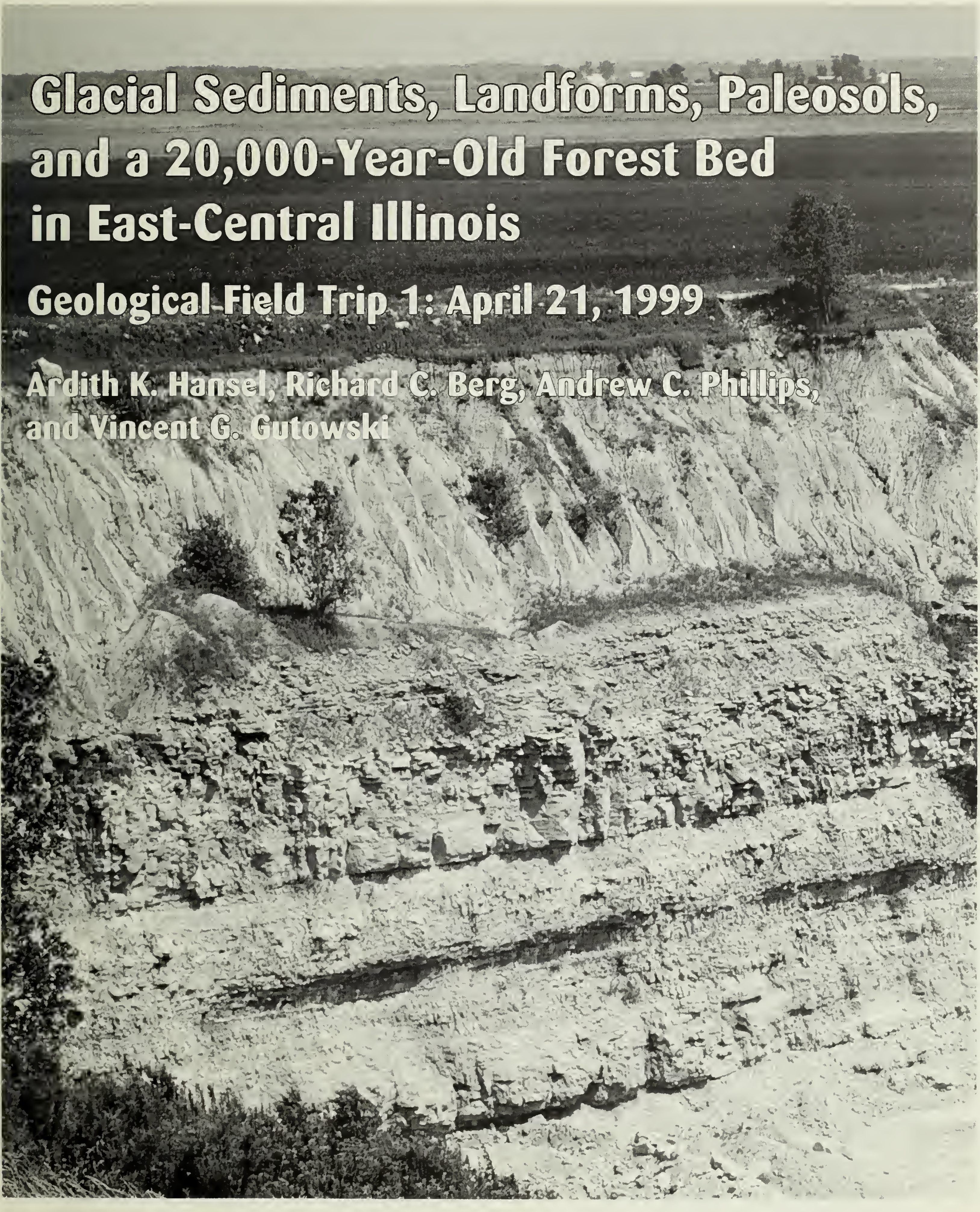
Glacial Sediments, Landforms, Paleosols, and a 20,000-Year-Old Forest Bed in East-Central Illinois

Geological Field Trip 1: April 21, 1999

Ardith K. Hansel, Richard C. Berg, Andrew C. Phillips, and Vincent G. Gutowski



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http://www.isgs.uiuc.edu

Cover photo *East wall of the Tuscola quarry showing succession of pre-Illinois, Illinois, and Wisconsin Episode diamictons above carbonate bedrock.*

Plate 1 *Infrared satellite view of east-central Illinois (see page iv).*

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Ardith K. Hansel, Richard C. Berg, and Andrew C. Phillips
Illinois State Geological Survey
Vincent G. Gutowski
Department of Geology and Geography, Eastern Illinois University

contributions by
François Hardy
Illinois State Geological Survey
William P. White
Illinois Department of Natural Resources, Division of Natural Heritage
Robert E. Szafoni
Illinois Department of Natural Resources, Office of Realty and Environmental Planning

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University of Illinois, Department of Geology
1301 West Green Street
Urbana, IL 61801-2999

U.S. Geological Survey, Water Resources Division
221 North Broadway Avenue
Urbana, IL 61801

To **W. Hilton Johnson**

1935–1997

Hilt Johnson devoted nearly four decades to studying the glacial and periglacial geology of Illinois. Central Illinois was the focus of much of his research, from his Ph.D. thesis and early papers on till stratigraphy, to his research documenting evidence for short-lived permafrost conditions during the last glacial maximum, to his synthesis of the late Wisconsin landscape, sediment sequences, and ice sheet dynamics. Even though many of us initially found the flat terrain of central Illinois uninspiring, Hilt effectively used the area as his teaching laboratory and motivated us to appreciate its uniqueness and subtleties. It is his example that inspired this field trip.

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PLATE

TABLE

Plate 1 Infrared satellite view of east-central Illinois. The arcuate and lobate end moraines (light tone) have abrupt distal slopes and long proximal slopes merging with till and/or lake plains (dark tone) in the up-ice direction. Field trip stops 1, 3, and 7, areas of small-scale fluting (see arrows), the Champaign (C) and Urbana (U) Moraines, the Embarras River (E), and glacial Lake Douglas (LD) are shown. (Landsat 1 MSS acquired on June 11, 1978, Scene ID-LM2024032007816290)

INTRODUCTION

Trip Overview

This field trip will traverse end moraines, till plains, and lake plains of the Wisconsin Episode glaciation in east-central Illinois. Our focus will be the landforms, sedimentary environments, glacial processes, and ice sheet dynamics during the advance and retreat of the Lake Michigan Lobe. At quarry stops, we will examine deposits of the Wisconsin Episode as well as deposits and soils of earlier glacial and interglacial episodes. During the trip, we will discuss our approach to three-dimensional geologic mapping in areas of thick drift.

Whether we are on end moraine, till plain, or lake plain, the landscape over which we travel may seem flat, but there are subtle features to observe. We will demonstrate that even though landscape variations are subtle, the landforms are significant (plate 1) and have important implications for understanding the glacial processes and ice sheet dynamics of the Lake Michigan Lobe in central Illinois.

On our trip south from Champaign, we will follow the route of the Embarras River (plate 1 and fig. 1), which begins on the distal slopes of the Champaign and Urbana Moraines. The Embarras River originated as a glacial meltwater stream that drained the central part of the Decatur sublobe of the Lake Michigan Lobe (fig. 1, inset) as the ice melted back from the Shelbyville Moraine between about 20,000 and 17,000 ^{14}C years B.P.

At the first stop, in the village of Villa Grove, the Embarras River flows across low-relief till plain enclosed by lobate recessional moraines. After heavy rains in the drainage basin, the river overtops its banks causing flooding problems for the village. Near the village of Camargo, the Embarras River flows through a gap in the end moraines; south of there, the river cuts through the delta and lake plain of glacial Lake Douglas (plate 1), which formed when meltwater of the retreating glacier was ponded by the Arcola Moraine to the south.

At Charleston, the Embarras River begins its cut through the upland of the Shelbyville Morainic System (herein called the Shelbyville Moraine); the upland consists of three distinct ridges east of Charleston (the Paris, Nevins, and Westfield Moraines). Headward erosion of the river's tributaries have formed steep, V-shaped valleys in the Shelbyville Moraine at Fox Ridge State Park, where we will stop for lunch. After lunch, we will drive beyond the Shelbyville Moraine onto the Illinoian till plain. Here, tributaries of the Embarras River that head in the Shelbyville Moraine dissect the till plain surface to form rather rugged topography (for central Illinois, that is!), and Illinois Episode glacial deposits of the Glasford Formation can be seen.

We will stop at the Charleston and Tuscola quarries on the way to and from the Shelbyville Moraine to examine glacial successions typical for east-central Illinois. Unfortunately, quarries are few in this area since the drift is thick and averages 10 to 60 m. To understand and map the glacial sediment record, we must rely on shallow cuts exposed in construction sites and along streams and roads. We augment such information with data from engineering borings, water-well cuttings, and our own stratigraphic borings.

Classification and Nomenclature

The glacial deposits of Illinois have been classified into lithostratigraphic units, primarily on the basis of till and loess lithology (color, texture, composition) and stratigraphic position, particularly with respect to intertonguing, proglacial sorted sediments and buried soils. The lithostratigraphic classification used here is from Hansel and Johnson (1996), Lineback (1979), and Willman and Frye (1970). Where these classification systems differ (mostly in classification of the deposits of the Wisconsin

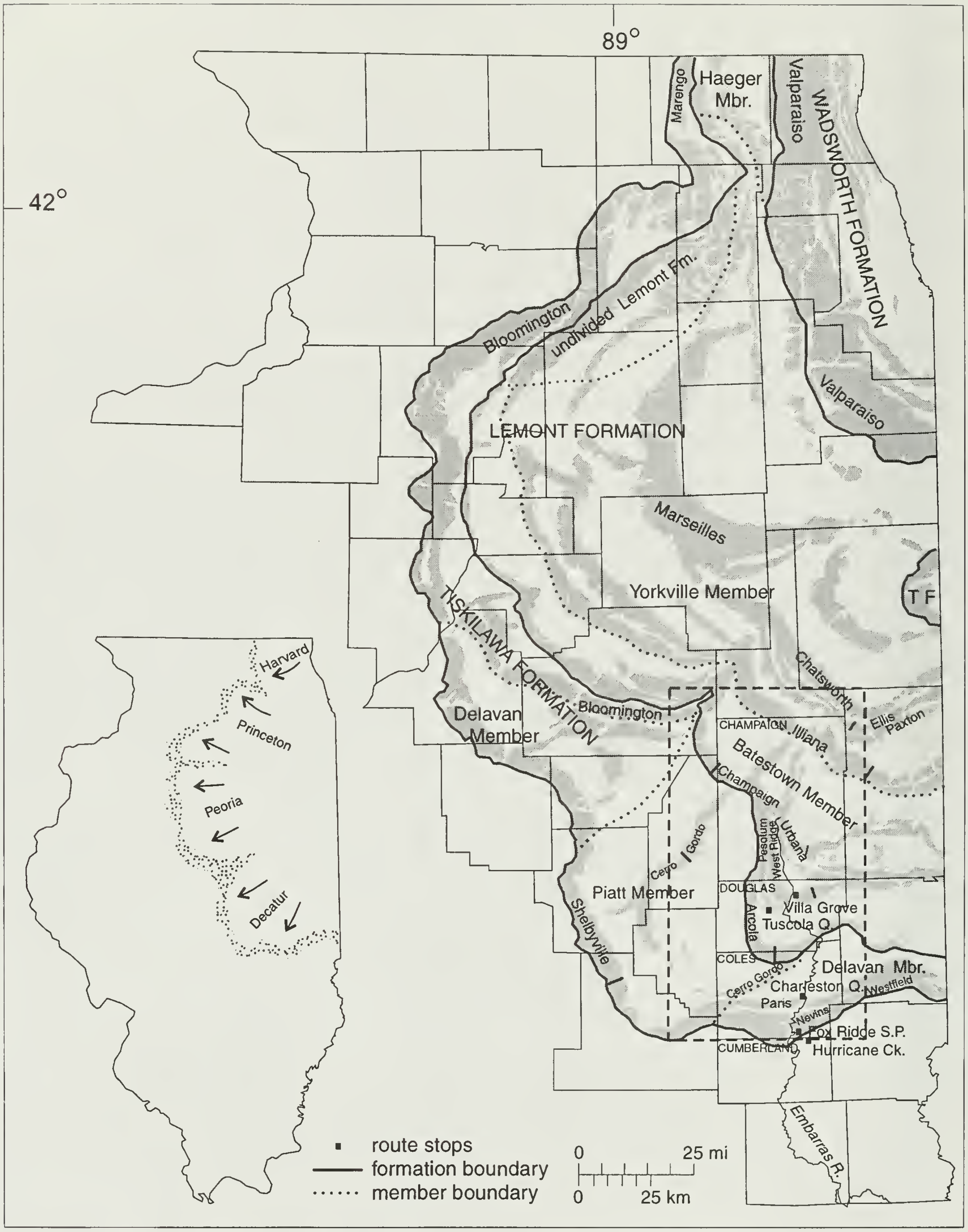


Figure 1 Map of eastern Illinois showing Wisconsin Episode lithostratigraphic units, end moraines (gray), and the sublobes of the Lake Michigan Lobe during the last glacial maximum (inset map). Also indicated are the locations of (1) the satellite view in plate 1 (dashed line), (2) the moraine profiles in figure 4 (heavy dark line segments perpendicular to morianes), and (3) the Villa Grove, Charleston, Fox Ridge State Park, Hurricane Creek, and Tuscola field trip stops. TF stands for Trafalgar Formation, which is not part of the Wedron Group (fig. 2) (after Hansel and Johnson 1996).

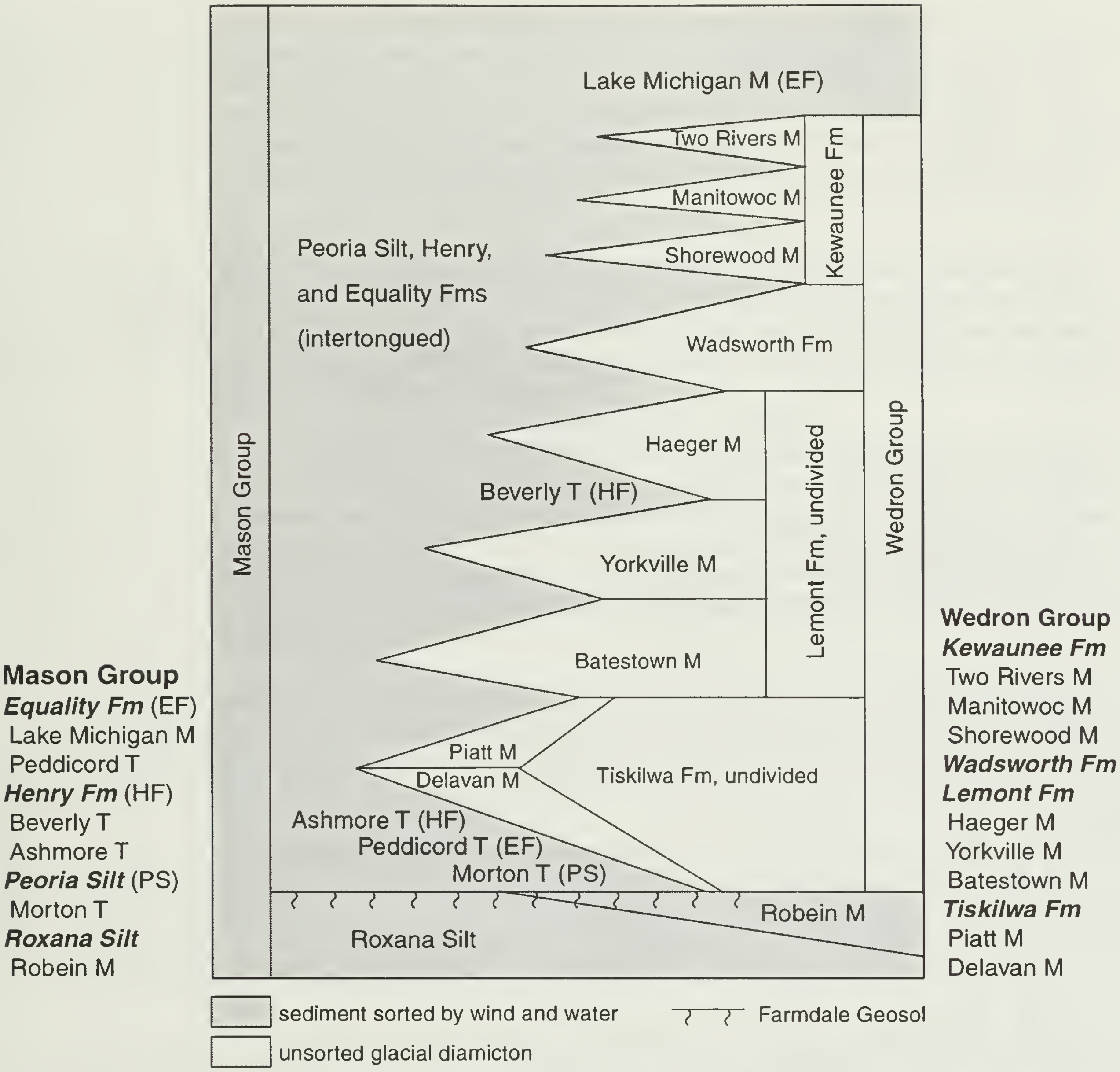


Figure 2 Stratigraphic relationships of diamicton (Wedron Group) and sorted-sediment (Mason Group) units of the Wisconsin Episode in Illinois (from Hansel and Johnson 1996).

glaciation), we have used the most recent system of Hansel and Johnson (fig. 2). The temporal classification used is diachronic (Hansel and Johnson 1996, Johnson et al. 1997) and recognizes the unequal spans of time for events recorded by time-transgressive material units. The time-distance diagram in figure 3 shows both the nonglacial (Athens Subepisode) and glacial (Michigan Subepisode) phases of the Wisconsin Episode in Illinois.

Landforms and the Sediment Record

The following description and interpretation are summarized from Johnson and Hansel (in press). The Wisconsin Episode landscape of east-central Illinois is characterized by a series of subparallel end moraines separated by low-relief till plains and lake plains. The configuration of the end moraines reflects glacial flow out of the Lake Michigan basin and the development of several sublobes where bedrock topographic highs influenced ice flow (fig. 1; Johnson et al. 1986).

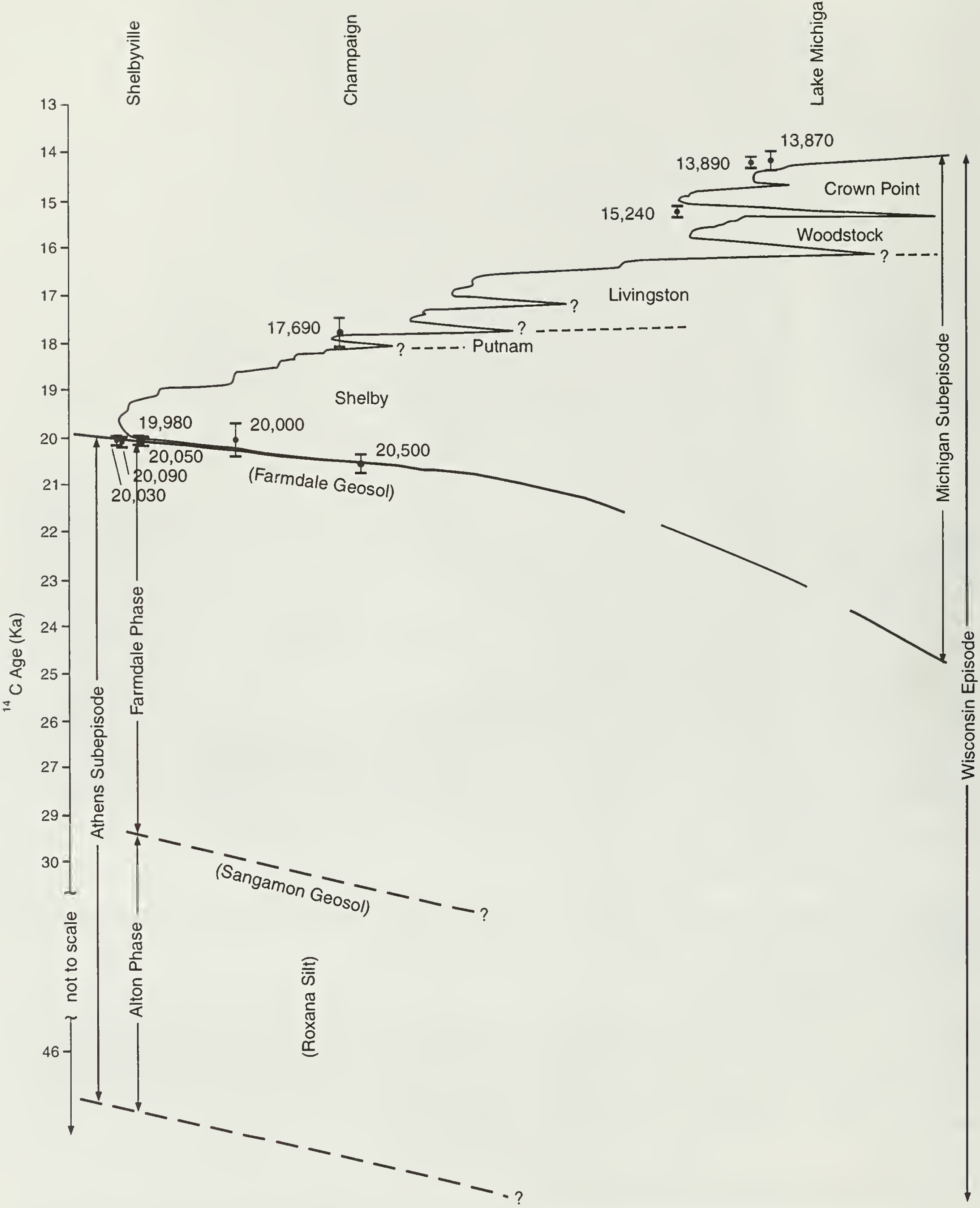


Figure 3 Time-distance diagram for the Lake Michigan Lobe in Illinois representing phases of the Wisconsin Episode including nonglacial phases (Alton, Farmdale) of the Athens Subepisode and glacial phases (Shelby, Putnam, Livingston, Woodstock, Crown Point) of the Michigan Subepisode. The lithostratigraphic and pedostratigraphic units upon which nonglacial phases are based are shown in parentheses. Key ^{14}C control is also indicated (after Johnson et al. 1997).

Most of the moraines are true end moraines; that is, they are composed predominantly of till and formed at an ice margin during the last till deposition event (Mickelson et al. 1983). The end moraines in central Illinois are either simple or superposed (overridden). The broader, multiple-crested morainic systems (Shelbyville, Bloomington, Illiana, Marseilles; fig. 1) are superposed end moraines; these moraines are made up of tills of multiple readvances or stillstands during which the ice built a new moraine on the proximal slope of an older moraine or, in some cases, overrode the older moraine.

In transverse cross section, the end moraines are asymmetric; the distal slopes are steeper and more prominent than the long, gentle, ramp-like proximal slopes (fig. 4). The end moraines are composed of till (Johnson et al. 1971). Both distal and proximal slopes are low (distal slopes are generally 2% or less and proximal slopes less than 1%; fig. 4). Moraine height ranges from about 10 to 60 m. Moraine width ranges from about 2 to 20 km.

In map view, some end moraines are broadly arcuate (e.g., Champaign and Shelbyville Moraines), whereas others are more lobate (e.g., Arcola, Pesotum, and West Ridge Moraines) (plate 1; fig. 1). Unlike the arcuate moraines, the more lobate ones generally lack outwash along their distal slopes and beneath the till of the moraine. On the basis of sediment assemblages, Johnson et al. (1986) and Johnson and Hansel (in press) interpreted the arcuate moraines to represent advance or readvance positions of the entire Lake Michigan Lobe and the more lobate moraines to represent recessional positions of a sublobe.

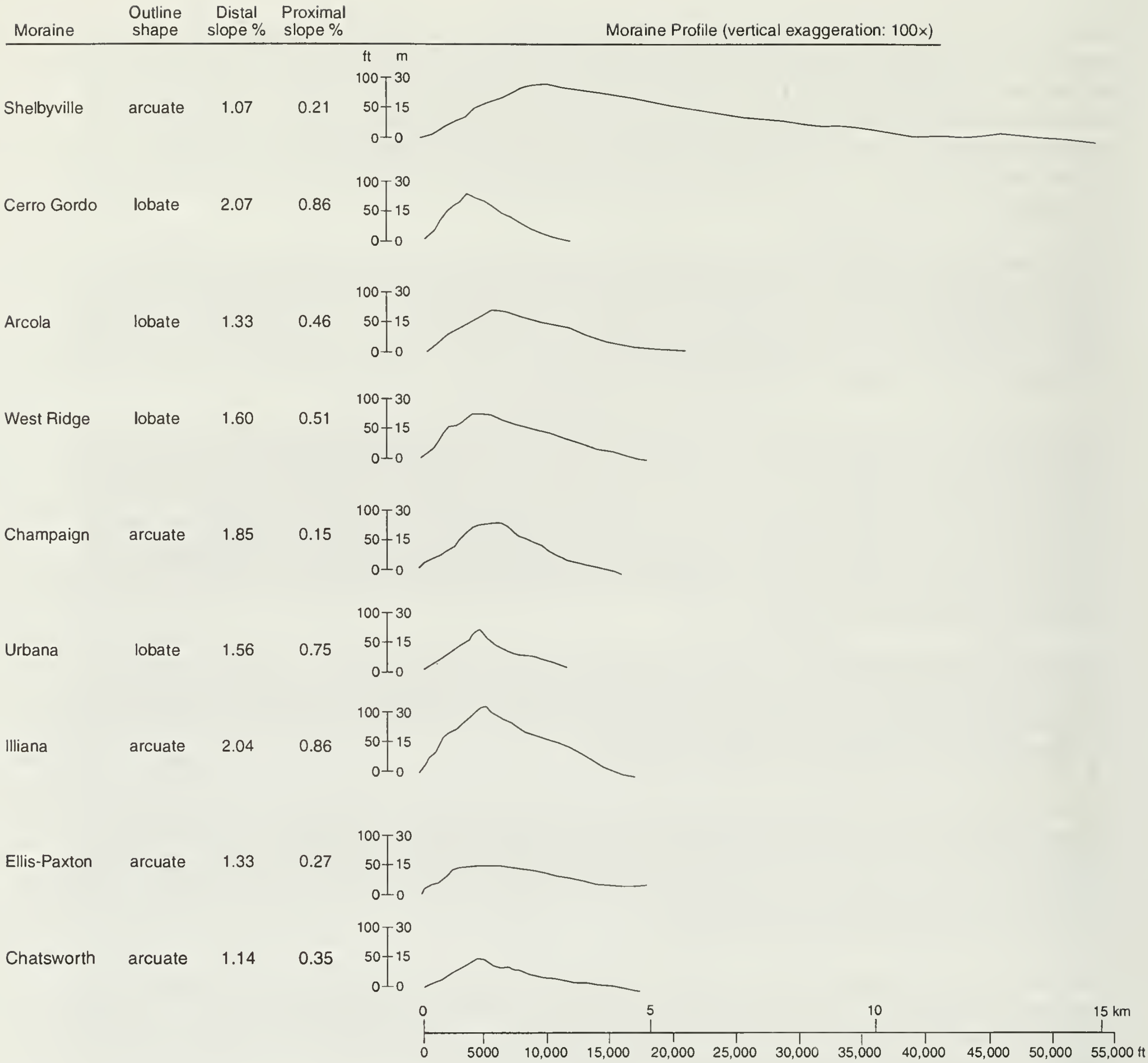
Overall, the landscape and the sediment record lack hummocky topography, kettles, drumlins, eskers, and tunnel valleys—all characteristic features typical of a glaciated landscape. Outwash plains with their associated glaciofluvial deposits are either absent or small, discontinuous, and poorly developed along the distal slopes of most moraines.

The end moraines are separated by lake plains or low-relief till plains that gradually merge with the gentle proximal slopes of the end moraines (Johnson and Menzies 1995; plate 1; figs. 1, 4). Till-plain relief commonly is 3 to 6 m. The linear features parallel to ice flow give some till-plain surfaces a fluted appearance on the satellite photo (plate 1). In lake plain areas, pre-existing relief is subdued by a cover of laminated silt and clay (fig. 5).

The Wisconsin Episode glacial succession in Illinois consists of a series of offlapping drift sheets. The drift sheets (mostly diamicton) pinch out beneath successively younger drift sheets in the direction of Lake Michigan (fig. 5). Locally, tongues of proglacial sorted sediment separate till units of different drift sheets and provide evidence for a fluctuating ice margin.

The generalized cross section from Shelbyville to Lake Michigan shown in figure 5 shows that diamictons (tills) form wedge-shaped units overthickened in end moraines. The base of the Wisconsin drift is marked by a relatively smooth, predominantly erosional contact with paleosols and older drift that had filled bedrock valleys prior to the Wisconsin Episode glaciation. The last interglacial soil (Sangamon Geosol) and in some cases the cold-climate soil (Farmdale Geosol, Athens Subepisode, Wisconsin Episode; fig. 3) are preserved beneath proglacial outwash and lake sediment and/or diamicton in much of the outer 50 to 80 km of the Wisconsin drift (Kempton and Gross 1971). Only in the region of the Silurian bedrock high in northern Illinois have most of the older drift and paleosols been eroded.

The thick, widespread, uniform till sheets and the numerous, large, broad end moraines of central Illinois have generally been attributed to a wet-based, fast-moving Lake Michigan Lobe that had a low ice-surface profile and remained active during retreat from the late glacial maximum position (for example, Willman and Frye 1970, Mckelson et al. 1981 and 1983, Clayton et al. 1985, Begét 1986, Clark 1992, 1994, and 1997, Johnson and Hansel 1990, Hansel and Johnson 1992, Johnson and Hansel in press, Alley 1991, Boulton 1996a and 1996b). Johnson and Hansel (in press) concluded



Moraine	Outline shape	Distal slope %	Proximal slope %
Shelbyville	arcuate	1.07	0.21
Cerro Gordo	lobate	2.07	0.86
Arcola	lobate	1.33	0.46
West Ridge	lobate	1.60	0.51
Champaign	arcuate	1.85	0.15
Urbana	lobate	1.56	0.75
Illiana	arcuate	2.04	0.86
Ellis-Paxton	arcuate	1.33	0.27
Chatsworth	arcuate	1.14	0.35

Figure 4 Sample profiles (vertical exaggeration approximately 4.5x) and distal and proximal slopes for arcuate and lobate moraines in east-central Illinois. Locations are indicated in figure 1 (after Johnson and Hansel, in press).

that both the low-relief landscape and Wisconsin Episode sediment succession are consistent with subglacial deposition from basal ice and/or a deforming bed.

The series of end moraines that formed in Illinois during Wisconsin Episode deglaciation required (1) actively flowing ice to deliver debris to the glacier terminus and (2) conditions whereby the ice margin was stationary for tens to hundreds of years to build up the 30 to 60 m of diamicton in the end moraines. The large number of end moraines that formed between Shelbyville and Lake Michigan between about 20,000 and 14,000 ^{14}C years B.P. (figs. 1, 3, 5) indicates that the ice margin stabilized numerous times during the overall retreat. Whereas most of the moraines record recessional stillstands or slight readvance positions of the ice margin, others represent readvances on the order of tens of kilometers.

The lack of landforms characterized by supraglacial sediment and stratified drift and the small amount of redeposited sediment on the central Illinois landscape are consistent with relatively clean ice in the southern Great Lakes area during the last glaciation (Mickelson et al. 1983). The lack of eskers and tunnel channels on the landscape and the absence of R-channel deposits in the uniform till beds are consistent with predictions by Walder and Fowler (1994) and Clark and Walder (1994). On the basis of glaciological theory, they predicted that the subglacial drainage network at the base of gently sloping ice sheets that rest on fine-grained deforming sediment should consist of many wide, shallow, braided channels. Slower water velocities in shallow, wide channels, as opposed to faster velocities in a few large, dendritic subglacial tunnels such as might develop over a rigid bed, could account for the general lack of outwash along the margins of many moraines in central Illinois (Clark and Walder 1994, Johnson and Hansel, in press). The greater cross-sectional area for a channel network would reduce the ability of the subglacial streams to transport large volumes of coarse material.

Road Log

Miles

0.0 Exit parking lot of the Clarion Hotel and Convention Center and TURN RIGHT on U.S. Route 45 (Neil Street). Follow this road south to Curtis Road.

1.1 At Windsor Road, the route crosses a swale between the east–west-trending Champaign Moraine and the north–south-trending West Ridge Moraine. The route follows the crest of the West Ridge Moraine. The surface diamicton in the moraines of the Champaign-Urbana area (i.e., Champaign, Urbana, Hildreth, West Ridge, and Pesotum Moraines) and in the Arcola Moraine is mapped as the Batestown Member, Lemont Formation.

2.2 TURN LEFT on Curtis Road. For the next mile, the route descends the proximal slope of the West Ridge Moraine. The ridge on the horizon ahead is the juncture of the Champaign and Urbana Moraines.

3.5 Cross the Embarras River, which here is a small stream made up of intermittent tributaries that begin on the distal slopes of the Champaign and Urbana Moraines. Farther south along the route, the Embarras River served as a major meltwater channel draining away from the retreating Wisconsin glacier. The route crosses the Embarras River numerous times on this trip.

4.3 Ascend the distal slope of the Champaign Moraine.

4.5 Cross the crest of the Champaign Moraine. Within the next half mile, the Champaign Moraine is truncated by the Urbana Moraine (as mapped by Willman and Frye 1970).

5.5 Cross the crest of the Urbana Moraine.

6.3 The proximal slope of the Urbana Moraine merges with till plain. As is typical of east-central Illinois, for the next 2.5 to 3 miles, the surface of the till plain is more undulating than that of the end moraines.

6.7 TURN RIGHT on Illinois Route 130. The crest of the Urbana Moraine can be seen on the horizon to the right as the route proceeds south.

8.2 The route rises onto the proximal slope of the Urbana Moraine. Although the moraine averages only 2 miles wide, because the route crosses this stretch of the moraine at an oblique angle, the route traverses the moraine for the next 5 miles.

11.0 Enter the village of Philo.

11.7 Cross the crest of the Urbana Moraine. For the next mile, the crest of the West Ridge Moraine can be seen on the horizon to the right.

13.5 Leave distal slope of the Urbana Moraine.

15.3 Good view of the Urbana Moraine at 7 o'clock. This is one of the more impressive views of an end moraine in central Illinois.

15.8 Cross bridge over the East Branch of the Embarras River.

18.2 Terraces along the East Branch of the Embarras River to the right.

18.7 The Multi-County Landfill is at 10 o'clock.

19.0 After heavy rains in the Embarras River watershed, water ponds in swales to form lakes in the fields in the low area that extends for the next 4 miles along the route. Although water likely accumulated in this low area between moraines as the glacier melted back across the landscape, lake sediment is thin to absent.

20.2 Enter Douglas County. A pit dug approximately 0.5 miles east and 0.5 miles south of here to extract fill for capping the Multi-County Landfill exposed about 2.5 m of spoil fill over 5.5 m of gray silt loam diamicton (Batestown Member, Lemont Formation) over 7.5 m of red gray loam diamicton (Tiskilwa Formation). A striated clast pavement was present between the two diamictons, which we interpret as advance and retreat tills of the Shelby Phase (fig. 3).

20.7 Enter the village of Villa Grove.

21.2 Cross the Embarras River.

21.3 TURN LEFT on Front Street (Douglas County Route 6) and then immediately left again into a parking lot. **Stop 1: Villa Grove.**

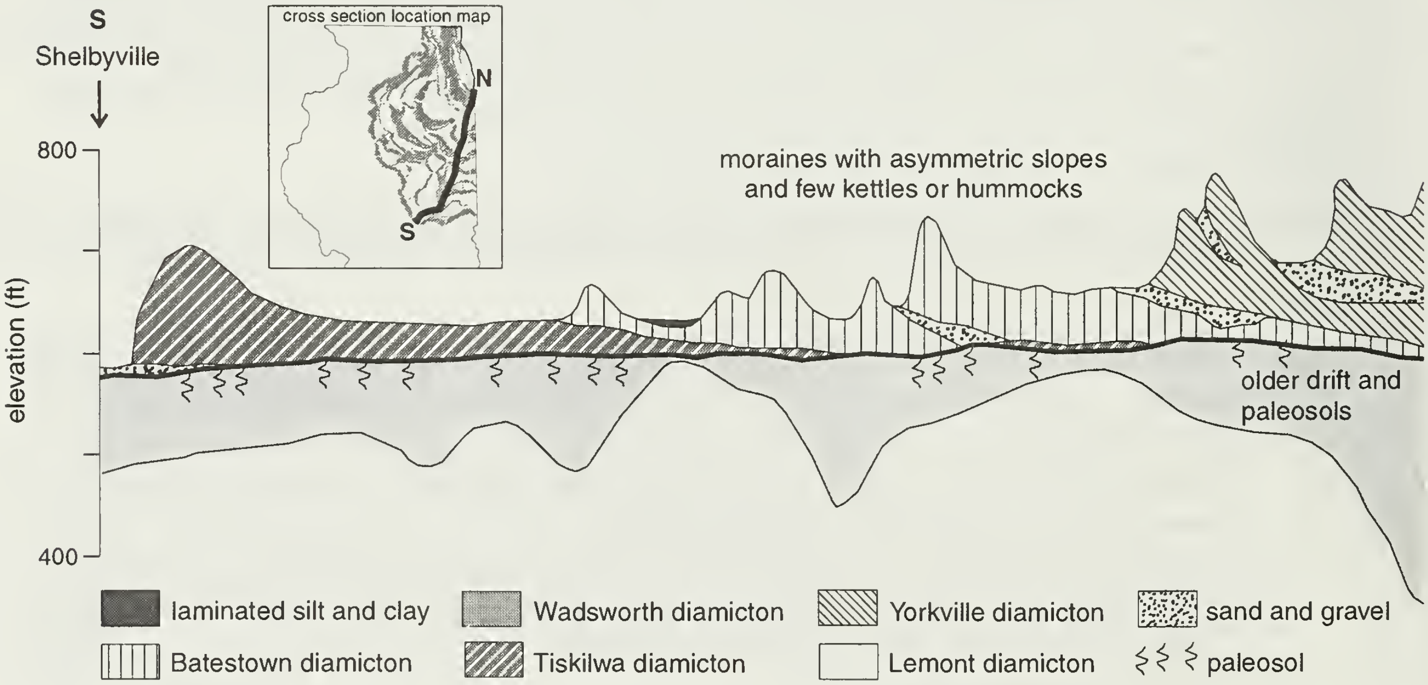


Figure 5 Generalized cross section of glacial drift from Shelbyville to Lake Michigan. Bedrock surface data from Herzog et. al. 1994 (after Johnson and Hansel, in press).

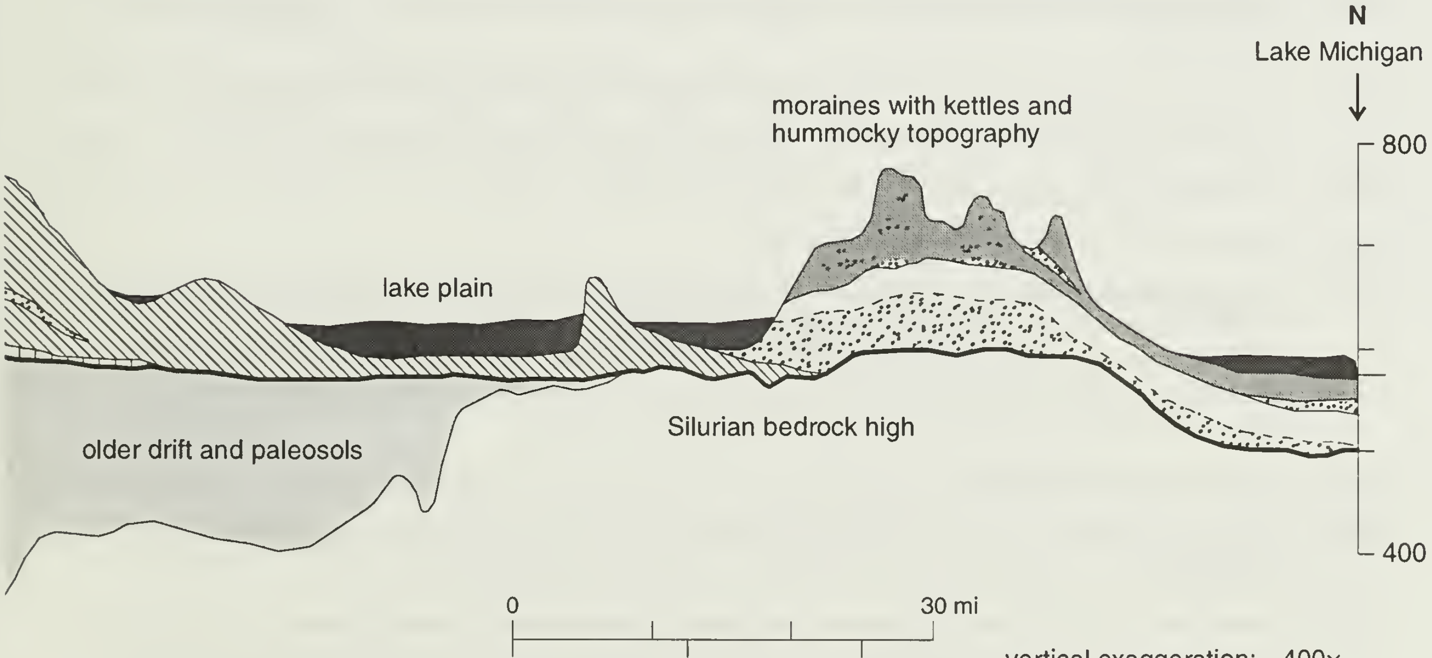
FLOODING PROBLEMS IN VILLA GROVE—*Richard C. Berg*

Most cities and towns in east-central Illinois are located on moraines. Such sites offered relatively better drainage and pleasing views of an otherwise flat landscape. Villa Grove, however, is one of the few towns that was built on a floodplain. Because of its precarious position, repeated inundation by flood waters from the Embarras River has caused many thousands of dollars in damage. A USGS hydrograph from a gaging station near Camargo (about 7 km south of Villa Grove) recorded the area's worst flood on April 12, 1995, when the river rose about 4 m over a three-day period. Recent severe floods also occurred in 1952, 1974, 1992, 1996, and 1997.

Geomorphologic, geologic, and anthropogenic conditions contribute to flooding problems in Villa Grove. The most obvious condition, of course, is that the village is located in the floodplain. Further, the Embarras River traverses very flat till- and lake-plain topography once it emerges from its headwaters in the Champaign and Urbana Moraines. From about 5 km north of the Champaign-Douglas county line to near the town of Oakland (just southeast of the Arcola Moraine), a river distance of about 50 km, the elevation of the Embarras River decreases by only about 4 m (fig. 1). In addition to its relatively low gradient, along almost its entire length, the riverbed consists of diamicton of low erodibility and permeability. Thus, rainwater flows quickly to river courses and rapidly fills the banks.

These natural watershed characteristics have also been substantially altered by settlement. Continued urbanization in Champaign-Urbana, about 27 km upriver from Villa Grove, is often thought to contribute to increased runoff. Villa Grove mayor Ron Hunt (personal communication 1998) contends, however, that heavy rainfall in the Champaign-Urbana area alone does not cause serious flooding in the village. Rather, the most severe flooding is associated with local heavy rainfall.

Kovacic and Gentry (1997) reported that by 1900 almost all of the original acres of prairie in north-central, central, and south-central Illinois had been converted to agriculture. Tile drainage, drainage ditches, and the steel plow allowed farmers to convert even the poorly drained wet prairies into some of the most productive farmland in the world. Nearly half of Champaign County once consisted



of wetlands, either permanent ponds or seasonally flooded hydric soils (total of about 309,000 acres). Today more than 490,000 acres are intensively farmed, and about 80% of this acreage has been drained. About 5% of the county is now classified as wetlands. Recent investigations of the upper Embarras River watershed in Champaign County have revealed that 95% of the annual flow in the river is from agricultural drainage. Kovacic and Gentry (1997) argued that the effectiveness of a modern, more integrated drainage network has resulted in greater water volumes being removed rapidly from the soil and, therefore, that wetlands should be constructed to mitigate the negative effects of this artificial drainage.

The community of Villa Grove is discussing flood alleviation measures, including (1) rerouting the river, (2) diverting Jordan Slough (which enters the Embarras River just north of the village), and (3) cutting shallow, wide ditches to help divert flow away from the village. The latter option seems most cost effective. The village has also purchased and removed several floodplain residences. Presently, the U.S. Army Corps of Engineers is evaluating the flooding problem, and the Embarras River Management Authority is seeking additional federal funds.

21.3 TURN LEFT out of parking lot on Front Street (Piatt County Route 6).

22.3 The Multi-County Landfill is at 9 o'clock.

23.6 The low ridge on the horizon to the right is the West Ridge Moraine.

24.8 Cross Jordan Slough.

25.3 TURN RIGHT on Road 2050E. For the next 2.5 miles, the route ascends the proximal slope of the West Ridge Moraine, which rises about 12 m in elevation to the moraine crest.

27.8 Cross the crest of the West Ridge Moraine. For the next mile, the route descends the steeper distal slope of the moraine. The flat bed of glacial Lake Douglas is visible ahead.

29.7 The route passes off the distal slope of the West Ridge Moraine.

30.0 The route passes onto the lake plain of glacial Lake Douglas.

30.4 TURN RIGHT on U.S. Route 36. The West Ridge Moraine is to the right, and the lake plain is to the left.

34.0 The route rises onto the distal edge of the Pesotum Moraine, which is overlapped to the northeast by the West Ridge Moraine.

34.5 Intersection with Illinois Route 130 (north) on the right.

35.4 TURN LEFT on Illinois Route 130 (south).

35.9 For the next 2.5 miles, the route crosses deltaic sediments (predominantly sand and silt) deposited in glacial Lake Douglas where the glacial Embarras River spilled through a gap in the Pesotum and West Ridge Moraines. Here the sandy deltaic sediments are up to 3.3 m thick and overlie finer-grained lake sediments up to 6 m thick. The deltaic sediments occur as low, ridge-like bars that thin away from the delta head.

37.2 Cross the Embarras River.

38.9 Cross the Embarras River. For the next 4 miles, the route crosses the floor of glacial Lake Douglas.

41.2 Cross Deer Creek. The low ridge on the horizon ahead is the Arcola Moraine.

43.2 Cross the junction with Illinois Route 133. Begin to ascend the proximal slope of the Arcola Moraine. This moraine ponded meltwater to form glacial Lake Douglas. The Arcola Moraine is approximately 4 miles wide here; the proximal slope is 3 miles wide.

46.5 Cross the crest of the Arcola Moraine. For the next 0.6 mile, the route descends the distal slope of the moraine.

47.3 Cross the Flat Branch, a small, westward-flowing tributary of the Kaskaskia River that originates between the Arcola and Cerro Gordo Moraines. The surface diamicton in the Cerro Gordo and Shelbyville Moraines is mapped as the Piatt Member, Tiskilwa Formation. Diamicton of the Piatt Member is grayer and sandier and less clayey than type Tiskilwa diamicton.

47.5 Rise onto a northeast–southwest-trending segment of the Cerro Gordo Moraine.

48.1 Cross the first crest of the double-crested Cerro Gordo Moraine.

48.6 Cross the second crest of the Cerro Gordo Moraine.

48.8 Leave the Cerro Gordo Moraine. For the next 6 miles, the route crosses a gently undulating till plain between the Cerro Gordo Moraine and the Shelbyville Moraine.

54.7 Enter Charleston city limits.

56.2 TURN RIGHT on Madison Street.

56.5 TURN LEFT on Division Street.

56.7 TURN RIGHT into City of Charleston Kiwanis Park.

56.9 **Stop 2: Kiwanis Park.** Coffee and rest stop.

57.1 TURN LEFT on Division Street and begin to ascend the proximal slope of the Paris Moraine, the northernmost moraine of the Shelbyville Morainic System.

57.7 TURN LEFT on Illinois Route 16 (Lincoln Avenue).

58.1 The castle-like building on the right is Old Main, which houses administrative offices on the Eastern Illinois University campus.

58.7 Intersection with Illinois Route 130. CONTINUE AHEAD on Illinois Route16.

59.8 Pass from the proximal slope of the Paris Moraine onto till plain.

62.0 TURN LEFT into the Charleston Stone Company quarries. The Embarras River can be seen on the right.

62.4 TURN LEFT and proceed past "the turtle" up the hill.

63.1 **Stop 3: Charleston Stone Company quarry**

CHARLESTON STONE COMPANY QUARRY—*Ardith Hansel, Vincent Gutowski, Andrew Phillips, and François Hardy*

Overview

Quaternary exposures in a series of pits at the Charleston quarries have been studied for the past three decades (e.g., Ford 1973, Gutowski et al. 1991 and 1998, Hansel and Johnson 1996, Johnson and Hansel in press). These exposures provide an opportunity to examine the sediment succession of the Wisconsin Episode at a site near the last glacial maximum (fig. 1). Above the last interglacial soil, proglacial deposits consist of (1) loess in which a forest soil (A horizon of the Farmdale Geosol) is developed, (2) lake sediment that contains a diamicton tongue interpreted to be a subaqueous flow deposit, and (3) outwash sand and gravel (fig. 6). The Farmdale Geosol has tree trunks (spruce) rooted in it (fig. 7a). A planar, erosional contact separates the outwash from a subglacial

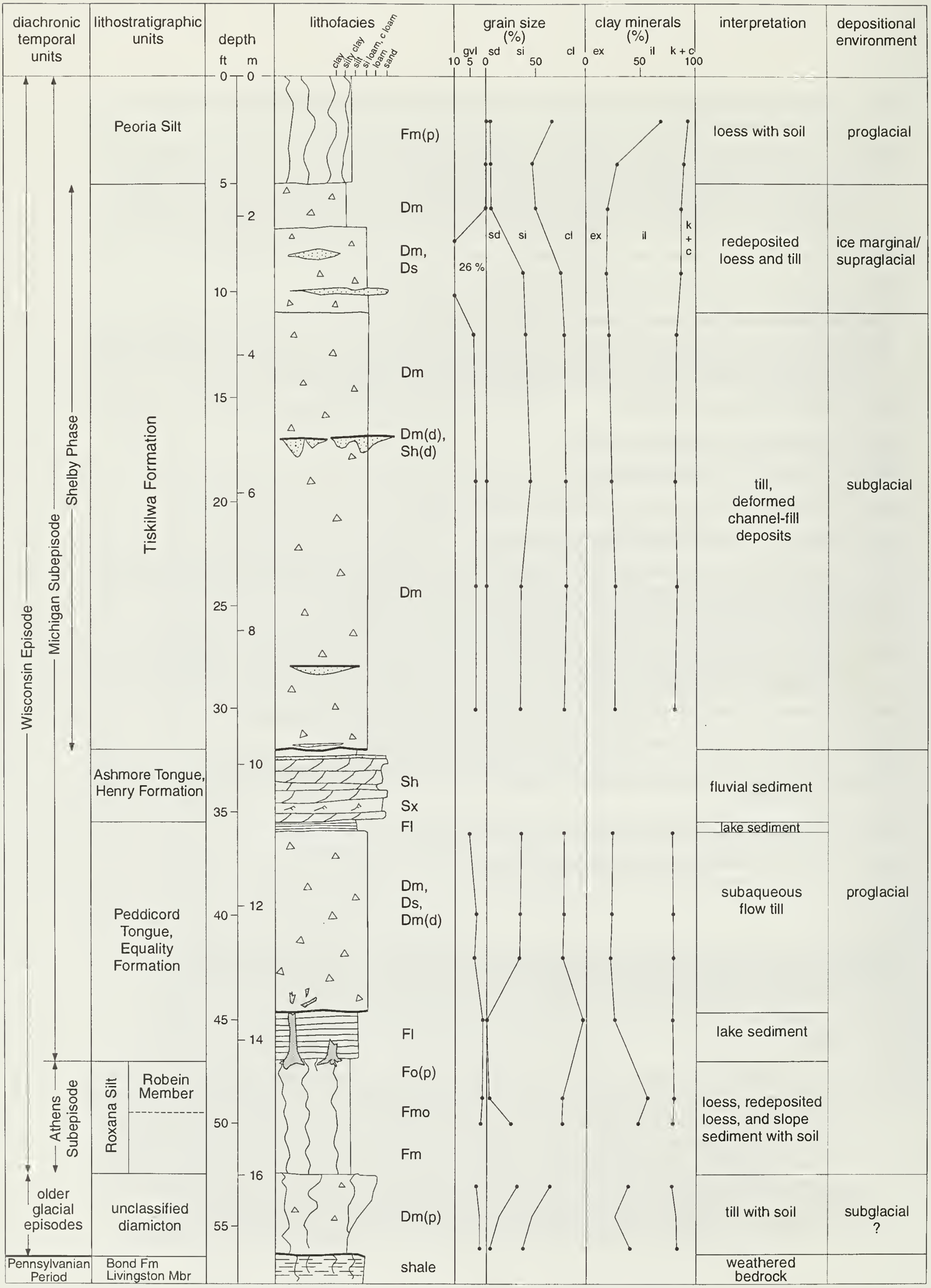


Figure 6 Lithofacies characterization, classification, and interpretation at Charleston Stone Company quarry.

till (figs. 7b, c). The subglacial till contains irregular sand lenses, the long axes of which trend north to south; these lenses may represent deformed channel-fill deposits (fig. 7d). Loess caps the section.

Section Description

The lithofacies in a large gully near the north end of the west wall of the pit are described in figure 6. The upper part of the Pennsylvanian bedrock is altered by soil formation. The lowermost unit is a leached, reddish-black clay diamicton that grades upward into a leached, light brown (5YR 6/3) clay loam diamicton. The Sangamon Geosol and older paleosols are developed through these diamictons, which are attributed to the Illinois and pre-Illinois glacial episodes. The lithology of the lower part of the till reflects incorporation of weathered bedrock.

Overlying the Sangamon Geosol is a massive loam to silt loam interpreted to be loess and redeposited loess of the Athens Subepisode, Wisconsin Episode (Roxana Silt). The lower part of this unit contains more sand and clay and some pebbles where it overlies the Sangamon Geosol; the lower contact is gradational. Leached throughout its thickness, the unit has a distinct though gradational upward color change from brownish red (10YR 4/3) to black to dark brown (10YR 2/2) accompanied by an increase in organic material and a slight increase in expandable clay minerals. The Farmdale Geosol is developed in the upper part of the unit (Robein Member). Forest litter, including rooted spruce trunks (fig. 7a), is abundant. The litter layer, which locally includes a moss bed at the top, marks a paleosurface. Four ^{14}C ages for wood and organic silt place development of the forest somewhere between 20,660 ± 170 and 19,340 ± 180 ^{14}C years B.P.

The sequence of sediments above the Farmdale Geosol is interpreted to reflect (1) the infilling of a proglacial low area by lacustrine, subaqueous flow, and fluvial deposits; (2) glacial overriding and deposition of till, possibly under deforming-bed conditions; (3) deposition of supraglacial/ice marginal sediment as the glacier receded; and (4) loess deposition and reworking along slopes. The origin of the proglacial lake is not known, but could be related to damming of the local drainage as a result of glaciofluvial sedimentation in the pre-Embarras River valley at about 20,000 ^{14}C years B.P. The lake probably was not regional; lacustrine silts pinch out in the southern portion of the pit and are not present in quarry pits east of the Embarras River. The lake sediments are gray silts containing faintly oxidized laminae. The silts are classified as the Peddicord Tongue (Equality Formation). Some of the tree trunks rooted in the subjacent Farmdale Geosol extend through the lacustrine silt, which is 1.8 m thick in the measured section.

lithofacies

- D diamicton
  - m massive
  - s stratified
  - (d) deformed
  - (p) pedogenized
- F fine-grained sediment
  - m massive
  - l laminated
  - o organic
  - (p) pedogenized
- S sand
  - h horizontal bedded
  - x crossbedded
  - o organic
  - (d) deformed

materials

- △ diamicton
- □ fine-grained sediments
- ▒ sand
- ⁘ gravel

contacts

- ☰ conformable
- ≈ erosional
- ⌣ clast concentration/ pavement

structures/ inclusions

- ⬭ lens
- ▽ subglacial channel-fill deposits
- ≡ laminae
- ⌒ trough crossbeds
- ⌃ ripple crossbeds
- ♣ trunk/wood fragments
- ⦀ soil

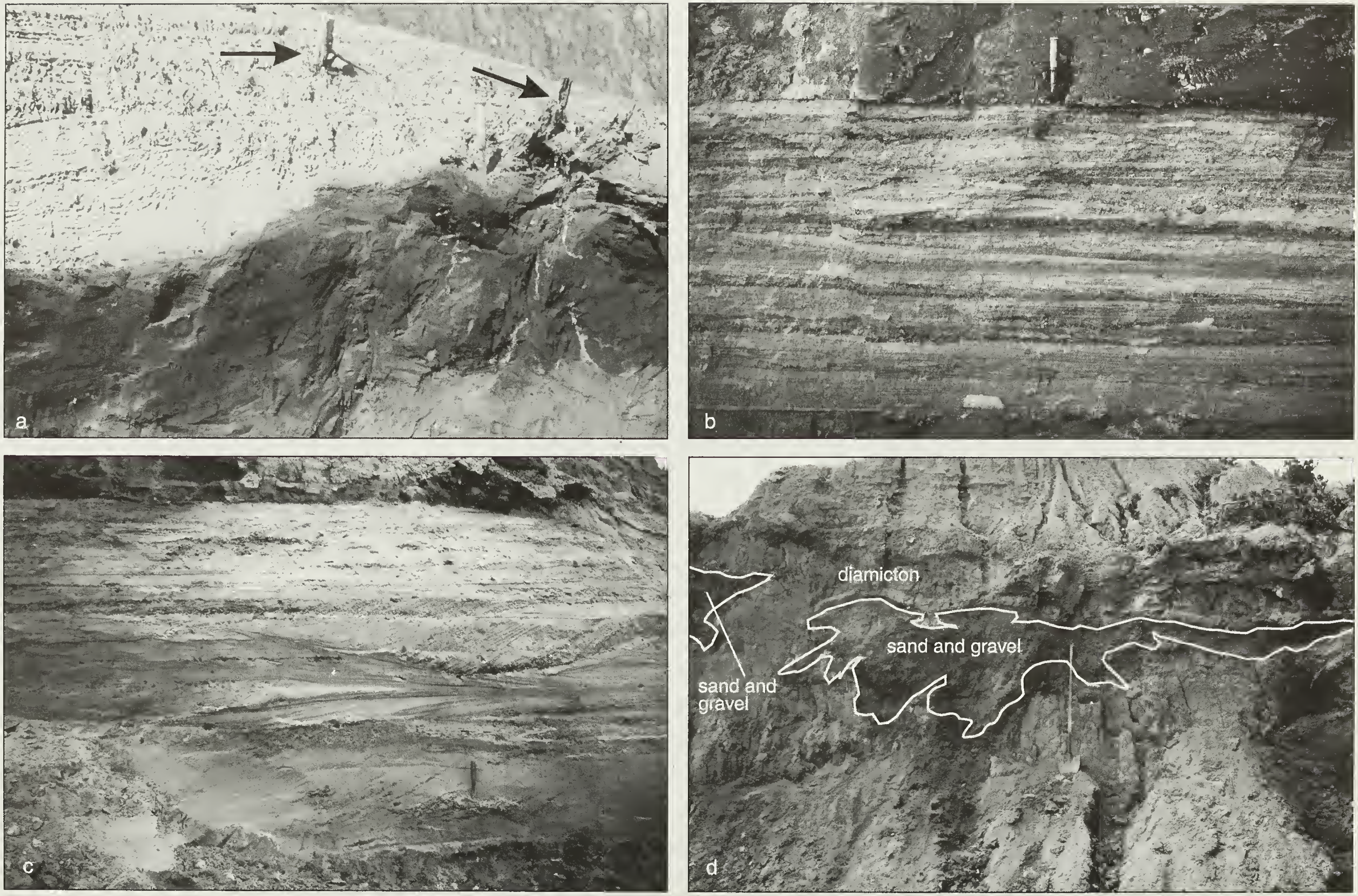


Figure 7 Sedimentary features at the Charleston quarry: (a) tree trunks (arrows) rooted in the Farmdale Geosol and buried in laminated lacustrine silt; (b) planar, erosional contact between subglacial till and outwash sands; (c) sedimentary structures typical of sandy, braided streams in outwash sands; and (d) cross-sectional view of deformed channel sand bodies within till (shovel for scale). Knife for scale, except in photo d.

One interesting feature of this stop is a large tongue of diamicton that separates the lacustrine deposits into upper and lower beds (figs. 6, 8). In 1995, the tongue, which ranged up to 2.9 m thick and pinched out southward, extended 100–130 m across the exposure. To the north (up-ice direction), the upper lacustrine bed and overlying sands pinch out and the tongue merges with the overlying diamicton. Diamicton in the tongue is similar to the overlying diamicton in grain size, color, and clay mineral composition (fig. 6). The mainly uniform diamicton of the tongue locally contains thin, discontinuous silt streaks parallel to the silt-diamicton contact and folded, attenuated wisps of organic-rich silt. Pebble fabrics measured in the diamicton tongue, though relatively strong (fig. 8), indicate pebbles dipping to the southwest or southeast. The diamicton tongue is interpreted to be a subaqueous flow deposit.

The bed geometry, internal variability, pebble fabrics, and similarity to the overlying subglacial till are consistent with a subaqueous, debris-flow origin for the diamicton tongue. Additional evidence includes a tree trunk that was observed by Gutowski and Hansel in 1995. The trunk was rooted in the Farmdale Geosol and extended through the lacustrine silt and into the diamicton. The trunk was bent to the south, the assumed direction of debris-flow movement.

Overlying the lacustrine silts containing the diamicton tongue is a gradational contact with an overall coarsening-upwards sequence consisting of a 1.1-meter-thick subunit of fine to coarse sand overlain by a few centimeters of silt. Sedimentary structures in the unit include horizontal laminae, planar crossbeds, silt and gravel lenses, and ripple trough crossbeds (figs. 7b, c). Primary bedding is undeformed in the sand, which is separated from the overlying diamicton by a sharp, planar, erosional contact. This sand unit, classified as the Ashmore Tongue (Henry Formation), is interpreted to be overridden outwash (fig. 6).

The particular depositional environment of the outwash sands is unclear. No large-scale foreset beds typical of a prograding delta, however shallow, have been observed. Could the lake have been completely filled, or did it drain prior to progradation of the outwash sands?

More than 6 m of silt loam diamicton (Tiskilwa Formation) are present above the proglacial sands. In lithology, the upper diamicton is like that of the subaqueous flow deposit in the diamicton tongue (fig. 6). The upper diamicton is mainly uniform, although attenuated lenses of sand and silt are present near the base. A strong fabric (CQ196 in fig. 8) with pebble long axes dipping to the northeast (up-ice direction) was measured in the upper diamicton, whereas four weaker fabrics (fig. 8) with pebble long axes dipping in the down-flow direction were measured in the diamicton tongue.

In some parts of the quarry, stratified gravelly to fine sand bodies within the diamicton reach about 1 to 3 m across and are less than 1 m thick (fig. 7d). The sand bodies are channel shaped, generally with flat tops and parabolic bottoms; some bodies show evidence of deformation including compressed and rotated sediments and intruded diamicton diapirs. On the basis of sedimentary characteristics, we interpret the diamicton overlying the diamicton tongue to be till that was deposited subglacially as the glacier advanced and retreated over the area. The sand bodies may reflect infilling of subglacial channels that were eroded into soft substrate materials and later deformed.

Above the diamicton interpreted to be subglacial till is a distinct contact with 2 m of diamicton, separated into two beds, also classified as Tiskilwa Formation (fig. 6). Although color and overall grain-size distributions do not change across the contact between till and the lowermost overlying diamicton bed, gravel concentrations quadruple (from 6% to 26%). Lenses of crudely stratified gravelly sand, silt, and diamicton are also more abundant than in the underlying more uniform till. The lower and upper diamicton beds are separated by a sharp contact. The upper bed contains more clay and less gravel than the lower one (fig. 6). The two diamicton beds are interpreted to reflect resedimentation of supraglacial debris and loess deposited during glacial retreat. The section is capped by 1.5 m of uniform, leached silty clay loam interpreted to be loess with modern soil developed in it; the loess is classified as the Peoria Silt.

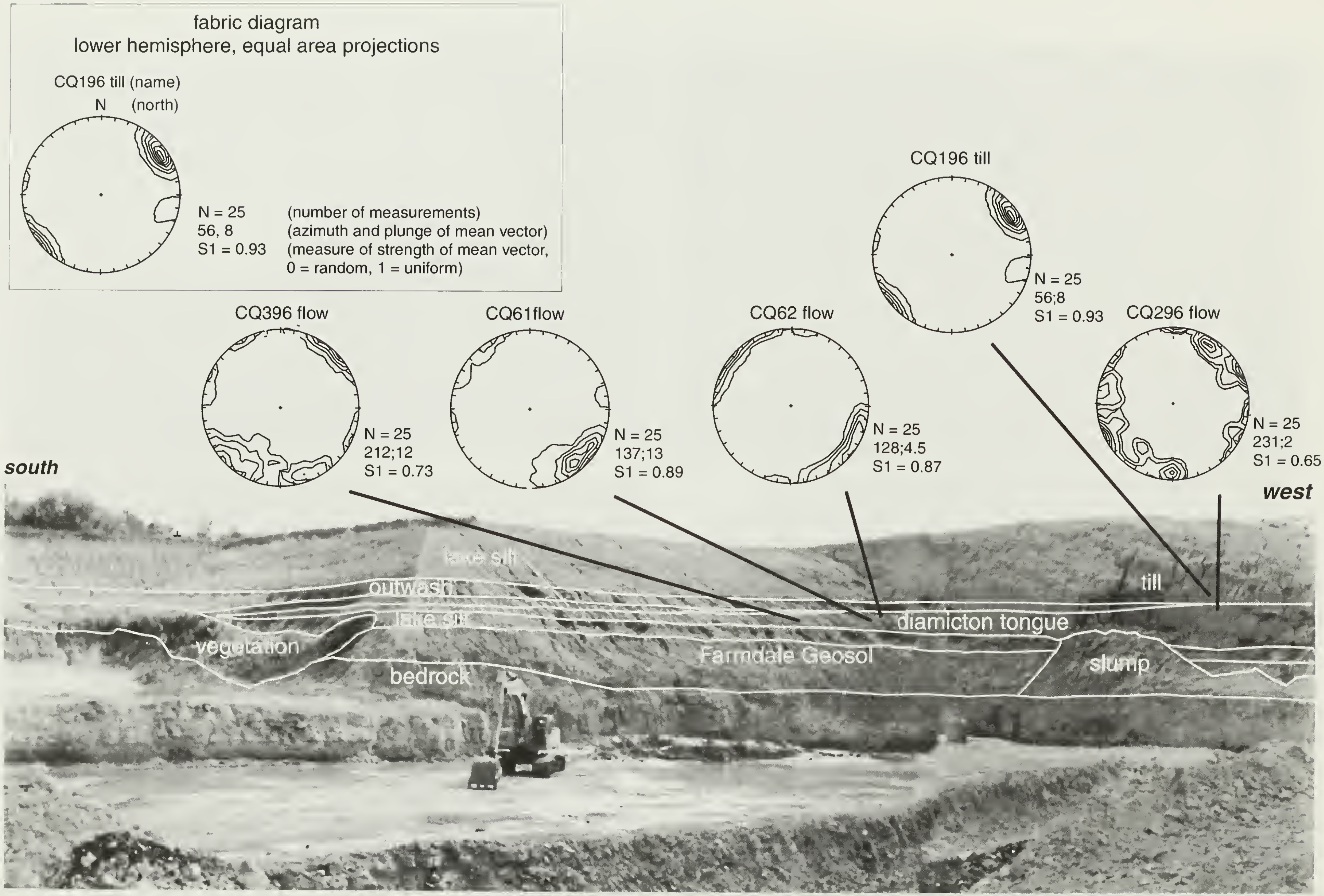


Figure 8 Photomosaic of diamicton tongue (interpreted to be a subaqueous debris flow deposit) in relationship to other units at the Charleston quarry. The tongue, approximately 100–130 m across and 2.9 m thick in this exposure, intertongues with proglacial lacustrine silts, which are overlain by outwash sands and/or till interpreted to be subglacial till. Pebble fabrics in the tongue show dips trending southeast to southwest, whereas pebble fabrics in the overlying, lithologically similar diamicton show dips to the northeast (up-ice direction).

Paleoecological Indicators during the Farmdale-Shelby Phase Transition

Gutowski et al. (1998) investigated the stratigraphic relationship of sediments and plant macrofossils found in the Farmdale Geosol and adjacent sediment at the Charleston quarries to determine environmental conditions just prior to overriding of the Lake Michigan Lobe during the Shelby Phase advance to the Shelbyville Moraine in east-central Illinois (fig. 3). The Robein Member (Roxana Silt), in which the Farmdale Geosol is developed, and the Peddicord Tongue (Equality Formation) contain abundant plant fragments, mosses, seeds, insect fragments, gastropods, and spruce stumps. Gutowski and his students collected and washed bulk samples of sediment for plant, shell, and insect remains.

Donald Schwert (North Dakota State University) identified fragments of *Olophrum latum* and *Agonum quinquepunctatum* from the lower part of the Peddicord Tongue. The former is an arctic/subarctic beetle species that is today restricted to northern North America west of Hudson Bay, whereas the latter is a northern, boreal to lower arctic beetle that today is found around the shoreline of Hudson Bay. *Cryobius*, probably *ventricosus,* was identified from the upper part of the Farmdale Geosol. Today this beetle is restricted to the lower arctic and to mountaintops of the northern Appalachians. These beetle remains appear to indicate a forest to tundra environment, rather than a strictly tundra environment.

Plant macrofossils collected from the silts of the Peddicord Tongue at the Charleston quarry and identified by Richard Baker (University of Iowa) are listed in Table 1. The 22 taxa are presently either widespread or found in boreal environments. Several samples contained *Selaginella selagnoides*, a subarctic spikemoss. Numerous *Picea* stumps are found rooted in the Farmdale Geosol and encased in the overlying lacustrine silt (fig. 7a). Some *in situ* stumps are over 2 m in height; although stumps average 12 cm in diameter, some are up to 25 cm. The bark is well preserved, as are fine limbs and needles. Two *in situ* stumps yielded ages of 20,050 ± 170 (ISGS-2593) and 19,980 ± 150 (ISGS-2842) ^{14}C years B.P.

Paleoecological interpretations of environmental conditions by Gutowski et al. (1998) at Charleston are consistent with those of Garry et al. (1990) at Wedron in north-central Illinois and Baker et al. in western Illinois (1989). Both studies concluded that the interval between about 28,000 and 21,000 ^{14}C years B.P. was one of constant climatic cooling with boreal to subarctic environments near the ice margin. This interpretation is also consistent with Johnson's conclusion (1990) that permafrost in central Illinois was limited to a narrow zone that migrated with the Wisconsin ice margin.

Evidence for Bioturbation?

The Farmdale Geosol at the Charleston quarry site has a well-preserved O horizon that consists of a 1- to 3-centimeter-thick litter layer that is rich in Bryophytes. Unusual depressions in the geosol surface were observed by Gutowski et al. (1998). The depressions occur along the edge of a shallow water area interpreted to be a proglacial lake that underwent fairly continuous aggradation. The depressions in the very dark brown, organic-rich Farmdale Geosol are filled with light gray lacustrine silts of the Peddicord Tongue (fig. 9). This disturbed geosol surface was mapped at 10-cm intervals over a 4 square meter grid (fig. 10a). The larger depressions have a roughly circular outline approximately 70 cm in diameter and 25 cm deep.

The lower portions of the fill sediments are draped to conform to the concavity of the depressions, whereas the upper layers of fill are nearly horizontal. In the lower portions, dark brown silt (Robein Member) interfingers with light gray silt (Peddicord Tongue) (fig. 9). The surrounding rim area is several centimeters higher than the original land surface and in places appears to have been ripped up and emplaced unconformably on top of younger sediments. This configuration is consistent with physical removal and redeposition of the Farmdale O material accompanied by its rapid burial in

Table 1 Plant taxa from lacustrine silts of the Peddicord Tongue at the Charleston quarry

				Location and sample number							
				Upper Peddicord					Lower Peddicord		
Taxon	Common Name	Distribution	Habitat	28	35	38	39	53	40	41	50
Selaginella selaginoides	Spikemoss	A, SA, NB	Rich fens, mossy areas		•	•	•			•	
Picea sp.	Spruce	B	Forest, scrub, bog			•	•	•	•		
Menyanthes trifoliata	Buckbean	B	Wetland			•			•		
Sparganuim angustifolium	Burreed	B	Wetland			•			•		
Scirpus heterochaetus	Great bulrush	B	Aquatic						•		
Ranunculus flabellaris	Yellow water crowfoot	B	Aquatic						•		
Hippuris vulgaris	Marestail	B	Wetland						•		
Carex aquatilis	Sedge	B, T	Emergent aquatic			•					
Potamogeton filiformis	Pondweed	B, T	Aquatic	•	•	•	•	•	•		
Naias flexilis	Naiad	T	Submerged aquatic		•	•	•		•		
Ranunculus aquatilis	White water crowfoot	W	Submerged aquatic	•		•		•	•		
Myriophyllum	Water milfoil	W	Submerged aquatic				•				
Scirpus validus	Bulrush	W	Emergent aquatic					•			
Brasenia schreberi	Watershield	W	Aquatic						•		
Ceratophyllum demersum	Coontail	W	Aquatic						•		
Viola	Violet	W	Many possible habitats	•		•	•	•			
Carex (trigonus)	Sedge	W	Many possible habitats	•				•	•		
Carex (biconvex)	Sedge	W	Many possible habitats	•	•	•	•		•		
Ranunculus sceleratus	Cursed crowfoot	W	Many possible habitats		•	•	•		•		•
Characea	Stonewort	W	Aquatic			•	•		•		
Bryophytes	Moss			•	•	•	•	•	•	•	•
Alismataceae						•					

A = Arctic, SA = Subarctic, NB = Northern boreal, B = Boreal, T = Temperate, W = Widespread lake silt. Indeed, the general appearance of the exhumed geosol resembles tracks in a barnyard (fig. 10b).

The morphology of the depressions in the Farmdale Geosol at the Charleston site is similar to the morphology of paleosurfaces interpreted by Haynes in southeastern Arizona (1991) and in Missouri (1985) to represent proboscidean (mastadon) trackways. Jeffrey Saunders (Illinois State Museum, personal communication) observed that the morphology of the depressions at the Charleston site is consistent with proboscidean bioturbation. Analysis of the depressions and speculation about their origin continues.

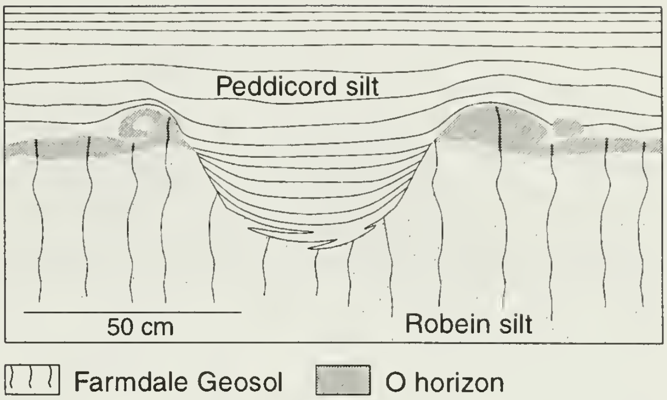


Figure 9 Cross section of a depression on the Farmdale Geosol surface. Infilling lacustrine silts are conformable to the disturbed surface. Note raised, overturned rim of the depression and unconformable relationship to younger sediments (after illustration prepared by Chris Blakley, EIU, 1997).

Points for Discussion at the Charleston Quarry

1. Fairly continuous sand lenses and bodies within the Wisconsin Episode Tiskilwa till (fig. 7d) can be traced from north to south across the west wall of the pit. Generally, they have erosional, flat contacts at their top, although some are more lens shaped. Some sand bodies are clearly deformed. Are these features deformed subglacial channel-fill deposits?

2. Depressions in the Farmdale surface have been observed by Vince Gutowski and his students at EIU (figs. 9, 10). Could these depressions have been caused by large mammals, such as mastodons?

3. The contact at the base of the subglacial till is planar and erosional (fig. 7b,c). Little, if any, deformation is apparent in the underlying sand. Are contacts such as these formed by (1) the base of the glacier sliding across the substrate or (2) a deforming bed moving across the substrate?

4. Sedimentary structures in the proglacial sands are typical of braided streams (figs. 7b, c). What is the relationship of these streams to the proglacial lake? If the lake existed, there should be some evidence of delta progradation. Could the lake have been fortuitously filled with silts and debris-flow deposits prior to stream progradation? Or was it gently (and also fortuitously) drained?

5. The geometry of the lower diamicton bed in the Wisconsin Episode succession indicates that it is a flow deposit enclosed in lake sediment (fig. 8). In lithology and texture, the flow diamicton is very similar to the till (fig. 6). What is the source of this subaqueous flow? Was it derived from subglacial till that flowed into the lake?

63.8	Pass “ the turtle” and TURN RIGHT onto quarry road.
64.2	TURN RIGHT on Illinois Route 16.
66.3	Ascend the proximal slope of the Paris Moraine.
67.4	TURN LEFT on Illinois Route 130.
68.5	Leave the Paris Moraine and begin to descend into the valley of the Embarras River.

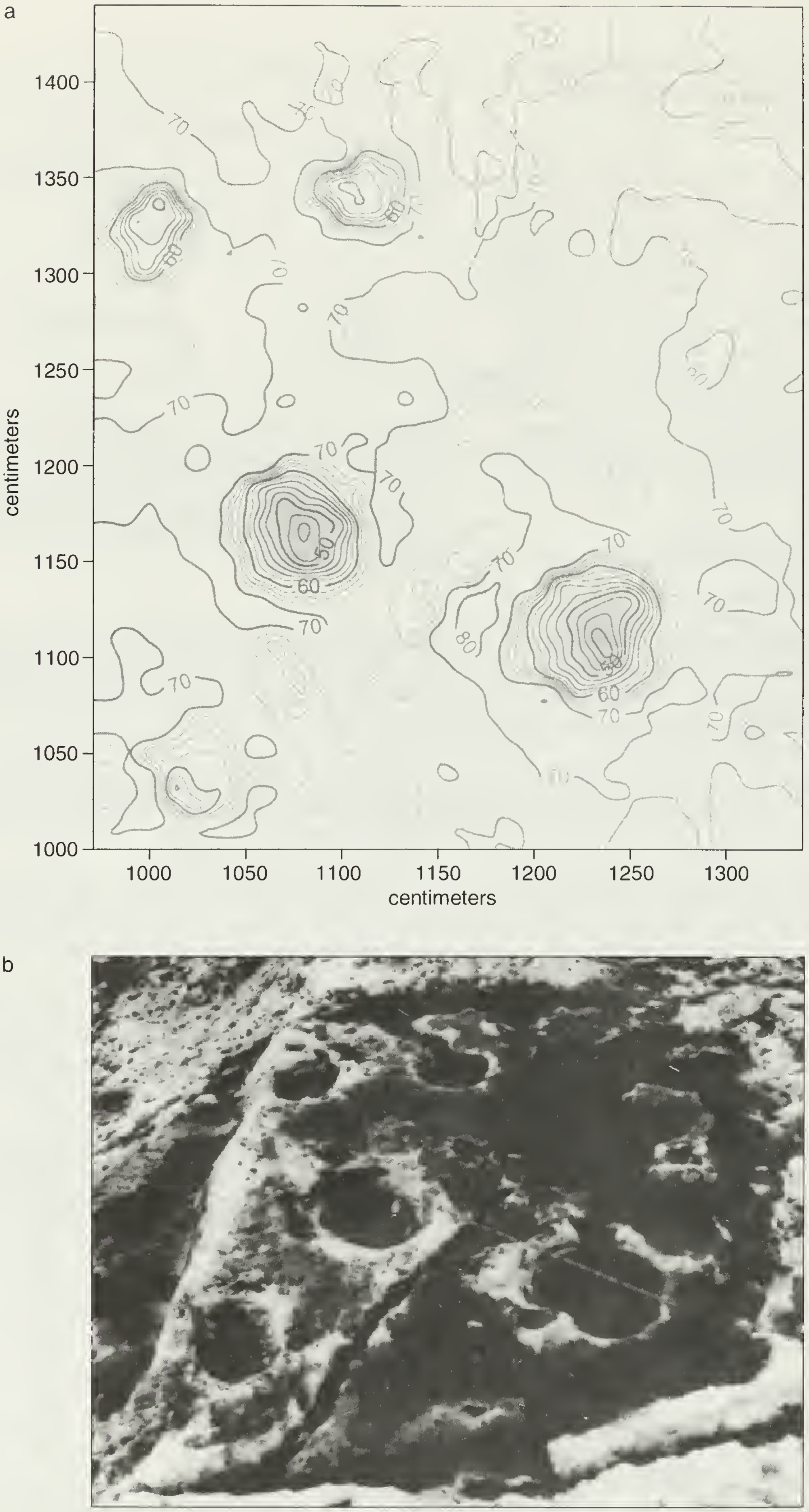


Figure 10 Disturbed Farmdale Geosol surface at the Charleston quarry: (a) topography of the exhumed geosol surface and (b) oblique photograph of area mapped in (a).

69.7 View of Charleston Side-Channel Reservoir on the left; the Embarras River was dammed to form this reservoir for Charleston's domestic water supply and recreational use.

69.9 Cross the Embarras River. For the next mile, the route rises onto the upland of the Nevins and Westfield Moraines of the Shelbyville Morainic System (also called the Shelbyville Moraine). The two moraines form about a 4.5-mile-wide upland in this area. The Shelbyville Moraine is the outermost moraine that formed during the Wisconsin Episode in Illinois. Six ^{14}C dates on wood from tree trunks and forest litter beneath till of the Shelbyville Moraine in this area average 19,998 ^{14}C years B.P. The glacier likely was at the position of the Shelbyville Moraine for 1,000 years or more.

71.5 Cross the crest of the Nevins Moraine.

74.1 Cross the crest of the Westfield Moraine.

74.2 TURN RIGHT into Fox Ridge State Park.

75.0 Bear left at fork in the road.

75.3 TURN RIGHT into the parking lot of the brick pavilion. **Stop 4: Fox Ridge State Park.** Lunch.

75.4 TURN RIGHT on park road.

76.5 TURN RIGHT into parking lot on the terrace surface at the end of the road. **Stop 5: Fox Ridge State Park.**

EMBARRAS RIVER EROSION CONTROL—*William White and Bob Szafoni*

Approximately 250,000 people visit Fox Ridge State Park annually, and the trail system, with its steep topography and forests, is a main attraction. Erosion along the outside of a meander bend of the Embarras River has caused a problem for park officials at this site, because a park trail is located near the river bank. In the spring of 1995, a 10-meter section of the bank sloughed off into the river. Because another similar event would jeopardize access to the lower trail system by tractor or all-terrain vehicle, park officials are developing an erosion-control plan.

This section of the Embarras River is included in the Illinois Natural Areas Inventory, a systematic, statewide listing of the highest-quality aquatic and terrestrial communities remaining in Illinois. Additionally, this section of the river supports five state-listed species: snuffbox and little spectaclecase mussels, eastern sand darter, harlequin darter, and Kirtland's snake.

An active Ecosystem Partnership composed of private landowners and other concerned citizens is addressing landowner-identified problems of flooding and erosion along the Embarras River with funding from the Conservation 2000 program of the Illinois Department of Natural Resources (DNR). By its handling of this problem, DNR intends to set an example for stewardship of highly complex resource problems in a dynamic system.

76.6 TURN LEFT out of parking lot and return to park entrance.

78.7 TURN RIGHT on Illinois Route 130. For the next 1.5 miles, the route descends the distal slope of the Shelbyville Moraine.

80.2 Pass onto the Illinoian till plain.

80.6 Enter Cumberland County.

81.6 TURN LEFT on County Road 1300N.

82.5 Cross Opossum Creek.

83.9 Cross Hurricane Creek. For the next 0.3 mile, the route crosses the floodplain of Hurricane Creek.

84.4 TURN LEFT on County Road 2100E

84.7 **Stop 6: Hurricane Creek roadcut.** Diamicton is exposed in the roadcut on the right.

HURRICANE CREEK ROADCUT

This brief stop affords a view of highly weathered diamicton of the Glasford Formation (Illinois Episode) at a site beyond the distal edge of the Shelbyville Moraine.

The highly weathered soil profile, which is leached of carbonates, is here a combination of modern soil superimposed onto the Sangamon Geosol. Loess is thin at this site, probably because of erosion. The Illinoian till plain is older and in places more dissected than the Wisconsin till plain to the north. Where the loess is thin, the leached soils are less productive for agriculture.

85.5 Enter Coles County and cross Hurricane Creek.

85.7 Ascend from a river terrace onto a distal-slope outwash fan of the Shelbyville Moraine.

86.0 Watch for views of the Shelbyville Moraine through the trees at 2 o'clock.

86.6 Cross the West Branch of Hurricane Creek and begin rise to the upland of the Westfield Moraine (Shelbyville Morainic System).

86.9 Through the trees in a streamcut along the West Branch of Hurricane Creek is the Center School Section, which was visited on the 1972 Midwest Friends of the Pleistocene Field Conference (see ISGS Guidebook Series 9, Johnson et al. 1972). Located about 1 km north of the frontal margin of the Shelbyville Moraine, the Center School Section consists of a succession similar to that exposed at the Charleston Stone Company quarries. Because the cut is steep and there is no platform on which to stand during high-water flow, we elected not to stop during this spring field trip.

87.7 TURN LEFT at T-intersection and continue on County Road 2100E.

88.3 TURN LEFT on Hutton Road (County Road 250N) in the settlement of Hutton.

91.3 Cross crest of the Nevins Moraine.

91.3 TURN LEFT at T-intersection onto Westfield Road (County Road 480N).

92.9 TURN RIGHT on Illinois Route 130. We retrace our route for the next 21 miles, except for a different route through Charleston.

96.6 Cross intersection with Illinois Route 16.

97.5 TURN LEFT on Madison Street following Illinois Route 130.

98.2 TURN RIGHT following Illinois Route 130 north out of Charleston.

115.4 Cross the Scattering Fork of the Embarras River.

117.2	Cross the Embarras River.
118.9	TURN LEFT on U.S. Route 36.
119.5	Cross the Embarras River and begin rise onto the southernmost remnant of the Pesotum Moraine.
121.3	Cross the Hackett Branch of the Scattering Fork of the Embarras River. This stream originates in the swale between the Pesotum and West Ridge Moraines.
122.7	TURN LEFT. **Stop 7: Tuscola Stone Company Quarry.**

TUSCOLA STONE COMPANY QUARRY—*Richard C. Berg, Ardith K. Hansel, and Andrew C. Phillips*

Overview

The Tuscola quarry offers an opportunity to examine the Wisconsin Episode succession as well as successions of two older glacial episodes (Illinois and pre-Illinois), two interglacial soils (Sangamon and Yarmouth), and a preglacial soil developed in bedrock (fig. 11) at a site about 50 km from the Wisconsin Episode glacial maximum (fig. 1). The drift succession is dominated by diamicton (fig. 12). Although lenses of sorted sediment and laminated fine-grained sediment are present within diamictons, proglacial sediment between diamictons of the different glacial episodes is thin to absent. Rarely are deposits of three glacial episodes and soils of the interglacial episodes exposed at one site, as they are at the Tuscola quarry.

The Tuscola quarry is located on the Tuscola Anticline, the largest anticline on the La Salle Anticlinorium (Nelson 1995). This structure results in older bedrock units close to the land surface in a small geographic area (~2 km^2); Devonian and Silurian rocks are shallow enough to be mined economically. At the quarry, glacial drift is only about 11–13 m thick. Within about 4 km of the quarry, however, drift thickness increases markedly to about 30 to 60 m. A preglacial soil is developed in carbonate rocks on some parts of the bedrock surface. Near the northeast corner of the pit, this preglacial soil is preserved in a paleokarst depression (fig. 11).

Section Description and Interpretation

Figure 12 shows the drift succession in a gully near the east end of the north wall of the quarry. Here, diamicton is present above bedrock; the diamicton is oxidized to dark yellow brown (10YR 3/4), leached, and contains a large percentage of expandable clay minerals. Unaltered diamicton of this unit is present along the north end of the east wall of the pit, where the diamicton is dark brown (10YR3/3), has a silt loam texture, is highly calcareous, and contains few pebbles. This diamicton is correlated with highly calcareous diamicton of the pre-Illinois Episode Banner Formation. It contains less illite in the clay fraction than do diamictons of younger glacial episodes. Although the sedimentology of the unit has not been studied in detail, the uniformity of the diamicton is consistent with a subglacial origin. The weathered upper part of the diamicton is interpreted to be a truncated Yarmouth Geosol. Locally, a concentration of pebbles and cobbles is present as a lag deposit at the top of the geosol.

The Yarmouth Geosol is truncated by an erosional contact with a diamicton unit about 4 to 5 m thick that is calcareous and has a sandy silt loam texture. Diamicton in this unit is sandier and has considerably more large clasts than that in the overlying and underlying units. The upper part of the unit is oxidized and yellowish brown (10YR 3/3) to dark yellowish brown (10YR 4/4), whereas the lower portion is brown (10YR 5/3) and less oxidized. The upper 60 cm of the diamicton is leached of

Figure 11 East wall of the Tuscola quarry showing succession of pre-Illinois, Illinois, and Wisconsin Episode diamictons above carbonate bedrock. A preglacial soil is preserved in a paleokarst depression on the bedrock (lower left). The weathering profiles of the Yarmouth and Sangamon interglacial episodes and the postglacial episode are also evident.

carbonates, and contains larger percentages of expandable clay minerals. On the basis of lithology and stratigraphic position, the diamicton is classified in the Illinois Episode Glasford Formation (Vandalia Member). The Sangamon Geosol is developed in the upper part of the unit and can be readily traced around the pit by the oxidized colors.

Except for lenses of sand (Sh, fig. 12) that occur about 1.5 to 2 m below the top of the unit and stratified diamicton and sorted sediments (Ds and Sh, fig, 12) that are present in the upper 0.5 m, the Glasford Formation consists of fairly uniform diamicton. Two pebble fabrics (4 and 5, fig. 12) in the diamicton have a strong orientation of pebbles dipping to the north and northeast. The sand lenses that occur 1.5 to 2 m below the top of the unit are up to several meters wide, but less than 0.5 m thick (fig. 13a); they generally are made up of medium sand to very fine sand and silt and have graded to crude horizontal bedding and occasional ripple trough cross beds. Diamicton intercalated with the sand lenses has angular edges. Small-scale faults are common. We interpret the fairly uniform diamicton of this unit to be meltout till, probably of basal origin. The sand lenses likely represent sediment that was deposited in channels beneath relatively passive ice.

The stratified diamicton and sorted sediments (mostly sand) in the upper part of the Glasford Formation are interpreted to be materials that melted out on top of the glacier and were then redeposited along the ice margin. It is in these sediments and the upper part of the meltout till that the Sangamon Geosol is developed. Only the lower part of the Sangamon B horizon is preserved at this site; but elsewhere in the area, up to 2 m of the Sangamon Geosol is present.

The Sangamon Geosol is truncated by an erosional contact with a thin red diamicton unit that locally pinches out but ranges up to about 0.5 m thick. In the measured section (fig. 12), the red diamicton is 40 cm thick. It is calcareous, loamy, brown (10YR 5/3) to red brown (10YR 5/4), less illitic than the overlying gray diamicton, and less sandy than the underlying brown diamicton. In places the red diamicton above the Sangamon Geosol contains dark gray organic-rich silt and weathered sediment likely derived from the glacially overridden landscape. The red diamicton is correlated with the Wisconsin Episode Tiskilwa Formation, a distinct red diamicton that ranges up to about 10 m thick in the subsurface of the area. A pebble fabric (3 in fig. 12) measured in the Tiskilwa diamicton indicates a strong orientation of clasts dipping to the northeast (the inferred up-ice direction), and the diamicton is interpreted to be subglacial till deposited beneath active ice.

Both the upper and lower contacts of the Tiskilwa till are erosional. The upper contact is marked by a stone concentration, which in places approaches a striated clast pavement (fig. 13c). Although large clasts (cobbles and boulders) at the upper contact may be both faceted and striated, small clasts are often only striated. The most prominent striae occur on the larger clasts. Striae orientations are variable and multiple, but the most common orientations are north-northeast to south-southwest and are consistent with the orientations of pebble fabrics measured in both the Tiskilwa till and the overlying gray diamicton. Where the red till is absent, the striated clast pavement is between the Sangamon Geosol and the gray diamicton. Striae on the upper surface of clasts trend from about NNE to SSW.

The overlying gray (10YR 4/1) diamicton is 5 to 6 m thick, calcareous, and loam to silt loam in texture (fig. 12). It is slightly more illitic than the underlying Tiskilwa till. The upper oxidized part of the diamicton is yellowish brown (10YR 5/4) to a depth of about 4 m. The upper 4.5 m of the unit is less homogeneous than the lower part; it contains lenses of sorted sediment (mostly silt, Fl(d) in fig. 12) that are crudely bedded and sometimes folded, faulted, and deformed (fig. 13d). The gray diamicton is classified as the Wisconsin Episode Batestown Member (Lemont Formation), which is the surficial diamicton mapped in the Arcola, Pesotum, and West Ridge Moraines and adjacent till plains.

A pebble fabric in the basal part of the Batestown diamicton (2 in fig. 12) indicates a strong orientation of clasts dipping to the northeast. This orientation is consistent with striae measured on clasts along the erosion surface at the top of the Tiskilwa till (see above), and we interpret the lower, more

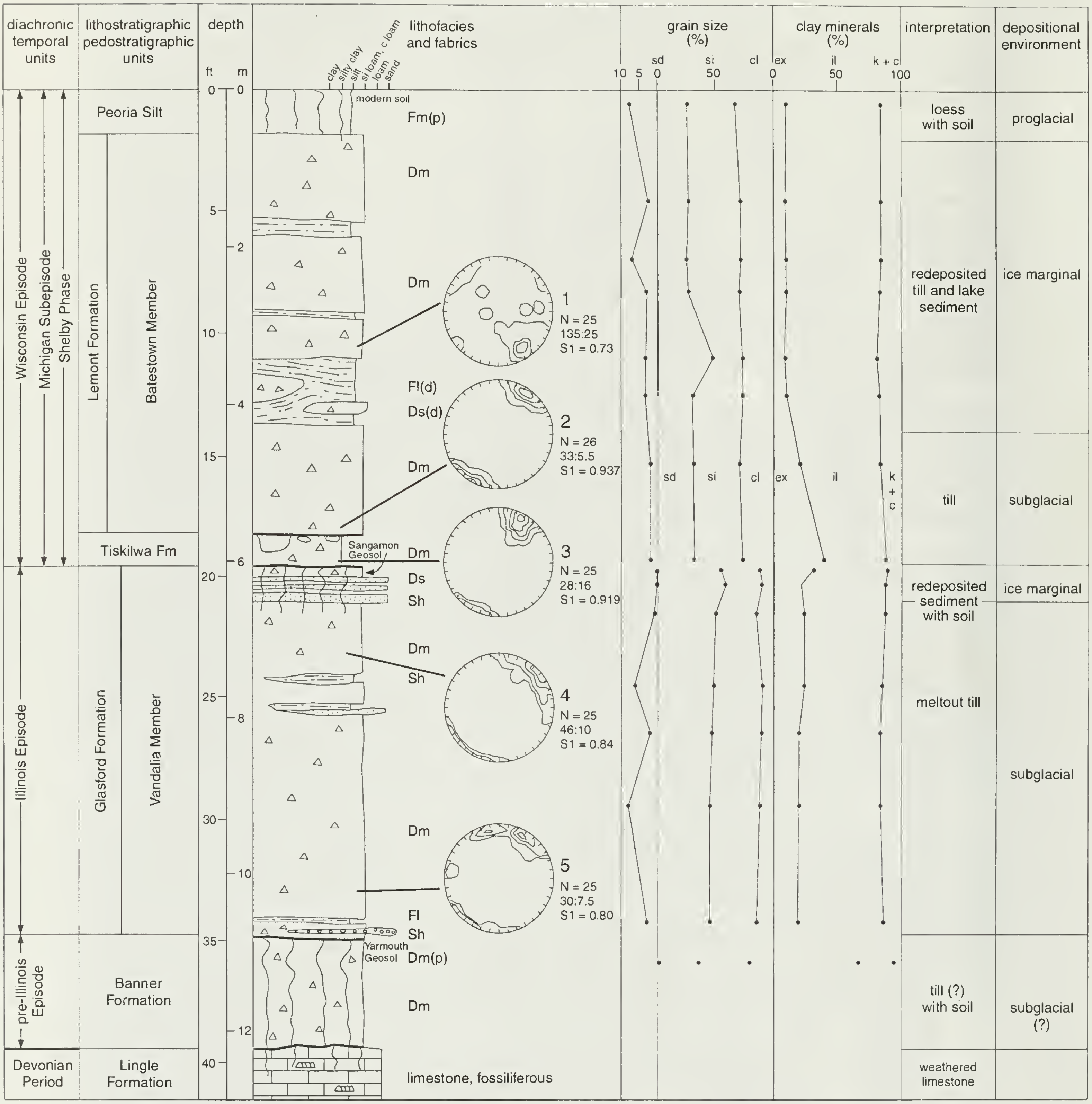


Figure 12 Lithofacies characterization, classification, and interpretation at the Tuscola quarry. Key to fabric diagrams is given in fig. 8.

lithofacies

D diamicton
  m massive
  s stratified
  (d) deformed
  (p) pedogenisized

F fine-grained sediment
  m massive
  l laminated
  o organic
  (p) pedogenisized

S sand
  h horizontal bedded
  x crossbedded
  o organic
  (d) deformed

materials

△ diamicton
☐ fine-grained sediments
▒ sand
⁘ gravel

contacts

☐ conformable
☐ erosional
☐ clast concentration/pavement

structures/ inclusions

☐ lens
☐ subglacial channel-fill deposits
☰ laminae
☐ trough crossbeds
☐ ripple crossbeds
☐ trunk/wood fragments
☐ soil

homogeneous part of the Batestown Member to be subglacial till. A pebble fabric (1 in fig. 12) in a 70-centimeter-thick diamicton bed between silt beds in the middle of the unit indicates a moderately strong orientation of clasts to the southeast. This orientation is inconsistent with an interpretation of till deposited from a glacier flowing from the northeast and may reflect debris flow from the distal slope of the Pesotum Moraine, mapped just north of the quarry. In places in the pit, the upper part of the Batestown diamicton has been observed to be in facies relationship with silt and clay interpreted to be lake sediment.

In the measured section (fig. 12), the Batestown diamicton is overlain by about 0.5 meter of massive silty clay loam that is oxidized to dark yellow brown (10YR4/6) and leached of carbonates. This unit is interpreted to be loess in which the postglacial soil developed; it is classified as the Peoria Silt. Along most of the pit wall, the A horizon of the postglacial soil is present and can be traced around the pit below spoil from the quarry operation (fig. 11).

Striated clast pavements between red and gray tills have also been observed north of this area in an excavation near Villa Grove and in one in Champaign. At those sites, the clasts are mostly cobbles and boulders, and facets and striae are well developed on their upper surfaces. We interpret the erosion surface between the red and gray tills in east-central Illinois to have developed subglacially when the sites were in the zone of erosion as the glacier margin advanced to and retreated from the Shelbyville Moraine during the Shelby Phase (fig. 3). We interpret the red and gray tills to represent advance- and retreat-phase tills, respectively. Boulton's theory (1996b) for glacial erosion, transport, and deposition as a consequence of subglacial sediment deformation predicts erosion surfaces marked by boulder pavements between lithologically distinct advance- and retreat-phase tills. Whether the subglacial erosion occurred at the base of the ice or at the base of the deforming bed, at the Tuscola quarry it appears that much (and locally all) of the advance-phase till (Tiskilwa) was eroded.

Points for Discussion at the Tuscola Quarry

1. An erosional contact with a clast concentration occurs between the gray and red till beds (Batestown Member and Tiskilwa Formation). Do these units represent advance and retreat tills separated by a subglacial erosion surface? If not, what do they represent?

2. What is the origin of the sand lenses (fig. 13a) in the Glasford Formation?

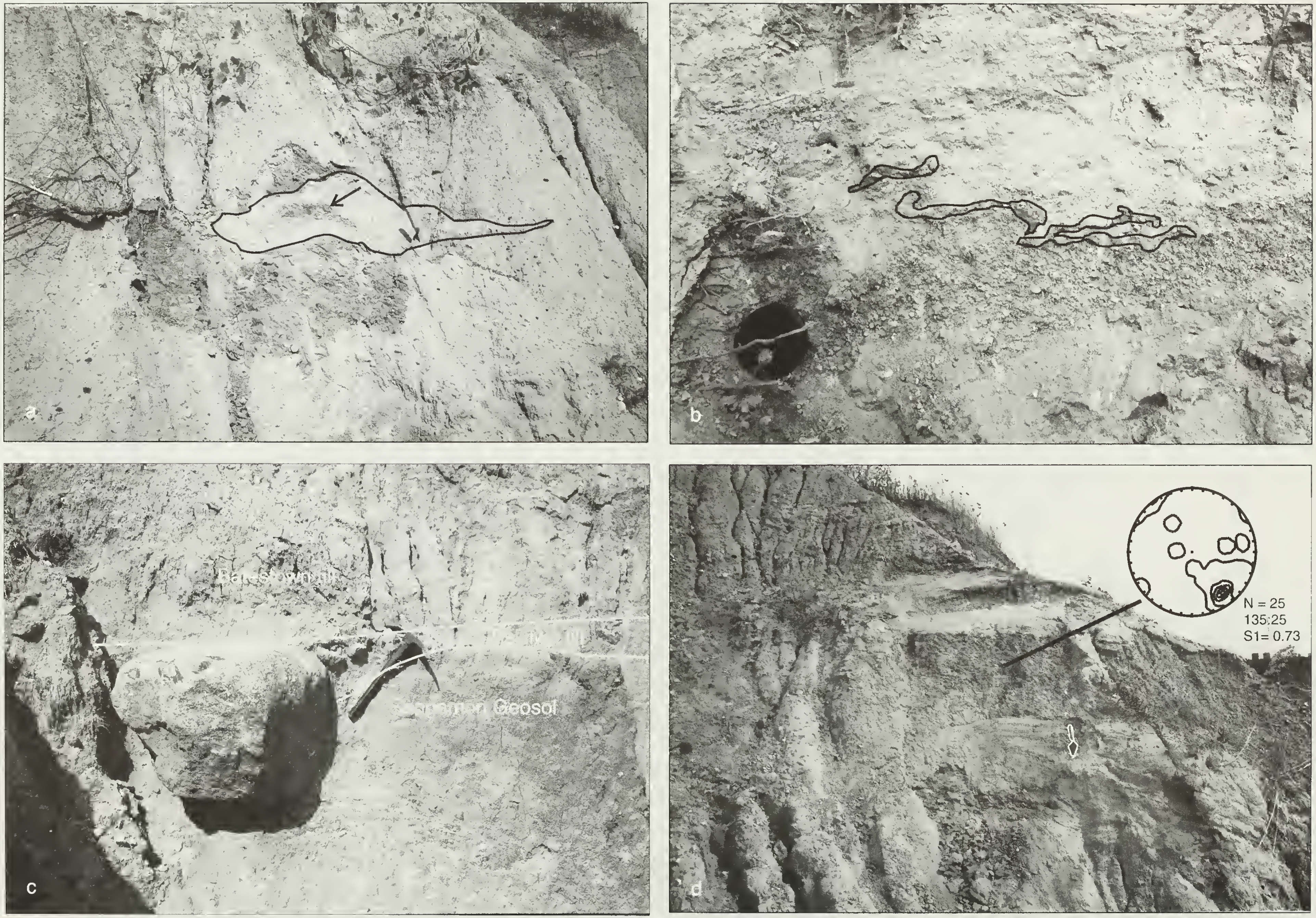


Figure 13 Sedimentary features at the Tuscola quarry: (a) sand body (outlined) with diamicton inclusion (arrow) in Glasford Formation diamicton (width of sand body is approximately 1 m); (b) folded diamicton within graded sand body within Glasford diamicton; (c) striated, faceted boulder in clast concentration that marks the erosion surface between the Batestown and Tiskilwa diamictons (pick for scale); and (d) redeposited diamicton and lacustrine silt in the upper portion of the Batestown Member diamicton and location and diagram of measured pebble fabric (trowel for scale). Key to fabric diagrams is given in fig. 8.

3. Why were paleosols (Sangamon and Yarmouth Geosols) not eroded in this area?

4. Why is so little proglacial sediment present between deposits of the three glacial episodes?

123.9 Leave Tuscola Stone Company quarry and TURN LEFT on U.S. Route 36.

124.8 TURN RIGHT on the entrance ramp to Interstate 57 North.

125.8 The route rises onto the Pesotum Moraine, which parallels Interstate 57. The ridge on the horizon to the left is the Arcola Moraine.

131.0 Enter Champaign County.

134.5 Juncture of the Arcola and Pesotum Moraines.

133.6 For the next 6 miles, the crest of the Pesotum Moraine is about 1.5 miles to the right of the route.

141.7 EXIT Interstate 57 at Monticello Road. TURN RIGHT on County 1000N.

142.8 Cross the crest of the Pesotum Moraine.

143.8 Cross the crest of the West Ridge Moraine.

144.4 TURN LEFT on U.S. 45.

145.4 A good view of Urbana Moraine is on the right.

149.0 Cross the crest of the Champaign Moraine.

149.5 TURN LEFT into parking lot of the Clarion Hotel and Conference Center.

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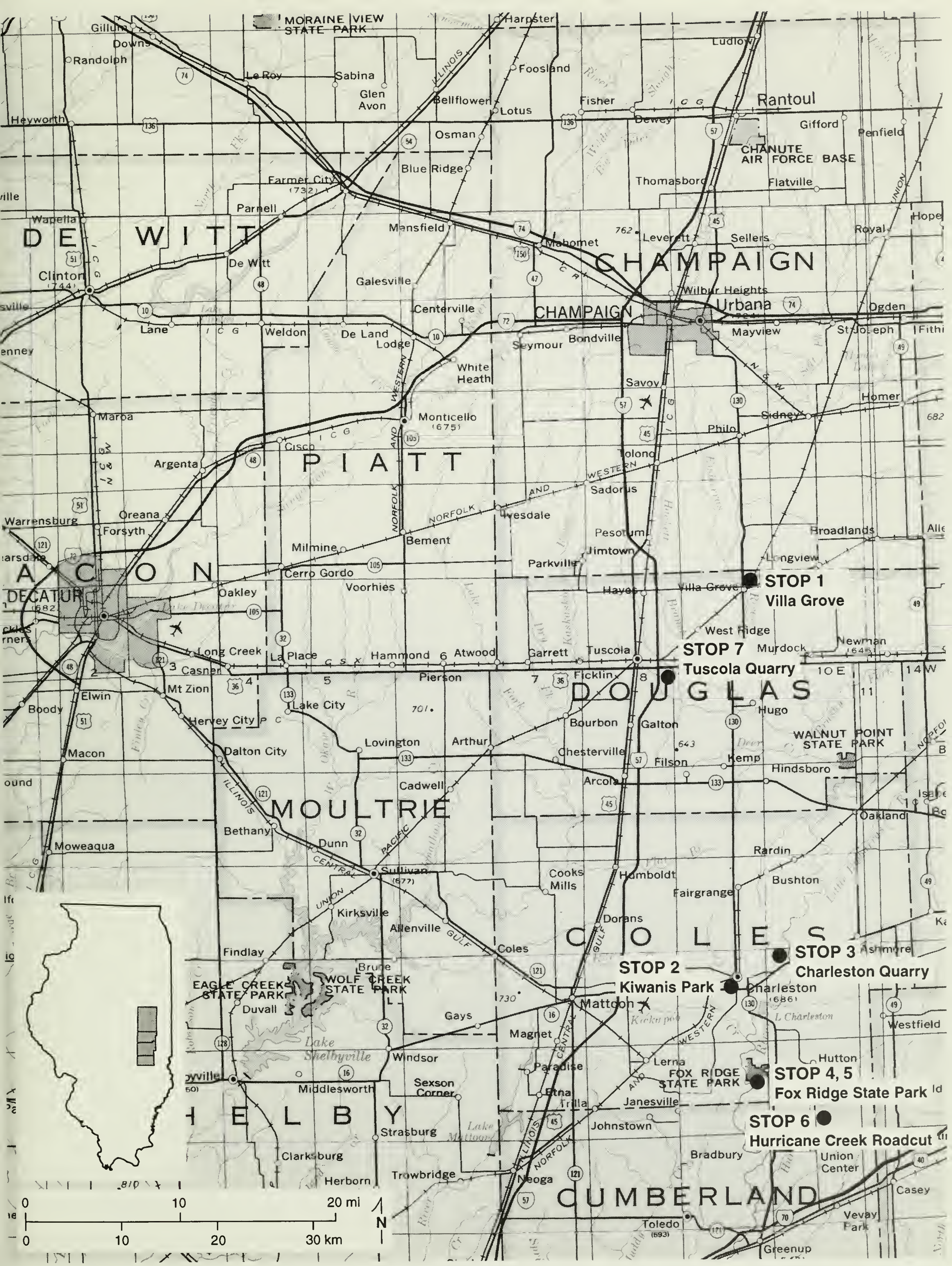
MORAINE VIEW STATE PARK
Harpster
Gillum
Downs
Randolph
Le Roy
Sabina
Glen Avon
Bellflower
Foosland
Lotus
Fisher
Dewey
Rantoul
Ludlow
Heyworth
Osman
Gifford
Penfield
CHANUTE AIR FORCE BASE
Blue Ridge
Farmer City (732)
Thomasboro
Flatville
Parnell
Wapella
DE WITT
Mansfield
762
Leverett
Sellers
Royal
Hope
Mahomet
Clinton (744)
De Witt
CHAMPAIGN
Galesville
Wilbur Heights
Urbana
Centerville
CHAMPAIGN
Lane
Weldon
De Land
Lodge
Seymour
Bondville
Mayview
St Joseph
Ogden
White Heath
Savoy
Homer
Maroa
Monticello (675)
Philo
Sidney
682
Argenta
Cisco
PIATT
Tolono
Sadorus
Oreana
Warrensburg
Forsyth
Ivesdale
Pesotum
Broadlands
Milmine
Bement
Jimtown
Longview
Cerro Gordo
Parkville
STOP 1
Villa Grove
DECATUR (682)
Oakley
Voorhies
Hayes
Villa Grove
West Ridge
Murdock
Newman (645)
Long Creek
La Place
Hammond
Atwood
Garrett
Tuscola
STOP 7
Tuscola Quarry
Casner
Pierson
Ficklin
DOUGLAS
Elwin
Mt Zion
Lake City
Hugo
Boody
Hervey City
701
Bourbon
Galton
Macon
Dalton City
Lovington
Arthur
643
WALNUT POINT STATE PARK
Chesterville
Filson
Kemp
Hindsboro
Cadwell
Arcola
Oakland
MOULTRIE
Bethany
Moweaqua
Dunn
Rardin
Sullivan (677)
Cooks Mills
Humboldt
Bushton
Fairgrange
Kirksville
Dorans
Allenville
COLES
STOP 3
Charleston Quarry
Ashmore
Findlay
Coles
Bruce
STOP 2
Kiwanis Park
Charleston (686)
EAGLE CREEK STATE PARK
WOLF CREEK STATE PARK
730
Mattoon
Duvall
Gays
Magnet
L Charleston
Westfield
Lake Shelbyville
Windsor
Lerna
Hutton
Paradise
FOX RIDGE STATE PARK
STOP 4, 5
Fox Ridge State Park
Middlesworth
Sexson Corner
Etna
Trilla
Janesville
SHELBY
STOP 6
Hurricane Creek Roadcut
Strasburg
Lake Mattoon
Johnstown
Clarksburg
Bradbury
Union Center
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Herborn
Trowbridge
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Casey
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