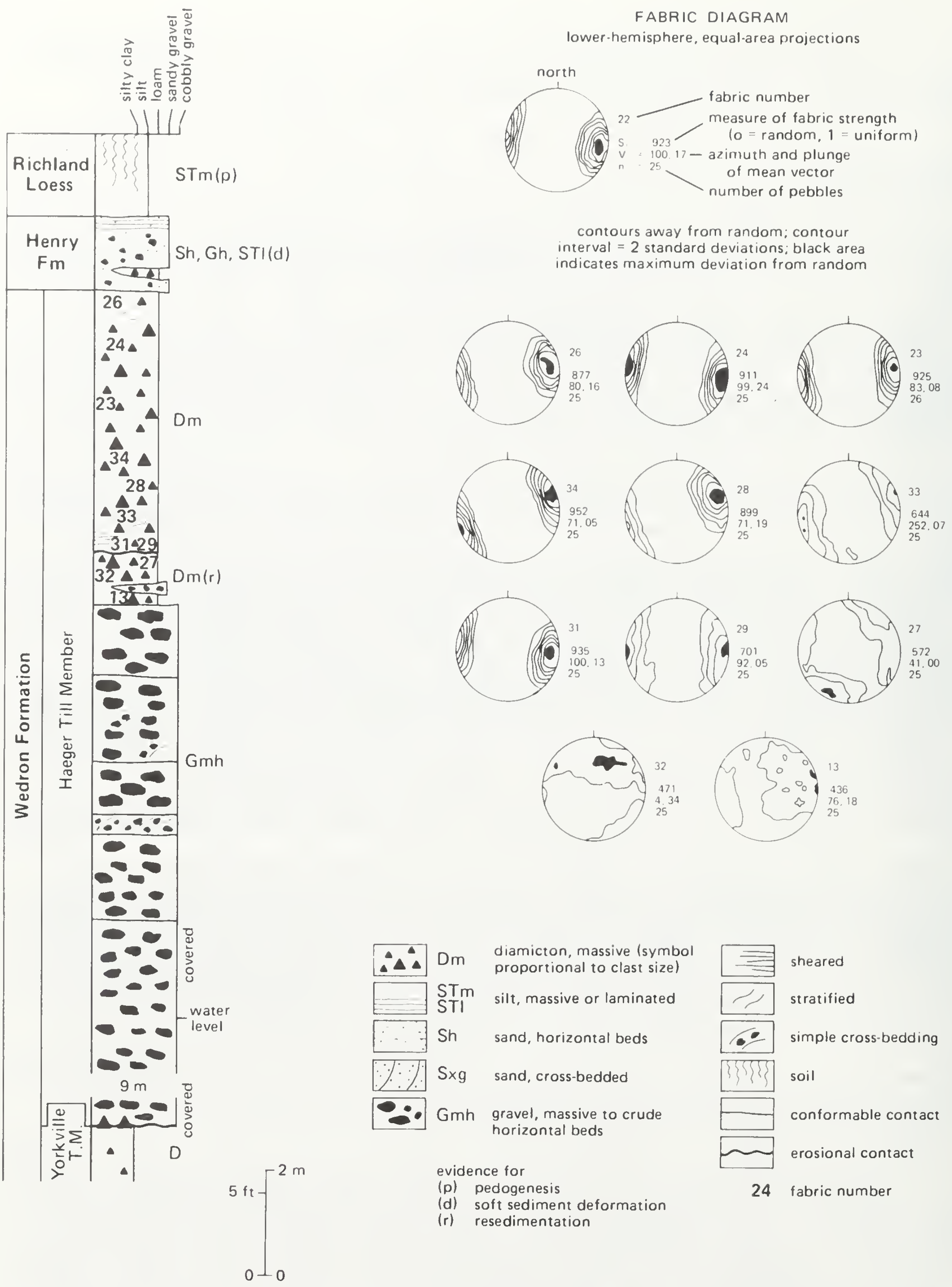


Figure 11-1. Composite section, lithofacies, descriptions, and pebble fabrics at Beverly pit. All fabrics are based on prolate pebbles except fabrics 13 and 19, for which disc and blade-shaped pebbles were also measured.

STm(p)	silt loam; 10YR 4/4; Modern Soil developed in top 0-1.5m (loess).
Sh, Gh, STl(d)	sand, with gravel and silt; 10YR 5/4; lenticular bodies of diamicton present locally; calcareous, 0-2.5m. (outwash, lake and sediment flow deposits)
Dm	pebbly loam, ranges to sandy loam and silt loam, gravel fraction dominantly dolomite; 10YR 5/1, upper 4 to 5m oxidized to 10YR 5/4; contains lenses of sorted sediment, locally stratified with diffuse grain size and color lamination (Ds), locally fissile with evidence of shearing (Dm(s)); calcareous, 0-6.5 m. (till)
Dm(r)	pebbly loam, ranges to sandy loam and silt loam, gravel fraction dominantly dolomite; 10YR 5/1 to 2.5Y 4/2; contains zones of greater clast concentration, rafts of fine textured laminae, silt stringers and lenses and interbeds of massive or crudely bedded gravel; calcareous, 0-2.0m. (sediment flow deposits)
Gmh	cobbles to boulders, with less than 20% sand or finer particle sizes; gravel fraction dominantly dolomite (75%), about 10% metamorphic and igneous rocks; pale yellowish brown to light brownish yellow; calcareous, up to 18m. (outwash)
D	pebbly silty clay; 5Y 4/1; dredged from floor of pit, crane operators report boulder lag at upper contact; calcareous.

DISCUSSION

Johnson et al. (1985) recognized two distinct clay mineral compositions in the Haeger diamicton at the Beverly pit; one contained about 10% less illite than the other. The two compositions were present in both the sediment flow and till lithofacies. One composition (about 65% illite) was similar to that characterizing most of the Haeger in McHenry County; the other composition (about 75% illite) was similar to that of the Lemont drift in its type area. Johnson et al. (1985) suggested that these two compositions could be explained by the convergence in the Beverly pit area of two sublobes (Harvard and Joliet) (fig. I-3) with different flow paths. Lake Michigan Lobe ice that advanced into the Harvard Sublobe area occupied a position on the west flank of the Lake Michigan basin and flowed southwest across southern Wisconsin and northern Illinois. In contrast, the Joliet Sublobe flowed farther south through the Lake Michigan basin before spreading out to the west. Ice with debris from somewhat different source areas would have converged in the area where the two sublobes coalesced and, depending on flow dynamics between the two sublobes, would stack or interfinger. The two distinct compositions present in the Haeger at the Beverly pit are interpreted as reflecting differences in the composition of debris entrained by sublobes of a glacier whose ice margin extended across the Harvard and Joliet Sublobe areas.

CORRELATION WITH THE LEMONT DRIFT

The Haeger Till Member exposed at the Beverly pit is similar to the Lemont drift; correlation of the two units is supported by the following observations:

- Both units occur stratigraphically below the Wadsworth Till Member. The contact between the Wadsworth and the Lemont is exposed at the Land and Lakes Landfill and Green Valley Landfill sections and the Lemont type section. Test boring and water well samples indicate that Haeger is present beneath Wadsworth several km east of the Beverly pit; both units were also exposed at a nearby construction site. The sand and gravel facies of the Haeger Till Member occurs beneath the Wadsworth Till Member in numerous gravel pits at the front of the West Chicago Moraine between Naperville and Elgin (fig. 9-2).

- Both sediment assemblages represent prograding proglacial-glacial successions. Thick proglacial outwash is associated with both units.

- Both units are present in end moraine (West Chicago and Woodstock), which is characterized by kame and kettle topography. The West Chicago Moraine is mapped as Wadsworth, the Woodstock as Haeger. In both the Lemont and the Elgin area, exposures in the moraine indicate that the moraine consists of loam diamicton over gravel and sand, even though the moraine is capped by silty clay diamicton of the Wadsworth south of Elgin to the Lemont area.

- The average matrix textures in tills from the section at the Beverly pit near Elgin and the Lemont type section are nearly identical. Haeger till averaged 38% sand, 49% silt, and 13% clay. Lemont till

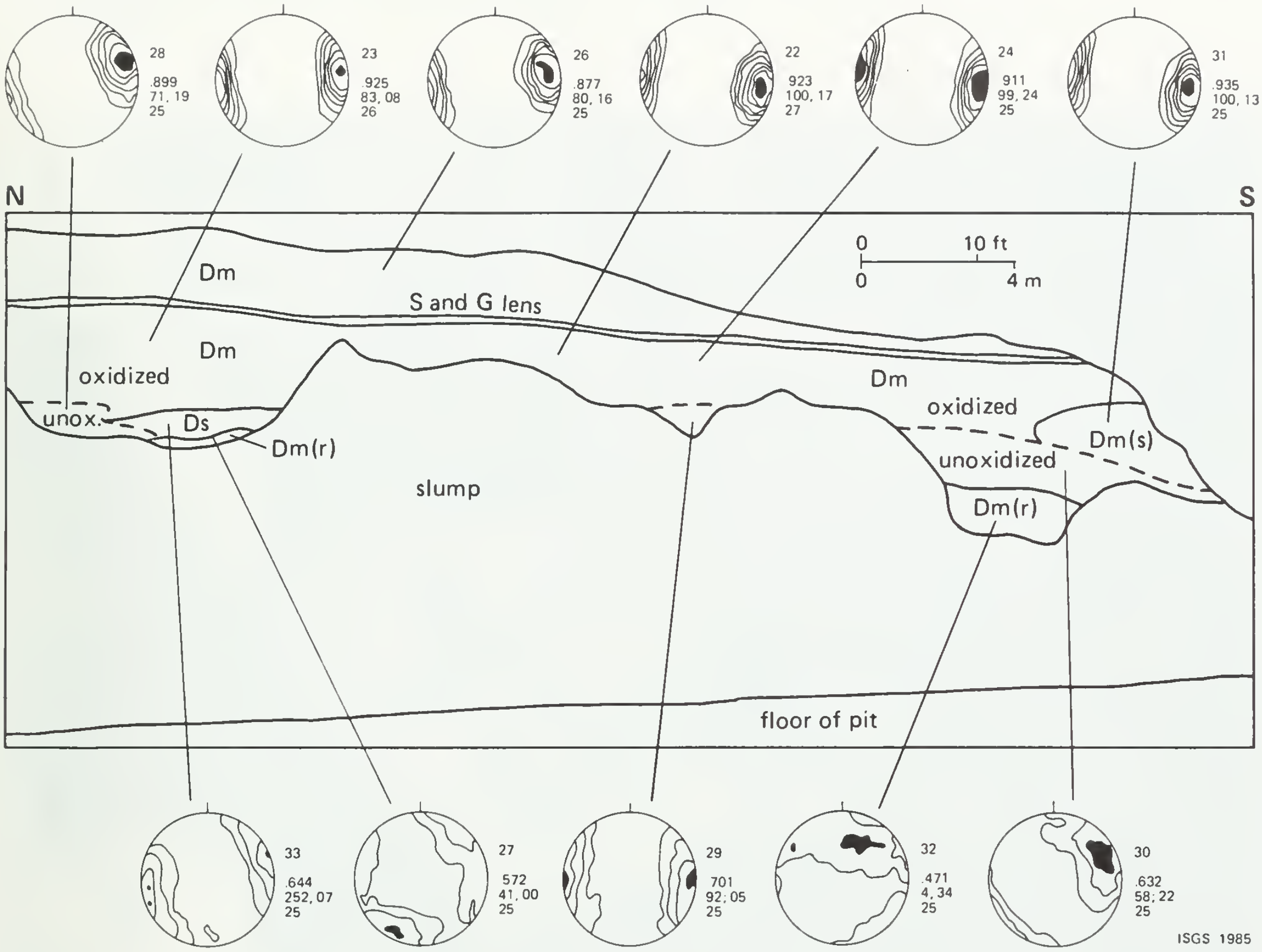


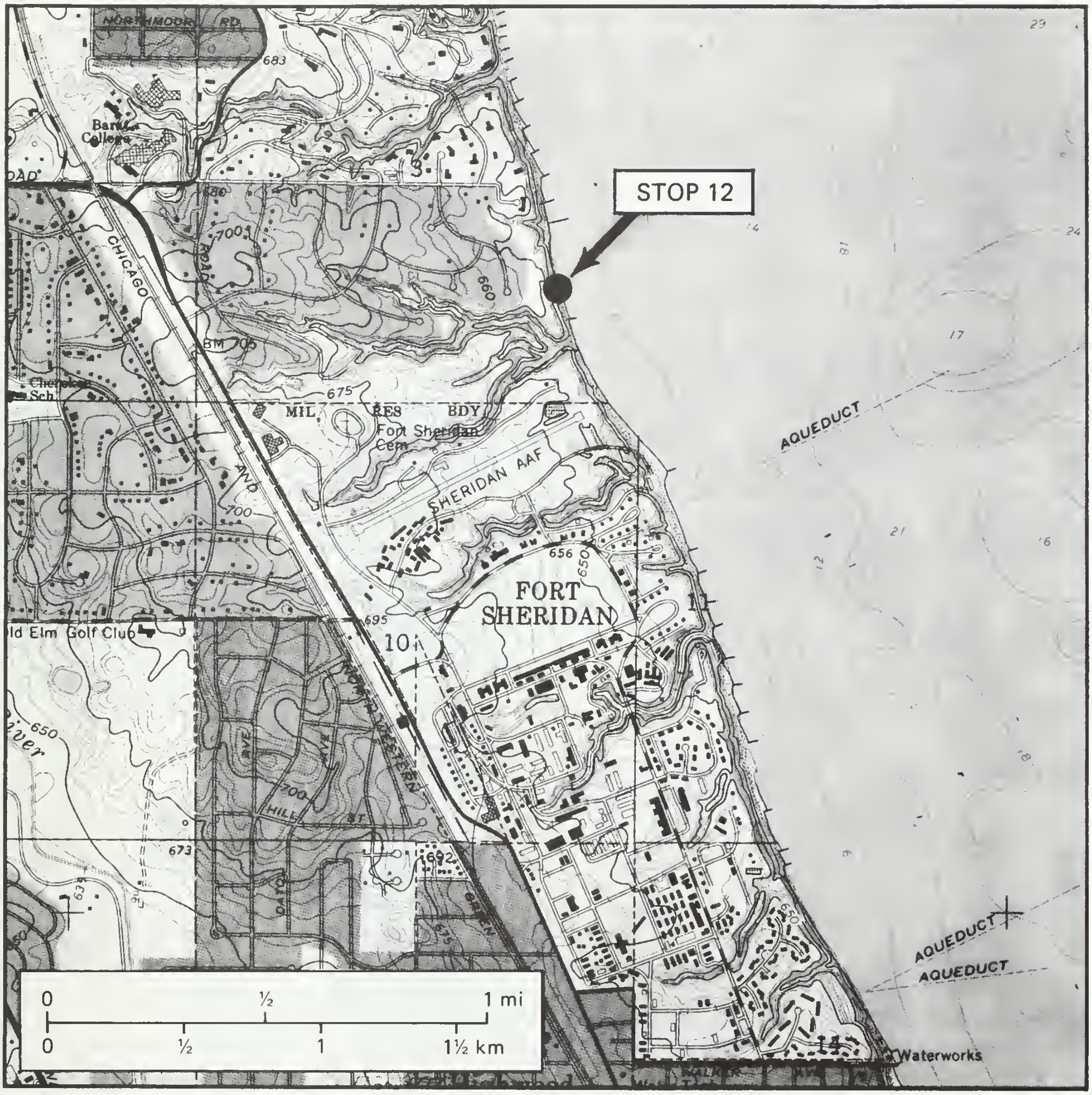
Figure 11-2. Sketch of Haeger Till Member along an east face at Beverly pit. (Fabric and symbols explained in fig. 11-1.)

averaged 40% sand, 48% silt, and 12% clay. Greater sand percentages are reported for the Haeger farther north.

- Dolomite is by far the most abundant coarse clast in both deposits, and the matrix of both units is highly dolomitic.
- Although Lemont diamicton generally contains more illite (about 75%, this report) than does Haeger diamicton--for which averages of 62% (S. Wickham, 1979) and 63% (Schneider, 1983) have been reported--Haeger containing more illite (76% or greater) is present at the Beverly pit. The latter composition, as well as that of the Lemont, is interpreted to reflect a Lake Michigan basin source and deposition by the Joliet Sublobe.

LATE PLEISTOCENE STRATIGRAPHY OF LAKE MICHIGAN COASTAL BLUFFS, FORT SHERIDAN, ILLINOIS

Peter Clark



STOP 12. Fort Sheridan Lake Bluff Section
E½ SE Sec. 3, T43N, R12E, Lake County, IL

This complex sequence of diamictons and stratified glacilacustrine sediment exposed in the lake bluffs of northern Illinois records sediment flows, proglacial lacustrine environments, glacitectonic deformation, and subglacial deposition.

INTRODUCTION

The coastal bluffs here provide excellent exposures that have received little attention from geologists; previous work here has emphasized the nature of the parent material and its effect on rates of bluff erosion. Our objectives during this field trip stop are to (1) describe the stratigraphy and sedimentology of these sediments, (2) interpret their genesis from field properties and fabric data, and (3) discuss how these genetic interpretations affect interpretations of the glacial history of this part of the Lake Michigan basin.

The study area is underlain by Silurian dolomite (Willman, 1971). Coastal bluffs are forming along the Lake Michigan shoreline in northern Illinois where wave erosion is attacking the Lake Border Morainic System. The bluffs, which are generally 10-20 m high, expose interbedded lacustrine clay, silt and sand, and diamicton.

Lineback (1974) assigned glacial sediments in the bluffs to the Wadsworth Till Member of the Wedron Formation. Compositional and textural data reported on samples of diamictons exposed in the bluffs indicate low gravel (<10%) and sand (<10%) percentages, with the remainder being roughly equal proportions of silt and clay (Lineback, 1974). Illite is the dominant clay mineral (70-73%) (Lineback, 1974; DuMontelle et al., 1976). Glacial sediment in the bluffs comprising the Lake Border Moraines was deposited from ca. 14,500 to 13,500 BP (Willman, 1971; Hansel et al., 1985b). Lacustrine sediment overlying the Wadsworth Till Member was assigned to the Equality Formation by Willman (1971); this sediment was deposited in glacial Lake Chicago following retreat of the ice margin northward in the Lake Michigan basin.

METHODS

High water in Lake Michigan during 1985 actively eroded the bluffs, resulting in removal of slump and exposure of fresh outcrops. Detailed field descriptions, sediment logging, and mapping of the bluffs. identified major lithofacies. Water levels have remained high through the 1985-1986 winter, and the outcrops described here will undoubtedly have retreated by the time we visit them.

Sediment samples were collected for standard granulometric analyses (pipette and sieve). The orientation (trend and plunge) of 25 pebbles was measured from each of ten sites in diamictons exposed in the bluffs. We restricted measurements to those pebbles with long axes >2 cm and a long-to-short axis (a/c ratio >2). The data were plotted on Schmidt equal-area lower hemisphere projections by computer and then contoured at 2 σ intervals using the method of Kamb (1959). We then used Mark's (1973) eigenvalue method to statistically evaluate the fabric data in three dimensions.

STRATIGRAPHY

Four units were identified in bluff exposures north of Fort Sheridan (fig.12-1). Reconnaissance work north and south of this area suggests that these units can be recognized along most of the bluffs from Highland Park north to Lake Bluff. This is supported by the generalized sediment descriptions published by DuMontelle et al. (1975, 1976) and Lineback (1974). Furthermore, Jung and Powell (1985) described similar stratigraphic and lithofacies relationships in coastal bluffs from the Illinois/Wisconsin border north toward Milwaukee, although correlations with units described here are not yet possible.

The four units are described briefly in the following section. More complete descriptions are provided in Clark and Rudloff (in press). The units are, from oldest to youngest: (1) a lower, muddy, predominantly stratified diamicton containing abundant sedimentary structures; (2) interbedded clay, silt, and sand, which has been deformed; (3) an upper, muddy, massive diamicton with stratified sand lenses at its base; and (4) clay and sand (fig. 12-1).

Lower Diamicton

When poorly exposed and/or desiccated, this unit appears massive. Fresh exposures created by wave erosion and slumping, however, expose a variety of

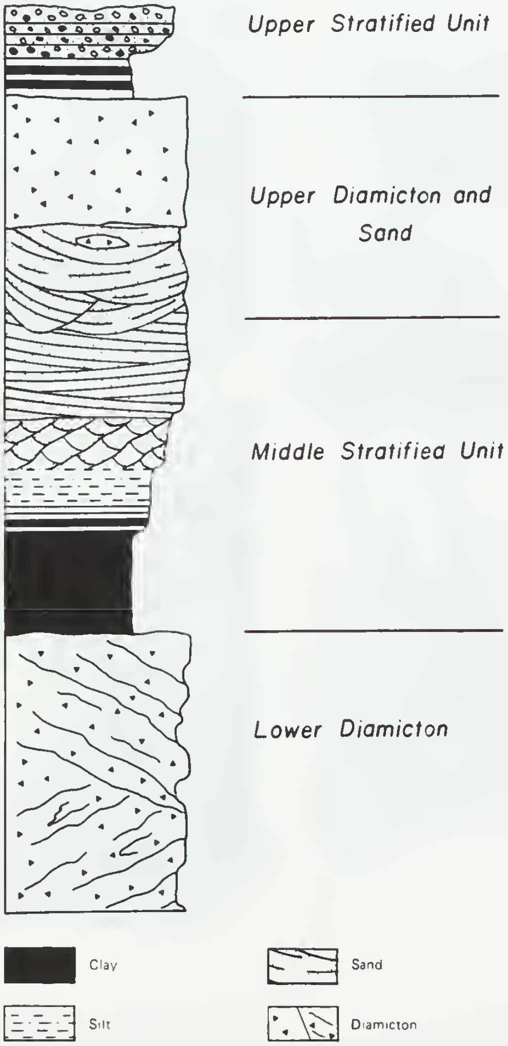


Figure 12-1. Generalized stratigraphic column showing major units described in this paper (not to scale).

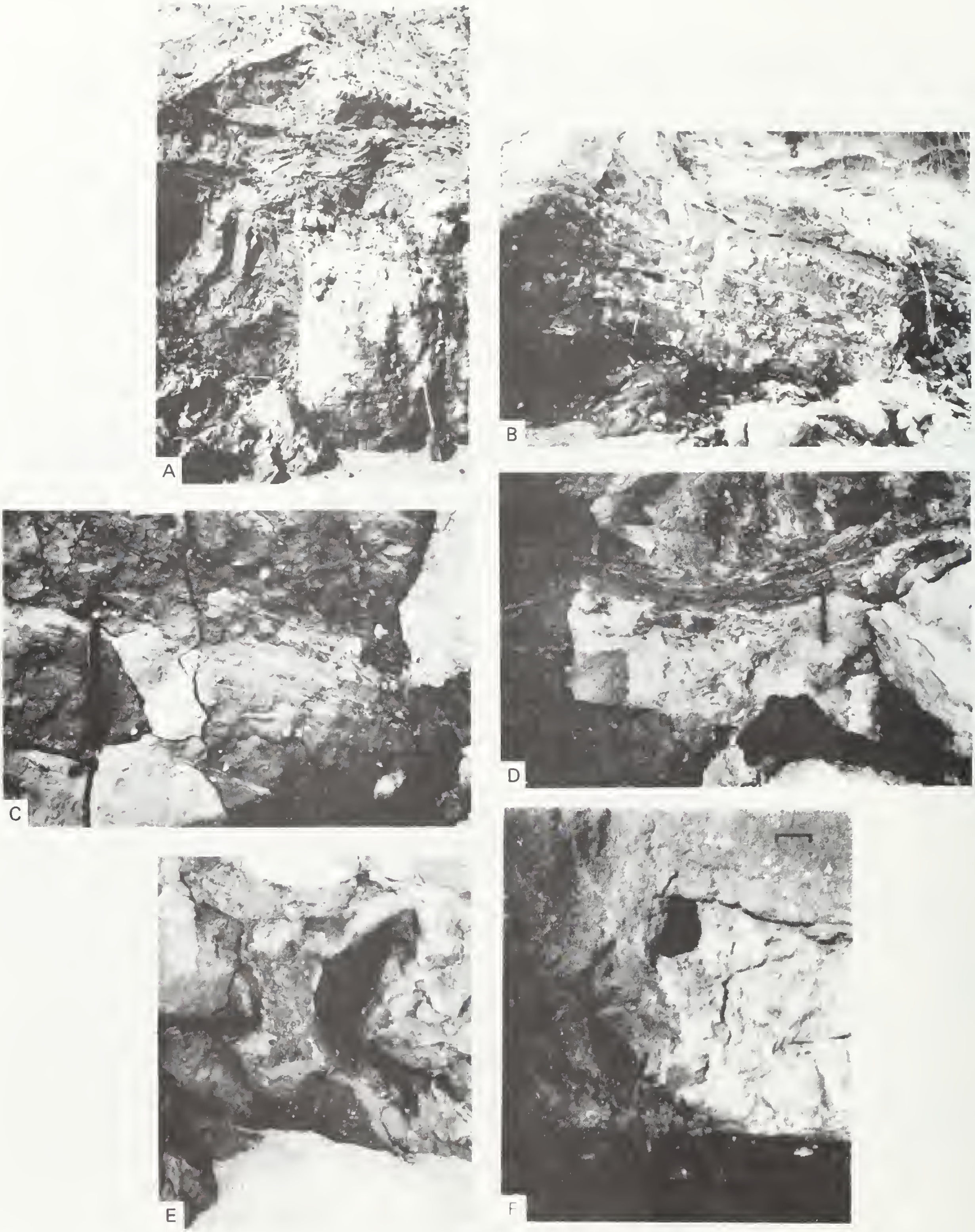


Figure 12-2. Examples of sedimentary structures in lower diamicton. (A) Thin superposed diamicton beds with tractional gravel (especially at handle of shovel). (B) Intraformational units within lower diamicton (outlined). Note silt stratification in center of photo, dipping to the right, and stratification etched by wave erosion dipping to the left in lower left of photo. (C) Loaded and folded silt laminations or "stringers." (D) Interbedded clay and diamicton. Note silt laminations (e.g., at top of pencil) and variability of grain sizes. (E) Folded beds. Gravel has weathered out, leaving cavity. Axial plane dipping to the left. Pencil (for scale) circled. (F) Two cavities formed by wave removal of gravel. Note stratification completely encircling lower cavity. Scale bar = 25 cm.

sedimentary structures. A significant proportion of this unit is stratified (fig. 12-2). Stratification in the diamicton may be identified by distinct, thin (<10 cm) superposed diamicton beds (fig. 12-2a), interbedded diamicton and clay beds (fig. 12-2d), color variations, discontinuous silt and fine sand laminae or "stringers" (fig. 12-2c), and continuous silt laminae extending several meters across the outcrop and defining the geometry of intraformational units (fig. 12-2b).

Several exposures of deformed bedding occur within the unit. Deformation is represented by silt laminae in diamictons where laminae are convoluted and may be isoclinally folded with axial planes oriented parallel to bedding and dipping in the downslope direction (fig. 12-2c). Larger scale deformed structures are represented by overturned and recumbent open folds (fig. 12-2e). Stratified sediments and clay beds are involved in the folding around the fold nose, while diamicton is found only in the core of the fold. Similar structures have been widely reported from stratified diamictons (cf. Boulton, 1972; Evenson et al., 1977; Hicock et al., 1981).

Intraformational stratified diamicton bodies within this unit are characterized by variable geometries and dip orientation and by erosional contacts (fig. 12-2b). The geometry of these bodies is defined by their lower contacts, which are generally concave upward and have dips ranging from nearly horizontal to 46°. The dimensions of the bodies range from 2-4 m thick and 2-15 m across.

Grain-size analyses of the lower diamicton show a greater range in grain size (including gravel) and, on average, higher percentages of sand and silt in comparison to data reported by Lineback (1974).

Scatter plots of pebble fabrics show a large scatter in individual pebble orientation and dip (fig. 12-3). Contoured Schmidt equal-area nets show random fabrics, girdle patterns, or poorly defined maxima (fig. 12-3). Low eigenvalues (S_1), which range from 0.43 (statistically insignificant if <0.46) to 0.66, reflect the fabric patterns and demonstrate little or no clustering about the calculated mean axis (V_1).

Middle Stratified Unit

The contact between this unit and the lower diamicton is conformable. This unit has a maximum observed thickness of 7 m and consists of a coarsening upward sequence from massive and laminated clay and silt to stratified sand.

The entire unit has been deformed, with most intense deformation occurring in the upper half of this unit. Deformation is by faulting, folding, diapiric injection of clay into sand, penetrative deformation, and tilting of beds. Intensity of deformation seems to decrease from top to bottom, away from the overlying diamicton.

Upper Diamicton

This diamicton has a generally uniform thickness of 2-3 m across the upper part of the bluff. The contact between this unit and underlying sediments of the middle stratified unit is erosional. The diamicton is massive, and matrix supported. Grain-size data show a uniform texture with low sand and gravel percentages (<13%) and high silt and clay percentages. Stratified sand bodies are associated with the diamicton.

Pebble fabrics (fig. 12-3) show poorly defined or well-defined fabric maxima reflected by relatively high S_1 values. Orientations of the mean axes (V_1) lie within 16° of each other, and generally trend southwest-northeast. This trend is nearly parallel to the southwesterly ice flow in the region. Dip angles are low to medium, and calculated plunges are toward the northeast, or imbricated in the up-ice direction.

Stratified sand associated with the upper diamicton occupies concave-planar lens-shaped bodies up to 1.2 m thick at the base of the diamicton. Their lower surfaces are eroded ("cut and fill") into underlying silt, clay and sand of the middle stratified unit. Several thin (<5 cm) discontinuous (<1 m) intact diamicton beds occur in the upper part of the sand bodies and are aligned parallel to sand stratification.

Upper Stratified Unit

This unit conformably overlies the upper diamicton. It has a variable thickness, with maximum observed thicknesses >3 m. Sediments range from laminated silt and clay to stratified coarse sand and fine gravel.

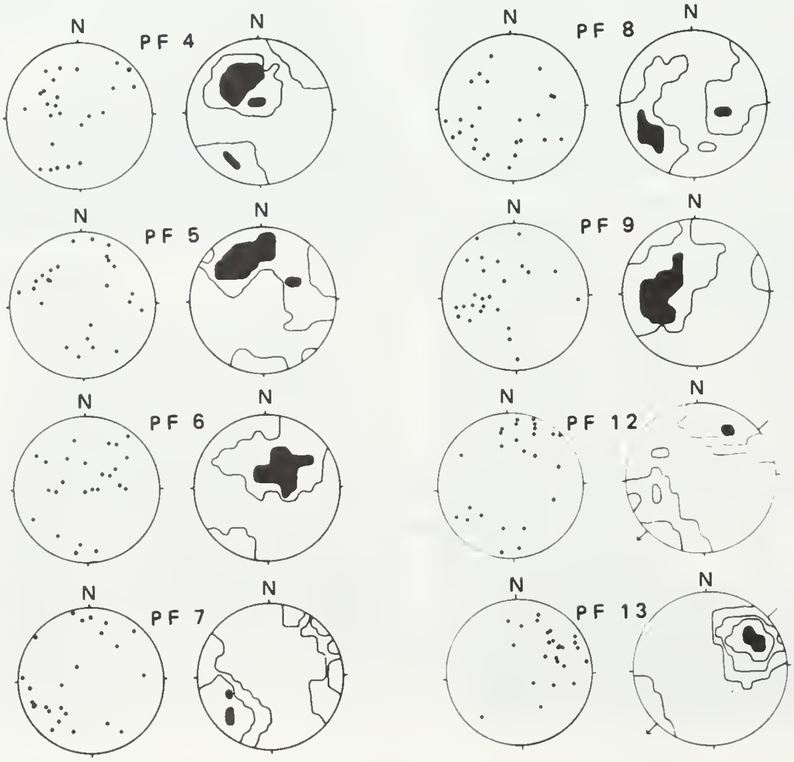


Figure 12-3. Scatter plots and contoured Schmidt equal-area nets for lower (PF 4 to PF 9) and upper (PF 12 and PF 13) diamictons, based on 25 observations each. Contour intervals of 2°.

SEDIMENT GENESIS

Sedimentary structures and pebble fabrics described from the lower diamicton collectively preclude deposition of this unit by glacier ice. Foreign pebble lithologies, clay mineralogy (Lineback, 1974), and striated clasts suggest that much of the sediment in the lower diamicton was initially derived from a glacier source. Deposition of the lower diamicton by lodgement is rejected, however, by the preservation of small-scale sedimentary structures that could not have survived the lodgement process. Deposition by meltout is also dismissed because of the geometry of intraformational units, including their erosional contacts and variable dip directions and slopes. Furthermore, a subglacial origin should be reflected by a strong pebble fabric alignment parallel to ice flow, whereas fabrics measured from the lower diamicton are random or poorly defined, with variable orientations. Sedimentary structures and pebble fabrics characteristic of the lower diamicton, however, are consistent with an origin involving disaggregation and resedimentation by sediment gravity flows.

Proximity of the ice margin to the study area during deposition of the lower diamicton is not known. Variable dip directions of intraformational units suggest an uneven and unstable depositional surface. Unstable slopes and multiple sediment flows may have occurred immediately adjacent to an ice margin, involving a series of coalescing sediment lobes (cf. Evenson et al., 1977; Hicock et al., 1981). Alternatively, the ice margin may have retreated some distance northwards in the basin, and deposition of sediment flows occurred by slumping and remobilization of till on a hummocky, unstable moraine surface. The latter interpretation is supported by concave erosional contacts between intraformational units and variable dip directions. In either case, deposition of the lower diamicton in close proximity to an ice margin is implied.

Sediment of the middle stratified unit was deposited in a proglacial lake. A coarsening-upward sequence from massive silt and clay to stratified sand is interpreted to indicate either a shallowing of the basin or a prograding proglacial delta system related to an advancing ice margin. Subsequent overriding of the area by advancing ice resulted in glacitectonic deformation of the middle stratified unit.

Several characteristics of the upper dimicton suggested that it was deposited by lodgement during this advance: the lack of sedimentary structures, the uniform texture, and the relatively strong pebble fabrics aligned parallel to the direction of ice flow with pebbles imbricated up-ice. Subtill stratified sand bodies are interpreted to have been deposited in channels cut subglacially into the underlying deformed mud and sand. This is supported by diamicton lenses within the sand, which suggest debris masses dropping from an ice roof into the subglacial channel.

Stratified sediment overlying the upper diamicton was deposited in glacial Lake Chicago following retreat of the ice margin northwards into the Lake Michigan basin, and belongs to the Equality Formation.

CONCLUSIONS

Not all diamictons in this part of the Lake Michigan basin are till. This is a significant conclusion with respect to correct genetic classification of glacigenic sediments and stratigraphic interpretation of glacial sequences. In fact, several studies in the Great Lakes region have identified a glacilacustrine origin for diamictons such as described here for the lower diamicton (cf. Evenson et al., 1977; Eyles and Eyles, 1983), suggesting that diamictons may form an important part of the glacilacustrine record.

Interpretations of sediment genesis permit the reconstruction of a more detailed history of late Woodfordian events than previously proposed, although the general framework remains unmodified. Generally, the lower diamicton is interpreted to be reworked till because of compositional properties, and thus indirectly records a glacial advance in the Lake Michigan basin. Genetically, however, the unit is a part of the glacilacustrine record that includes overlying clay, silt, and sand of the middle stratified unit. Deposition of proglacial deltaic and outwash sediment preceded an advancing ice margin. This ice advance overrode its own outwash, glacitectonically deforming the outwash and underlying lacustrine sediment, and then depositing lodgement till over the deformed sediment. Subsequently, glacial Lake Chicago was established over the study area following retreat of the ice margin northwards, and clay, silt, and sand were deposited over the lodgement till.

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ADDITIONAL REFERENCES

Additional work has been completed on a number of the sites since this publication was issued in 1986. A list of new references is given below.

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