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ILLINOIAN AND PRE-ILLINOIAN STRATIGRAPHY OF SOUTHEAST IOWA AND ADJACENT ILLINOIS

Edited by
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FOREWORD

This publication is the culmination of a long series of investigations undertaken to interpret and classify the Pleistocene deposits and the soils in this region. This report includes observations from cores drilled through the entire sequence of Pleistocene deposits at several key locations. These observations, in concert with the large amount of quantitative data on the physical, mineralogical, and geotechnical properties, allow the development of a new stratigraphic framework. An understanding of the stratigraphy and areal distribution of these materials is fundamental to their proper utilization.

Re-evaluation of the deposits near Yarmouth, Iowa is of particular scientific importance. The interpretation of these deposits has played a major role in the classification of Pleistocene deposits throughout North America for over 80 years. Placing them in a modern context will contribute to the further understanding of Pleistocene deposits.

All of the papers in this publication are the result of extensive cooperative work between personnel of the Iowa Geological Survey, the Iowa Cooperative Soil Survey, the Departments of Agronomy and Civil Engineering at Iowa State University, the U.S.D.A. Soil Conservation Service, the Department of Geology at the University of Iowa, and the Illinois State Geological Survey. It is a particular pleasure to have co-workers from the Illinois State Geological Survey join in this work and this publication. These cooperative efforts make the results more meaningful to all parties involved in working with the unconsolidated or Pleistocene materials in this region.

Donald L. Koch
Acting Director and
State Geologist
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PRE-WISCONSINAN STRATIGRAPHY IN SOUTHEAST IOWA

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ABSTRACT

The Pleistocene stratigraphy of southeast Iowa was investigated as a part of ongoing stratigraphic and engineering-geologic investigations. The stratigraphy and materials were analyzed in exposures and drill-cores which penetrated the entire Pleistocene sequence.

The deposits in the area below the Wisconsinan loess are formally subdivided into three formations: the Alburnett and Wolf Creek Formations of Pre-Illinoian age, and the Glasford Formation of Illinoian age. The formations are composed principally of till and some inter-till stratified sediments. The Pre-Illinoian tills were deposited by glaciers which moved through Iowa, whereas the Illinoian age till was deposited by Lake Michigan lobe ice which moved through Illinois into Iowa. The differences in provenance of the tills produced differences in physical and mineralogic properties which allow differentiation of the deposits. The till deposits in the formations are recognized and correlated by their physical stratigraphy, pebble lithologies, and by the quantitative characterization of their clay mineralogy, particle-size distribution, matrix carbonates, and sand-fraction lithologies.

The Alburnett and Wolf Creek Formations are composed of uniform, dense, overconsolidated, basal tills. The Alburnett and Wolf Creek Formations are separated by their distinct differences in clay mineralogy.

Only one till of the Alburnett Formation was recognized at any locality in southeast Iowa. The Wolf Creek Formation is subdivided into the Winthrop, Aurora, and Hickory Hills Till Members. The stratigraphic relations and the physical and mineralogical properties of the till members

are essentially identical to their properties in their type areas.

Soil-stratigraphic units are also associated with the Wolf Creek Formation. The Franklin Paleosol occurs below the Aurora Till Member, and in the study area is developed in unnamed sediments and the Winthrop Till Member. The Dysart Paleosol occurs below the Hickory Hills Till Member. The Yarmouth Paleosol occurs below the base of the Illinoian age deposits of the Glasford Formation. In its type area, and throughout the study area, the Yarmouth Paleosol is developed in unnamed fine-textured sediments and the underlying Hickory Hills Till Member. Beyond the depositional limits of the Glasford Formation the Yarmouth and Sangamon Paleosols and surfaces merge. In this area the Yarmouth-Sangamon and Late-Sangamon Paleosols are developed in undifferentiated sediments and in the underlying Wolf Creek Formation deposits (principally the Hickory Hills Till Member in the study area).

The Glasford Formation is represented in southeast Iowa by the Kellerville Till Member and some related sediments. The Kellerville is the oldest till of Illinoian age and overlies the Yarmouth Paleosol. The Kellerville Till Member is readily separated from the Pre-Illinoian tills by its relatively high illite content, high dolomite content, and the abundance of Pennsylvanian lithologies in the very coarse sand through cobble sizes. The Kellerville Till Member is separated into a subglacial or basal till and a superglacial facies based on stratigraphic relations, sedimentological properties, and the consistency-density-consolidation properties of the deposits. The basal till facies is comprised of firm, dense, overconsolidated till of rather uniform texture. The superglacial facies is composed of a wide variety of sediments and is highly variable in texture and density. The sediments in the superglacial facies include: till, diamictons, or reworked till such as superglacial debris flows, sorted fluvial and lacustrine sediments, and peat beds. In some sections these deposits are clearly interbedded, but in others they occur as a contorted melange.

The Sangamon and Late-Sangamon Paleosols are developed in the top of the Kellerville Till Member, and/or sediments which overlie the Kellerville in a variety of settings from modified remnants of the Kellerville depositional surface to erosion surface positions.

The broad tabular divides in southern Iowa exist because they are bedrock-defended. Other landscape differences in the region may be related to the nature of the superglacial facies of the Kellerville Till Member.

INTRODUCTION

This study was conducted as part of an ongoing program of detailed Quaternary stratigraphic investigations in Iowa. This program is part of the regional engineering geologic investigations of the Iowa Geological Survey. The investigations in southeast Iowa were also conducted in part as soil geomorphic investigations in relation to the Iowa Cooperative Soil Survey program. Portions of the field investigations were done cooperatively with the Illinois State Geological Survey to aid in correlation with ongoing work in Western Illinois.

The area covered by this report includes portions of Des Moines, Henry, Lee and Louisa Counties in the southeast corner of Iowa (figure 1). The area was selected for a modern stratigraphic study primarily because of the need to re-evaluate the Yarmouth type area and to place it into a modern context (see Hallberg and Baker, this volume).

Core drilling and observations of exposures in stable, upland, landscape positions were used to establish as complete a stratigraphic framework as possible (see figure 1; Table 1). These observations were used as benchmarks from which to evaluate observations on isolated exposures throughout the area. Table 1 provides an index to the stratigraphic sections shown in figure 1. The data and observations were related to the existing stratigraphic framework from surrounding areas (Hallberg, 1980; Wickham, 1979; Lineback, 1979). This report will deal principally with the stratigraphic evaluation of the Pre-Wisconsinan deposits in the area. Separate reports will deal with the geotechnical aspects of the materials in the region.

In the descriptions of the stratigraphic sections, standard pedologic terminology and horizon nomenclature are used for soils and paleosols (see Soil Survey Staff, 1951, 1975). For convenience, enumeration of different materials within a paleosolum begins with the uppermost material in the paleosol, instead of at the landsurface. For the descriptions of the Quaternary sediments other than in the solum or paleosolum, standard weathering zone terminology is used as outlined in Hallberg, Fenton, and Miller (1978). Standard USDA - SCS textural classes and terms are also used (see Soil Survey Staff, 1975; Walter, Hallberg, and Fenton, 1978). Laboratory data are presented to quantify the physical characteristics of the materials. Laboratory methods used are (in Hallberg, ed., 1978): particle-size analysis -- Walter, Hallberg, and Fenton, 1978; clay-mineralogy -- Hallberg, Lucas, and Goodmen, 1978; and analysis of sand-fraction lithology -- Lucas, et. al., 1978. Matrix carbonate content of the deposits was also evaluated using a Chittick apparatus, following the procedures outlined by Walter and Hallberg (this volume). Data from analyses of clay mineralogy, matrix carbonates, and particle-size by the Illinois State Geological Survey (ISGS) is also shown in the tables. A word of caution is in order because some of these data are not compatible with the Iowa data presented because of differing lab techniques. The matrix carbonate analysis by ISGS is performed on the <0.074mm fraction whereas the Iowa data are based on the <2.0mm fraction (Walter and Hallberg, this volume). Also, the particle size analyses by ISGS are done with a hydrometer considering the clay fraction as <0.004mm, while the Iowa analyses use a pipette and consider the clay fraction as <0.002mm (see Walter, Hallberg and Fenton, 1978). Conversely, the analysis of the clay mineralogy is compatible. The Iowa methods (Hallberg, Lucas, and Goodmen, 1978) are slightly modified from those of Dr. H. D. Glass of the ISGS. In the tables it will be noted that the numerical data are quite similar. As a consequence, in the summary of the various data only the Iowa values are used, except where clearly indicated otherwise.

Acknowledgements

Many people aided or participated in this project, and their assistance is gratefully appreciated. Valuable assistance and direction in field investigations was provided by Mr. Mel Brown and Mr. Bennie Clark of the U.S.D.A. - Soil Conservation Service. Further cooperation in field investigations were provided by Mr. Dale Lockridge, U.S.D.A. - S.C.S., and by Dr. Thomas Fenton, Dr. Alan Lutenegger, Dr. Gerald Miller, Mr. Thomas Bicki, and Ms. Mary Collins, of Iowa State University, and by Dr. Jerry Lineback of the Illinois State Geological Survey, and by Mr. Darwin Evans, Mr. M. Patrick McAdams, and Mr. Timothy Kemmis of the Iowa Geological Survey. All wood identifications were made by Dr. Dwight Bensend, Iowa State University. A substantial portion of the lab work was done by Mr. Neil Walter, and Ms. Terry Etzel, Iowa State University, and by Ms. Catherine Goodmen Sammis, Ms. Sue

Lenker, Mr. Timothy Tvrdik, and Mr. John Coughlin, University of Iowa. Dr. Herbert Glass of the Illinois State Geological Survey provided x-ray analysis on selected samples.

The illustrating and artwork which makes all the reports in this volume comprehensible was done by Mr. John Knecht and Ms. Pat Lohmann of the Iowa Geological Survey.

PREVIOUS INVESTIGATIONS

The first detailed observations of the Pleistocene deposits in this region were made by Leverett in his investigation of the "Illinois glacial lobe (1899)." During these studies Leverett (1898) formulated and named the Yarmouth interval for the "soil" and deposits which separated the Illinois lobe till from the Kansan till (see discussion in Hallberg and Baker, this volume). Leverett concluded that the Illinois lobe till had moved from the east through Illinois and into Iowa on the basis of eastern-derived erratics, and on the basis of the prominent west-facing morainal ridge which marked the terminus of these deposits. He traced out this terminal ridge through part of the present study area to map the boundary of the Illinois lobe deposits.

Most subsequent work in this area has simply discussed interesting stratigraphic sections (Kay and Apfel, 1929; Kay and Graham, 1943). Leverett's terminus of the Illinoian drift has been little modifed in subsequent reports (Kay and Graham, 1943; Ruhe, 1969).

In the 1950's and 1960's work in Illinois began which quantitatively characterized the mineralogy and petrography of the Illinoian till deposits. The Illinoian deposits were subdivided into multiple till units and related to substages of the Illinoian stage. Leverett's Illinoian till was termed the Payson drift and was considered to be the earliest Illinoian till (Willman, Glass, and Frye, 1963). The eastern provenance of this till was confirmed by: 1. high illite content (at least illite values were greater than kaolinite plus chlorite) and the presence of chlorite in the clay minerals; 2. the greater garnet than epidote values in the heavy min-

Table 1. Index to sections shown on map of southeast Iowa study area (figure 1).

Des Moines County (29) Sections:
1m. 29 WH-2.
2. 29 WH-1.
3. 29 WH-4.
4m. Yarmouth Core.
5. 29 WH-8.
6. 29 WH-7.
7m. Mediapolis Outcrop Section.
8m. Mediapolis Core-2.
9m. Mediapolis Core-1.
10. 29-76-1.
11. 29 WH-6.
12. 29 WH-5.
13m. Nelson Quarry Section.
14m. Kingston Section.
15. 29 WH-9.
16m. Pleasant Grove Section.
17. 29-77-425-53.
18m. Franklin Section.
19. 29-76-36.
20. Beck Farm Section.
21. 29-4-75 (JTW-34-78).
22. West Lake Section.
23. 29 WH-34.

Henry County (44) Sections:
1. Mt. Union Cemetery Core.
2. 44 H-1.
3. 44 H-2.
4. 44 W-77-1.
5. 44 W-77-2.
6. 44-LC.
7. 44 W-77-3.
8. Baltimore Cut (44-BC-1).
9m. Schroder Site (44-SS).
10. 44 W-77-5.
11. 44 W-77-4.

Lee County (56) Sections:
1m. 56-697R, 698R.
2. 56-61.
3. Galland School.
4. Gateway Terminal.
5m. 56-79-2-1.
6m. 56-79-2-2.
7m. 56-JTW-33-78.
8. 56W-79-2.
9m. 56W-79-1.

Louisa County (58) Sections:
1. Bjork Farm Transect.
2. 58-JW-70.
3. 58-74-33.
4. 58-JW-69.
5. 58-JW-68.
6. 58-JW-67.
7. Wapello Bridge Cut (58 EH-1).
8. 58-74-3.
9. 58-CC-1.
10. 58-CC-2.
11. 58-X37-1.
12. 58-CJ-1.

Figure 1 (facing page). Generalized surficial geologic map of study area.

Stratigraphic Sections shown with symbols indicating surficial till unit.

Illinoian - GLASFORD FORMATION

▲ Kellerville Till Member

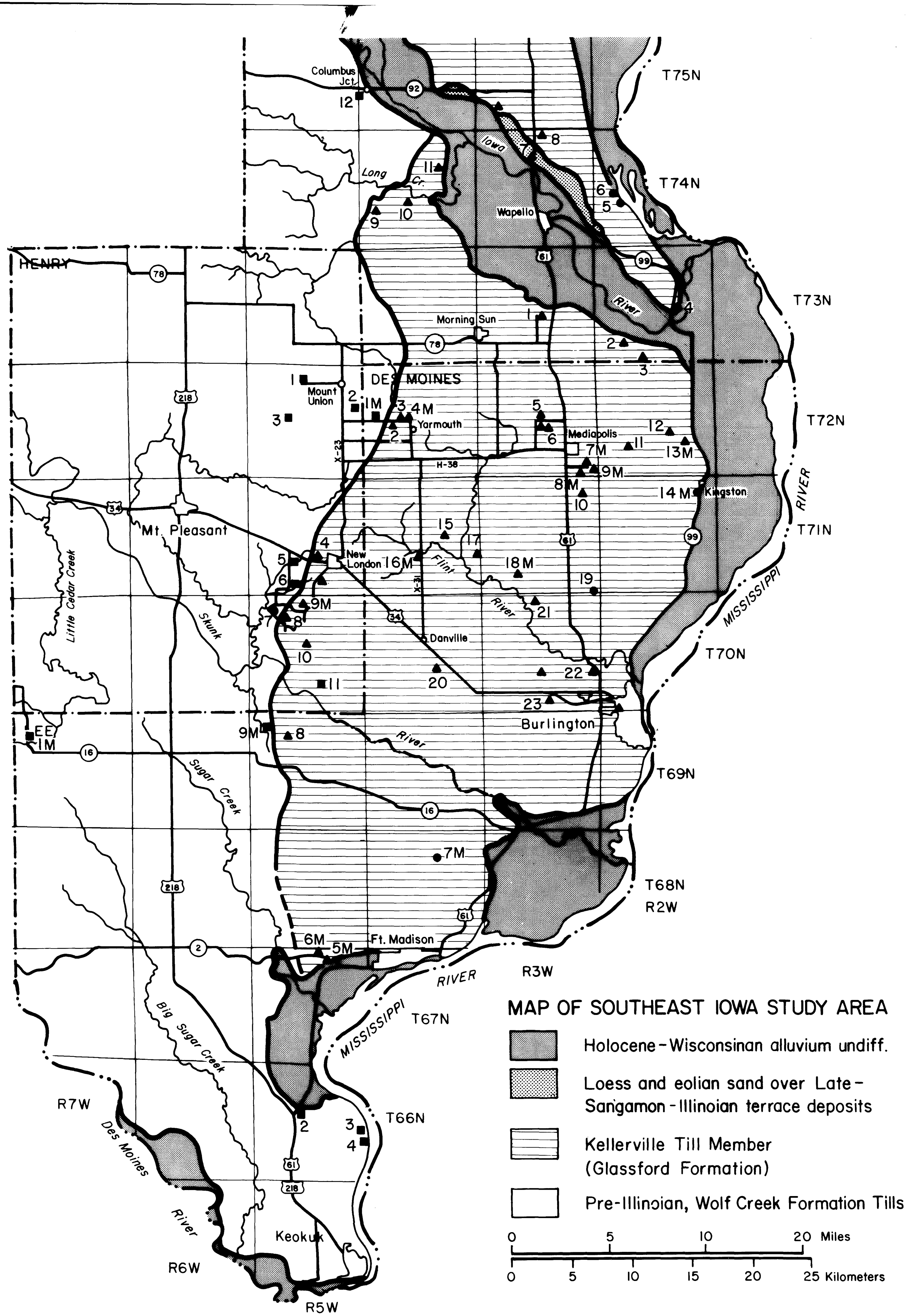
Pre-Illinoian - WOLF CREEK FORMATION

■ Hickory Hills Till Member

● Other WOLF CREEK or ALBURNETT FORMATION tills

1. See Table 1 for section name or number.

1m. Multiple tills encountered at section.


MAP OF SOUTHEAST IOWA STUDY AREA
Holocene-Wisconsinan alluvium undiff.
Loess and eolian sand over Late-Sangamon-Illinoian terrace deposits
Kellerville Till Member (Glassford Formation)
Pre-Illinoian, Wolf Creek Formation Tills
0 5 10 20 Miles
0 5 10 15 20 25 Kilometers
Columbus Jct.
Wapello
Morning Sun
DES MOINES
HENRY
LEE
Mount Union
Yarmouth
Mediapolis
Kingston
Mt. Pleasant
New London
Danville
Burlington
Ft. Madison
Keokuk
Iowa River
Long Cr.
Flint River
Skunk River
Little Cedar Creek
Sugar Creek
Big Sugar Creek
Des Moines River
MISSISSIPPI RIVER
T75N
T74N
T73N
T72N
T71N
T70N
T69N
T68N
T67N
T66N
R2W
R3W
R5W
R6W
R7W

erals of the sand fraction; and 3. the greater dolostone than limestone content in pebble counts and by x-ray analysis (Willman, Glass, and Frye, 1963).

Later these Pleistocene deposits in Illinois were more formally classified and the Illinoian till which occurs in the study area was named the Kellerville Till Member of the Glasford Formation of the Illinoian Stage (Willman and Frye, 1970). Although the Illinoian stratigraphy in Illinois is now known to be more complex than previously assumed the correlation with the Kellerville Till Member is still considered valid (Linebeck, 1979; Wickham, and Linebeck, this volume).

The history of investigations in areas peripheral to the study area has recently been reviewed by Hallberg (1980), Wickham (1979), and Lineback (1979) and will not be addressed further here.

The stratigraphy of the Pleistocene deposits of east-central Iowa has now been analyzed in detail, as well, and formal stratigraphic nomenclature defined (Hallberg, 1980). Two formations, the Alburnett and the Wolf Creek, are recognized. Table 2 shows the stratigraphy and nomenclature as now recognized in eastern Iowa, including the present study area. As shown, the Alburnett and Wolf Creek Formations are classified, time-stratigraphically, as Pre-Illinoian. This designation is now used because on-going work in the classic type area of Kansan and Nebraskan deposits in southwestern Iowa and Nebraska also shows a more complex series of glacial deposits, and well-developed buried soils ranging in age from less than 600,000 y.b.p. to over 2.2 million y.b.p. (Hallberg and Boellstorff, 1978; Boellstorff, 1978). Analysis of the stratigraphic sequence shows that these classical terms have been widely misused and miscorrelated. Until the stratigraphy of these deposits is resolved, the designation of Pre-Illinoian will be used for their time-stratigraphic reference.

Table 2 also shows other terms which will be used in this report which are informal, but have been used for many years in Iowa (see Ruhe, 1967; 1969). Their background will not be discussed at this time.

STRATIGRAPHY

This report will only discuss the pre-Wisconsinan Pleistocene stratigraphy in the southeast Iowa study area (figure 1). As shown in Table 2 these deposits are separated into three formations: the Alburnett and Wolf Creek Formations of Pre-Illinoian age; and the Glasford Formation of Illinoian age. The formations are comprised principally of till and related glacial sediments, and a variety of unnamed, undifferentiated sediments which occur between tills. Soil-stratigraphic units are also recognized. These are shown in Table 1 and will be discussed in later sections.

The till deposits in the formations are recognized and correlated by their physical stratigraphy, to some extent by the field characteristics of their pebble lithologies, and by the quantitative characterization of their particle-size, sand-fraction lithologies, clay mineralogy and matrix carbonates. Quantitatively the tills are most easily distinguished by their matrix carbonate data, clay mineralogic composition, and to a lesser degree by their sand-fraction lithologies. The Kellerville Till Member of the Glasford Formation exhibits matrix carbonate C/D (calcite/dolomite) ratios less than 0.40, whereas 95% of all the Wolf Creek and Alburnett Formation till samples have C/D ratios greater than 0.40 (Kemmis and Hallberg, this volume). The clay mineralogy of these deposits is also a useful parameter for differentiation at the formation level. Table 3 summarizes the clay mineralogy from 287 analyses by the Iowa Geological Survey and an additional 114 analyses by the Illinois State Geological Survey. The eastern-provenance Kellerville Till Member of the Glasford Formation exhibits higher percentages of illite than Kaolinite plus chlorite. This is in contrast to the western-derived Pre-Illinoian tills where kaolinte plus chlorite is nearly always greater than illite. In only 3.8% of the Kellerville Till Member analyses (5.8% of ISGS analyses) was illite less than Kaolinite plus chlorite. Illite was higher than kaolinite plus chlorite in only 6.4% of the Wolf Creek samples (10.1% of ISGS analyses)

Table 2. Present Pleistocene stratigraphic nomenclature for eastern Iowa.

Time Stratigraphy		Rock Stratigraphy		Soil Stratigraphy	
PLEISTOCENE SERIES	WISCONSINAN STAGE	Wisconsinan loess * Basal loess sediments and peat. *		Basal loess paleosol. *	
	SANGAMON STAGE	Yarmouth-Sangamon Sediments undif. *	Unnamed sediments; * includes Sangamon and Late Sangamon Pedisediment and Alluvium; and undifferentiated sediments.	Sangamon and Late-Sangamon Paleosols	YARMOUTH-SANGAMON Paleosol
	ILLINOIAN STAGE		GLASFORD FORMATION Kellerville Till Member superglacial and subglacial-basal till facies.		
	YARMOUTH STAGE		WOLF CREEK FORMATION (including unnamed, undifferentiated sediments)	YARMOUTH Paleosol	
	PRE-ILLINOIAN STAGES undifferentiated	Hickory Hills Till Member Aurora Till Member Winthrop Till Member		Dysart Paleosol Franklin Paleosol Westburg Paleosol	
		ALBURNETT FORMATION unnamed sediments, unnamed till members.			

* Informal names.

and in 8.3% of the Alburnett Formation samples (5.6% of ISGS analyses). Also, chlorite peaks are frequently apparent in the Kellerville Till Member samples (determined as chlorite by H.D. Glass, see Willman, Glass, and Frye, 1963). Chlorite (or vermiculite) peaks have not been seen in unweathered samples from the Wolf Creek Formation, but they have been apparent occasionally in analyses of the Alburnett Formation.

As defined in their type area, the Alburnett and Wolf Creek Formations are defined and discriminated on the basis of their distinct clay mineralogy (Hallberg, 1980). The Alburnett

Table 3. Clay mineralogy and sand fraction lithologies for tills in southeast Iowa.

	Clay Mineralogy		
	EX. - % Mean s.d.	Ill. - % Mean s.d.	K+C - % Mean s.d.
	GLASFORD FORMATION - Kellerville Till Member		
n=150	46±7.6	34±6.3	20±3.5
n=52 (ISGS)*	49±9.8	32±9.0	19±2.9
	WOLF CREEK FORMATION - All till samples		
n=125	59±3.3	18±2.6	23±2.5
n=44 (ISGS)*	60±5.6	19±3.3	21±2.7
	ALBURNETT FORMATION - All till samples		
n=12	44±5.7	24±3.5	32±4.5
n=18 (ISGS)*	45±4.3	25±3.2	30±3.1

	Sand-fraction Lithology		
	C/D Mean s.d.	T.C. Mean s.d.	T.S. Mean s.d.
	GLASFORD FORMATION - Kellerville Till Member		
n=58	1.8±2.3	38±10	44±9
	WOLF CREEK FORMATION - All till samples		
n=80	4.9±3.0	28±5.9	29±5.5
	ALBURNETT FORMATION - All till samples		
n=7	5.8±4.6	18±4.0	21±5.3

EX. - expandable
Ill. - illite
K+C - kaolinite plus chlorite
C/D - limestone/dolostone grain ratio
T.C. - total carbonate grains
T.S. - total sedimentary rock grains
(ISGS)* - Analyses by Illinois State Geological Survey; H.D. Glass

Formation averages 44% expandable clay minerals while the Wolf Creek averages 59% in the study area (Table 3).

Calcite and dolomite in the clay fraction were also evaluated in some of the x-ray analyses. The eastern-provenance Kellerville Till Member often showed no carbonate peaks. Those that did have carbonate peaks averaged about 30 counts per second (cps) for both calcite and dolomite. In contrast, the western-provenance Alburnett and Wolf Creek Formation samples averaged about 105 cps calcite and 35 cps dolomite.

Data on the lithologies of the very coarse sand fraction in the tills are also summarized in Table 3. The Kellerville Till Member of the Glasford Formation is marked on the average by a lower C/D ratio, but higher total carbonate and particularly by higher percentages of total sedimentary grains than the western-provenance Pre-Illinoian tills. Coal fragments were noted in 58% of the samples from the Kellerville Till Member. The coal fragments and high total sedimentary grain percentages in the Kellerville Till reflect incroporation of Pennsylvanian bedrock which is widespread in western Illinois. This is also apparent in the field, as the pebble and cobble fraction of the Kellerville Till Member has abundant Pennsylvanian lithologies.

Other properties and pertinent data will be described in the discussion of the individual stratigraphic units.

ALBURNETT FORMATION

The Alburnett Formation is the oldest Pleistocene stratigraphic unit currently recognized in eastern Iowa. The type area for the Alburnett Formation is in Linn County, Iowa (Hallberg, 1980). The Alburnett Formation is composed principally of multiple till units, but includes a variety of fluvial sediments. In the type area some minor (A/C or O/C) paleosols occur within the deposits also. Deposits of the Alburnett Formation fill in and bury the deep channels in the bedrock surface throughout eastern Iowa. The properties of the formation have been described in detail by Hallberg (1980).

The Alburnett Formation is recognized by its stratigraphic position and by its distinct clay mineralogy. The Alburnett shows significantly lower percentages of expandable clay minerals and higher kaolinite than the Wolf Creek Formation. The lab data for the Alburnett Formation are summarized in Table 4. The data from the type area are included in Table 4 for comparison. As shown in Table 4 the data from southeast Iowa are essentially identical to the data from the type area in east-central Iowa. There is also excellent agreement between the clay mineralogic analyses by the Iowa and Illinois State Geological Surveys. Data on the matrix carbonate content are summarized in

Table 4. Summary of properties for the tills of the Alburnett Formation.

		Particle Size - %		
		Clay	Silt	Sand
n=9	mean	18.7	36.8	44.4
	s.d.	1.2	3.6	3.2
*[n=185]	mean	[22.1]	[34.4]	[43.8]
	s.d.	[3.3]	[5.0]	[4.6]

		Clay Mineralogy - %			
		EX.	ILL.	K+C	
n=12	mean	44	24	32	
	s.d.	5.7	3.5	4.5	
	range	(39-51)	(19-29)	(26-41)	
n-18	mean	45	25	30	Ill. State
	s.d.	4.3	3.2	3.1	Geol. Survey
	range	(38-53)	(22-35)	(23-36)	Analyses
*[n=163]	mean	[43]	[25]	[32]	
	s.d.	[5.6]	[4.1]	[3.9]	
	range	[28-55]	[15-35]	[21-48]	

		Sand-fraction Lithology		
		C/D	TC	TS
n=7	mean	5.8	18	21
	s.d.	4.6	4.0	5.3
*[n=56]	mean	[U]	[18]	[21]
	s.d.	[U]	[7.8]	[7.8]

*[] Data from type area.
U - Uncalculable because many samples have no dolostone (see Hallberg, 1980).

Kemmis and Hallberg (this volume).

Alburnett Formation deposits have not been widely recognized in southeast Iowa. This is principally because only a small amount of deep core-drilling has been done. Till of the Alburnett Formation was recognized in both core-holes which were drilled to bedrock (Yarmouth Core and Mediapolis-1 core; see Hallberg and Baker, this volume). At both sites only one till unit of the Alburnett Formation was recognized, with a maximum thickness of 19 feet. The till rested directly on Mississipian bedrock, but contained some minor inclusions of sand and gravel toward the base of the unit. At both sites the Alburnett Formation till was overlain directly by the Aurora till

Member of the Wolf Creek Formation.

In outcrop, Alburnett Formation tills have only been identified along or near the bluffs of the Mississippi River. This is likely the only area where dissection of the landscape is deep enough to expose these lowermost Pleistocene deposits. Alburnett Formation till is exposes in the Kingston Section in Des Moines County, and in section 56-JTW-33-78, in Lee County (see Appendix). In both cases the Alburnett Formation till is directly overlain by deposits of the Wolf Creek Formation. The lower contact is not exposed. Till of Alburnett Formation mineralogy was also identified in outcrop by Willman, Glass, and Frye (1963) in their Ft. Madison Section, Lee County (see discussion in Hallberg, 1980, p. 102-103).

Soil Stratigraphic Units - Westburg Paleosol

In complete sections, in the type area, the upper boundary of the Alburnett Formation is the top of the Westburg Paleosol. At this time, the Westburg Paleosol has not been encountered in southeast Iowa. The only evidence of weathering occurs in the Yarmouth Core where the top of the Alburnett Formation till is leached to a depth of 3 feet below the contact with the Aurora Till Member. In all other sections the Alburnett Formation is calcareous to its upper contact.

WOLF CREEK FORMATION

The Wolf Creek Formation constitutes the youngest Pre-Illinoian rock stratigraphic unit in eastern Iowa. The formation is composed principally of multiple basal tills and inter-till stratified sediments. Three till members are currently recognized which are separated in complete sections by soil stratigraphic units (see Table 1). The type areas for the formation and the till members are located in Tama and Buchanan Counties, in east-central Iowa (Hallberg, 1980).

In the sections analyzed in this report the base of the Wolf Creek Formation is marked by either the contact with the

Paleozoic bedrock or by the contact with the Alburnett Formation. The Wolf Creek Formation deposits are separated from the Alburnett Formation on the basis of their distinctly different clay mineralogy (Table 3).

In the most complete stratigraphic sections in southeast Iowa the upper boundary of the Wolf Creek Formation is the unconformable contact with the overlying deposits of the Glasford Formation of Illinoian age. In these sections the top of the Yarmouth Paleosol marks the top of the Wolf Creek Formation. The most nearly conformable sections are found at the Yarmouth Core Site (Hallberg and Baker, this volume) and at the Schroder Site (in Appendix). In these locations an Early or Pro-Illinoian peat forms a complex Ob horizon with the Yarmouth Paleosol.

Beyond the limits of the Glasford Formation, Wisconsinan loess directly overlies the merged Yarmouth-Sangamon Paleosol. In both southeast and east-central Iowa the Yarmouth-Sangamon Paleosol is developed in undifferentiated fine-textured sediments and the Hickory Hills Till Member of the Wolf Creek Formation. These fine-textured sediments have not been included within the Wolf Creek Formation because of the uncertainty of their temporal relations (Hallberg, 1980). In southeast Iowa the Yarmouth Paleosol is developed in similar fine-textured sediments. In this stratigraphic setting, these sediments, though unnamed, are included in the Wolf Creek Formation because they are clearly limited in space and time by the overlying deposits of the Glasford Formation.

The Wolf Creek Formation is subdivided into three till members: the Winthrop, Aurora, and Hickory Hills. The general characteristics and variations with weathering are the same in southeast Iowa as in the type area (see Hallberg, 1980). As in the type area these tills are considered basal tills (in the generic sense of Dreimanis, 1976), based on their very uniform properties vertically and laterally, their sedimentologic features (see Hallberg, 1980), and their consolidation characteristics and density.

The quantitative data used to characterize and discriminate the tills of the Wolf Creek Formation are summarized in Tables

5-7, and in Kemmis and Hallberg (this volume). For comparative purposes the data from the type area are also shown. In general there is excellent agreement between the data for the individual members from this study and the type area.

The clay mineralogy is the main property used to discriminate the Wolf Creek Formation from the Alburnett Formation (Tables 3 and 4). The particle-size data and the combined matrix carbonate and particle size data are the principle means of discriminating the Winthrop, Aurora, and the Hickory Hills Till Members.

All the till members of the Wolf Creek Formation average 58-60% expandable clays (Table 5). There is very good correspondence between the clay mineralogic analyses by the Iowa and the Illinois State Geological Surveys, and with the data from the type area (Hallberg, 1980). There is a tendency for the Wolf Creek Formation deposits in southeast Iowa to be slightly lower in expandable clays than in the type area (Tables 3 and 5).

As in the type area all three till members are generally loam-textured, although the Winthrop Till Member ranges to a light clay loam (Table 6; figure 2). There is again an excellent correspondence in the particle-size distributions of the three till members between southeast Iowa and the type area (Table 6). The Hickory Hills Till Member is relatively sandy, the Aurora and Winthrop are relatively silty, but the Aurora has more clay. In fact, in southeast Iowa the particle-size data for the three till members are much more consistent than in the type area, as evidenced by the small standard deviations. The differences are more significant as well. The Hickory Hills and the Aurora Tills average a separation of 2.7 standard deviations in mean sand content, and a separation of 3.1 standard deviations in mean silt content. The Aurora and Winthrop Till Members show a separation of 3.1 standard deviations in mean sand content and a 3.5 standard deviation separation in mean clay content. Their textural distribution is shown on figure 2.

The particle-size data combined with the matrix carbonate

Table 5. Summary of clay mineralogy for till members of the WOLF CREEK FORMATION.

	Clay Mineralogy - %			
	EX. Mean s.d.	Ill. Mean s.d.	K+C Mean s.d.	
Hickory Hills Till Member				
n=68 (range)	60±2.4 (55-64)	18±2.4 (8-23)	22±2.1 (19-28)	
n=23 (range)	59±4.1 (49-64)	19±2.5 (16-26)	22±2.1 (18-26)	Illinois State Geological Survey analyses.
[n=101] [range]	[63±4.5] [52-73]	[17±3.3] [11-23]	[20±2.2] [14-25]	Data from the type area. *
Aurora Till Member				
n=37 (range)	58±4.1 (50-66)	19±2.4 (15-24)	23±2.6 (17-27)	
n=8 (range)	55±5.3 (49-63)	22±3.7 (16-26)	23±2.3 (21-26)	Illinois State Geological Survey analyses.
[n=82] [range]	[62±3.6] [55-70]	[18±2.5] [13-24]	[21±2.3] [17-24]	Data from the type area. *
Winthrop Till Member				
n=15 (range)	60±4.6 (52-69)	16±2.8 (12-21)	24±3.6 (18-29)	
n=9 (range)	64±4.1 (58-69)	17±2.2 (14-20)	19±2.3 (16-22)	Illinois State Geological Survey analyses.
[n=24] [range]	[60±4.3] [51-68]	[17±2.2] [10-20]	[24±3.8] [16-31]	Data from the type area. *

* From Hallberg (1980).

Table 6. Summary of particle-size data for till members of the WOLF CREEK FORMATION.

	Particle Size - %		
	Clay mean s.d.	Silt mean s.d.	Sand mean s.d.
Hickory Hills Till Member			
n=87 *[n=187]	21.6±1.7 [21.8±3.6]	32.9±2.4 [34.4±4.6]	45.5±2.3 [43.7±4.7]
Aurora Till Member			
n=41 *[n=145]	20.5±2.2 [22.1±4.4]	41.6±3.4 [39.9±5.2]	38.0±3.5 [38.4±5.6]
Winthrop Till Member			
n=21 *[n=27]	27.6±1.9 [25.0±5.0]	42.0±2.3 [40.7±3.6]	30.4±1.9 [33.5±5.3]

*[] Data from type area, from Hallberg (1980).

Table 7. Summary of sand-fraction lithology data for till members of the WOLF CREEK FORMATION.

	Sand-fraction lithologies		
	C/D mean s.d.	TC mean s.d.	TS mean s.d.
Hickory Hills Till Member			
n=43 *[n=93]	3.8±1.7 [1-5]**	26±4.3 [24±6.3]	27±3.8 [27±6.9]
Aurora Till Member			
n=28 *[n=79]	6.1±4.0 [>15]**	30±6.6 [22±6.5]	32±5.6 [24±6.5]
Winthrop Till Member			
n=9 *[n=18]	5.2±2.9 [>15]**	32±7.4 [15±5.1]	32±7.3 [18±6.5]

*[] Data from type area, from Hallberg (1980).
** - see text for discussion.

data provide the principal means of discriminating the three till members. The textural dependence of the matrix carbonates has provided an excellent relationship for discriminating the till members. This is fully outlined in Kemmis and Hallberg (this volume). Again, the matrix carbonate data from southeast Iowa is very consistent with the data from the type area (Hallberg, 1980, figure 38).

The sand-fraction lithology data (Table 7) from southeast Iowa do not compare as closely with the type area as the other data sets. The data for the Hickory Hills Till Member are quite similar to the type area, but the Aurora and Winthrop Till Members in southeast Iowa are higher in total carbonate and total sedimentary grains than in the type area. This trend, however, was noted in the east-central Iowa area (Hallberg, 1980). The major difference in the southeast Iowa data is that the Aurora and Winthrop Till Members have substantially lower C/D ratios than in the type area. In east-central Iowa 40-50% of the Aurora and Winthrop Till Member samples had no dolostone (by the techniques used). For both till members the median and modal class was a C/D of greater than 15 whereas the median and mode for the Hickory Hills was in the C/D of 1-5 class. In southeast Iowa only 3 Aurora and 1 Winthrop Till samples showed no dolostone. The mean C/D ratios for southeast Iowa samples of the Aurora and Winthrop are still higher than the Hickory Hills Till Member, but they are not as high as in east-central Iowa.

In spite of the variation in sand-fraction lithologies, the correlations of the individual till members to their type area are felt to be quite good. The quantitative data on clay mineralogy, particle-size and matrix carbonate relationship, and most importantly the physical stratigraphic relations are essentially identical between southeast Iowa and the east-central Iowa type areas. A few particular notes about the individual till members will be discussed below.

In many sections (See Appendix) a single Wolf Creek Formation till occurs, and the till has been correlated with a particular member. This has been possible in southeast Iowa

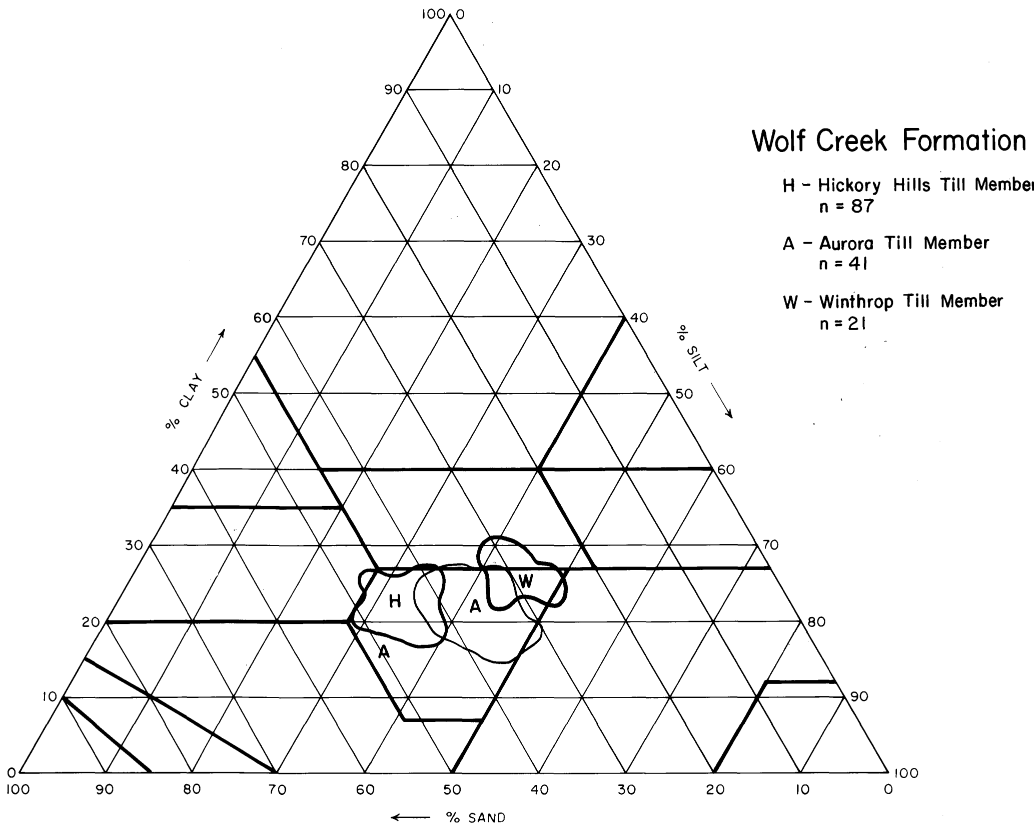


Figure 2. Range of textures in the Wolf Creek Formation tills in southeast Iowa.

because the lab data and properties of the till members are more consistent and distinct than they are in the type area. Isolated exposures of tills have also been evaluated in terms of their landscape position and elevation in relation to deeper and more complete stratigraphic sections in their immediate vicinity. Even with these efforts in some sections the Winthrop and Aurora Till Members could not be discriminated with certainty.

Winthrop Till Member

The Winthrop Till Member is the oldest till member of the Wolf Creek Formation. It has only been encountered in a few localities in the southeast Iowa study area. It is best exposed in the Franklin locality transect (see figure 4). At this locality its upper boundary varies laterally and is marked by: (1) undifferentiated fine-textured, leached sediments, in which the Franklin Paleosol (new name; see discussion in later section) formed; or (2) by the base of the Aurora Till Member which contains many sheared inclusions of stratified sediments and block inclusions of the Franklin Paleosol. The lower contact of the Winthrop Till Member has not been examined in the study area.

Aurora Till Member

The Aurora Till Member is widespread throughout the study area. It has been present in every section where the Hickory Hills Till Member has been penetrated except the Nelson Quarry Section where the Hickory Hills lies on bedrock. In the study area the Aurora Till Member may be directly overlain by: (1) the Hickory Hills Till Member (Franklin Transect; figures 4-7); (2) by undifferentiated glaciofluvial deposits, which separate it from the Hickory Hills Till Member (Yarmouth and Mediapolis-1 Core Sites; see Hallberg and Baker, this volume); or (3) by undifferentiated sediments in which the Dysart Paleosol formed (Sections 56-697R and 698R, and 56 W-79-1, in Appendix, Lee County). Sites 56-697R and 698R are cores taken during investigations for the relocation of state highway 16, in northwestern Lee County (see figure 1, Table 1). Figure 3 shows the stratigraphy and particle-size data for core 698R (additional data and locations for 56-697R and 698R are in Appendix, Lee County sections). In core 698R, the top of the Aurora Till Member is marked by the contact with the gleyed leached sediments. The Dysart Paleosol here consists of an organic soil, a peat which grades downward into a mucky silt loam and then into the gleyed leached silts. To the south from this site and higher in elevation, the Dysart Paleosol becomes a well-developed buried soil with a gleyed Btgb horizon.

The lower contact of the Aurora Till Member is variously marked in the study area by: (1) a till-till contact with either an Alburnett Formation till (Kingston Section, in Appendix;

Yarmouth Core Site, in Hallberg and Baker, this volume) or the Winthrop Till Member (Franklin Transect, figure 4); (2) a contact with stratified glaciofluvial sediments (e.g. - Kingston Section, in Appendix); or (3) a contact with the Franklin Paleosol and undifferentiated sediments, which separate the Aurora from the Winthrop Till Member (Franklin Transect, figures 4-7). The lower portion of the Aurora Till Member often contains small inclusions of substrate material which may obscure the exact contact (Meidapolis-1 Core Site, see Hallberg and Baker, this volume; Franklin Transect, figure 4).

The Aurora Till Member is texturally very similar to the Kellerville Till Member of the Glasford Formation. However, it is easily separated from the Kellerville on the basis of stratigraphic position, clay mineralogy, and matrix carbonate data.

Another similarity between the Aurora and Kellerville Tills is that the Aurora shows traces of coal and other Pennsylvanian lithologies in the sand and pebble fractions. However, these lithologies are not nearly as abundant in the Aurora as in the Kellerville. Only 23% of the sand-fraction samples showed traces of coal. These lithologies were not present in the Aurora Till Member in the type area (Hallberg, 1980). The occurrence of the Pennsylvanian lithologies seems to indicate that the ice-flow direction for the Aurora Till Member was more from the west or northwest than the Hickory Hills or Winthrop Till Members, in this area.

Hickory Hills Till Member

The Hickory Hills Till Member is the youngest Till Member of the Wolf Creek Formation. It is widespread throughout the study area. It is the till in which the Yarmouth Paleosol is formed. The Hickory Hills Till Member has been encountered below the Kellerville Till Member of the Glasford Formation in every section which has penetrated the Kellerville. Beyond the limits of the Illinoian-age Glasford Formation the Hickory Hills Till Member is the surface till (see figure 1) in which the Yarmouth-Sangamon or Late Sangamon Paleosols formed.

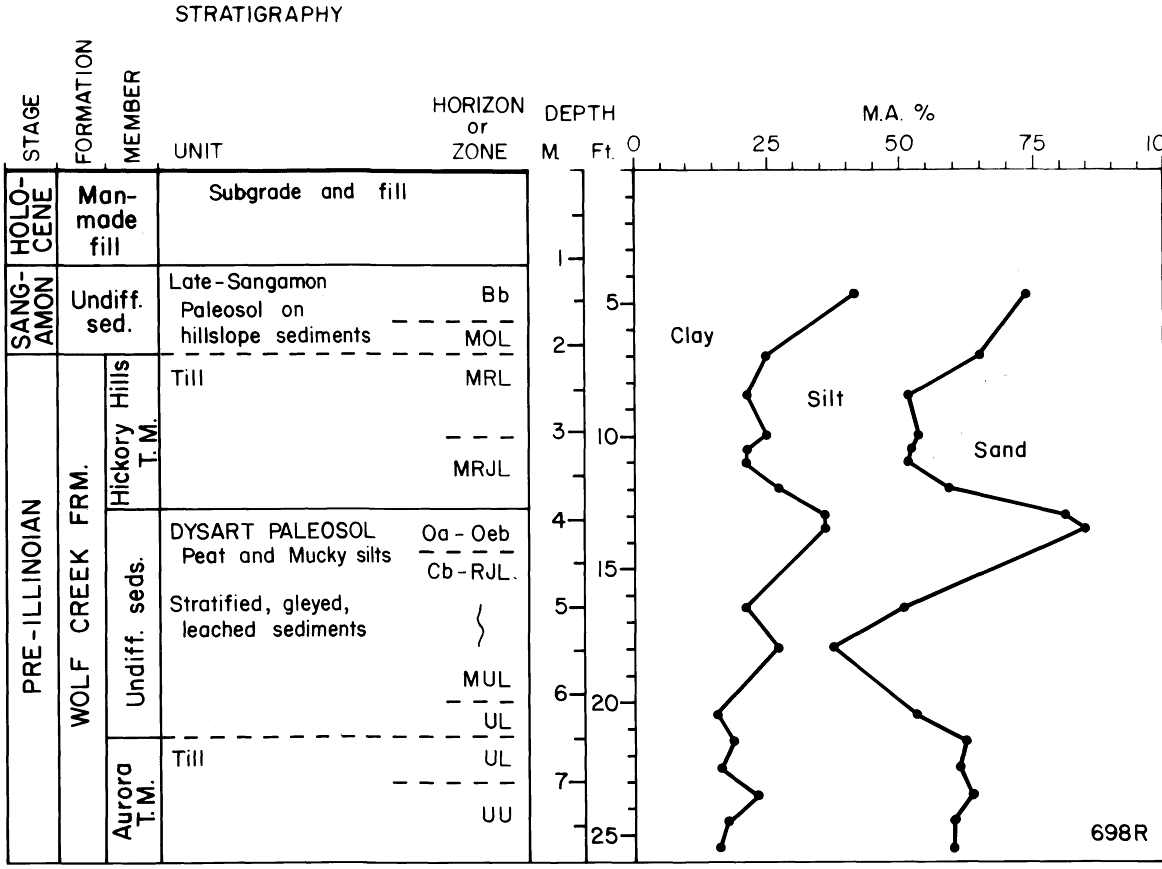


Figure 3. Stratigraphy and particle-size data for Core Site 56-698R.

In the study area the lower unconformable boundary of the Hickory Hills Till Member ranges from: (1) a contact with the top of the Dysart Paleosol and related sediments (figure 3; Section 56 W-79-1, in Appendix); (2) a direct contact with the Aurora Till Member (Franklin Section, figure 4); (3) a contact with undifferentiated fluvial sediments, which separate it from the Aurora Till Member (Yarmouth and Mediapolis-1 Core Sites, see Hallberg and Baker, this volume); or (4) a contact with the Paleozoic bedrock (Nelson Quarry Section, in Appendix).

The upper boundary of the Hickory Hills Till Member is also variable. Within the area covered by the Glasford Formation deposits the upper contact is marked by: (1) the upper limits of the till-derived portion of the Yarmouth Paleosol (see sections in Hallberg and Baker, this volume); (2) the contact with overlying silts or organic silts (Nelson Quarry

Section, in Appendix); or (3) a till-till contact between the Kellerville Till Member and the Hickory Hills Till Member (Mediapolis-1 Core Site; Pleasant Grove Section, Description 1). Till-till contacts where the intervening paleosol is missing are much more common than sections where the paleosol is preserved. The Pleasant Grove Section in Des Moines County is an excellent example of such a contact. As shown in Description 1 and Table 8, an abrupt change in color, texture, mineralogy and density occur at the contact of the Kellerville and Hickory Hills Till Member. Where the section was described the top of the Hickory Hills Till Member was leached, but in many places along the exposure the Hickory Hills was calcareous to its upper contact.

Outside of the limits of the Glasford Formation the upper contact of the Hickory Hills Till Member is marked by the upper limits of the till-derived portion of the Yarmouth-Sangamon or Late-Sangamon Paleosols (see Section 44LC, Description 3 for example).

The Hickory Hills Till Member is very uniform in properties, both vertically and laterally, throughout the study area (see Tables 5-7; figure 2). In its lowermost portion it may contain some block inclusions of substrate materials, however.

Basal Inclusions in Tills in Eastern Iowa

As has been noted here and elsewhere (Hallberg, 1980), the Pre-Illinoian tills in eastern Iowa are remarkable uniform in their properties, both laterally and particularly vertically. In many sections in eastern Iowa an individual till unit may be 30 to 40 feet (9-12 m) thick, yet it will vary only a few percent in particle-size distribution, except in the lowermost portion. This is one of the criteria which points to the interpretation of these units as basal tills (see Hallberg, 1980, p. 130-132).

The variations in the lower portions of the unit fall into two categories. First, in some sections the lowermost part of the till may be transitional in properties from its modal

Description 1. Pleasant Grove Section (29-PG-21); a road cut on the west side of relocated county highway X-31, located in the NE¼, of the SE¼, of the SE¼, of the SE¼, of sec. 21, T.71N., R.4W., Des Moines County, Iowa; elevation at top of cut approximately 685 feet. The cut is a borrow area on a hillslope, and begins in Illinoian till; vertical cuts just to the south show thin loess over a Late-Sangamon or Sangamon Paleosol.

Depth-Feet (meters)	Horizon or Zone	Description
GLASFORD FORMATION - Kellerville Till Member, subglacial facies, basal till.		
0 - 2 (0 - 0.6)	OL	Yellowish brown (10YR 5/6), loam till; texturally uniform; firm; abundant coal, black shale, siderite concretions (Pennsylvanian lithologies in pebble fraction).
2 - 7.9 (0.6- 2.4)	OU	As above, gray mottles increase with depth, abrupt lower contact.
WOLF CREEK FORMATION - Hickory Hills Till Member		
7.9- 9.4 (2.4- 2.9)	OL	Strong brown (7.5YR 5/6) loam till; some iron oxide cement; no Pennsylvanian lithologies, very firm; maximum depth of leaching 1.5 feet (0.5 m), but in places no leaching evident at contact.
9.4-10.4 (2.9- 3.2)	OU	Strong brown (7.5YR 5/6) loam till.
10.4-10.9 (3.2- 3.3)	OU2	As above with abundant secondary carbonate concretions; color grading to yellowish brown (10YR 5/6), or dark yellowish brown (10YR 4/6).
10.9-18.7 (3.3- 5.7)	OJU	Yellowish brown to dark yellowish brown loam till; some joints with iron-oxide stains; gray mottles increase with depth.

characteristics above, to that of the substratum. These changes may be nearly imperceptible in the field, because minor amounts of the substrate materials have been thoroughly incorporated in the tills. In the second category is the occurrence of identifiable inclusions of coherent blocks of the substrate materials. Obviously variations between these extremes exist.

The Franklin Section in Des Moines County presents some excellent examples of block inclusions. The Franklin Locality consists of a series of shallow cores, road cuts, and the freshly graded surface of a dirt road. It is located along the north-south dirt road which forms the boundary between secs. 28 and 29, T.71N., R.3W. (Franklin Township) Des Moines County. The section follows the east boundary of the NE ¼ of the SE ¼ of sec. 29, beginning at an elevation of approximately 700 feet.

The section was first noticed, described, and sampled in

Table 8. Laboratory data Pleasant Grove Section (29-PG-21).

Sample Horizon or Zone	Sample Depth (feet)	Clay Mineralogy ID.	EX.	Ill.	K+C	Sand-fraction Lithologies C/D	T.C.	Sh.	T.Sed.	Q.F.	Tx.	Notes	Ca	Matrix CO_3 Do	TC	C/D	Particle Size Clay	Silt	Sand	Density g/cc	Atterberg Limits L.L.	P.L.	P.I.
			- % -						- % -					- % -				- % -					
GLASFORD FORMATION - Kellerville Till Member, subglacial facies; basal till																							
OL	1.5																24.2	38.7	37.1				
OU	2.2																21.4	41.3	37.3				
OU	* 2.3	Ill.	56	26	18							*	2.9	8.4	11.3	0.35	*						
OU	4.0					4.3	20	5	27	67	73						20.4	42.2	37.4				
OU	5.0	2080	49	35	17												21.4	40.3	38.3				
OU	5.1					1.1	29	11	44	51	56	Coal	2.2	11.7	13.9	0.19	20.4	42.2	37.4				
OU	* 5.6	Ill.	53	30	17							*	2.5	8.0	10.5	0.31	*						
OU	6.0					2.2	30	6	38	58	62						23.0	39.9	37.1	1.80	34.7	21.2	13.5
OU	6.2	3508	51	31	18								2.0	8.7	10.7	0.23	20.6	45.3	34.1	1.79	35.6	23.2	12.4
OU	* 6.6	Ill.	58	25	17							*	3.4	7.8	11.2	0.44	*						
OU	7.0	2081	48	34	17	3.8	29	8	41	50	59	Coal					20.7	42.1	37.2	1.89	32.5	19.4	13.1
OU	7.2												2.9	8.5	11.4	0.34	18.4	43.1	38.5	1.86	35.6	21.6	14.0
OU	* 7.6	Ill.	55	30	15							*	3.4	8.4	11.8	0.40	*						
OU	7.9	3507	56	28	16								2.6	10.3	12.9	0.25	22.1	45.9	32.0	1.83	29.2	18.0	11.2
WOLF CREEK FORMATION - Hickory Hills Till Member																							
OL	8.1	2082	65	15	20												20.3	29.9	49.8				
OL-OU	9.4												2.3	6.7	9.0	0.34	19.3	34.8	45.9	2.02	29.9	19.4	10.5
OU	9.5	3501	60	19	21								2.4	6.5	8.9	0.37	19.3	34.3	46.4				
OU	* 9.6	Ill.	54	20	26							*	5.5	4.7	10.2	1.17	*						
OU	9.8					4.0	10	2	21	74	79						20.4	29.9	49.7	2.01			
OU	* 9.9	Ill.	61	17	22							*	5.6	5.9	11.5	0.95	*						
OU	10.5	2083	61	18	21	5.7	18	--	19	77	81						19.6	38.3	42.1				
OU	*10.6	Ill.	57	20	23							*	6.4	5.7	12.1	1.12	*						
OU	10.8	3491	58	19	23								3.9	6.3	10.2	0.62	20.1	36.1	43.8				
OU	*11.5	Ill.	60	20	20							*	6.3	5.6	11.9	1.13	*						
OU	12.0					5.1	24	--	26	69	74						21.3	32.8	45.9				
OU	12.4												3.4	5.0	8.4	0.68	19.5	34.0	46.5				
OU	*12.6	Ill.	62	17	21							*	6.1	5.1	11.2	1.20	*						
OU	*13.5	Ill.	60	19	21							*	6.3	5.5	11.8	1.15							
OU	14.0	2084	61	17	22	6.1	20	2	27	61	73						20.3	30.5	49.2				
OU	*14.6	Ill.	64	16	20							*	5.9	5.8	11.7	1.02	*						
OU	15.0												3.1	5.3	8.4	0.58	20.3	32.5	47.2				
OU	*15.5	Ill.	63	17	20							*	5.5	5.4	10.9	1.02	*						

*Ill. - Analyses by the Illinois State Geological Survey; Clay min. - H.D. Glass; Matrix carbonates of the <0.74 mm fraction, J.T. Wickham.

1978 when road grading operations exposed fresh materials along the road bed. Later, in 1979, a series of cores were taken to work out the details of the stratigraphy. The composite section is shown in figure 4. The lab data are compiled by stratigraphic unit in Table 10. The composite section was described by G.R. Hallberg, J.T. Wickham, J.A. Linback, N.W. Wollenhaupt, T.J. Kemmis, and A.J. Lutenegger. The individual till units at the site are uniform and distinct in their particle-size distribution (see Table 9; figures 5-7). Additional laboratory data for the site are shown in Table 10.

The data for Core F-1 (figure 5) show an excellent example of inclusions at the base of the Hickory Hills Till Member. The top of the Hickory Hills Till Member is marked by an abrupt contact with the overlying Kellerville Till at about 7.5 feet (2.3 m) in depth. The Hickory Hills Till Member, from 7.5 to 11.3 feet (2.3 to 3.4m) in depth, is very uniform in texture and other properties. From 11.3 to 16.4 feet (3.4 to 5.0 m) there is a zone of till which exhibited many minor abrupt color changes and thin iron-oxide rinds oriented at various angles which appear to outline and separate different blocks of till. At about 16.4 feet (5.0 m) there is another abrupt contact with the underlying Aurora Till Member. Below this depth the Aurora Till Member is also quite uniform in its characteristics and properties (figure 5). In the intermediate zone (11.3 to 16.4 feet) between the uniform Hickory Hills and Aurora Till Members, the particle-size and carbonate data for the individual till blocks vary abruptly from values typical of the Hickory Hills to values typical of the Aurora Till Member. This is interpreted to be a zone of Hickory Hills Till with block inclusions of the underlying Aurora Till Member.

The base of the Aurora Till Member shows similar features at this site. Core site F-3 (figure 6) shows the Franklin Paleosol developed in sediments which rest on the Winthrop Till Member. Up-slope and in road cuts Aurora Till overlies the compacted peat which forms the top of the paleosol. Further up-slope at core site F-2 (figures 5 and 7) the Franklin Paleosol is missing. In its place occurs the lower portion of the Aurora

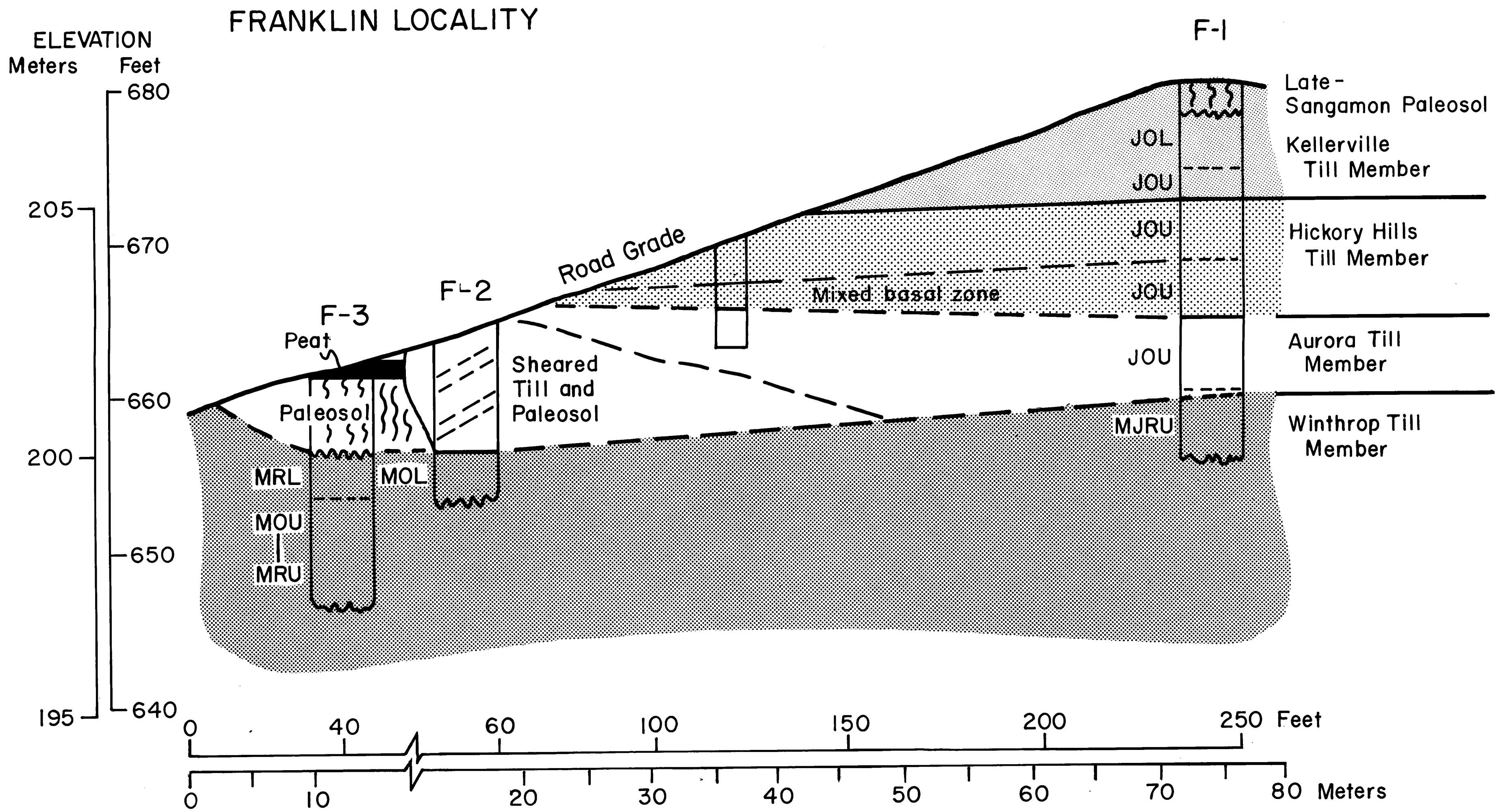


Figure 4. Cross-section of Franklin Transect Locality.

Table 9. Particle-size data summary - Franklin section.

		Clay	Silt	Sand
	GLASFORD FORMATION Kellerville Till Member (basal till)			
n=15				
mean		24.2	41.4	34.4
s.d.		1.5	3.9	3.0
	WOLF CREEK FORMATION Hickory Hills Till Member			
n=15				
mean		21.0	35.4	43.6
s.d.		1.4	1.4	1.3
	Aurora Till Member			
n=14				
mean		20.2	41.6	38.1
s.d.		1.8	3.3	2.7
	Winthrop Till Member			
n=15				
mean		27.6	41.6	30.8
s.d.		2.0	1.6	1.7

Till Member which contains identifiable blocks of the paleosol (figure 7). Some of the blocks show slickensides, indicating some differential shearing. These relationships exhibit a very complex geometry in the contacts between the stratigraphic units (figure 4).

Inclusions such as these are common in the lower portion of the tills in eastern Iowa. Their mode of occurrence points to a subglacial or basal till origin (Dreimanis, 1976; Boulton, 1976). Their frequent occurrence also points out that care must be taken in sampling and interpreting data where only a thin lower increment of till is present in a stratigraphic section.

Soil-Stratigraphic Units

Several soil-stratigraphic units are related to deposits of the Wolf Creek Formation. The Franklin Paleosol and Dysart Paleosol separate the Winthrop and Aurora Till Members, and the Aurora and Hickory Hills Till Members respectively. At the top

Table 10. Additional laboratory data, Franklin Section.

Sample			Clay Mineralogy				Sand-Fraction Lithology							Matrix CO_3				Particle Size		
Horizon or Zone	Depth (feet)	I.D.	EX. - % -	Ill.	K+C	C/D	T.C.	Sh. - % -	Sed.	Q.F.	T.X.	Notes	Ca	Co - % -	T.C.	C/D	Clay	Silt - % -	Sand
GLASFORD FORMATION - Kellerville Till Member, subglacial facies, basal till.																			
JOL	* R	ILL.	42	39	19 *														
JOL	* R	ILL.	55	27	18 *								See Figures 5, 6, and 7 also.						
JOL	* R	ILL.	52	25	23 *														
JOL	* R	ILL.	55	28	17 *														
JOU	* R	ILL.	54	30	16 C*														
JOU	* R	ILL.	61	23	17 *							*	0.9	6.2	7.1	0.15	*		
JOU	* R	ILL.	53	33	14 *							*	2.4	6.6	9.0	0.36	*		
JOU	* R	ILL.	57	26	17 *							*	1.9	7.8	9.7	0.24	*		
JOU	* R	ILL.	55	27	18 *							*	2.4	7.1	9.5	0.34	*		
JOU	* R	ILL.	61	24	15 *							*	2.6	7.5	10.1	0.35	*		
JOU	R	3276	52	32	16 C	0.8	40	2	42	50	58	Blk Shale	1.5	8.4	9.9	0.18	22.2	45.4	32.4
JOU	R					2.4	37	1	40	51	60	Coal	2.3	6.3	8.6	0.37	23.7	36.6	39.7
JOU	1-6	3305	51	28	21	1.3	37	-	37	55	63								
JOU	1-6.7	3308	48	30	22 C	1.4	42	-	42	55	58		1.6	7.6	9.2	0.21	25.1	44.8	30.1
JOU	1-7.3	3315	56	23	21	1.1	43	2	45	51	55	Coal	1.8	8.5	10.3	0.21	22.3	46.1	31.6
WOLF CREEK FORMATION - Hickory Hills Till Member																			
MJOU	1-7.7	3311	58	14	28	2.1	25	-	25	69	75		3.4	5.4	8.8	0.63	19.3	36.1	44.6
MJOU	1-9.2	3318	60	17	23	2.3	23	-	23	70	77		4.4	6.3	10.7	0.70	19.3	37.2	43.5
MJOU	1-10.8	3304	60	18	22	1.4	30	-	30	60	70		2.9	6.0	8.9	0.48	22.6	34.9	42.5
MJOU	R	3278	64	8	28	2.0	27	1	30	61	70		4.2	5.1	9.3	0.82	21.7	32.4	45.9
MJOU	R	3290	60	18	22	4.8	29	-	29	59	71		3.4	5.4	8.8	0.63	22.7	34.3	43.0
MJOU	* R	ILL.	63	17	20 *							*	5.7	5.2	10.9	1.10	*		
MJOU	* R	ILL.	62	17	21 *							*	5.7	4.5	10.2	1.30	*		
MJOU	* R	ILL.	61	20	19 *							*	5.2	5.2	10.4	1.00	*		
MJOU	* R	ILL.	60	19	21 *							*	5.0	5.6	10.6	0.89	*		
MJOU	* R	ILL.	59	20	21 *							*	5.4	5.1	10.5	1.06	*		
MJOU	* R	ILL.	65	16	19 *							*	5.9	5.8	11.7	1.02	*		
Mixed basal Hickory Hills Till Member (with Aurora inclusions?)																			
JOU	R					6.3	22	-	22	71	78		5.1	7.5	12.6	0.68	23.0	36.5	40.5
JOU	1-12.8	3307	62	16	21	2.5	14	-	14	74	86		3.4	6.0	9.4	0.57	21.8	34.2	44.0
JOU	1-14.5	3317	58	18	24	9.0	30	1	31	66	69	Blk Shale	4.1	5.8	9.9	0.71	21.0	36.2	42.8
JOU	1-15.3	3313	60	19	21	2.5	28	1	29	66	71								
WOLF CREEK FORMATION - Aurora Till Member																			
JOU	1-17.3	3310	58	20	22	9.7	32	-	32	60	68		4.9	10.4	15.3	0.47	19.6	43.2	37.2
JRU	1-17.8	3316	62	17	21	3.9	39	-	39	61	61								
JRU	1-19.7					11.0	32	-	33	58	67	Coal	3.5	9.3	12.8	0.38	20.6	42.8	36.6
RU	1-20.3	3309	62	18	20	1.6	34	-	34	65	66		4.2	7.4	11.6	0.57	8.0	12.7	79.3
MOU	2-3.0												6.4	8.8	15.2	0.73	19.5	40.2	40.3

Table 10, con't.

MOU	2-4.3	3335	62	18	20									7.0	10.2	17.2	0.69	19.7	39.6	40.7
MOU	R	3268	56	23	21		6.1	39	-	39	58	61		6.1	10.3	16.4	0.59	18.2	47.2	34.6
MOU	R	3288	56	19	25		3.1	40	1	41	51	59		5.3	8.9	14.2	0.60	21.5	42.1	36.4
MOU	* R	ILL.	55	24	21	*							*	8.3	8.4	16.7	0.99	*		
MOU	* R	ILL.	61	17	22	*							*	6.0	8.3	14.3	0.72	*		
		Sheared inclusions of weathered sediments																		
MOL	* R	ILL.	32	36	32	*														
MOL	R																	32.4	34.2	33.4
MRL	R																	40.9	27.3	31.8
MOL	R																	23.9	36.0	40.1
WOLF CREEK FORMATION - Undifferentiated sediments; FRANKLIN PALEOSOL																				
I0eb	R		uncalculable															16.9	43.8	39.3
I0eb	R		uncalculable															17.4	43.3	39.3
I0eb	R		uncalculable															16.9	41.6	41.5
IIA1b	R		uncalculable															17.2	46.0	36.8
IIB2tgb	R		uncalculable															33.6	36.0	30.4
WOLF CREEK FORMATION - Winthrop Till Member																				
MOL	* R	ILL.	63	19	18	*														
MOL	* R	ILL.	58	20	22	*														
MOL	* R	ILL.	67	15	18	*														
MOU	* R	ILL.	60	19	21	*							*	4.8	4.6	9.4	1.04	*		
MOU	* R	ILL.	69	14	17	*							*	2.8	3.4	6.2	0.82	*		
MOU	* R	ILL.	67	17	16	*							*	3.6	5.8	9.4	0.62	*		
MRU	* R	ILL.	69	15	16	*							*	3.5	3.7	7.2	0.95	*		
MOU	R	3287	58	18	24		3.4	40	-	40	52	60		5.6	6.6	11.7	0.77	29.2	41.3	29.5
MOU	R	3285	58	18	24		2.9	31	-	31	54	69		6.3	8.0	14.3	0.80	27.3	43.3	29.4
MRU	R	3295	64	14	22		5.8	34	-	36	60	64		4.2	5.0	9.2	0.84	28.8	40.9	30.3
MJOU	1-22.2	3321	59	12	29		3.0	36	-	36	62	64		4.5	9.1	13.6	0.49	22.4	43.1	34.5
MJRU	1-25.0	3301	60	16	24															
MRU	3-10.8	3302	69	13	18		3.2	25	-	25	70	75		2.7	5.8	8.5	0.47	29.3	39.5	31.2
MRU	3-12.3	3312	64	16	20		4.5	39	-	39	57	61		4.9	9.8	14.7	0.50	28.6	42.1	29.3
MRU	3-13.3	3322	58	13	29		11.0	33	-	33	54	67		6.9	3.9	10.8	1.80	29.2	41.9	28.9

* ILL. - Analyses by the Illinois State Geological Survey; clay min. - H.D. Glass; Matrix carbonates of the <0.74 mm fraction, J.T. Wickham.
C - Chlorite peaks apparent.
Depth: R, sample from fresh cut road surface.
1-12.8; 1 - Core Franklin 1 - depth 12.8 feet.

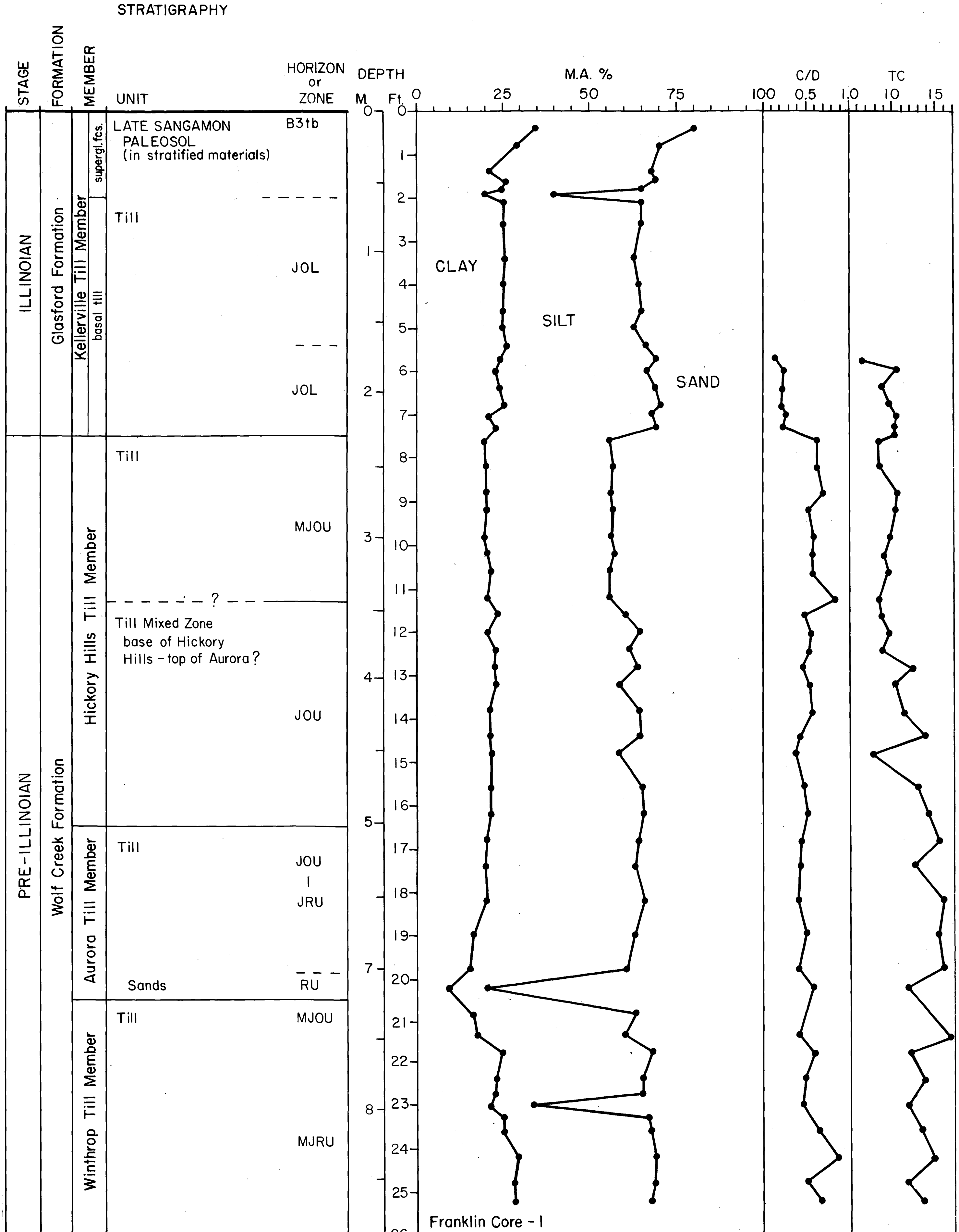


Figure 5. Stratigraphy, particle-size, and matrix carbonate data, Core F-1, Franklin Transect.

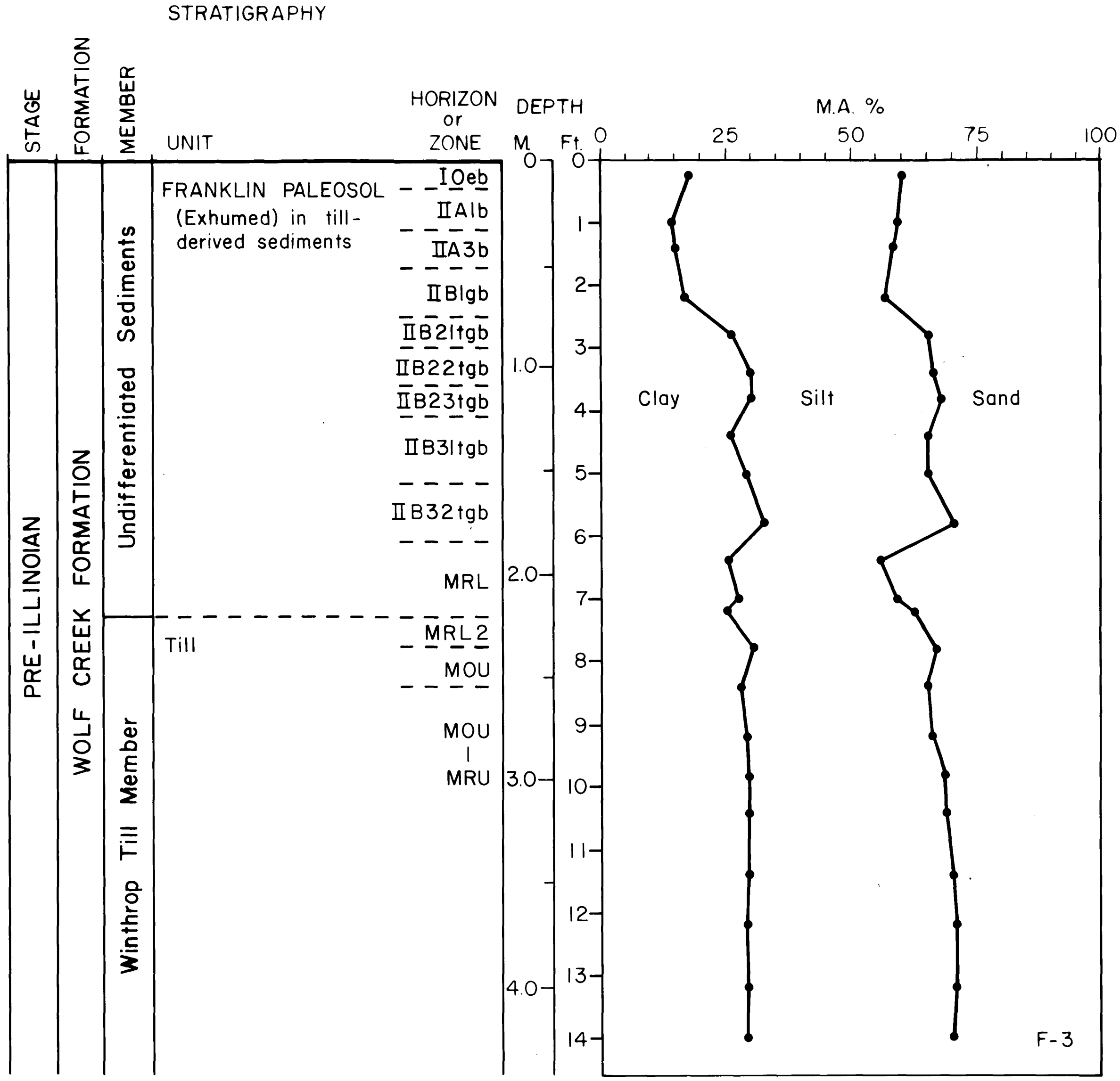


Figure 6. Stratigraphy and particle-size data, Core F-3, Franklin Transect.

of the Wolf Creek Formation, and at the top of the Hickory Hills Till Member in the southeast Iowa study area the Yarmouth, Yarmouth-Sangamon, and Late-Sangamon Paleosols occur.

Franklin Paleosol

The Franklin Paleosol is introduced in this report as a new soil-stratigraphic unit. The type section is the Franklin Locality located along the east section line, in the NE ¼, of

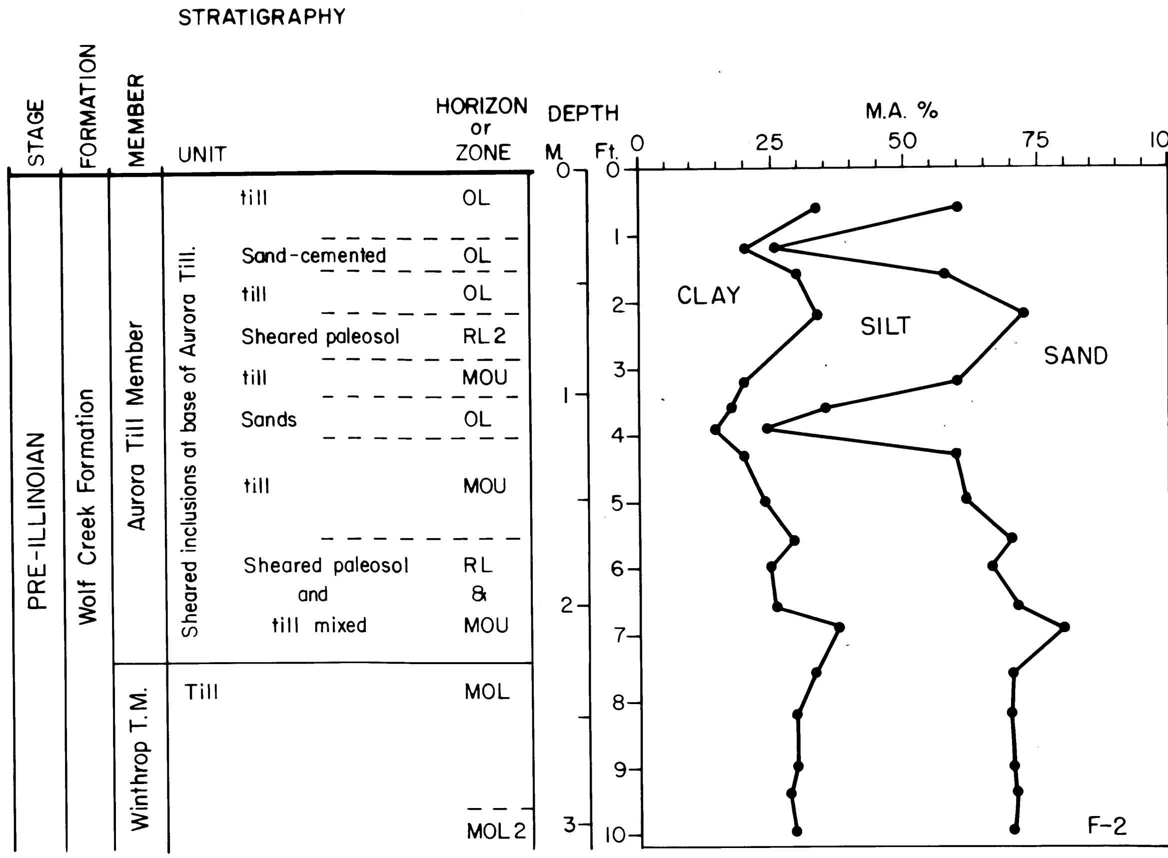


Figure 7. Stratigraphy and particle-size data, Core F-2, Franklin Transect.

the SE ¼, of the NE ¼, of the SE ¼, of section 29, T.71N., R.3W. (Franklin Township) Des Moines County. The Franklin Locality has been introduced in figures 4-7, and Tables 9 and 10. The Franklin Paleosol is bound at the top by the Aurora Till Member of the Wolf Creek Formation. The paleosol is developed in fine-textured, leached, gleyed, stratified sediments which overlie the Winthrop Till Member.

In their type area the Winthrop and Aurora Till Members (Hallberg, 1980) were separated by leached sediments and weakly developed A/C or O/C (peat) horizon paleosols. Also paleobotanical evidence suggested they were of interstadial character. Consequently, no formal soil-stratigraphic unit was named. However, the Franklin Paleosol in its type section (see figure 4) is a moderately well-developed soil equivalent in development to many soils on the modern land surface. The paleosolum thickness is 6.1 feet (1.9 m) including the compacted peat which forms an Ob horizon at the top of the paleosol. The paleosol exhibits a B-horizon with moderately strong subangular blocky structure and thin to moderate, discontinuous clay films throughout.

A well-developed paleosol has also been recognized between the Aurora and Winthrop Till Members in western Illinois (Wickham, 1979). With the grade of soil-development in evidence at the Franklin Locality, and because of the paleosol's stratigraphic setting below the Aurora Till Member it is appropriate to recognize the Franklin Paleosol as a formal soil-stratigraphic unit even with the very limited knowledge of its areal distribution.

Dysart Paleosol

The Dysart Paleosol occurs below the contact with the Hickory Hills Till Member. In complete sections it is developed in or above the Aurora Till Member. The type area for the Dysart Paleosol is in Tama County, east-central Iowa (Hallberg, 1980).

In the present study area the Dysart Paleosol has been recognized in sections in Lee County (sections 56 W-79-1, in Appendix; and 56-697R, see figure 3 and Appendix). As discussed, it varies from a well-developed paleosol to a simple organic paleosol (peat and mucky silt loam) over leached, gleyed, sediments.

Yarmouth Paleosol

The Yarmouth Paleosol occurs below the Kellerville Till Member or related sediments of the Glasford Formation of Illinoian age. The Yarmouth Paleosol marks the top of the Pre-Illinoian age deposits. Because of its historical and stratigraphic significance the Yarmouth Paleosol and its original type area in Des Moines County were the subject of detailed investigations in this study. The Yarmouth Paleosol is the subject of a separate paper in this volume, by Hallberg and Baker and further details are outlined there.

Yarmouth-Sangamon Paleosol

Beyond the limits of the Illinoian age deposits of the Glasford Formation, the Sangamon Paleosol, which is formed on top of the Illinoian deposits, and the Yarmouth Paleosol merge. The result is a very thick, strongly developed paleosol which occupies relatively stable upland divide surfaces of much of Iowa. This paleosol is buried by Wisconsinan age deposits and is called the Yarmouth-Sangamon Paleosol (Ruhe and Cady, 1967).

The nature of the Yarmouth-Sangamon Paleosol in various parts of Iowa has been discussed elsewhere (Ruhe and Cady, 1967; Ruhe, 1967, 1969; Hallberg, 1980). In the present study area, as in other parts of Iowa the thickness of the Yarmouth-Sangamon Paleosolum and the nature of the materials in which it formed is related to the paleo-landscape on the Pre-Illinoian tills. In swales or depressions on this old surface thick sequences of fine-textured sediments accumulated. Weathering and soil development must have kept pace with the accumulation of the sediments because in these positions "giant" paleosolums are now found. These paleosols will have a variable thickness of slope wash sediments, and possibly eolian sediments, over the till-derived portion of the paleosol. On the higher positions, or swells, on the paleo-surface thinner paleosolums are found, generally with only a thin increment of fine-textured sediments.

The Mt. Union Cemetery Site (Description 2), and the 44H-1 and 44H-2 Core Sites (in Appendix) are examples of the Yarmouth-Sangamon Paleosol just outside of the limits of the Illinoian deposits (figure 1). The Mt. Union Cemetery Site (description 2; Table 11) is an example of one of these swale-fill Yarmouth-Sangamon Paleosols. The paleosolum thickness is 21.4 feet (6.5 m). The upper 14.1 feet (4.3 m) of the paleosol is formed in a fine-textured, nearly pebble free, silty clay. The next 3.6 feet (1.1 m) is formed in slope-wash sediments which are more obviously derived from till, because of their higher sand and pebble content. Only the lowermost 3.7 feet (1.1 m) is formed in the Hickory Hills Till.

Description 2. Mount Union Cemetery Core Site (well 7). Located 255 feet (78 m) north and 180 feet (55 m) west of the SE corner, sec. 4, T 72N, R 5W, Henry County; elevation 740 feet.

Depth-inches (feet) (meters)	Horizon or Zone	Description (Fenton, Miller, and Hallberg)
		WISCONSINAN Loess
		Otley Soil Series (281 B)
0 - 6 (0-0.5) (0 - 0.2)	A11	Black (10YR2/1) silty clay loam; moderate, medium, granular structure.
6 - 11 (0.5-0.9) (0.2 - 0.3)	A12	Black (10YR2/1) silty clay loam; moderate, fine to medium granular.
11 - 15 (0.9-1.3) (0.3 - 0.4)	A3	Very dark grayish brown (10YR3/2) silty clay loam; common fine dark brown mottles (10YR3/3 and 4/3); moderate fine subangular blocky structure; common black (10YR2/1) coatings on peds.
15 - 23 (1.3-1.9) (0.4 - 0.6)	B21t	Brown (10YR4/3) heavy silty clay loam; moderate fine subangular blocky; common black (10YR2/1) coatings on peds; common, thin, discontinuous dark brown (10YR3/3) clay films.
23 - 28 (1.9-2.3) (0.6 - 0.7)	B22t	Dark yellowish brown (10YR4/4) heavy silty clay loam; common fine yellowish brown (10YR5/6) and few fine grayish brown (10YR5/2) mottles; moderate, fine to medium subangular blocky; common very dark grayish brown (10YR3/2) coatings on peds; common thin discontinuous dark brown clay films; few fine Fe and Mn oxides.
28 - 34 (2.3-2.8) (0.7 - 0.9)	B23t	Yellowish brown (10YR5/4) silty clay loam; common fine grayish brown (10YR5/2) and yellowish brown (10YR5/6) mottles; moderate, medium, subangular blocky; common thin discontinuous brown (10YR4/3) and grayish brown (10YR5/2) clay films; common fine Fe and Mn oxides.
34 - 50 (2.8-4.2) (0.9 - 1.3)	B31t	Grayish brown (2.5Y5/2) silty clay loam; common fine yellowish brown (10YR5/4 and 5/6), light brownish gray (2.5Y6/2), and light olive brown (2.5Y5/4) mottles; moderate medium subangular blocky; few, thin, patchy clay films; common fine Fe and Mn oxides.
50 - 58 (4.2-4.8) (1.3 - 1.5)	B32t	Olive gray (5Y5/2) silty clay loam; common fine light olive brown (2.5Y5/4), yellowish brown (10YR5/6), and light olive gray (5Y 6/2) mottles; weak, moderate subangular blocky; few thin, patchy clay films; common fine Fe and Mn oxides, and medium yellowish brown (10YR5/6) strong brown (7.5YR5/6), yellowish red (5YR4/6) Fe oxide segregations.
58 - 69 (4.8-5.7) (1.5-1.7)	C-MDL	Light olive gray (5Y6/2) light silty clay loam; common strong brown (7.5YR5/6 and 5/8) and yellowish brown (10YR5/6) mottles; few fine Fe and Mn oxides; few vertical root tubules with very dark gray (10YR3/1) filling; leached.
69 - 93 (5.7-7.7) (1.7-2.3)	MDL	As above, silt loam; with minor variations in mottling.
		Basal loess sediments and paleosol
93 - 96 (7.7-8.0) (2.3-2.4)	IAb?	Lightolive gray (5Y6/2) silt loam; coarse platy structure, with light gray (5Y6 and 7/1) grainy silty coats on plates; many coarse yellowish red (5YR4/6-8) Fe and Mn oxide concretions and segregations; few charcoal flecks, and very dark gray (10YR3/1) fillings in root tubules.
96 - 97 (8.0-8.1) (2.4-2.5)	IAb?	Grayish brown (2.5Y5/2) light silt loam; weak fine and medium subangular blocky; many coarse Fe and Mn oxide segregations, as above; few charcoal flecks, common very dark grayish brown (10YR3/2) organic coatings.

Description 2, con't.

Undifferentiated sediments

YARMOUTH-SANGAMON PALEOSOL

97 - 104 (8.1-8.7) (2.5-2.6)	IIA11b	Very dark gray (10YR3/1), silty clay; many fine yellowish brown (10YR5/6) and dark gray (10YR4/1) mottles; moderate fine subangular blocky; fine-textured swale-fill sediments?
104 - 107 (8.7-8.9) (2.6-2.7)	IIA21b	Grayish brown (10YR5/2) heavy silty clay loam; common dark brown (10YR4/3) mottles; weak coarse platy structure, with nearly continuous light gray (10YR7/1) coatings on plates.
107 - 116 (8.9-9.7) (2.7-2.9)	IIB1gb	Dark gray (10YR4/1) light silty clay; common fine dark brown (10YR3/3) and yellowish brown (10YR5/6) mottles; moderate fine and very fine subangular blocky.
116-127 (9.7-10.6) (2.9-3.2)	IIB21tgb	Dark gray (10YR4/1) light silty clay; strong very fine subangular blocky; discontinuous very dark gray (10YR3/1) coatings on ped exteriors, continuous thin clay films.
127 - 135 (10.6-11.3) (3.2-3.4)	IIB22tgb	Dark gray (10YR4/1) silty clay; few medium strong brown (7.5YR5/6 and 8) mottles; moderate medium prismatic breaking to strong fine and very fine subangular blocky; discontinuous very dark gray (10YR3/1) coats on peds; continuous clay films.
135 - 148.5 (11.3-12.4) (3.4-3.8)	IIB23tgb	Dark gray (10YR4/1) light silty clay; common fine and medium yellowish red (5YR 4/6 and 8) mottles; as above.
148.5-155 (12.4-12.9) (3.8-3.9)	IIIA2-Bb?	Gray (10YR5/1) light silty clay; common mottles as above; moderate medium prismatic breaking to moderate fine and medium subangular blocky, with nearly continuous light gray (10YR7/1) grainy coats on prisms; continuous clay films.
155 - 165 (12.9-13.8) (3.9-4.2)	IIIB21tgb	Grayish brown (10YR5/2) light silty clay; common fine yellowish red (10YR5/6) mottles; moderate medium prismatic breaking to strong fine and very fine subangular blocky; continuous clay films.
165 - 171 (13.8-14.3) (4.2-4.3)	IIIB22tgb	Grayish brown (10YR5/2) heavy silty clay loam; common fine and medium yellowish red (10YR5/6 and 8) mottles; as above.
171 - 185 (14.3-15.4) (4.3-4.7)	IIIB23tgb	Grayish brown (10YR5/2) silty clay; many coarse strong brown (7.5YR5/6 and 8) mottles; structure as above; few discontinuous light gray (10YR7/1) grainy coats; continuous clay films.
185 - 207 (15.4-17.3) (4.7-5.3)	IIIB24tgb	Gray (10YR5/1) silty clay; common fine yellowish brown (10YR5/6) mottles; as above.
207 - 211 (17.3-17.6) (5.3-5.4)	IIIB25tgb	Dark gray (2.5Y4/4) silty clay; many fine and medium strong brown (7.5YR5/6-8) mottles; as above.
211 - 227 (17.6-18.9) (5.4-5.8)	IV?B26tgb	Grayish brown (10YR5/2) clay with few pebbles few fine dark yellowish brown mottles; structure, coatings as above; till-derived sediments.
227 - 246 (18.9-20.5) (5.8-6.2)	IVB27tgb	Dark gray (N4 and 5/0) clay with few pebbles; as above.
246 - 266 (20.5-22.2) (6.2-6.8)	IVB28tgb	Mixed very dark gray and gray (N3 and N5/0) clay with few pebbles; common fine yellowish brown (10YR5/6) mottles; structure as above; discontinuous clay films.
266 - 310 (22.2-25.8) (6.8-7.9)	V?B31tgb	Dark gray (N4/0) light clay to silty clay; common medium dark yellowish brown (10YR4/4) and yellowish brown (10YR5/6) mottles; structure as above; discontinuous clay films; till or till-derived sediments?

Description 2, con't.

WOLF CREEK FORMATION

Hickory Hills Till Member

310 - 333 (25.8-27.8) (7.9-8.5)	VIB32gb	Dark gray (10YR4/1) heavy clay loam, with pebbles; common fine and medium yellowish-brown (10YR5/6 and 8) mottles; moderate medium prismatic, breaking to moderate fine and very fine subangular blocky structure; few clay films; till.
333 - 354 (27.8-29.5) (8.5-9.0)	VIB33gb	Dark gray (10YR4/1) clay loam; as above; gradual lower boundary.
354 - 394 (29.5-32.8) (9.0-10.0)	C-MOL	Yellowish brown (10YR 5/6 and 8) clay loam with pebbles; many fine and medium gray (N5/0) and common fine yellowish red (5YR4/6) mottles; massive.
394 - 420 (32.8-35.0) (10.0-10.7)	MOU	As above, loam; calcareous, with secondary carbonate nodules at upper contact.

The Mt. Union Cemetery Site can be compared with the Yarmouth-Sangamon Paleosol in the 44H-2 Core Site (in Appendix). At this site only 2.7 feet (0.8 m) of the fine-textured sediments occur over the till-derived sediments (the nature of these buried soils will be more fully discussed in Hallberg, et al., 1980).

These sections are within a few miles of the boundary of the Illinoian age Glasford Formation deposits. The clay mineralogy from samples in these Yarmouth-Sangamon Paleosols do not show any apparent influence from sediments related to the Glasford Formation, however. The clay mineralogy of paleosols can be difficult to interpret because of alterations from weathering (see Willman, Glass, and Frye, 1966; Hallberg, Lucas, and Goodmen, 1978; Jackson, 1964). However, the Glasford Formation deposits are high in illite. Even in the well-developed Sangamon Paleosols formed in the Glasford Formation illite peaks are still readily apparent. However, in the Yarmouth-Sangamon Paleosols (Table 11; 44H-1 data, in Appendix) illite peaks were very obscure or non-existent. Any deposition of materials related to the Glasford Formation on the Yarmouth-Sangamon plain in front of the Illinoian terminus would seem to be relatively minor.

Table 11. Summary of mineralogy data - Mount Union Cemetery Core.

Depth (Feet)	Horizon or Zone	Clay Mineralogy: I.D.	EX. (%)	ILL. (%)	K+C (%)
YARMOUTH PALEOSOL in undifferentiated sediments					
9.2	IIB1gb				
10.0	IIB21tgb				
12.0	IIB23tgb	Broad and very high expandables peaks; illite absent or obscured.			
16.0	IIIB24tgb				
18.0	IVB26tgb				
WOLF CREEK FORMATION - Hickory Hills Till Member					
35.0	MOU	3801	59	19	22

All data below for Hickory Hills Till Member

Depth (Feet)	Horizon or Zone	Particle Size: Clay (%)	Silt (%)	Sand (%)	Matrix Carbonate: C	D	T.C.	C/D
34.8	MOU	22.7	33.3	44.0	3.6	5.2	8.8	0.69
35.0	MOU	21.9	33.2	44.9	3.8	5.1	8.9	0.75

Depth (Feet)	Horizon or Zone	Sand-fraction lithologies: C/D	TC	TSed.	Q-F	TX.
35.0	MOU	3.0	26	29	60	71

Late-Sangamon Paleosol

The Late-Sangamon Paleosol occurs throughout the study area. It is also overlain by Wisconsinan age deposits, principally loess. Outside of the limits of the Glasford Formation deposits it has only been observed developed in the Hickory Hills Till Member in the southeast Iowa study area. The Late-Sangamon Paleosol formed on the Late-Sangamon pediment or erosion surface, which is cut below the Yarmouth-Sangamon surface. The Late-Sangamon surface forms the second step of the typical sequence of stepped erosion surfaces in the older Pleistocene regions in Iowa (see Ruhe, 1969; Hallberg, et al., 1978).

An excellent exposure of the Late-Sangamon Paleosol developed on the Hickory Hills Till Member occurs at the 44LC Section in Henry County (figure 1; Description 3; Table 12). As shown in figure 8 this exposure is typical of the Late-Sangamon Paleosol. It is a two-story soil developed in pedisediment and till, which are separated by a stone line. Strong B-horizon development is evident in the pedisediment as well as the underlying

Description 3. The 44-LC Section is exposed in a long road cut on the east and south side of a gravel road located in the E½, of the NE¼, of the NW¼, of the SW¼, of sec. 33, T 71N, R 5W, Henry County; elevation 700 feet.

The first section is from the south end of the road cut.

Depth-inches (feet) (meters)	Horizon or Zone	Description
		WISCONSINAN Loess
0 - 12 (0-1) (0.0-0.3)	OL	Dark yellowish brown (10YR4/4) light silty clay loam.
		LATE-SANGAMON Pedisediment-LATE-SANGAMON PALEOSOL
12 - 17 (1-1.4) (0.3-0.4)	IIA2b	Dark yellowish brown (10YR4/4) medium clay loam; weak medium platy breaking to moderate fine and medium subangular blocky structure, with nearly continuous light gray (10YR7/1) grainy coatings.
		STONE LINE - WOLF CREEK FORMATION
		Hickory Hills Till Member
		LATE SANGAMON PALEOSOL in upper part.
17 - 29 (1.4-2.4) (0.4-0.7)	IIIB21tb	Dark brown (7.5YR4/4) clay; with common fine and medium light olive brown (2.5Y5/4 and 6) and few fine grayish brown (2.5Y5/2) mottles; strong fine angular blocky structure; continuous clay films.
29 - 40 (2.4-3.3) (0.7-1.0)	IIIB22tb	Strong brown (7.5YR5/6) clay; with many fine yellowish red (5YR4/6 and 8) and few fine olive gray (5Y5/2) mottles; strong fine and medium angular blocky; continuous clay films.
40 - 64 (3.3-5.3) (1.0-1.6)	IIIB23tb	Mixed yellowish brown (10YR5/6 and 8) and light brownish gray (10YR6/2) heavy clay loam; moderate fine and medium angular blocky; discontinuous clay films, some thick coatings on root tubules.
64 - 84 (5.3-7.0) (1.6-2.1)	IIIB31b	Mixed color as above, clay loam; weak fine and medium subangular blocky; very dark brown (7.5 YR2/0) Fe and Mn oxide concretions and coatings on peds.
84 - 104 (7.0-8.7) (2.1-2.6)	MOL	Yellowish brown (10YR5/6) loam till; common fine mottles; massive to weakly jointed; leached.
104 - 120 (8.7-10) (2.6-3.0)	MJOU	Yellowish brown (10YR5/6) loam till; common fine mottles; vertical joints with grayish brown (10YR5/2) coats; calcareous, secondary carbonate nodules in upper part.

The second section is from the north end of the road cut and shows slightly different relationships within the Late-Sangamon Paleosol.

Depth-inches (feet) (meters)	Horizon or Zone	Description
		WISCONSINAN Loess
0 - 18 (0-1.5) (0.0-0.45)	OL	Dark yellowish brown (10YR4/4) light silty clay loam.
		LATE SANGAMON Pedisediment - LATE SANGAMON PALEOSOL
18 - 25 (1.5-2.1) (0.45-0.6)	IIA21b	Mottled light grayish brown (10YR6/2) and dark yellowish brown (10YR4/4) light silty clay loam; weak coarse platy, breaking to weak fine and very fine subangular blocky structure; nearly continuous light gray (10YR7/1) grainy coats on plates; common fine dark reddish brown (5YR2/2) Mn oxides.
25 - 28 (2.1-2.3) (0.6-0.7)	IIA22b	As above, but heavy silty clay loam.
28 - 42 (2.3-3.5) (0.7-1.1)	IIB21tb	Yellowish red (5YR4/6) clay; common fine grayish brown (2.5Y5/2) mottles; strong fine and very fine angular blocky structure; nearly continuous clay films and dark brown (7.5YR4/2) coats.
		STONE LINE
		WOLF CREEK FORMATION - Hickory Hills Till Member
42 - 55 (3.5-4.6) (1.1-1.4)	IIIB22tb	Reddish brown (5YR4/4) clay; strong fine and very fine angular blocky; continuous dark brown (7.5YR4/2) clay films.
55 - 70 (4.6-5.8) (1.4-1.8)	IIIB23tb	Mottled yellowish brown (10YR5/6 and 8) and light brownish gray (10YR6/2) clay; moderate medium subangular blocky; nearly continuous dark grayish brown (10YR4/2) clay films.

Below, as in section 1.

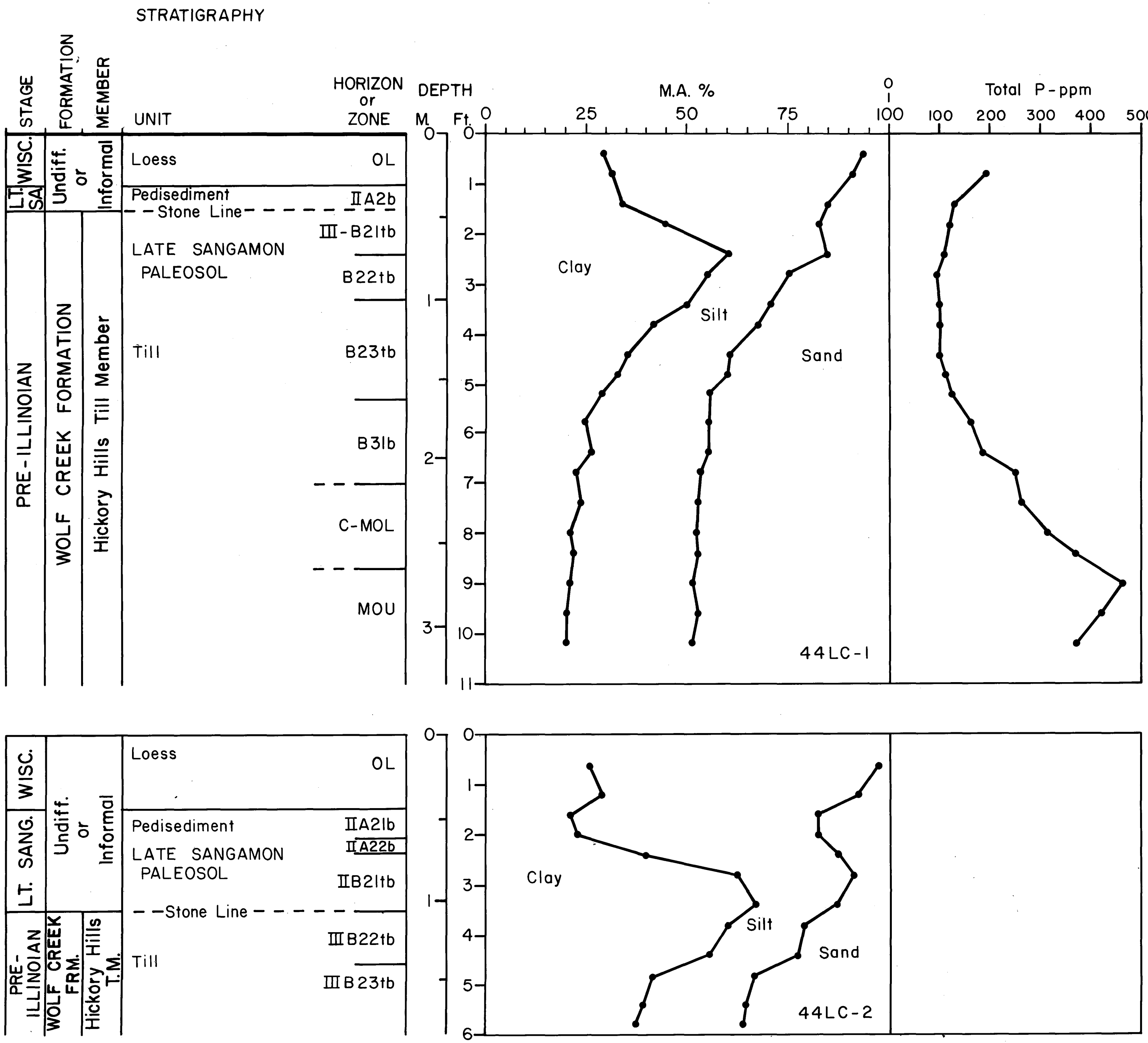


Figure 8. Stratigraphy, particle-size, and total phosphorus data, Section 44LC.

Table 12. Additional laboratory data for 44 LC Section.

Depth	Clay Mineralogy EX.	ILL.	K+C	Particle Size Clay	Silt	Sand	Matrix Carbonate Ca	Do	TC	C/D
		- % -			- % -			- % -		
All Miscellaneous OU-MOJU Hickory Hills Till samples.	61	17	22	18.3	35.3	46.4	2.4	6.5	8.9	0.37
	58	19	23	18.8	34.4	46.8	2.9	5.4	8.3	0.54
	60	18	22	19.5	34.0	46.5	3.4	5.0	8.4	0.68
				20.1	31.9	48.0				
	59	20	21	20.7	32.0	47.3				
				20.1	33.3	46.6	3.5	5.2	8.7	0.67

Sand-fraction Lithologies C/D	T.C.	Sh.	T.S.	Q.-F.	T.X.
5.5	26	-	26	73	74
1.9	22	1	25	68	75
5.3	25	-	25	70	75

till. This in indicative of the pedologic welding of the two materials into one coherent soil. This is also part of the evidence used to indicate that the pedisediment is temporally related to the cutting of the Late-Sangamon erosion surface and to the development of the Late-Sangamon Paleosol. This site will be discussed in more detail in Hallberg, et al. (1980).

GLASFORD FORMATION

The Glasford Formation was defined in Peoria County, Illinois (Willman and Frye, 1970). It is principally composed of Illinoian age tills and intercalated outwash deposits. It overlies the Petersburg Silt or, in the absence of the Petersburg Silt, rests on the Yarmouth Paleosol. Its upper boundary is the top of the Sangamon Paleosol. Current work on the Glasford Formation is reviewed by Lineback (1979, and this volume).

In southeast Iowa the Glasford Formation is comprised of the Kellerville Till Member, and some thin units of undifferentiated sediments whick occur above and below the Kellerville Till Member. The undifferentiated deposits above the Kellerville Till Member are principally fine-textured sediments which accumulated by erosion of the Kellerville, and are incorporated in the Sangamon Paleosol. The undifferentiated deposits below the Kellerville Till Member are early-(pro-)Illinoian peats, organic silts, or silts such as described in the Yarmouth Core Site (see Hallberg and Baker, this volume), the Schroder Site, and the Nelson Quarry Section (in Appendix).

Kellerville Till Member

The Kellerville Till Member is the oldest till member of the Glasford Formation (Willman and Frye, 1970; Lineback, 1979). The only Illinoian rock-stratigraphic unit older than the Kellerville is the Petersburg Silt, which is considered a pro-glacial deposit of the earliest Illinoian glacier which deposited the Kellerville (Willman and Frye, 1970). The history of the Kellerville and some of its properties in western Illinois are discussed in Wickham (this volume).

In southeast Iowa the Kellerville Till Member is subdivided into two facies: (1) an upper superglacial facies; and (2) a lower subglacial or basal till facies. The superglacial facies is composed of till and other diamictons (ablation till in the generic sense of Dreimanis, 1976), which are interbedded with sorted and stratified sediments. These deposits are sometimes bedded but at other sections are intertwined in a highly contorted melange of sediments. The superglacial facies occurs at the top of the Kellerville Till Member and varies in thickness (in stable divide positions) from just a few feet (1 m) to 93 feet (28.4 m) at the terminal ridge of the Kellerville at Yarmouth (see Hallberg and Baker, this volume). The basal till facies is subjacent to the superglacial facies and is composed of dense, uniformly-textured till. It sometimes contains inclusions of substrate materials in its lower portion, similar to those described for the Wolf Creek Formation. The nature and evidence for the two facies will be further discussed in the next section of this report.

The laboratory data for the Kellerville Till Member are summarized in Table 13 and figure 9. Texturally the basal till facies is on the average a loam till, relatively high in silt.

Its matrix texture ranges from silt loam to a light clay loam (figure 9a). In gross matrix texture it is similar to the Aurora and Winthrop Till Members of the Wolf Creek Formation. The Kellerville contains less coarse and very coarse sand than these other tills.

The relatively uniform matrix texture of the basal till is in sharp contrast to the wide range of textures found in the superglacial facies (figure 9b). The textural data for the till and till-like deposits or diamictons do cluster in the same general region as the basal till. However, these ablation tills show a much wider range in matrix texture varying from sandy loam, loam, silt loam, silty clay loam, clay loam, and to a clay. The stratified sediments contained within the superglacial facies range (in a strict textural sense; see figure 9b) from sand, and sand and gravel, to silt, to a very heavy clay in matrix texture. As noted in Hallberg and Baker (this volume) the superglacial facies also contains some peats and organic silts.

Although the two facies of the Kellerville Till Member vary widely in textural properties, they are very similar mineralogically. As shown in Table 13 the facies are essentially identical in terms of their clay mineralogy and sand-fraction lithologies. As previously discussed the Kellerville Till Member averages 46% expandable clays, 34% illite, and 20% kaolinite plus chlorite. The high illite content with respect to kaolinite plus chlorite, the moderate amounts of expandable clay minerals, and the frequent occurrence of discernible chlorite peaks distinguish the Kellerville from the other tills in the study area.

The clay mineralogy data for the Kellerville Till Member are more variable than the data for the other tills. The principal variance is in the expandable clays and illite; the kaolinite plus chlorite is more consistent (Table 13). This seems likely to be the effect of weathering and some alteration of the clay minerals. The greatest variability occurs in the oxidized samples. The percent of expandable clays generally goes up at the expense of illite. This is particularly true

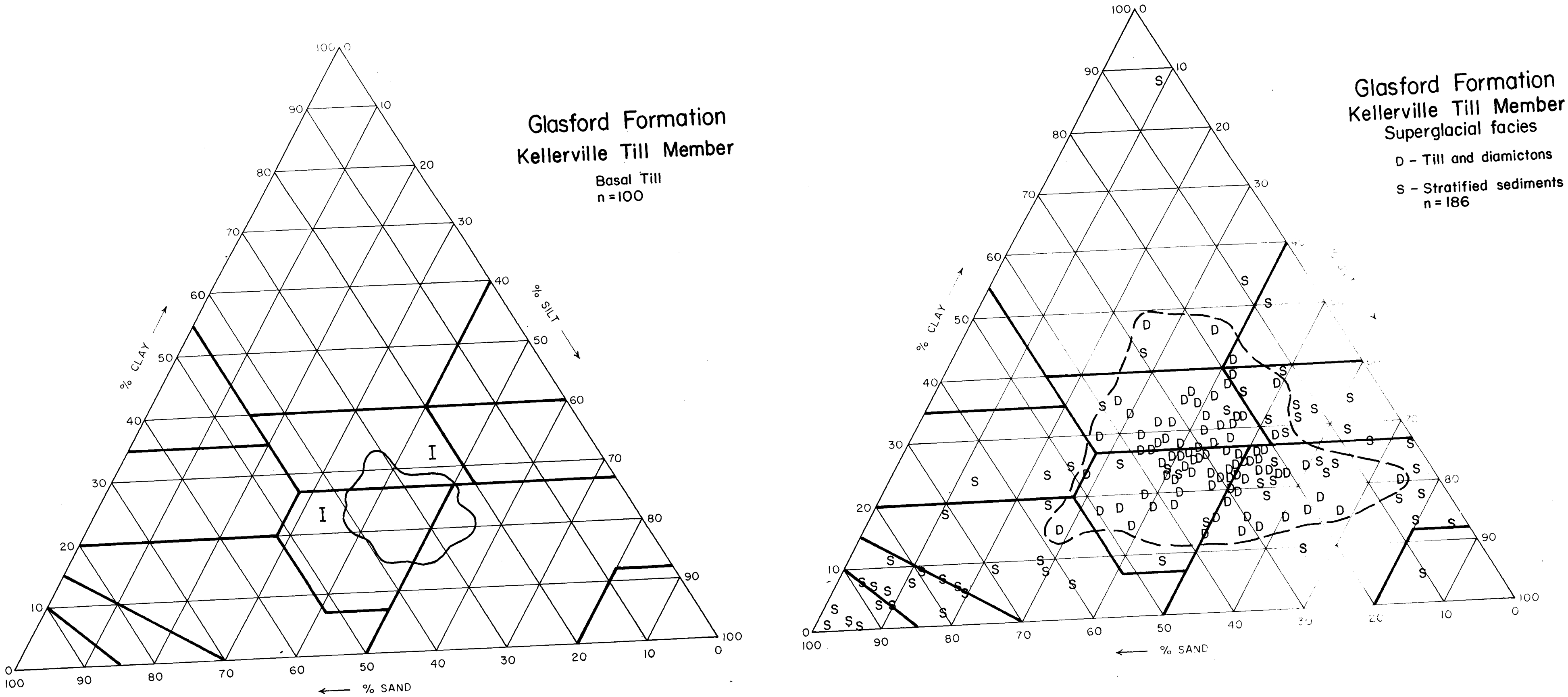
Table 13. Summary of properties for the Kellerville Till Member, GLASFORD FORMATION.

		Particle Size - %		
		Clay	Silt	Sand
Superglacial facies	See figure 9.			
Subglacial - basal till facies n=100	Mean s.d.	23.1 3.2	43.3 4.0	33.7 3.8

		Clay Mineralogy - %		
		EX.	ILL.	K+C
Superglacial facies n=53	Mean s.d. range	46 8.0 (31-65)	34 7.0 (20-49)	19 2.9 (10-25)
Illinois State Geol. Survey Analyses (n=11)	mean s.d. 	42 14.6 (25-68)	39 13.3 (16-63)	19 4.7 (12-28)
Subglacial -- basal till facies n=91	mean s.d. range	47 6.5 (29-62)	32 5.7 (18-47)	20 3.2 (15-28)
Illinois State Geol. Survey Analyses n=41	mean s.d. range	50 7.6 (30-61)	30 7.2 (21-51)	18 2.2 (15-24)
Total n=150	mean s.d.	46 7.6	34 6.3	20 3.5
Illinois State Geological Survey n=52	mean s.d.	49 9.8	32 9.0	19 2.9

		Sand Fraction Lithologies		
		C/D	T.C.	T.S.
Superglacial facies n=14	mean s.d.	1.1 0.5	43 13	50 11
Subglacial - basal till facies n=44	mean s.d.	1.9 2.6	36 9	43 8
Total n=58	mean s.d.	1.8 2.3	38 10	44 9

in the superglacial facies (Table 13) which tends to be more highly oxidized, probably because of its greater permeability. It exhibits a greater range (and higher standard deviation) in clay mineralogy than the basal till facies. A similar effect can be seen in the analysis of the strongly developed paleosols (see Hallberg, Lucas, and Goodmen, 1978). Often, in the paleosolum no illite peak is apparent, while the expandable peak is enhanced. This seems to indicate the alteration of illite to smectite. This trend may be more noticeable at depth in the



A.

B.

Figure 9. Textural distribution for the Kellerville Till Member: A. Basal till facies; B. Superglacial facies.

Kellerville Till Member than the Pre-Illinoian tills because of the Kellerville's high initial illite content (see Wickham, this volume, also).

The low C/D ratio and particularly the high total sedimentary grain content in the very coarse sand fraction are also important characteristics of the Kellerville. The abundance of coal and black shale fragments in the sand fraction are unique to the Kellerville in the study area. The abundance of Pennsylvanian lithologies in the pebble fraction is an important characteristic which often allows recognition of the Kellerville in the field.

As discussed, perhaps the most distinguishable characteristic of the Kellerville Till Member is its high dolomite content in the matrix carbonates (Kemmis and Hallberg, this volume). The Kellerville exhibits matrix carbonate C/D ratios less than 0.40, whereas 95% of all the Pre-Illinoian deposits have C/D ratios greater than 0.40.

The thickness of the Kellerville Till Member varies across the study area. The thickest section observed is 93 feet in the terminal ridge at the Yarmouth Core Site. Here, the entire Kellerville is composed of the superglacial facies. In the highly eroded landscapes near the Mississippi River on Late-Sangamon and Wisconsinan erosion surfaces it may be eroded off and absent (see the 58-JW-67, 68, and Kingston Sections; figure 1).

The color of the Kellerville Till Member normally varies from an oxidized, yellowish brown (10YR5/6 and 8) to an unoxidized dark gray to dark greenish gray (5Y and 5GY4/1). However, in the deep cores at Yarmouth some of the till-like materials ranged to dark bluish gray (5B4/1) and grayish green (5G4/2). Some of the diamictons in the superglacial facies have contained enough organic matter to be black (10YR2/1) in color also. Across the upland areas where the superglacial facies is relatively thin, (5-20 feet; 1.5-6.0 m) the superglacial facies is always well-oxidized, and often leached. Secondary carbonates will often appear at or slightly above the contact with the more dense, and less permeable basal till facies. Coarse sand and sand and gravel lenses in the superglacial facies will sometimes have strong brown (7.5YR5/6), yellowish red (5YR 5/6-8) or even red (2.5YR4/6-8) colors.

The lower boundary of the Kellerville Till Member is marked by the contact with: (1) the early-(pro-)Illinoian peats, organic silts, or silts, which may be correlative with the Petersburn Silt of Illinois (see Yarmouth Core Site, Hallberg and Baker, this volume; Schroder Site in Appendix, and Nelson Quarry Section, Description 4); or (2) the Yarmouth Paleosol (see Mediapolis Section, Hallberg and Baker, this volume); or (3) the Hickory Hills Till Member of the Wolf Creek Formation, where the Yarmouth Paleosol has been eroded (see Mediapolis Section, and Pleasant Grove Section, Description 1). The lower contact can be complex where glacial deformation has occurred. At the 56-79-2-2 Section (in Appendix) the Yarmouth Paleosol is sheared and contorted, and a few blocks of the paleosol occur within the base of the Kellerville.

The upper contact of the Kellerville Till Member is generally marked by the top of the till-derived portion of the Sangamon or Late-Sangamon Paleosolum. In swales on the surface of the Kellerville Till fine-textured slope-wash sediments may mark the top of the Kellerville. Also, where Wisconsinan age erosion surfaces (e.g.-58H-4 Core Site, figure 12) have removed the Paleosols the top of the Kellerville Till Member may be marked by a stone line which is overlain by Wisconsinan loess.

Superglacial and Subglacial Facies

The two facies of the Kellerville Till Member are represented by two very different associations of materials. Perhaps the best representation of these facies at their extremes of occurrence is at the Yarmouth Core Site (see Hallberg and Baker, this volume) and at the Nelson Quarry Section (Description 4; Table 14).

At the Yarmouth Core Site the entire 93 feet (28.4 m) of the Kellerville Till Member is made up of the superglacial facies. The sequence is comprised of beds of varying thicknesses of till, diamictons (reworked till and mudflows), fluvial sediments (sands, silts, minor gravel), and lacustrine or paludal deposits (silts, clays, peats, and mucks). Even the organic sediments are diamictons occasionally. The deposits are generally soft to slightly firm and of low density. Some of the sediments are even lower in density than the overlying loess.

In contrast to this sequence is the Nelson Quarry Section where 77 feet (23.5 m) of the basal till facies occurs. As shown in Description 4 and Table 14, the Kellerville Till Member at this site is a very uniform, unstratified, firm till. It is much higher in density than the deposits at Yarmouth. The only inclusion of stratified materials encountered was an elongate lens of silts, 2 feet (0.6 m) long by 0.5 feet (0.2 m) thick about 2 feet (0.6 m) from the base of the till.

The diamictons of the superglacial facies present an interesting contrast with what is called till in this discussion. The deposits called till or till-like, within the superglacial facies, are massive and rather uniform in particle distribution. The deposits called diamictons, although poorly sorted like the till (by definition), are different in many gross characteristics. They often show some of the following characteristics: (1) individual units may be very thin, and they may be stacked on top of one another; (2) there is often vertical gradation in matrix texture; (3) they often exhibit a vertical change in coarse (pebble) particle content, instead of the apparent uniform distribution of coarse fragments in the till; (4) this sometimes results (2 and 3) in a grossly graded texture from coarse at the bottom to fine at the top; (5) they often show crude layering of beds (with no sorted material); (6) sometimes there is evidence of deformation of these beds around the coarser pebbles; (7) the contacts between the diamictons range from sharp to diffuse; (8) where in contact with till or sorted sediments (e.g.- fluvial sands) the contacts are usually sharp, but on occasion coarse clasts may protrude from the diamicton

Description 4. Nelson Quarry Section; section exposed in the Raid Brother's Nelson Quarry, located in the NW¼, of the SW¼, of the SW¼, of the NE¼, of sec. 26, T 72N, R 2W, Des Moines County; elevation 640 feet. Abbreviated description of working overburden face (September, 1975).

Depth-feet (meters)	Horizon or Zone	Description
	WISCONSINAN Loess (truncated; incomplete section)	
0 - 5.0 (0 -1.5)	OL-MOL	Silt loam loess
	Basal loess sediments	
5.0 - 6.5 (1.5-2.0)	OL	Silt loam to loam
	LATE - SANGAMON PALEOSOL in undifferentiated pedisediment and underlying till	
6.5 - 11.2 (2.0-3.4)	Ab-Bb	Undifferentiated (slumped).
	GLASFORD FORMATION - Kellerville Till Member subglacial facies - basal till.	
11.2 - 13.1 (3.4-4.0)	OJL	Loam till; dense; uniform texture; vertical joints; leached.
13.1 - 36.0 (4.0-11.0)	OJU	As above; joints very prominent; calcareous.
36.0 - 46.0 (11.0-14.0)	MOJU-MRJU	As above; colors grade from oxidized to reduced, to unoxidized.
46.0 - 58.0 (14.0-17.7)	UJU	As above, dominantly unoxidized colors except near joints.
58.0 - 76.0 (17.7-23.1)	UU	Dark greenish gray (5GY4/1), to dark olive gray (5Y3 and 4/2) loam till; occasional weak, very thin 0.1-0.2 in (2.5-5.0 mm) joints, with olive (5 Y4/3-4) colors

(The Kellerville Till above contains abundant coal and other Pennsylvanian rock fragments in the pebble through boulder size fractions, including large Lepidodendron and Sigillaria fossils, and even an intact marcasite nodule. The Hickory Hills till described below does not exhibit such lithologies.)

On the east side of the exposure the section described above lies directly on oxidized bedrock. To the west a broad sag in the bedrock surface revealed further deposits described below. The depths are given in continuity with the section above.

Depth-feet (meters)	Horizon or Zone	Description
	GLASFORD FORMATION - Kellerville Till Member	
76.0 - 77.0 (23.1-23.5)	UU	Loam till, as described above
	GLASFORD FORMATION? - Undifferentiated sediments and organic silts.	
77.0 - 78.0 (23.5-23.8)	IA-Oab[1]	Very dark gray (10YR3/1) mucky silt loam; leached; abundant organic debris, including spruce and larch wood.*
78.0 - 78.5 (23.8-23.9)	Cb-UU	Olive gray silt loam; calcareous; some organic debris.
78.5 - 78.7 (23.9-24.0)	UU	Loam sediments; occasional pebbles.
	WOLF CREEK FORMATION - Hickory Hills Till Member	
78.7 - 81.0 (24.0-24.7)	UU	Dark gray (5Y4/1) loam till.
	MISSISSIPPIAN - BURLINGTON LIMESTONE	

[1] Laterally, to the northeast, the mucky silt loam grades into a reddish-brown (5YR4/4-6), platy, leached, silty clay loam (0-6 inches depth; sample A) over an olive gray (5Y4/2), massive, calcareous silty clay loam with a few pebbles (6-14 inches depth; sample B). This overlies 19 inches of the Hickory Hills Till (sample C). Further to the east the reddish zone grades back into six inches of mucky silt loam (sample D) which rests directly on bedrock.

*Wood identified by Dr. Dwight W. Bensend Department of Forestry, Iowa State University.

Table 14. Laboratory data, Nelson Quarry Section

Sample Horizon or zone	Depth (feet)	I.D.	EX.	Clay Mineralogy Ill. - % -	K+C	H.S.I.	D.I.	D. -cps-	C.	Particle Size Clay	Silt - % -	Sand	Matrix Carbonates Ca	Do	T.C.	C/D	Sand-Fraction Lithology C/D	T.C.	Sh.	Sed.	Q.F.	T.X.	Notes	Density g/cc
WISCONSINAN Loess																								
OL	2.4	1167	64	22	14	20.0	1.07																	
OL	3.4	1168	64	26	10	22.5	1.88			29.6	69.4	1.0												
OL	5.4	1169	59	30	11	23.0	1.85			22.8	63.5	13.7												
GLASFORD FORMATION - Kellerville Till Member, subglacial facies - basal till.																								
OJU	14.0	2111	32	47	21		NC	NC		25.4	42.8	31.8												
OJU	*14.0	ILL.	30	51	19	*						*	2.2	9.5	12.7	0.23	*							
OJU	*16.0	ILL.	40	41	19	*						*	4.0	8.7	12.7	0.46	*							
OJU	*18.0	ILL.	40	42	18	*						*	3.1	10.0	13.1	0.31	*							
OJU	18.0	1165	39	38	23	C 8.0	1.09	85	80	20.6	43.4	36.0					0.6	34	10	50	41	50	Coal	1.81
OJU	*20.0	ILL.	38	42	20	*						*	4.5	9.8	14.3	0.46	*							
OJU	*22.0	ILL.	37	43	20	*						*	5.1	10.1	15.2	0.23	*							
OJU	22.0	3244	35	41	24		NC	NC		22.4	49.9	27.7	2.8	12.0	14.8	0.23								
OJU	*26.0	ILL.	48	29	23	*						*	4.4	10.7	15.1	0.41	*							
OJU	*29.0	ILL.	41	34	24	*						*	5.2	9.2	14.4	0.57	*							
MOJU	30.0	1163	42	39	20	7.0	1.31	t	t	22.1	41.1	36.8					1.2	61	--	62	33	38		
RJU	40.0	2108	40	40	20		NC	NC		24.9	38.2	36.9												1.91
UJU	49.0	1166	43	40	17	C 6.0	1.58	t	t	25.2	39.8	35.0					2.1	44	3	51	39	49	Coal	1.89
UJU	55.0	2109	48	32	20		NC	NC		21.4	40.1	38.5												1.90
UU	68.0	624	41	33	26	10.0	0.78	20	25	21.8	42.1	36.1					0.8	49	2	51	44	49		
UU	*75.0	ILL.	52	28	20	*																		
UU	75.0	621	59	21	20	23.0	0.62	15	40	18.1	45.7	35.7					5.0	30	8	40	53	60		1.87
UU	76.5	1162	41	33	26	7.0	0.84	t	t	20.2	46.3	33.5												1.86
GLASFORD FORMATION? - Undifferentiated sediments and organic silts.																								
IA-Oab	77.5	1158	28	44	28	5.0	1.03			10.8	85.7	3.6												
IA-Oab	D[1]	1161	36	44	20	3.0	1.45																	
OL	A[1]	1164	34	40	26	10.5	1.03																	
UU	78.1	1160	28	38	34	3.0	0.75	t	50	5.2	83.1	11.7												
UU	78.6	622	33	39	28	5.0	0.83	t	20	18.9	46.5	34.6												
UU	B[1]	625	33	43	24	6.0	1.05	10	15															
WOLF CREEK FORMATION - Hickory Hills Till Member																								
UU	78.8	623	56	23	21	20	0.70	--	50	25.6	35.4	39.0					1.4	27	1	28	69	72		2.16
UU	80.0	1159	55	21	24	22	0.57	--	20	21.7	33.2	45.1					4.3	21	--	21	68	79		
UU	81.0	1170	62	17	21		NC	NC		21.4	30.9	47.7												

1 - See section description for sample location.
C - Chlorite peaks apparent.
NC - Not calculated.
*ILL. - Analyses by Illinois State Geological Survey; Clay Min. - H.D. Glass; matrix carbonates of the <0.74 mm fraction - J.T. Wickham.

into the adjacent sediment. Although the diamictons are difficult to describe, their gross characteristics resemble many features described from superglacial sediment flows described by Lawson (1979).

Between the extremes of the Yarmouth and Nelson Quarry Sections are various locations where the two facies are in vertical succession. One principal locality is the Bjork Farm Transect (location given in Description 5). In a series of coreholes, beginning on the divide (figure 10; Description 5; Tables 15 and 16), below the Wisconsinan loess a Sangamon or Late-Sangamon is developed in the superglacial facies of the Kellerville Till Member. The Kellerville consists of interbedded silty diamictons and some sorted sediments (figure 11). This can be traced down through the landscape to site 58 H-4 (figure 10; figure 12; Description 6) on a late-Wisconsinan (Iowan) erosion surface. Here, the superglacial facies is about 7 feet (2.1 m) thick and has a friable to loose consistency, and a moderate density (figure 12). The base of the superglacial facies is an abrupt contact with the underlying firm and dense texturally uniform basal till (or subglacial facies).

Core site 58H-4 is immediately adjacent to two stream cuts which expose the sediments as well. A shallow cut on the west exposes about 4.5 feet (1.4 m) of the superglacial facies. Figure 13 is a photograph of a portion of this exposure showing the contorted, intercalated mixture of sediments which occur (see Table 17 also). To the east in a larger exposure (figure 14) up to 4 feet (1.2 m) of these superglacial deposits abruptly overly the dense and uniform basal till facies. At this section a large lense of folded sand and gravel is incorporated at the top of the basal till facies.

As summarized in figure 15 there is a marked difference in the range of textures in the two facies. The basal till facies is quite uniform, while the superglacial facies has a wide-range of sediments (see also figure 9). There is also a marked difference in consistency and density. The superglacial deposits tend to be loose and friable and range in density from 1.54 to

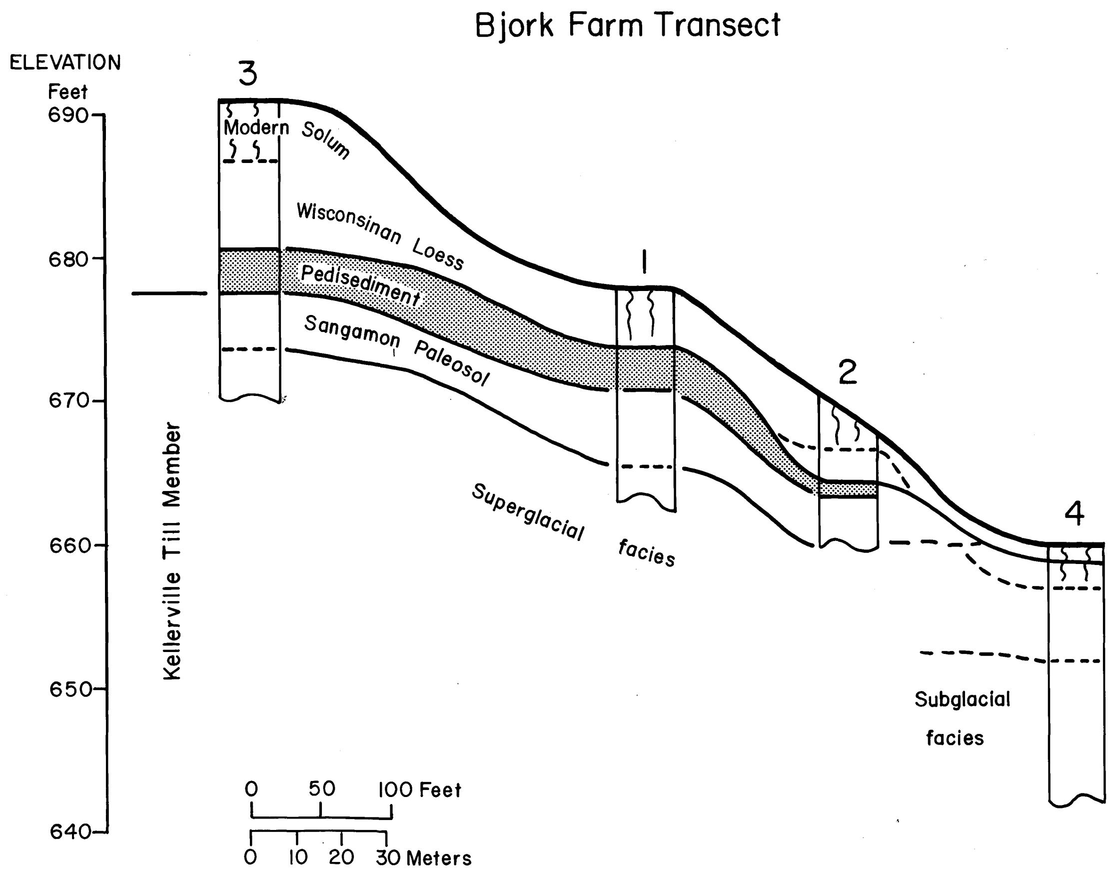


Figure 10. Cross section of the Bjork Farm Transect (outcrop sections, adjacent to Core 4). Note that the transect cuts across the interfluves from 58H-3 to -1, and from 58H-2 to -4.

1.80 g/cc (Table 16; figure 12). The subglacial or basal till tends to be firm to very firm, exhibits jointing, and ranges in density from 1.83 to 2.06 g/cc.

Another good example of the stratification often apparent in the superglacial facies is the Baltimore Cut Section (figure 16; Table 18). Across the uplands, back from the terminus of the Kellerville the superglacial facies gets thinner as shown at site 29WH-8 (see figure 18, and other data in Appendix), and in places is entirely absent, particularly on eroded Late-Sangamon interfluves such as the Nelson Quarry Section. (Other excellent exposures of the superglacial facies occur at sections

Description 5. Bjork Farm Transect; core 58 H-3 located on long gently sloping upland surface in the SW¼, of the NW¼, of the SW¼ of sec. 22, T.73N., R.3W., Louisa County. (75 feet E of center line of gravel road; 457 feet N of SW ¼-¼ fence line.) Elevation approximately 691 feet.

Depth-inches (feet) (meters)	Horizon or Zone	Description
WISCONSINAN LOESS		
0- 4 (0 - 0.3) (0 -0.1)	A1	Solum
4- 13 (0.3- 1.1) (0.1-0.3)	A2	
13- 50 (1.1- 4.2) (0.3-1.3)	B	
50- 71 (4.2- 5.9) (1.3-1.8)	C-MOL	Light silty clay loam; loess.
71- 90 (5.9- 7.5) (1.8-2.3)	MOL-DL	Silt loam; loess.
90-135 (7.5-11.3) (2.3-3.4)	DL	Light brownish gray (2.5Y 6/2) silt loam; common fine to medium strong brown (7.5YR 5/6 and 8) mottles; massive.
LATE-SANGAMON Pedisediment? and Paleosol.		
135-145 (11.3-12.1) (3.4-3.7)	IIA21b	Dark yellowish brown (10YR 4/4) silt loam; massive to very weak granular; few fine charcoal flecks; common fine dark reddish brown (5YR 2/2) Mn oxides and few fine yellowish red Fe oxides.
145-152 (12.1-12.7) (3.7-3.9)	IIA22b	Silt loam, as above; weak medium prismatic, breaking to weak fine subangular blocky structure.
152-160 (12.7-13.3) (3.9-4.1)	IICb-A23b? (B1b?)	Dark yellowish brown (10YR 4/4) light clay loam; massive to very weak fine subangular blocky structure.
-- Stone Line --		
GLASFORD FORMATION - Kellerville Till Member, superglacial facies LATE-SANGAMON PALEOSOL in upper part.		
160-169 (13.3-14.1) (4.1-4.3)	IIIB21tb	Strong brown (7.5YR 5/6) light silty clay with occasional pebble; common fine light brownish gray (2.5Y 6/2) and yellowish red (5YR 4/4) mottles; moderate fine to medium angular blocky; discontinuous clay coatings; many fine Mn oxides.
169-177 (14.1-14.8) (4.3-4.5)	IIIB22tb	Dark yellowish brown (10YR 4/4) light silty clay, with occasional pebble; common fine strong brown (7.5YR 5/6) and light brownish gray (2.5Y 6/2) mottles; nearly continuous dark brown (7.5YR 4/4) clay coats; moderate fine to medium angular blocky; common fine to medium Mn oxides.
177-185 (14.8-15.4) (4.5-4.7)	IIIB23tb	Mottled yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) silty clay loam (no pebbles?); common fine yellowish red (5YR 4/4) mottles; strong fine to very fine angular blocky; nearly continuous dark yellowish brown (10YR 4/4) clay films; common fine to medium Mn oxides.
185-192 (15.4-16.0) (4.7-4.9)	IIIB31b	Mottled as above (10YR 5/6 and 2.5Y 6/2) silty clay loam (no pebbles); common fine strong brown (7.5YR 5/6) mottles; moderate medium prismatic breaking to weak medium to coarse subangular blocky; many fine Mn oxides.
192-207 (16.0-17.3) (4.9-5.3)	IIIB32b	Mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/6) silty clay loam with few pebbles; mottles and structure as above.
207-235 (17.3-19.6) (5.3-6.0)	IIIC-MOL	Color as above, heavy silt loam with pebbles; till-like but variable texture, with some thin silty and sandy seams.

Table 15. Clay mineralogy for core site 58 H-3, Bjork Farm Transect.

Depth (feet)	Horizon or Zone	EX.	ILL. - % -	K+C
WISCONSINAN Loess				
6.1	MDL	67	22	11
6.7	DL	69	19	12
10.0	DL	75	15	10
11.0	DL	68	18	14
		(11.0 Vermiculite peak apparent)		
Late SANGAMON Pedisediment and Paleosol?				
11.5	IIA21b	Very broad expandable peaks;		
12.1	IIA22b	illite present; mixed layer?		
12.9	IIC-A23b?	"		
GLASFORD FORMATION - Kellerville Till Member; superglacial facies. LATE SANGAMON PALEOSOL in upper part				
13.5	IIIB21tb	Broad expandable peak; illite present, but obscured.		
15.0	IIIB23tb	Broad expandable peak; illite present; chlorite peak		
15.4	IIIB31tb	present.		
16.3	IIIB32b	51	29	20
		Broad, but clear expandable peak, chlorite peak present.		
17.5	MOL	45	35	20
		Chlorite apparent.		
18.0	MOL	45	36	19
		Chlorite apparent.		

58CC-1, 58CC-2, 58X-37-1, and 58JW-70, in Appendix.)

As shown, one of the principal characteristics of the superglacial facies is its variability in texture and sediment type. In some sections it is composed wholly of interbedded and contorted sediments, while at other sites (Mediapolis Section) it is made up entirely of soft to friable till-like deposits.

In addition to the contrast in texture and sedimentology there is a pronounced difference in density between the facies. Table 19 summarizes the bulk density measurements in the area. Density is a relative measure of the consolidation history of the deposit. If materials are allowed to drain they will assume a higher density under a greater overburden pressure (within certain limiting values). Many tills are overconsolidated, that is they were consolidated or compressed under a greater

Table 16. Additional laboratory data, Bjork Farm Section.

Sample			Particle-size			Matrix Carbonates				Density	Clay Mineralogy				Sand-fraction Lithologies					
Depth (feet)	Horizon or Zone	Material	Clay	Silt - % -	Sand	Ca	Do	Tc	C/D	g/cc	EX.	ILL - % -	K+C	C/D	T.C.	Sh.	T.S.	Q.F.	T.X.	Notes
GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																				
(4) 4.8	OL	Till	31.6	44.0	24.4					1.61	45	35	20							
(4) 6.2	OL	Diamicton	25.8	40.1	34.1					1.67										
E	MOU	Si Cl Diamicton	35.0	40.9	24.1	1.8	3.1	4.9	0.58		59	21	20							
* E	MOU	* Si Cl Diamicton *	42.0	38.0	20.0					*	68	16	17	*ILL.						
E	MOU	Till	23.9	45.9	30.2	2.5	14.5	17.0	0.17		36	47	17C	1.7	45	1	47	53	53	Coal
* E	MOU	* Till *	29.0	50.0	21.0	4.6	18.7	23.3	0.25	*	32	49	19	*ILL.						
E	MOU	Till-like	20.8	55.4	23.8	3.3	22.7	26.0	0.15		42	38	20	0.4	49	-	49	48	51	
* E	MOU	* Till-like *				6.3	17.8	24.1	0.35	*	41	41	19	*ILL.						
E	OU	Sand	6.6	4.7	88.7															
E	MRU	CL Diamicton	37.1	27.6	35.3															
E	OU	Co. Sand	23.8	12.8	63.4															
E	MOU	Till	23.9	49.5	26.6	2.0	17.6	19.6	0.11	1.65	40	39	21	0.8	32	1	33	51	67	
E	MOL	C Diamicton	48.0	25.1	26.9															
E	MOU	Diamicton	35.5	37.7	26.8					1.70	47	33	20	2.1	28	9	39	59	61	Coal
E	OL	Diamicton	43.4	26.8	29.8															
E	OL	S and G	9.1	11.8	79.1															
E	RU	Silts	22.4	54.2	23.4	4.0	23.7	27.7	0.17	1.54	41	35	20							
E	MOU	Si Diamicton	23.4	63.2	13.4															
E	OU	Sand	8.6	15.0	76.4	0.1	38.0	38.1	0.01											
E	MRU	CL Diamicton	30.1	38.1	31.8					1.80	56	27	17	1.1	64	1	67	24	33	Coal
E	OU	Sandy loam	6.4	33.7	59.9	0.7	34.6	35.3	0.02											
W	OL	S and G	6.9	17.8	75.3															
W	OU	Loam	15.3	37.6	47.1															

Table 16, con't.

W	MOU	SiDiamicton	24.2	60.6	15.2															
W	MOU	S Diamicton	10.2	27.4	62.4															
W	MOL	Till																		
W	MOU	Till																		
		- Kellerville Till Member, subglacial facies, basal till.																		
W	MJOU	Till	22.3	42.2	35.5	2.8	7.8	10.6	0.36	1.92	47	33	20	1.2	42	4	47	48	53	
W	MJOU	Till	23.9	42.1	34.0	2.1	11.1	13.2	0.19											
W	MJOU	Till	25.4	45.5	29.1	2.5	9.2	11.7	0.27	1.91	49	30	21							
W	MJOU	Till	23.6	41.6	34.8	2.0	8.8	10.8	0.23											
W	MJRU	Till	24.9	41.7	33.4	1.6	5.6	7.2	0.29	1.94				0.4	42	-	42	53	58	
W	MJRU	Till	22.4	42.0	35.6	1.6	10.2	11.8	0.16	2.06	47	27	26							
W	MJRU	Till	22.8	43.5	33.7									1.0	40	8	51	41	49	Coal
W	MJOU	Till	22.4	44.7	32.9															
W	MJOU	Till	23.9	43.4	32.7	2.5	9.0	11.5	0.28		50	30	20	1.0	47	-	49	48	51	Coal
* W	MJOU	* Till *	30.0	40.0	30.0	4.1	8.7	12.8	0.47	*	51	30	19	*ILL.						
* W	MJOU	* Till *	33.0	42.0	25.0	3.2	9.4	12.6	0.34	*	60	21	19	*ILL.						
W	MOU	Till	24.4	44.2	31.4						51	28	21							
(4)12.3	MRL	Till	25.9	39.2	34.9					1.83	54	27	19							
(4)12.9	MOU	Till	23.2	43.0	33.8	1.6	8.5	10.1	0.19		49	29	22	1.1	32	5	39	54	61	Coal
(4)13.8	MOU	Till	23.0	42.7	34.3	2.0	10.2	12.2	0.20	1.91	50	31	19							
(4)14.6	MOU	Till	23.8	41.7	34.5	2.3	9.2	11.5	0.25											
(4)15.4	MOU	Till	23.9	41.7	34.4	2.1	8.4	10.5	0.25	1.83	44	30	26	0.9	36	4	40	51	60	

Depth: (4) - depth in core 29 H-4; W or E from west or east outcrop
Material: Si - silty; S - sandy; G - gravelly; CL - clay loam; C - clay; Co - coarse.
*ILL. - Analyses by the Illinois State Geological Survey; Clay min. - H.D. Glass; Matrix carbonates of the < 0.074 mm fraction - J.T. Wickham; particle size by hydrometer, clay = 0.00 4 mm.
K+C: C - Chlorite peak apparent.

Description 6. Bjork Farm Transect; core site 58 H-1 located on high sloping interfluve in the NW¼, of the SW¼, of the SW¼, of sec. 22, T.73N., R.3W., Louisa County. (88 feet E of center line of gravel road; 104 feet S of SW ¼-¼ fence line.) Elevation 678 feet.

Depth-inches (feet) (meters)	Horizon or Zone	Description
WISCONSINAN Loess		
0- 3 (0.0- 0.3) (0.0-0.1)	A1	Dark grayish brown (10YR 4/2) silt loam; moderate very very fine granular structure.
3- 8 (0.3- 0.7) (0.1-0.2)	A2	Brown (10YR 5/3), with minor dark grayish brown (10YR 4/2) silt loam; moderate medium platy; discontinuous light gray (10YR 7/2) grainy silt coats.
8- 12 (0.7- 1.0) (0.2-0.3)	B1	Brown (10YR 4/3) and dark brown (10YR 3/3) silt loam; weak fine to very fine subangular blocky; discontinuous light gray (10YR 7/2) grainy coats.
12- 20 (1.0- 1.7) (0.3-0.5)	B21t	Yellowish brown (10YR 5/4) light to medium silty clay loam; moderate very fine to fine angular to subangular blocky; discontinuous clay films and light gray grainy coats; continuous yellowish yellowish brown (10YR 5/6) coatings on exteriors; few medium dark reddish brown (5YR 2/2) Mn oxides.
20- 27 (1.7- 2.3) (0.5-0.7)	B22t	Yellowish brown (10YR 5/6) medium silty clay loam; few fine brown (10YR 5/3) mottles; weak coarse prismatic breaking to moderate fine to medium angular blocky; discontinuous light gray grainy coats; continuous moderate and thick dark yellowish brown (10YR 4/4) clay films; common fine (5YR 2/2) Mn oxides.
27- 34 (2.3- 2.8) (0.7-0.9)	B23t	Yellowish brown (10YR 5/6) light silty clay loam; few fine brown (10YR 5/3) and strong brown (7.5YR 5/6) mottles; moderate medium to coarse prismatic breaking to moderate fine subangular blocky; continuous dark yellowish brown (10YR 4/4) clay films and discontinuous light gray (10YR 7/2) grainy coats; common fine Mn oxides.
34- 40 (2.8- 3.3) (0.9-1.0)	B31t	Yellowish brown (10YR 5/6) light silty clay loam; many fine yellowish brown (10YR 5/4) and common fine strong brown (7.5YR 5/6) mottles; weak coarse prismatic breaking to moderate fine and coarse subangular blocky; nearly continuous clay films and discontinuous grainy coats.
40- 49 (3.3- 4.1) (1.0-1.2)	B32t	Yellowish brown (10YR 5/4) heavy silt loam; few fine brown (10YR 5/3) and strong brown (7.5YR 5/6) mottles; moderate coarse prismatics breaking to weak medium subangular blocky; common very fine pores; few discontinuous brown (10YR 4/4) clay films.
LATE-SANGAMON Pedisediment? and Paleosol		
49- 65 (4.1- 5.4) (1.2-1.7)	IIA21b	Dark yellowish brown (10YR 4/4) silt loam; weak coarse platy; thin patchy light gray (10YR 7/2) grainy coats; few very fine Fe oxide segregations, few fine Mn oxides.
65- 76 (5.4- 6.3) (1.7-1.9)	IIA22b	Dark yellowish brown (10YR 4/4) loam; weak thin platy structure; thin patchy light gray (10YR 7/2) grainy coats; many fine dark reddish brown (5YR 2/2) Mn oxides.

Description 6, con't.

76- 85 (6.3- 7.1) (1.9-2.2)	IIB1tb	Yellowish brown (10YR 5/6) loam; weak medium prismatic breaking to weak fine to medium subangular blocky; few discontinuous dark yellowish brown (10YR 4/4) clay films.

-- Stone Line --

GLASFORD FORMATION - Kellerville Till Member, superglacial facies (occasional pebbles throughout)

LATE SANGAMON PALEOSOL in upper part.

85- 92 (7.1- 7.7) (2.2-2.3)	IIIB21tb	Strong brown (7.5YR 5/6) clay loam; few fine grayish brown (2.5Y 5/2) mottles; moderate fine to very fine subangular blocky; nearly continuous dark brown (7.5YR 4/4) clay films; few fine Mn oxides.
92- 97 (7.7- 8.1) (2.3-2.5)	IIIB22tb	Strong brown (7.5YR 5/6) clay; common fine yellowish red (5YR 5/6) mottles; strong very fine angular blocky; continuous clay films.
97-107 (8.1- 8.9) (2.5-2.7)	IIIB23tb	As above; many medium dark reddish brown (5YR 2/2) Mn oxides.
107-117 (8.9- 9.8) (2.7-3.0)	IIIB24tb	Yellowish brown (10YR 5/6) heavy clay loam; moderate medium prismatic breaking to strong fine angular blocky; nearly continuous dark brown (10YR 4/3) clay films on prisms; common medium (5YR 2/2) Mn oxides.
117-126 (9.8-10.5) (3.0-3.2)	IIIB25tb	Yellowish brown (10YR 5/6) clay loam; common fine light brownish gray (10YR 6/2) mottles; moderate medium prismatic breaking to moderate fine to medium subangular blocky; discontinuous dark brown (10YR 3/3-4) clay coats on prisms.
126-136 (10.5-11.3) (3.2-3.5)	IIIB31tb	Yellowish brown (10YR 5/6) heavy loam; weak medium prismatic breaking to weak medium to coarse subangular blocky; few dark yellowish brown (10YR 4/4) clay films on prisms; few fine reddish yellow (7.5YR 6/8) Fe oxides.
136-145 (11.3-12.3) (3.5-3.7)	IIIB32b	Yellowish brown (10YR 5/4) heavy loam; common fine yellowish brown (10YR 5/6) mottles on vertical faces; strong coarse and medium prismatic breaking to weak medium to coarse subangular blocky; nearly continuous dark reddish brown (5YR 2/2) Mn oxide coatings on prisms.
145-150 (12.3-12.5) (3.7-3.8)	IIIB33b	As above; loam; moderate coarse prismatic; also with secondary carbonate on prism faces.
150-168 (12.5-14.0) (3.8-4.3)	C-MOL2	As above; loam; weak prismatic; secondary carbonates present; till-like material with subtle stratification.

stress than the present overburden could exert. The explanation for this is that either the till was overridden by and/or deposited beneath a substantial thickness of glacier ice.

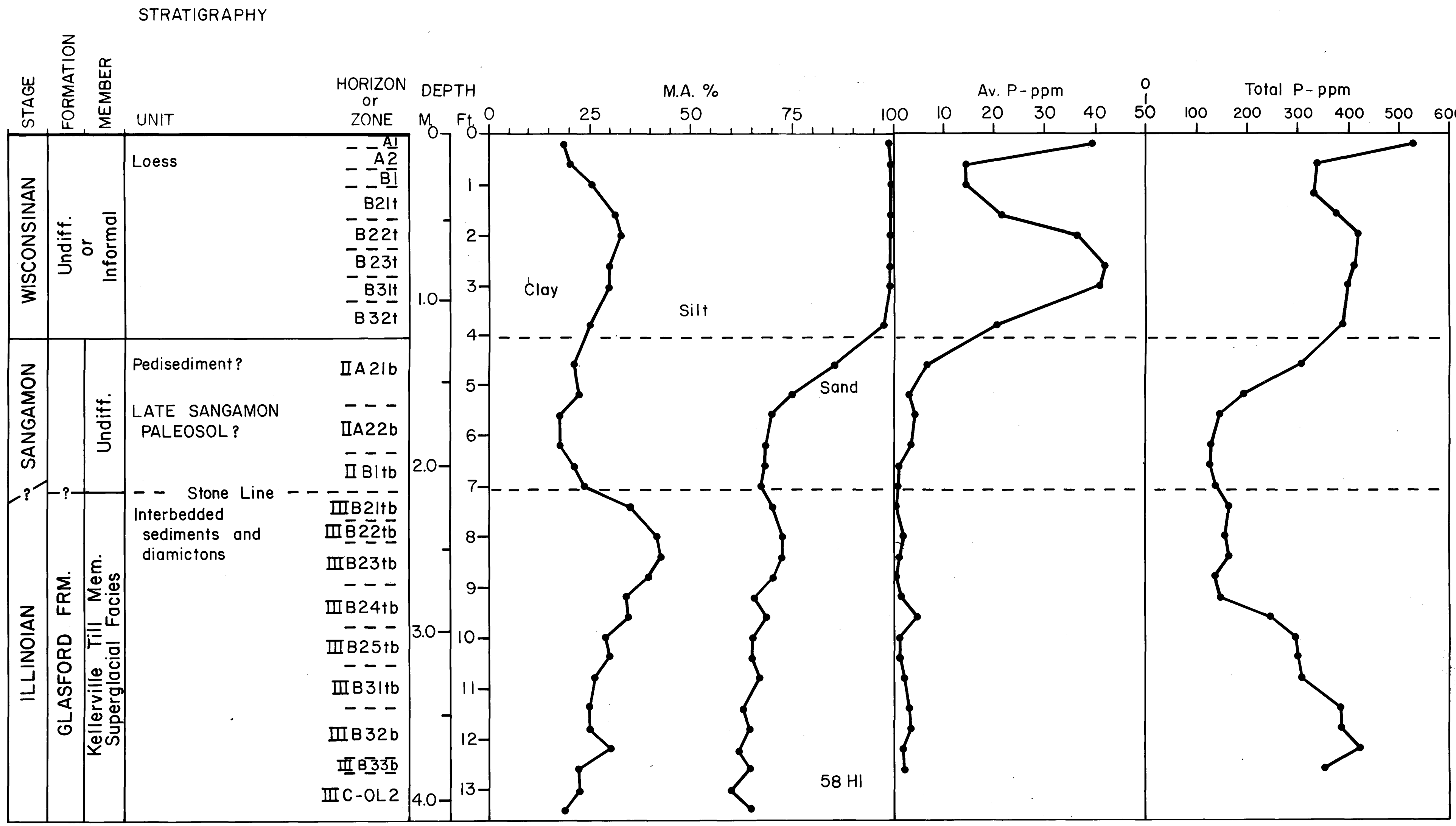


Figure 11. Stratigraphy, particle-size, and phosphorus data for Core 58H-1, Bjork Farm Transect.

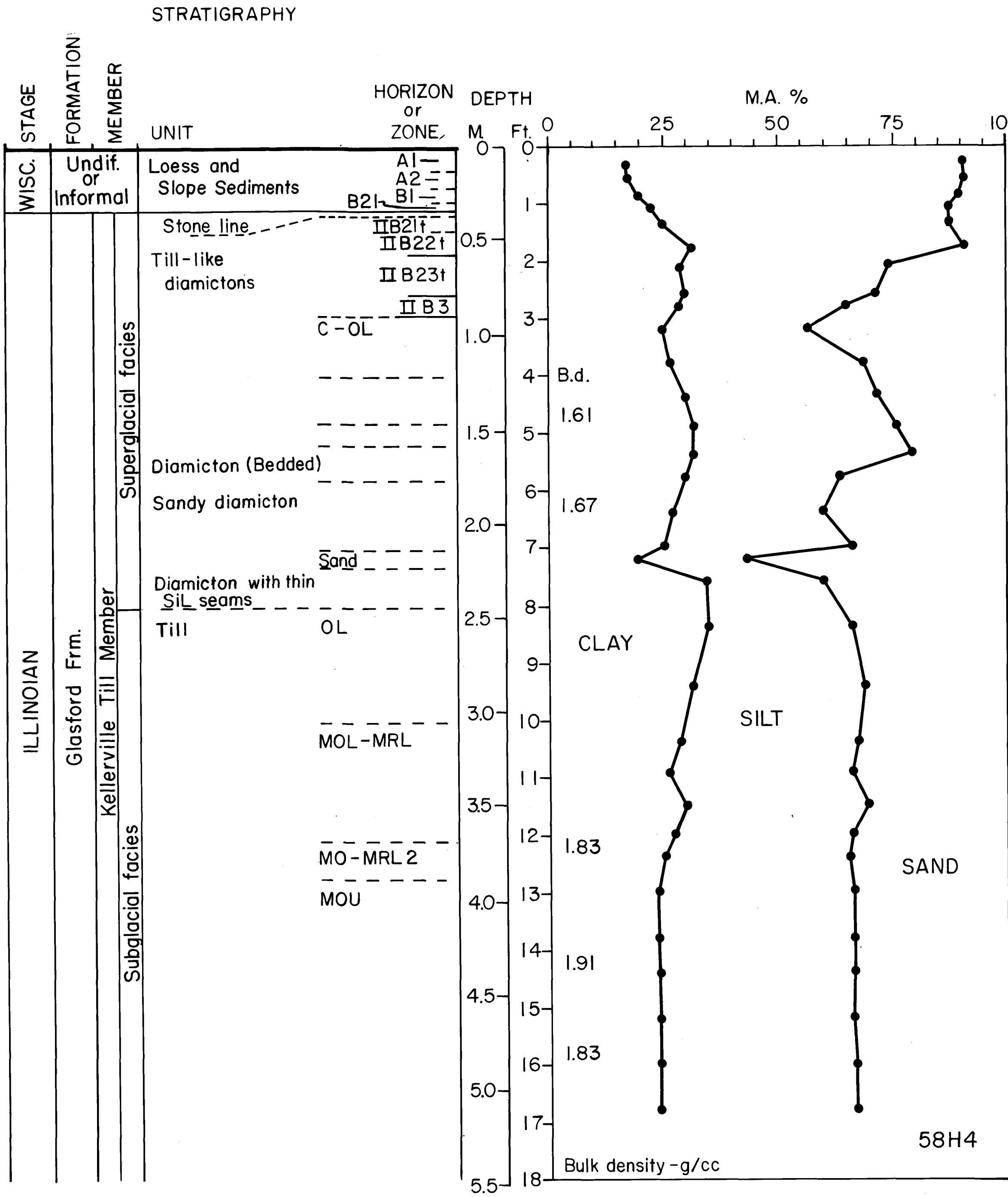


Figure 12. Stratigraphy and particle-size data, Core Site 58H-4, Bjork Farm Transect.

Table 19 shows the data for: (1) the Hickory Hills Till, where it has been overridden by the ice which deposited the Kellerville Till Member; (2) the Hickory Hills Till Member where it is the surface till; and (3) the overridden Aurora Till Member. These tills are all overconsolidated and are

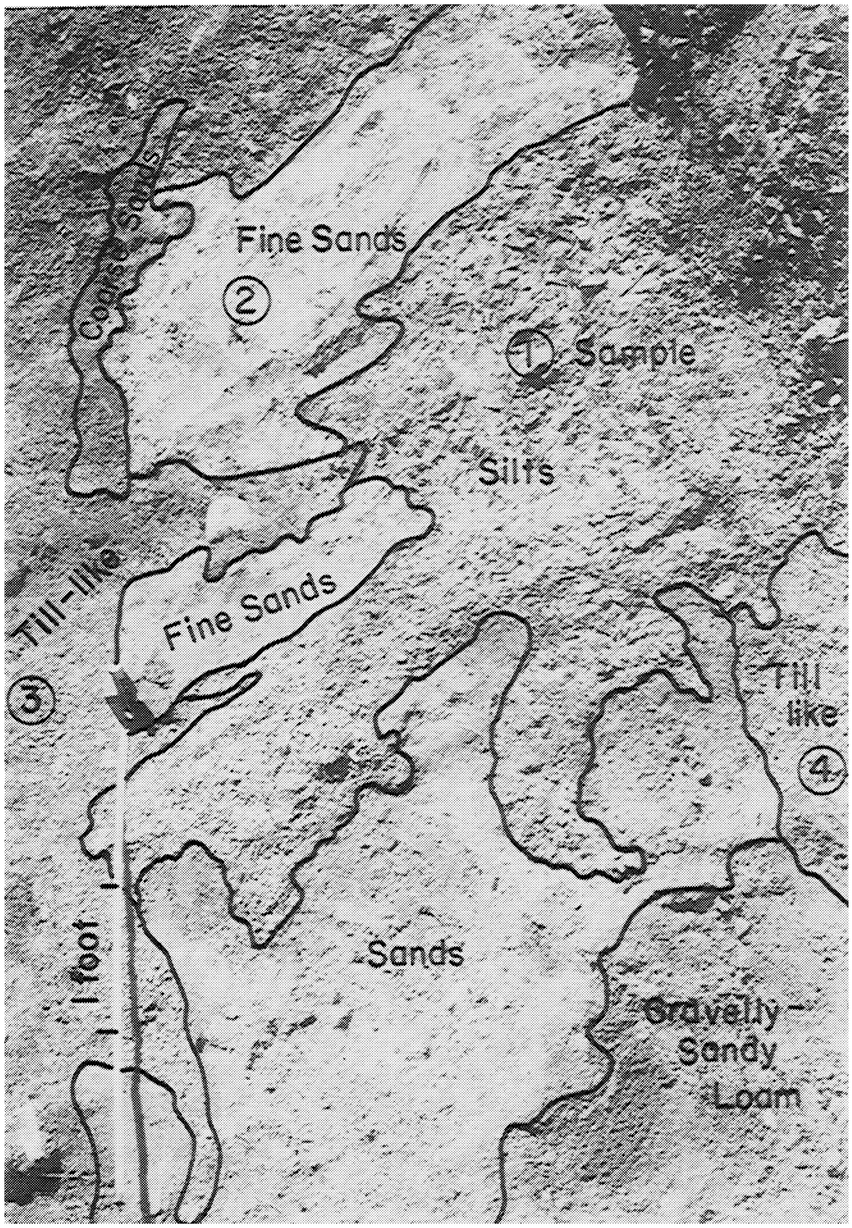


Figure 13. Photograph of portion of west exposure, Bjork Farm Transect, showing superglacial facies sediments.

Table 17. Particle-size data for samples in figure 13.

	Clay	Silt - % -	Sand
1 - Silts	22.4	54.2	23.4
2 - Fine Sands	8.6	15.0	76.4
3 - Till-like	26.8	37.7	35.5
4 - Till-like	29.8	26.8	43.4

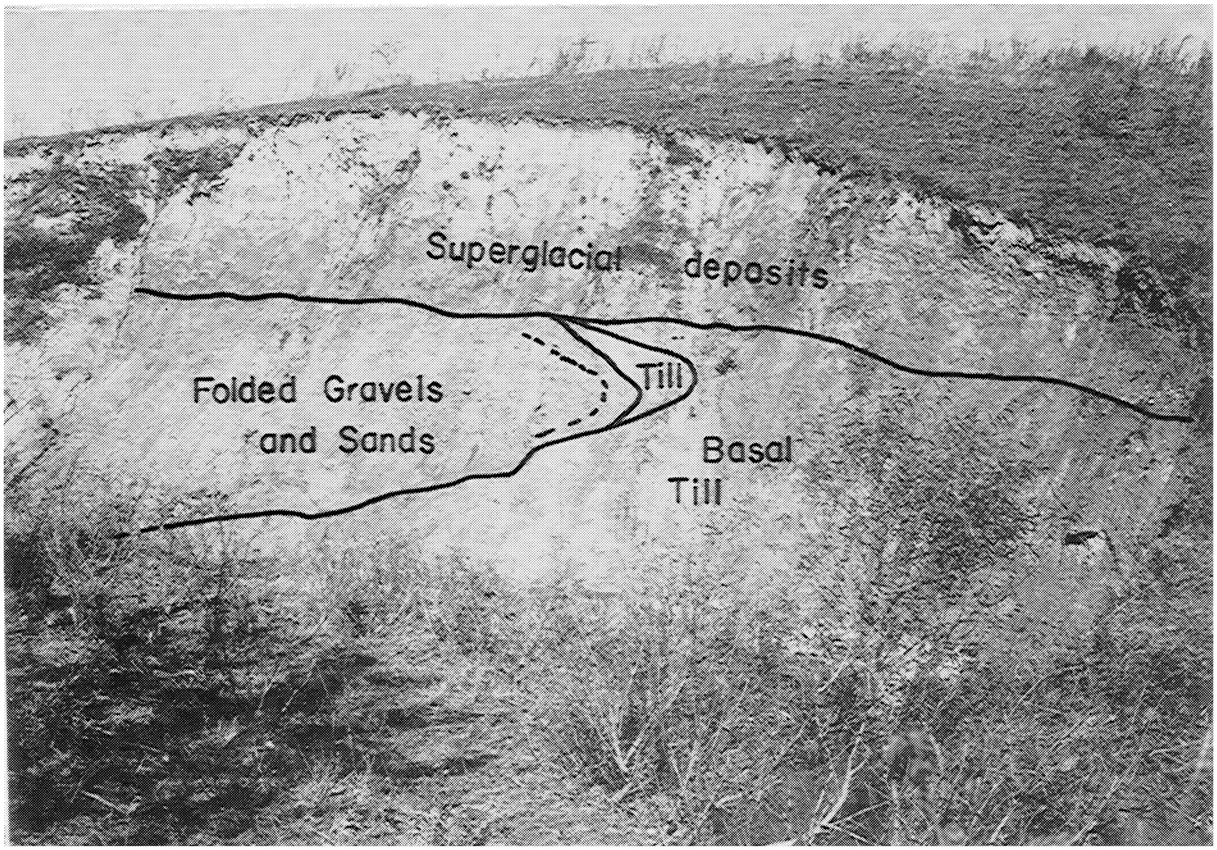


Figure 14. Photograph of east exposure at Bjork Farm Transect.

considered to be basal tills (Hallberg, 1980). Table 19 also shows density data for the loess. The loess is eolian in origin and in this area is generally normally consolidated (in some areas loess is actually underconsolidated).

By comparison the densities of the superglacial facies sediments are similar to the normally consolidated loess, whereas the basal till facies of the Kellerville is similar to the overconsolidated Pre-Illinoian tills. The superglacial facies exhibit much wider range (and larger standard deviation) in density than the other units. This is because it is composed of a wide variety of materials and also because some of the materials are surficial deposits such as lacustrine or paludal sediments, and mudflows, while at the other extreme it includes relatively unmodified till which melted out of the glacial ice

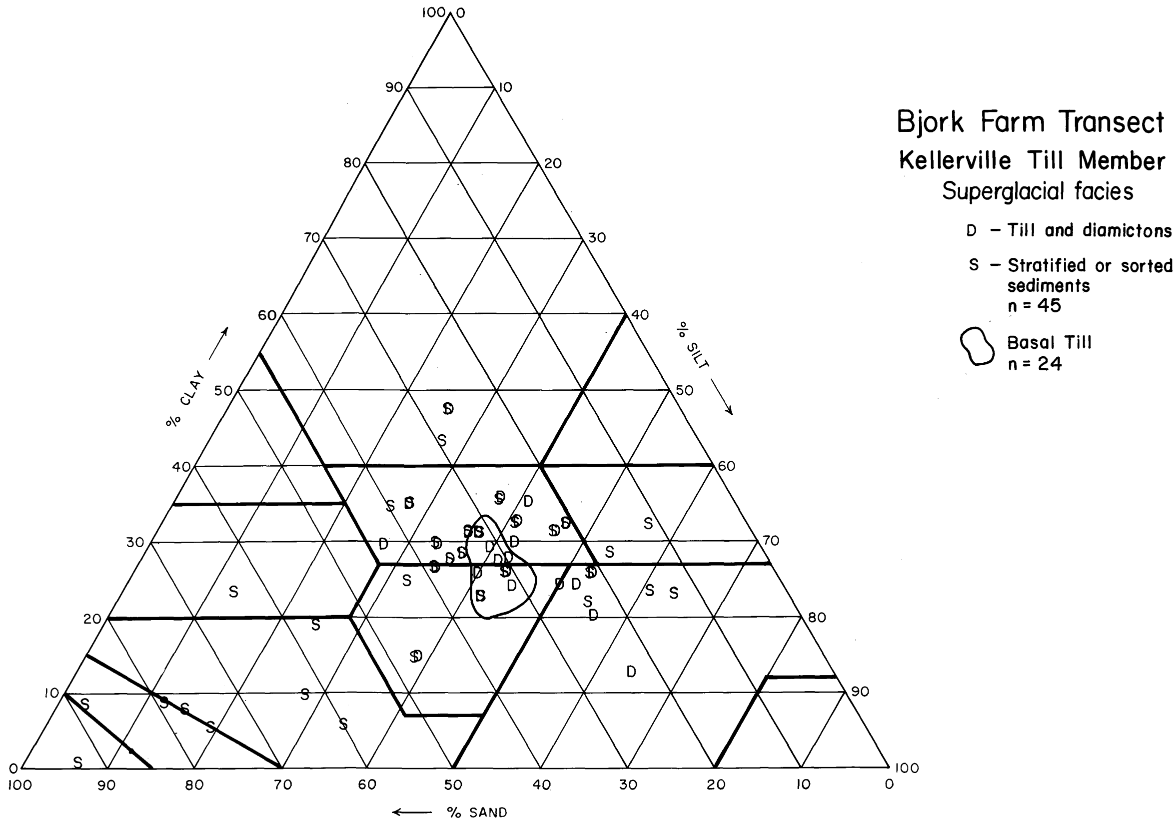


Figure 15. Summary of textural data, Bjork Farm Transect.

and which may be moderately overconsolidated.

The superglacial facies is interpreted to be the product of the deposition and reworking of debris on the surface of the ice. Till which reaches the surface of the ice during melting may be subjected to numerous processes. It may be reworked into mudflows, eroded and sorted into fluvial or lacustrine deposits. Subsequent collapse or melting out of debris capped ice may create a melange or contorted mixture of these various sediments. When the ice has completely melted this debris will be let down on the substrate. The superglacial facies is analagous to the generic-use of ablation till of Dreimanis (1976).

The basal till (or subglacial) facies is comprised of quite uniform materials resulting from the subglacial deposition of till. Although there are various modes of subglacial deposition (Boulton, 1970; Sugden and John, 1976) the resultant

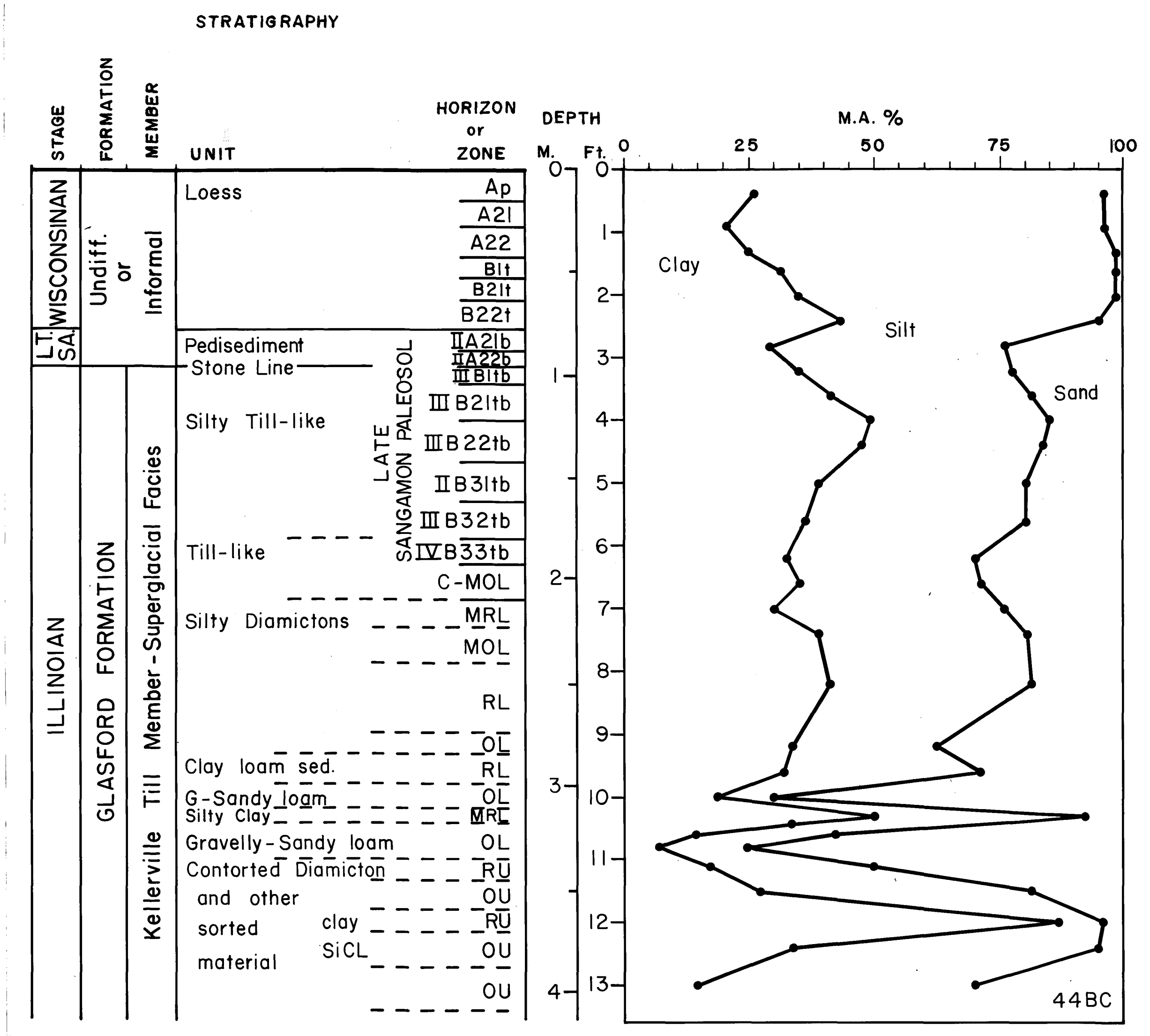


Figure 16. Stratigraphy and particle-size data, Baltimore Cut Section (44-BC). The section is composed of a core (0-7 ft; 0-2.1 m) and a road-cut, located in the NW ¼, of the NW ¼, of the SW ¼, of the NW ¼, of sec. 9, T.70N., R.5W., Henry County; elevation 725 feet.

product is similar, and all these deposits are simply referred to as basal till (also in the generic sense of Dreimanis, 1976) in this report (see also Hallberg, 1980).

Stratified and sorted sediments do occur occassionally within the basal till. Their principal occurrence is in the lowermost portion of the basal till as block inclusions (such

Table 18. Laboratory data for calcareous grab samples, Baltimore Section (44-BC).

Sample Horizon or Zone - Material	Clay Mineralogy			Particle-size			Matrix-Carbonates			
	EX.	ILL.	K+C	Clay	Silt	Sand	Ca	Do	TC	C/D
RU - Diamicton	50	32	18	21.6	55.8	22.6	2.0	16.6	18.6	0.12
RU - Diamicton	52	30	18	25.7	51.2	23.1	1.7	13.9	15.6	0.12
RU - Silts				20.1	54.9	25.0	2.0	16.6	18.6	0.12
OU - Loam				8.8	45.4	45.8	1.8	34.0	35.8	0.05
MOU - Diamicton	48	35	17	33.3	29.0	37.7				

as described for the Wolf Creek Formation). Sections 56-79-2-1 and 56-79-2-2 (in Appendix) seem to show the complete sequence; an upper superglacial facies composed of friable till with many inclusions of sand and gravel; which overlies a dense uniform till which includes in its lower portion either sheared inclusions of the Yarmouth Paleosol (56-79-2-2) or inclusions of sand and gravel and the underlying Hickory Hills Till Member (56-79-2-1).

The recognition of these facies is of significant practical necessity. The variable deposits of the superglacial facies have caused many problems with sewage lagoons, road construction, and foundation work.

Comparison With Upland Stratified Drift of East-Central Iowa

Stratified and contorted drift (till mixed with sorted deposits) are exposed in many upland areas in east-central Iowa (Hallberg, 1980). These deposits are grossly similar in appearance to the superglacial facies of the Kellerville Till Member. However, their origin is quite different. The mode of occurrence and formation of these deposits in east-central Iowa range from subglacial drumlinoids to interstadial fluvial deposits. Structures, fabrics, and consolidation data associated with these sediments indicate that they are overconsolidated and of subglacial origin or have been overridden by glacial ice. In

Table 19. Summary of bulk density measurements for Pleistocene deposits in the southeast Iowa study area.

	n	mean	s.d.	range
Wisconsinan loess *				
		density - g/cc (pcf)		
	31	1.50 (94)	0.06 (4.0)	1.39-1.59 (87-99)
GLASFORD FORMATION - Kellerville Till Member				
superglacial facies				
	21	1.59 (99)	0.12 (7.5)	1.42-1.83 (89-114)
subglacial facies - basal till				
	27	1.86 (116)	0.07 (4.4)	1.71-2.06 (107-129)
WOLF CREEK FORMATION - Hickory Hills Till Member				
where overlain by Kellerville Till Member				
	11	1.98 (124)	0.07 (4.4)	1.91-2.16 (119-135)
Where surficial till unit. **				
	105	1.79 (112)	0.08 (4.8)	1.61-1.96 (101-122)
- Aurora Till Member ** (overlain by Hickory Hills Till Member)				
	171	1.90 (119)	0.07 (4.5)	1.76-2.12 (110-132)

* Data from this study and Lutenegger (1979).
** Regional data from east-central and southeast Iowa.

all cases analyzed these deposits can be traced laterally to where they are related to the lower portions of thick basal till deposits or to inter-till stratigraphic positions. They are exposed at the present land surface in east-central Iowa only because they have been exhumed by the extensive erosion that has taken place in this area.

These properties are in marked contrast with the superglacial facies deposits of the Kellerville Till Member. As described, the Kellerville superglacial deposits: (1) always occur at the top of the Kellerville Till Member, the youngest till in the area; (2) are exposed across the most stable landscape positions; and (3) are generally normally consolidated.

In isolated exposures there are gross similarities in appearance between these deposits in east-central and southeast Iowa. However, when their three-dimensional distribution is analyzed and their properties quantified the origin of the deposits in these two areas is seen to be quite different.

Provenance

As discussed (see also Wickham, Lineback, this volume) the Kellerville Till Member is an eastern source till from the Lake Michigan Lobe. The high illite and dolomite content contrasts with the Pre-Illinoian tills in the area and is typical of the eastern derived tills. Also, the Kellerville exhibits an abundance of Pennsylvanian rock fragments in the sand through pebble and cobble particle sizes. In well-exposed sections, such as at the Nelson Quarry, large Lepidodendron and Sigillaria fossils were removed from the till. An intact marcasite nodule was also observed in the till at this section. The Pennsylvanian is the bedrock in much of eastern and central Illinois adjacent to the study area, and provides the obvious source for the clasts in the till.

Of particular interest are some of the clasts collected from the 58-CC-2 Section (see Appendix). At this site numerous Mazon Creek-style fossiliferous siderite concretions were found. Although the concretions were weathered one of the plant fossils was identifiable (figure 17) as the common fern tree fossil *Alethopteris* (pers. commun., R. Ravn, Ia. Geol. Survey). Mazon Creek fossils are only known from the central Illinois area.

Soil Stratigraphy

The principal soil-stratigraphic unit associated with the Kellerville Till Member is the Sangamon Paleosol. The Sangamon Paleosol is developed in the top of the Kellerville Till Member, and/or in sediments which overlie the Kellerville. The

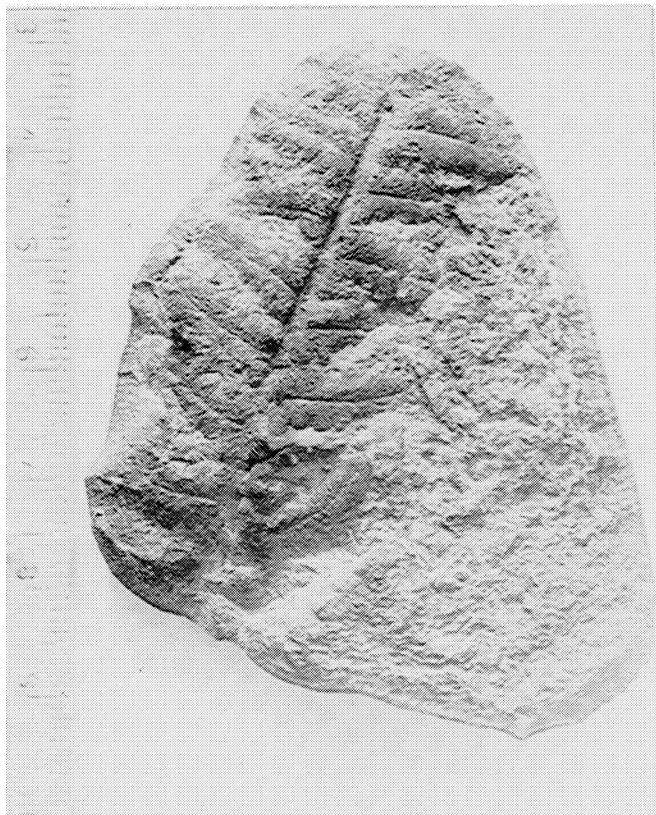


Figure 17. Pennsylvanian age *Alethopteris* in Mazon Creek style siderite concretion, which occurred as a clast in the Kellerville Till Member. Scale in cm.

Sangamon is overlain by the Wisconsinan loess, and where present (or recognizable) the Basal loess sediments, and Basal loess paleosol.

Under the loess across the broad, flat divide around the Mediapolis (Des Moines County) area modified, but undissected, remnants of the Kellerville Till plain can be observed. Core sites 29WH-7 and 8 provide examples of the Sangamon paleosol in this area. 29WH-8 (figure 18) shows a well-drained Sangamon Paleosol on a remnant knob on the Kellerville surface. The Sangamon Paleosol here exhibits a well-developed B-horizon within the Kellerville Till Member. In other cores in the vicinity of 29WH-8 a thin increment of hillslope sediments is incorporated in the paleosolum, above a weakly developed stone-line.

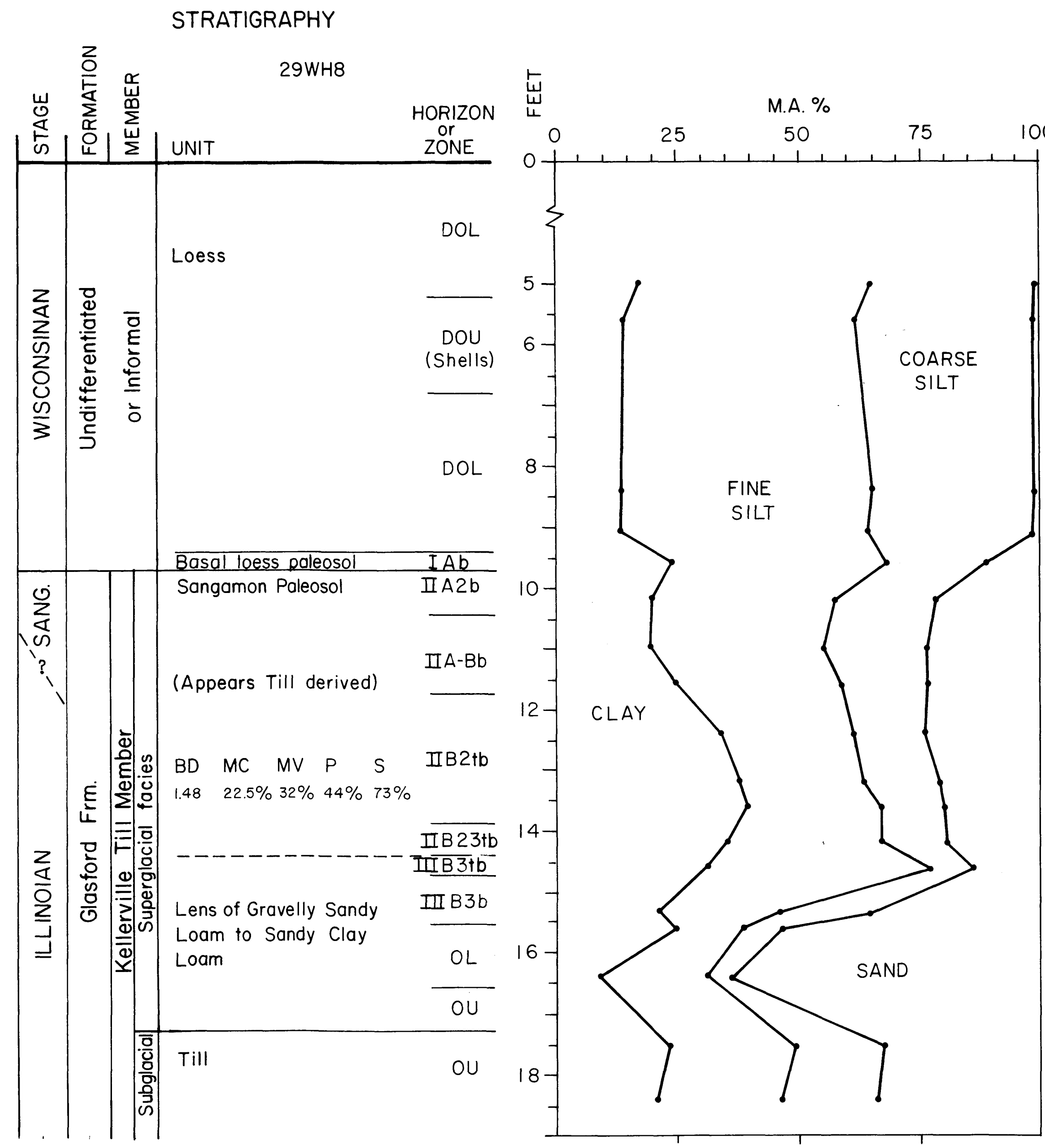


Figure 18. Stratigraphy and particle-size data, Core Site 29WH-8.

Cores 29WH-7 and -8 are located on the broad, relatively flat, upland divide northwest of Mediapolis. 29WH-7 (figure 19) was taken in a low position on the upland surface in the NE ¼, of the NE ¼, of the NE ¼, of the NW ¼, of sec. 22, T.72N., R.3W., Des Moines County; elevation approximately 777 feet. Core 29WH-8 (figure 18) was taken on a higher knob on the upland, just to the west of 29WH-7, located in the NW ¼, of the NE ¼, of the NW ¼, of the NW ¼, sec. 22; elevation 785 feet. Additional data in Appendix.

The elevation of both the present land surface and the Sangamon surface declines slightly in all directions from 29WH-8. In a low position to the north, Core Site 29WH-7 (figure 19) shows a Sangamon Paleosol developed on swale-fill sediments in a depression on the Kellerville Till surface. The data for 29WH-7 are incomplete because of coring problems, but later sampling shows that the paleosolum thickness is about 6.9 feet (2.1 m), and at least another 6 feet (1.8 m) of gleyed, leached sediments underlies the paleosolum. (These sections will be further discussed in Hallberg, et al., 1980).

The broad tabular divides, such as the Mediapolis flats, change into long and more narrow surfaces which gradually, but continuously slope toward the major streams which dissect the region. The paleosols encountered beneath the Wisconsinan loess on these divides have all been similar. They have all had the appearance of well or moderately well drained soils. In all instances they have also resembled the Late-Sangamon Paleosols in that the materials in which the paleosol developed consist of an upper unit of pebbleless loamy sediments (pedisediment?), which overlie the Kellerville Till Member. At times a stone-line is evident between the two materials. Examples of this variant of the Sangamon Paleosol are shown from core sites 29WH5 (figure 20), 29WH6 (figure 21), and 58H-3 from the Bjork Farm Transect (figure 22; see also figure 10; Description 5). The paleosurfaces upon which these paleosols developed are not analogous to the Late-Sangamon surface, however. The typical Late-Sangamon surface is a stepped erosion surface, or pediment, which is inset below the local divide (Ruhe, 1969; Hallberg, et al., 1978). The Sangamon Paleosols just described occur on gently sloping divide surfaces. The presence of the stone-line, the pedisediment, and the consistent presence of the well-drained paleosols all indicate that this is an eroded surface as well. However, these divide surfaces appear to gradually slope away from the remnant constructural surface of the broad Mediapolis flats area.

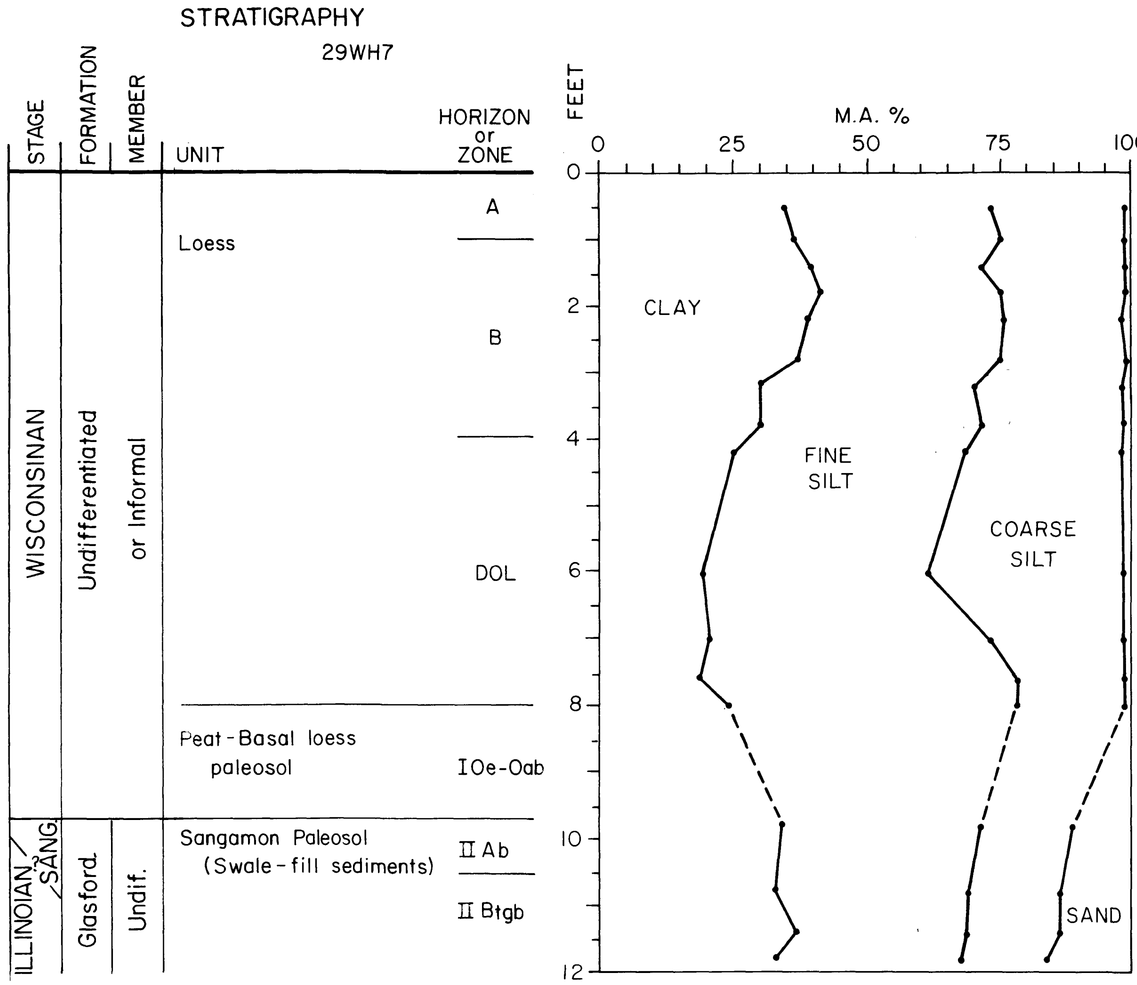


Figure 19. Stratigraphy and particle-size data, core site 29WH-7; see figure 18 for location; additional data in Appendix.

Another complexity in the Sangamon Paleosols and surfaces occurs along the interfluves which branch off from these narrower divides. In most areas the interfluves join these divides with a simple, gently rounded shoulder, and then slope away from the divide. Often there is no evident backslope between the surfaces, indicative of the stepped-erosion surface. The Sangamon Paleosols on these interfluves are very similar in all aspects to those described on the narrow divides. Core site 58H-1 (figure 11) is a good example of this type of Sangamon Paleosol on an interfluve. It can be compared with 58H-3 (figure 22) which occurs on the adjacent divide surface.

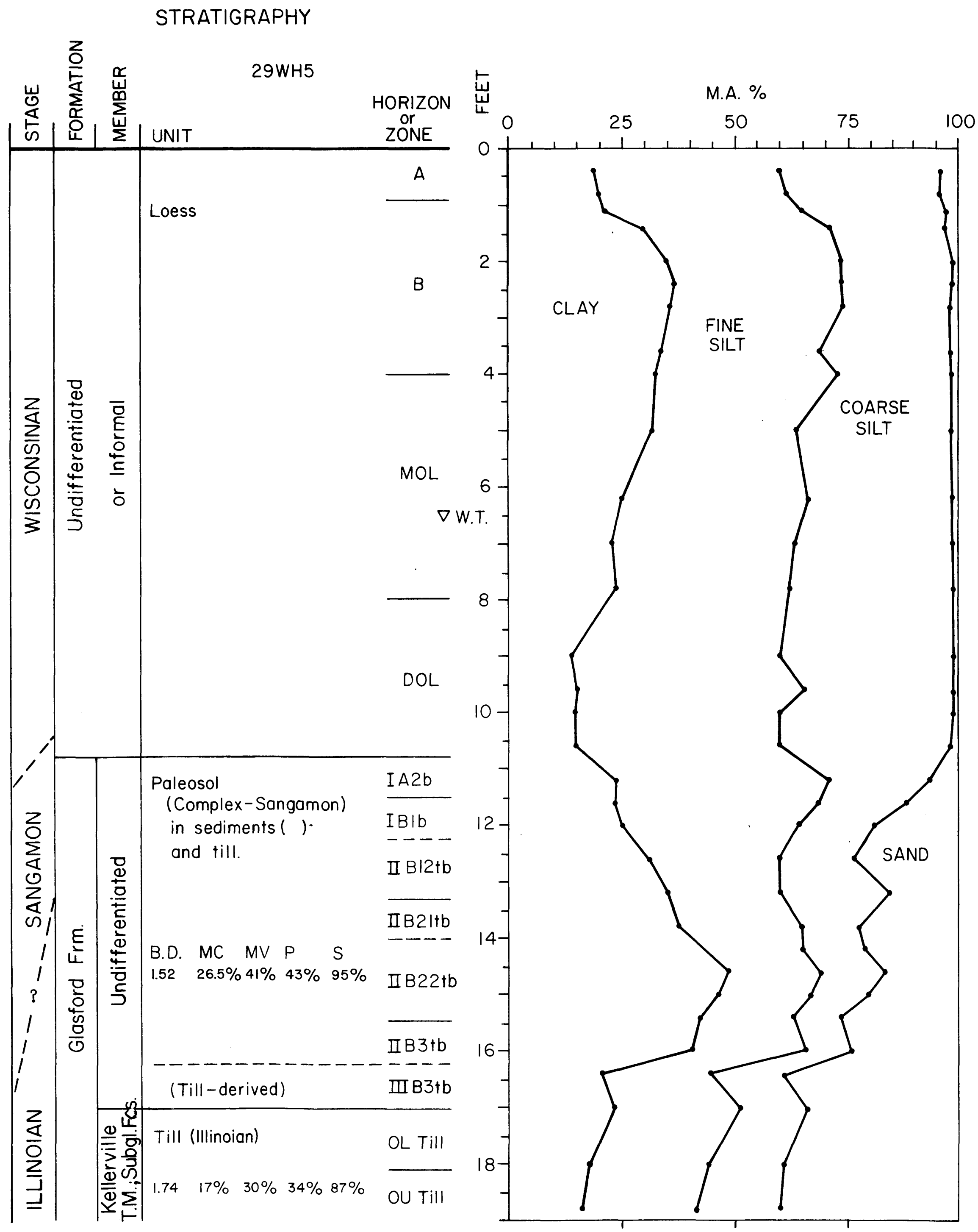


Figure 20. Stratigraphy and particle-size data core site 29WH-5. Core 29WH-5 was taken along the axis of the narrow upland divide surface, located in the SW ¼, of the SE ¼, of the NW ¼, of the SE ¼, of sec. 22, T.72N., R.2W., Des Moines County; elevation approximately 704 feet. Additional data in Appendix.

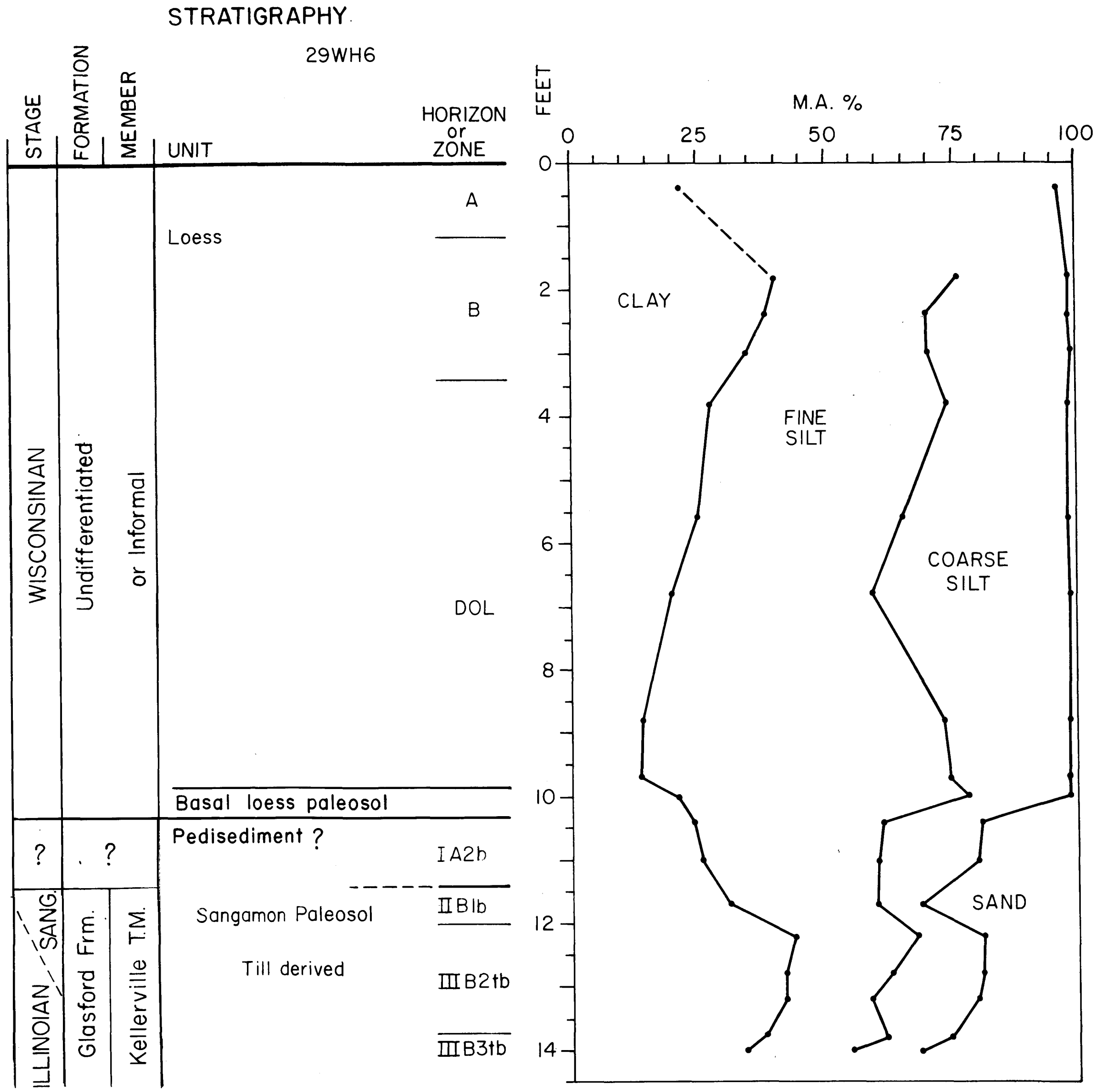


Figure 21. Stratigraphy and particle-size data core site 29WH-6. This site is located on the narrow upland divide surface, located in the NW ¼, of the NE ¼, of the NW ¼, of the NE ¼, of sec. 29, T.72N., R.2W., Des Moines County; elevation approximately 750 feet. Additional data in Appendix.

In some areas more typical Late-Sangamon surfaces and Paleosols are developed on the Kellerville Till Member. The stepped-erosion surface, or pediment morphology typical of the Late-Sangamon surface tends to be well developed in two settings: (1) in highly dissected areas near the major streams (the Baltimore Section is one example, figure 16); and (2) in areas where

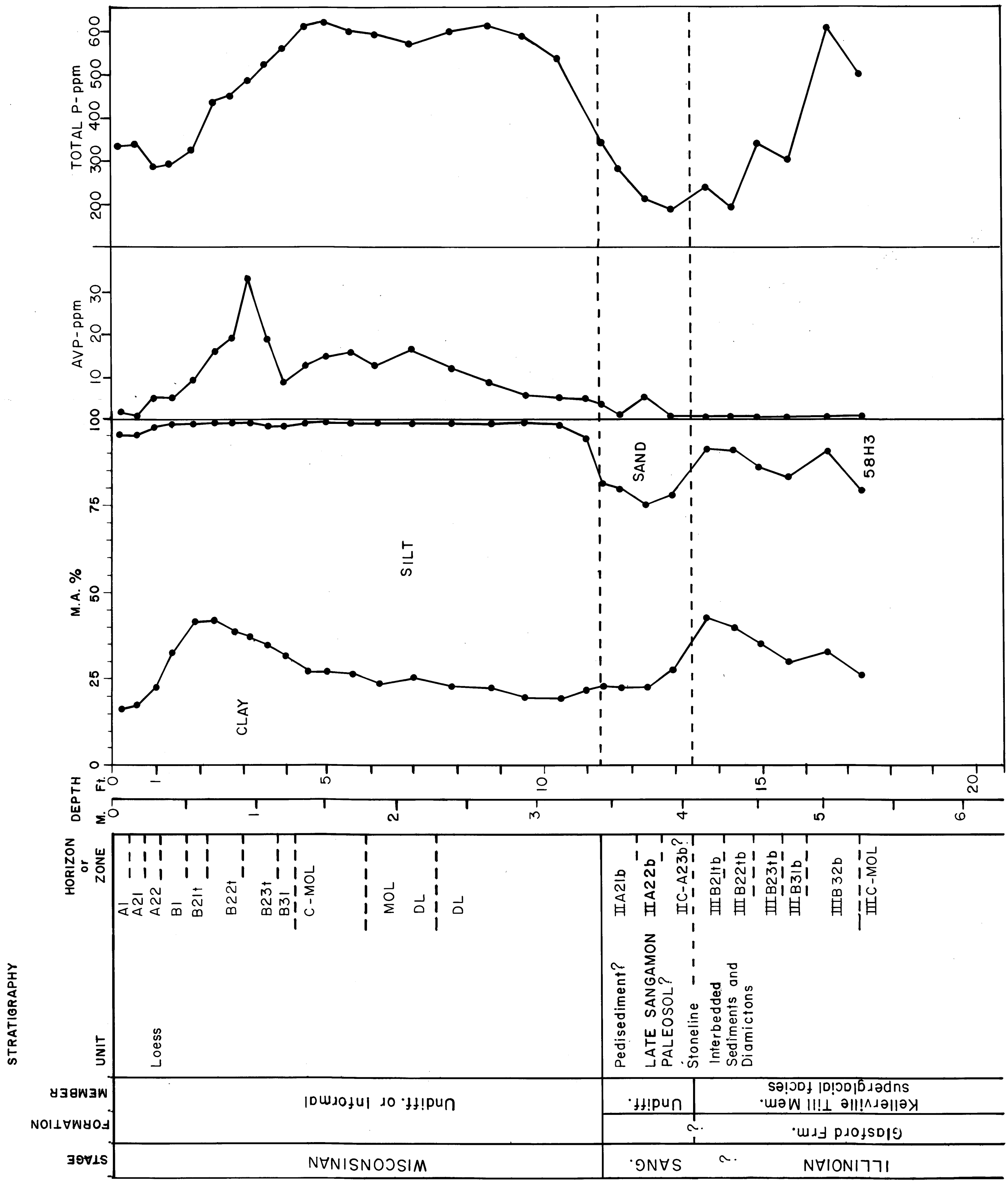


Figure 22. Stratigraphy, particle-size, and phorphorus data for core site 58H-3, Bjork Farm Transect (Description 5).

the superglacial facies is thin or absent, and the erosion surface is cut into the basal till facies (site 29WH-9, figure 23, and the area around the Nelson Quarry Section, Description 4, are good examples).

Other variations of the Sangamon and Late-Sangamon Paleosol also occur. In places the paleosols descend onto terrace surfaces and fluvial deposits inset within or in front of the Illinoian age tills (see 58EH-1, in Appendix).

The relationships of the landscapes and paleosols developed on the Kellerville Till Member suggest two ideas of note that should be analyzed by subsequent work. First, it would seem that drainage development, dissection and modification of the Kellerville Till plain may have taken place relatively quickly after deposition. The only remnants of the constructional till surface seem to be on tabular divides such as Mediapolis flats where buried swell-and-swale Sangamon Paleosols occur. In large part the area is dominated by the narrow, long sloping divides, and rounded interfluves. The Sangamon (or Late-Sangamon?) Paleosols on these surfaces are all very similar, and are also quite similar to the well-drained Sangamon Paleosols on the tabular divides. These paleosols are nearly identical in terms of their morphology, paleosolum thickness, maximum clay content in the B-horizon, A/B clay content ratios, and similar depth of leaching. This all suggests a similar relative age. Where more typical Late-Sangamon surfaces and paleosols have been analyzed, they are also quite similar, though the paleosolum thickness has been slightly less (4-5 feet, vs. 5-6 feet). Also, all of these sloping surfaces are graded toward the present major streams. Second, it seems possible that the more gently rounded nature to the divide and interfluve surfaces may be related to the presence of the superglacial facies of the Kellerville Till Member. As noted, the areas where more typical stepped-erosion surface hillslope morphology occur are in areas where the basal till facies dominates. Is it possible that the more loose stratified materials of the superglacial facies are part of the cause of the more gently rounded landscape in this area? These questions will have to be addressed by future work.

Description 7. Site 29WH-9; located in the west end of road cut along north side of the dirt road, in the very southwest corner of sec. 14, T. 71N., R. 4W. Abbreviated description of Late Sangamon soil on Illinoian till, on stepped erosion surface. (Loess thickness approximately 8.5 feet on summit; section described where cleanface was available. Elevation approximately 700 feet.

Depth-inches (cm)	Horizon or Zone	Description
		WISCONSINAN Loess
0 - 28 (0-71)		Severely eroded soil on Wisconsinan loess
		LATE SANGAMON Pedisediment
		LATE SANGAMON PALEOSOL
28 - 44 (71-112)	IA2b IB1b	Brown (10YR 4/3), light loam; moderate thin platy structure grading to weak fine subangular blocky with depth; grainy coats; leached pedisediment.
44 - 45 (112-114)		Stone line
		GLASFORD FORMATION - Kellerville Till Member
		Subglacial facies; basal till
45 - 55 (114-140)	IIB1b	Dark brown (7.5YR 4/4) clay loam; moderate medium subangular blocky structure; leached Illinoian till.
55 - 85 (140-216)	IIB2tb IIB3tb	Yellowish brown and strong brown (10YR and 7.5YR 5/8) clay and clay loam; dark brown coatings (7.5YR 4/3), abundant manganese stains and clay films; strong to moderate medium angular blocky, leached Illinoian till.
85 - 146 (216-371)	IIC OL	Dark yellowish brown (10YR 4/6) loam (some sandy loam); massive, jointed; leached Illinoian till.
146 - 168 (371-427)	OU	Yellowish brown (10YR 5/6); loam; unleached Illinoian till.

Distribution of the Illinoian Deposits

The distribution of the early Illinoian Kellerville Till Member was mapped through the study area as well. Figure 1 shows the stratigraphic sections, the surficial till deposit at each section, and the mapped limits of the Kellerville Till Member. The boundary of the Kellerville is based on the analysis of the stratigraphic data, and extrapolated by the detailed mapping (in the field and on 7.5 minute topographic maps) of the prominent ridge which forms the terminus of the Illinoian deposits, as first surmised by Leverett (1898). As noted by Hallberg and Baker (this volume) minor amounts of Illinoian deposits occur

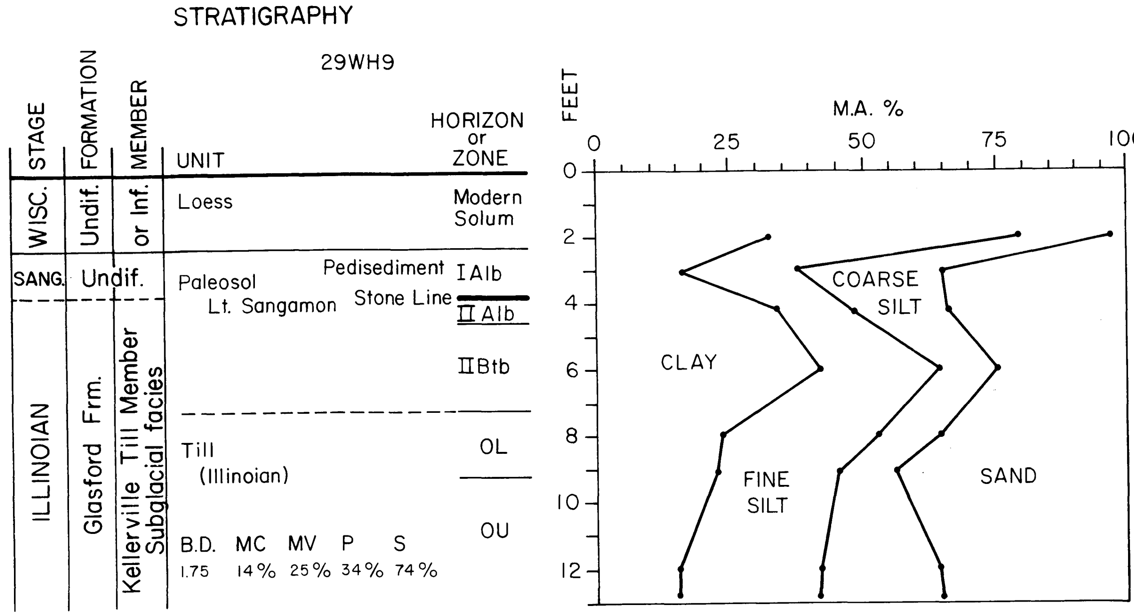


Figure 23. Stratigraphy and particle-size data section 29WH-9 (see Description 7).

just in front of the ridge.

The mapping of the terminus, although more detailed, generally conforms to previous maps (Kay and Graham, 1943; Ruhe, 1969). The only significant difference occurs in the northern portion of the study area, in Louisa County south of the Iowa River. Previous work (Schoewe, 1920) had suggested that the Illinoian terminus went more to the north to Columbus Junction. However, the prominent terminal ridge veers to the northeast as shown. Analysis of the surficial tills supports this interpretation. Data from this study and ongoing work (by Tom Bicki, Steve Esling, Jerry Nott, and the senior author) show that no Illinoian till exists in the Columbus Junction area.

OTHER ASPECTS OF THE GEOMORPHOLOGY IN THE STUDY AREA

The broad tabular divides, such as the Mediapolis flats area, are also found beyond the limits of the Illinoian deposits. To the northwest of Yarmouth, in the Mt. Union area, another tabular divide exists in the area of Pre-Illinoian deposits. Such divides occur in various areas in southern Iowa, and have been noted before (Kay and Apfel, 1928).

These divides are unique and contrast with the more highly dissected landscape present in much of southern Iowa. The reason for their occurrence is likely related to bedrock controls. Nearly all the streams which drain these tabular divides encounter resistant bedrock units in their valleys. It seems likely that this has inhibited the streams from eroding back into and dissecting these divides.

As a consequence of this the Late-Sangamon erosion surfaces are not as widespread or as well-developed as in other parts of southern Iowa (Ruhe, 1967; 1969). The Late-Wisconsinan or Iowan erosion surface is also not as extensively developed, as it is in most of southern Iowa (Hallberg, et al., 1978; Ruhe, 1967). In southeast Iowa it occurs in isolated areas on small interfluves (such as site 58H-4; figure 11). It is somewhat more prevalent along the major streams such as the Mississippi and Skunk Rivers in particular.

SUMMARY

The Pleistocene Stratigraphy of southeast Iowa was investigated as a part of on going stratigraphic and engineering-geologic investigations. Analysis of the materials and stratigraphy was done from drill-cores and exposures which penetrated the entire Pleistocene sequence. The deposits in the area are formally subdivided into three formations: the Alburnett and Wolf Creek Formations of Pre-Illinoian age, and the Glasford Formation of Illinoian age. The Pre-Illinoian tills are "western derived," deposited by glaciers which moved through Iowa. The Illinoian age till is "eastern-derived," deposited by Lake Michigan lobe ice which moved through Illinois into Iowa. The differences in provenance produced differences in physical and mineralogic properties which permit differentiation of the deposits. The till deposits in the formations are recognized and correlated by their physical stratigraphy, pebble lithologies, and by the quantitative characterization of their particle-size, sand-fraction lithologies, clay mineralogy, and matrix carbonates.

The Alburnett and Wolf Creek Formations can be recognized based on distinct differences in clay mineralogy. Both formations are composed principally of basal tills and inter-till stratified sediments.

The Alburnett Formation till was only recognized from a few localities: in the deepest cores, where the Alburnett till rested on bedrock; and in a few outcrops near the Mississippi River where stream dissection has been deep enough to expose these deposits. Only one till of the Alburnett Formation was noted at any locality in this study.

The Wolf Creek Formation is subdivided into the Winthrop, Aurora, and Hickory Hills Till Members based on physical stratigraphy and differences in particle-size, matrix carbonate content, and sand-fraction lithology. The stratigraphic relations and the physical and mineralogical properties of the till members are essentially identical to their properties in their type areas in east-central Iowa.

Soil-stratigraphic units are also associated with the Wolf Creek Formation. The Franklin Paleosol (defined in this report) occurs below the Aurora Till Member, and is developed in undifferentiated sediments and the underlying Winthrop Till Member. The Dysart Paleosol, which occurs below the Hickory Hills Till Member, was also recognized in the area developed in the Aurora Till Member and/or overlying sediments. The Yarmouth Paleosol occurs below the base of the Illinoian age deposits of the Glasford Formation. In its type area, and throughout the study area, the Yarmouth Paleosol is developed in unnamed fine-textured sediments and the underlying Hickory Hills Till Member. In this stratigraphic setting these sediments are included in the Wolf Creek Formation beacuse they are clearly defined, in space and in time, by the overlying Kellerville Till Member. Beyond the limits of the Illinoian deposits the Yarmouth and Sangamon Paleosols and surfaces merge into the Pre-Illinoian till plain of southern Iowa. In this area the Yarmouth-Sangamon and Late-Sangamon Paleosols are developed in undifferentiated sediments and in the underlying Wolf Creek Formation deposits. In this setting these sediments are not presently included in the Wolf Creek Formation because of the uncertaintly of their temporal relations.

The Glasford Formation is represented in southeast Iowa by the Kellerville Till Member and some related sediments. The Kellerville Till Member is the oldest till of Illinoian age and overlies the Yarmouth Paleosol. The Kellerville Till Member can be readily separated from the Pre-Illinoian tills by: (1) its relatively high illite and moderate expandable clay mineral content; (2) its high dolomite content; and (3) the abundance of Pennsylvanian lithologies in the coarse particle sizes. The Kellerville exhibits matrix carbonate C/D ratios less than 0.40, whereas 95% of all the Wolf Creek and Alburnett Formation till samples have C/D ratios greater than 0.40. Mazon Creek-style Pennsylvanian age fossils have been identified as cobbles in the Kellerville Till. These fossils are only known from central Illinois.

The Kellerville Till Member in southeast Iowa is subdivided into a superglacial and subglacial - or basal till facies. This subdivision is based on the stratigraphic relations, sedimentological properties, and the consistency-density-consolidation properties of the deposits. The basal till facies is comprised of firm, dense, overconsolidated till which is relatively uniform in texture. The superglacial facies is comprised of a wide variety of sediments including: (1) till -- which varies in texture, density and consolidation properties, but generally tends to be friable to soft; (2) diamictons -- poorly sorted "till-like" deposits but which exhibit structures and sedimentological variations analogous to superglacial mudflows; (3) a variety of sorted sediments -- fluvial silts, sands and gravel, and lacustrine or paludal deposits -- clays, silts, peats, etc. In some sections these deposits are clearly interbedded but in others they occur as a contorted melange of sediments.

The Sangamon Paleosol is developed in the top of the Kellerville Till Member and/or in sediments which overlie the Kellerville Till Member. Remnants of the modified Kellerville depositional surface remain on the broad tabular divides. Elsewhere the Sangamon (or Late-Sangamon) Paleosol occurs on a more eroded landscape.

The buried tabular divides in the areas of both the Illinoian and Pre-Illinoian deposits occur because they are bedrock-defended. Most of the streams which drain these divides encounter bedrock, which apparently has inhibited the dissection of these areas, in contrast to other regions in southern Iowa.

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APPENDIX:

Additional Stratigraphic Sections

and Laboratory Data

Index to Appendix

Description 8. Kingston Section; slumped road cut on west side state highway 99, just north of Kingston, along the bluffs of the Mississippi valley. Located in the SE¼, of the NW¼, of the SE¼, of the NW¼ of sec. 1, T 71N, R 2W, Des Moines County; elevation approximately 590 feet.

Depth-feet (meters)	Horizon or Zone	Description
		Section 1: North end of exposure
		WOLF CREEK FORMATION - Aurora Till Member
0 - 9.5 (0.0-2.9)	OJU	Yellowish brown (10YR5/6) firm loam till; with oxidized and reduced joints. Abrupt lower contact.
		ALBURNETT FORMATION - Undifferentiated till.
9.5 - 12.0 (2.9-3.7)	UJU	Gray (5Y5/1) very firm loam till; minor mottling and jointing in upper part; 1 to 2 in (2.5-5cm) iron-oxide segregation at abrupt upper contact.
12.0 - 22.0 (3.7-6.7)	UU	As above, but few joints or mottles.

To the south in the exposure the two tills become separated by a variable thickness of oxidized and unleached silts (sample A), sands, or sands and gravels (sample B). The lower till of the Alburnett Formation is oxidized in its upper 3 feet (sample C)where overlain by these sorted sediments. In this area of the exposure the Aurora Till has many inclusions of these stratified sediments in its lower portion (sample D).

Table 20. Laboratory data, Kingston Section.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX. - % -	ILL.	K+C	H.S.I.	D.I.	D. cps	C.	C/D	Sand-Fraction Lithology T.C. - % -	Sh.	Sed.	Q.F.	T.X.	Notes	Matrix CO_3 Ca - % -	Do	T.C.	C/D	Particle Size Clay - % -	Silt	Sand
WOLF CREEK FORMATION - Aurora Till Member																							
OJU	5.0	1185	56	21	23					1.4	27	1	28	69	72	*					21.8	45.1	33.1
OJU	* 5.0	ILL.	49	25	26 *											*	6.6	7.5	14.1	0.88 *			
OJU	7.0	1189	55	23	22					4.7	26	2	28	71	72						22.2	43.0	34.8
OJU	* 7.0	ILL.	50	24	26 *											*	7.2	7.2	14.4	1.0 *			
OJU	* 9.3	ILL.	53	22	25 *											*	6.0	9.6	15.6	0.63 *			
OJU	9.3	1190	56	19	25					4.0	30	-	30	65	70						22.1	44.2	33.7
- Stratified sediments and till with sheared inclusions.																							
OU Till	(D)	1187	54	21	25																16.7	33.0	50.3
OU Silts	(A)	1194	50	19	31																4.8	77.3	17.9
OU S and G	(B)	1188	39	20	41					1.1	28	2	30	62	70						3.8	2.8	93.4
ALBURNETT FORMATION - Undifferentiated till																							
OU	(C)	1191	54	19	27																17.6	40.3	42.1
UJU	9.7	1192	51	23	26					3.5	14	1	15	60	85						18.0	42.3	39.7
	* 9.7	ILL.	43	27	30 *											*	6.5	8.2	14.7	0.79 *			
UJU	11.0	1186	39	24	37					2.8	16	3	19	52	81						17.8	38.9	43.3
	* 11.0	ILL.	39	26	31 *											*	4.8	5.5	10.3	0.87 *			
UU	15.0	1193	49	21	30					3.0	13	3	16	74	84						19.7	37.7	42.6
UU	18.0	1196	39	26	35																19.3	38.7	42.0

* Analyses by the Illinois State Geological Survey; Clay min.-H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.

Table 21. Laboratory data and abbreviated description, West Lake Section, Des Moines County.

Stratigraphy:		Depth-ft. (meters)	Sample Data: Depth (feet)	Clay Mineralogy-% EX.	ILL.	K+C	D	C	Particle Size-% Clay	Silt	Sand	Matrix CO_3-% C	D	TC	C/D	Sand-fraction Lithology-% C/D	TC	Sh	Sed	Qf	TX	Notes
Site: West Lake Section; large road cut, along creek and west side U.S. Hwy. 61 relocation.																						
Location: SW¼, of NE¼, of NE¼, of NE¼, sec. 25, T.70N., R.3W., Des Moines County.																						
Elevation: 625 feet																						
GLASFORD FORMATION																						
Kellerville Till Member	OU	0 -25	* 5*	51	29	20			* 28	40	32	2.9	5.7	8.6	0.51	*ILL.						
(basal till?)		(0 - 7.6)	8	52	29	19			20.2	42.4	37.4					NoD	30	5	38	53	62	
Coal and Pennsylvanian	MJRU	25 -35	*10*	56	26	18			* 27	40	33	1.1	2.2	3.3	0.50	*ILL.						
lithologies common throughout		(7.6-10.7)	*15*	53	29	18			* 28	43	29	4.5	9.1	13.6	0.49	*ILL.						
(Loess and Sangamon paleosol	MJUU	35 -55	*20*	61	22	17			* 34	38	28	5.9	9.4	15.3	0.63							
occur above cut in hillslope.)		(10.7-16.8)	22	42	40	18		C	20.1	44.3	35.6	2.9	15.2	18.1	0.19	0.8	32	11	48	49	52	Coal
			25	43	39	18			* 28	45	27	4.1	10.6	14.7	0.39	*ILL.						
			30	56	24	20			29	40	31	3.8	9.4	13.2	0.40	*ILL.						
			33	47	35	18			22.8	41.4	35.8	3.5	11.9	15.4	0.29	3.1	36	9	48	50	52	Coal, Pyrite
			35	53	28	19			* 26	43	31	4.5	8.9	13.4	0.51	*ILL.						
			40	52	26	22			* 28	42	30					*ILL.						
			45	49	31	20			21.9	41.9	36.2					1.3	38	5	44	55	56	Coal
			45	47	30	23		C														

* Analyses by Illinois State Geological Survey; clay min. - H.D. Glass; Matrix carbonates of <0.074 mm fraction, J.T. Wickham; Particle-size by hydrometer, clay as < 0.004 mm.

C - Chlorite peaks apparent.

Table 22. Laboratory data from additional core sites, Des Moines County.

Sample			Clay Mineralogy								Sand-Fraction Lithology							Matrix CO_3			Particle Size		
Horizon or Zone	Depth (feet)	I.D.	EX. - % -	ILL.	K+C	H.S.I.	D.I.	D. cps	C.	C/D	T.C.	Sh. - % -	Sed.	Q.F.	T.X.	Notes	Ca	Do - % -	T.C.	C/D	Clay	Silt - % -	Sand
CORE - 29 WH-5																							
WISCONSINAN Loess																							
B3	3.5	2056	69	24	7	19	2.17														See figure 20		
MOL	7.8	2051	69	24	7	24	2.30														for other data.		
DOL	9.0	2050	60	30	10	21	1.92	t															
DOL	9.7	2053	65	26	9	21	1.92	t															
DOL	10.7	2054	54	31	15	18	1.40	t															
GLASFORD FORMATION - Undifferentiated sediments.																							
SANGAMON PALEOSOL																							
IIB21tb	13.9	2061	U1	U1	U1	3.1	0.55																
IIB22tb	15.0	2058	U1	U1	U1	2.8	0.96																
GLASFORD FORMATION - Kellerville Till Member																							
IIIB3tb	16.3	2052	U1	U1	U1	3.5	1.72	t															
OU	* 18.2	ILL.	39	45	16 C											*	3.6	8.6	12.2	0.42			
OU	18.4	2055	30	48	22 C	5.0	1.43	t	t	0.8	39	2	44	49	56								
OU	18.6	1543	33	41	25 C	7.0	1.0	30	40								2.4	16.1	18.5	0.15	17.6	44.3	38.1
OU	19.0	1544	43	35	22	8.0	0.94	30	t												16.3	44.2	39.5
CORE - 29 WH-6																							
WISCONSINAN Loess - Basal loess paleosol																							
IA2b	10.5	2064	(50)	(28)	(22)	5.2	0.83																
IA2b	11.0	2063	(32)	(39)	(29)	2.2	0.90																

Table 22 con't.

GLASFORD FORMATION - Kellerville Till Member

SANGAMON PALEOSOL

IIB1b	11.7	2072	(30)	(42)	(28)		4.5	1.01		
IIB2tb	12.4	2073	U1	U1	U1		1.5	1.10		

CORE - 29 WH-7

GLASFORD FORMATION - Undifferentiated sediments

SANGAMON PALEOSOL

IIAb	10.4	2065	(31)	(41)	(28)		4.5	1.00		

CORE - 29 WH-8

WISCONSINAN LOESS

DOU	6.0	2067	63	31	6		29.0	3.33	t	

GLASFORD FORMATION - Kellerville Till Member; SANGAMON PALEOSOL in upper portion.

IIABb	11.3	2057	U2	U2	U2		10.5	U2	-	t
IIB2tb	12.7	2066	(38)	(39)	(23)		6.1	1.10		
OL	* 15.8	ILL.	50	32	18					

- Subglacial facies; basal till.

OU	18.1	2071	29	45	26	C	6.5	1.18	t	t
OU	18.5	2074	48	32	20		9.0	0.98	40	t

CORE - 29 WH-9

GLASFORD FORMATION - Kellerville Till Member; subglacial facies; basal till. Late Sangamon Paleosol developed in upper part.

IIB3tb	7.0	2075	53	28	19		NC	NC	NC	NC						23.0	32.4	44.6
OL	9.0	2078	53	27	20						*	5.9	9.9	15.8	0.60			
OU	* 9.8	ILL.	58	21	21											20.0	46.0	34.0
OU	10.0	2076	49	31	20											21.1	43.6	35.3
OU	11.0	2077	43	35	22							2.4	12.0	14.4	0.20	20.3	43.8	35.9
OU	12.0	2079	47	34	19	C												

* Analyses by the Illinois State Geological Survey; Clay min.-H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.

U - Clay mineralogy uncalculable because of weathering effects.
1. Broad diffuse expandable peak
2. No illite peak apparent.
(31) % clay mineral calculated from weathered sample for discussion purposes.

C - Chlorite peaks apparent.

t - trace

NC - not calculated

Table 23. Additional sections in Des Moines County.

Stratigraphy:		Depth-ft.	Sample Data: Depth (feet)	Clay Mineralogy-% EX.	Ill.	K+C	D	C	Particle Size-% Clay	Silt	Sand	Matrix CO_3-% C	D	TC	C/D	Sand-fraction Lithology-% C/D	TC	Sh	Sed	Qf	Tx	Notes
Site: 29-4-75 (JTW-34-78); ditch cut along gravel road.																						
Location: NE¼, of NW¼, of SE¼, sec. 4, T.70N., R.3W., Des Moines County.																						
Elevation: 650 feet																						
GLASFORD FORMATION																						
Kellerville Till Member	OU	0 - 4	2	49	35	16		NC	21.1	46.7	32.2					1.2	33	9	46	47	54	Coal
			* 2	50	33	17		* ILL.														
Site: 29-WH-34; grab sample from borrow area, for relocation of U.S. 34.																						
Location: SW¼, of SE¼, of NE¼, of NW¼, of sec. 34, T.20N., R.3W., Des Moines County.																						
Elevation: 690 feet			GLASFORD FORMATION - Kellerville Till Member - basal till.																			
GLASFORD FORMATION			2	48	32	20			19.1	48.3	32.6											
Kellerville Till Member,			4	42	34	24			21.2	44.5	34.3											
basal till facies			6	42	38	20			20.9	44.8	34.3					1.6	26	14	43	51	57	Coal
uniform firm till	UU	0 - 6																				
Site: 29-76-1; roadcut on northwest side of gravel road.																						
Location: NE¼, of SW¼, of SE¼, of SW¼, sec. 1, T.71N., R.3W., Des Moines County.																						
Elevation: 730 feet																						
Wisconsinan loess	OL	0 - 1.2	GLASFORD FORMATION - Kellerville Till Member																			
SANGAMON PALEOSOL	Bb	1.2- 4.1	2.0						35.6	42.4	22.0											
GLASFORD FORMATION			5.0	55	24	21			24.7	40.3	35.0											
Kellerville Till Member			8.0	50	31	19			20.2	45.7	34.1					0.7	40	1	43	49	57	
(Pennsylvanian lithologies	OL	4.1- 5.8	12.0	50	30	20			19.4	43.9	36.7											
in pebble fraction)	OU	5.8-15																				
Site: 29-76-36; stream cut.																						
Location: NW¼, of NE¼, of SW¼, of SE¼, of sec. 36, T.71N., R.3W., Des Moines County.																						
Elevation: 640 feet																						
WOLF CREEK FORMATION			WOLF CREEK FORMATION - Aurora Till Member																			
Aurora Till Member	OU	0 - 6	2.0	63	20	17			24.5	41.0	34.5					1.1	21	10	31	48	69	Coal
			6.0	65	17	18			22.5	43.2	34.3											

Table 23 con't.

Site: 29-77-425-53; Core on sideslope of upland.
Location: 700 feet N, and 65 feet W, of SW corner, sec. 24, T.71N., R.4W., Des Moines County.
Elevation: 680 feet

			GLASFORD FORMATION - Kellerville Till Member							
Exhumed SANGAMON PALEOSOL		0 - 4.7	4.8					24.2	38.7	37.1
GLASFORD FORMATION Kellerville Till Mem.	MOL	4.7- 8.2	8.0	49	31	20		21.4	40.3	38.3

Site: Beck Farm Section; in excavation for sewage lagoon.
Location: SE¼, of SE¼, of SW¼, of SE¼, sec. 22, T.70N., R.4W., Des Moines County.
Elevation: 715 feet

Wisconsinan loess	DOL	0 - 7.5	GLASFORD FORMATION - Kellerville Till Member; note abundant coal and Pennsylvanian lithologies in pebble fraction.													
Wisconsinan peat	IOeb	7.5- 8.6														
SANGAMON PALEOSOL	Btgb	8.6-12.5					Basal till Facies									
GLASFORD FORMATION																
Kellerville Till Mem. Superglacial facies Till, sands and gravel, diamicton	OL	12.5-15.8	18.3	53	33	14	NC	18.1	45.0	36.9	1.1	24	9	35	59	65 Coal
	OU	15.8-16.6	24.0	48	32	20	NC	22.4	44.9	32.7	2.8	30	4	34	59	66
Basal Till facies uniform, firm, jointed till (lower 3 ft. with inclusions of underlying material.)	JOU	16.6-26.0														
YARMOUTH PALEOSOL in WOLF CREEK FORMATION Undiff. seds.	Btgb	24.7-26.0														

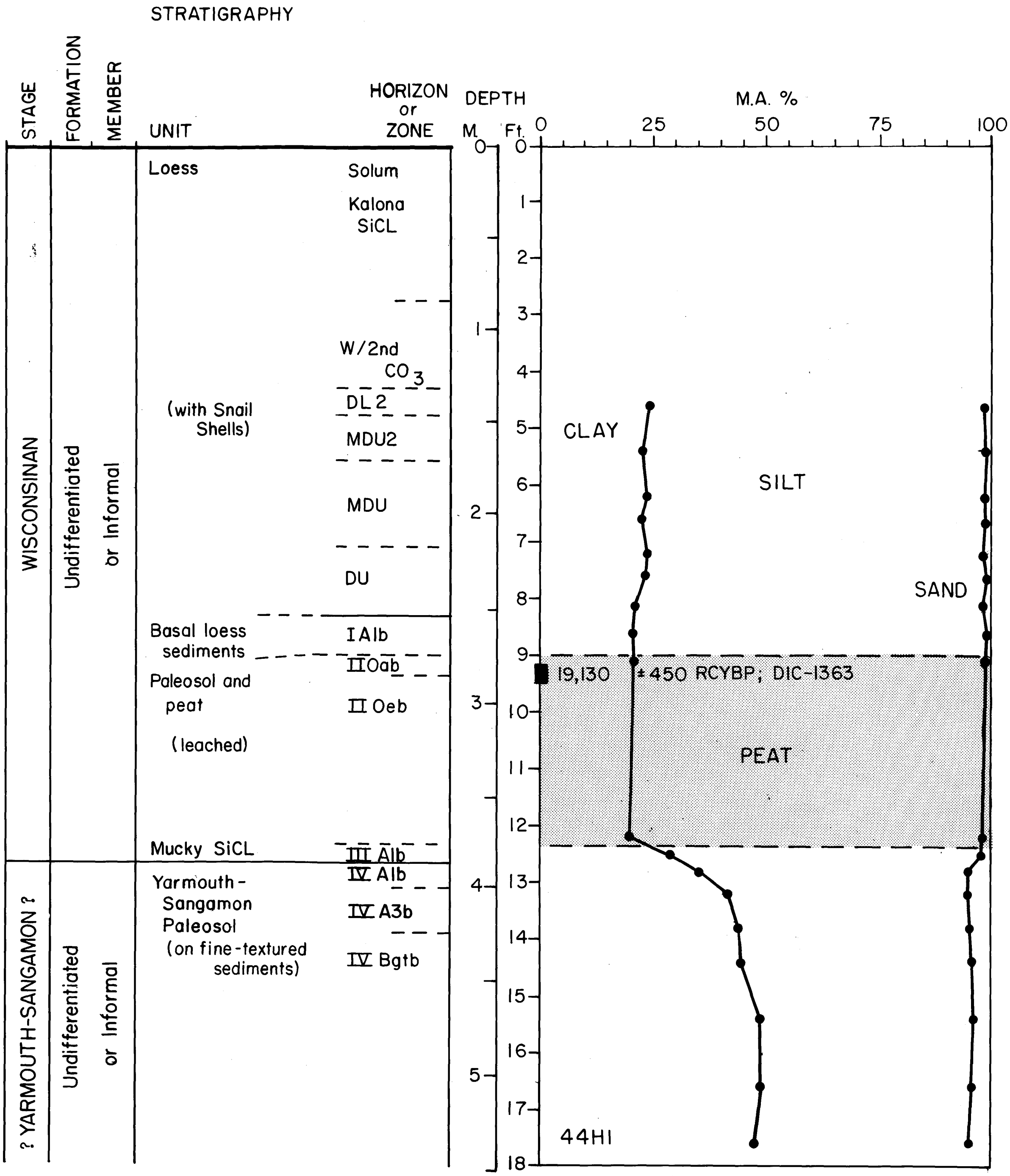

Figure 24. Stratigraphy and particle-size data Core Site 44 H-1. The site is located on the broad, flat upland divide in the NE¼, of the NW¼, of the NE¼, of sec. 13, T 72N, R 5W, Henry County. It is on the Steven's Farm, behind the machine shed, 535 feet (163 m) south of the center line of the gravel road. The elevation is approximately 739 feet.

Table 24. Clay mineralogy for core site 44 H-1.

Depth (feet)	Horizon or Zone	EX.	ILL. - % -	K+C
WISCONSINAN Loess				
6.3	MDU	68	18	14
7.0	MDU	78	15	7
7.6	DU	79	14	7
8.2	DU	78	12	10
	Basal loess sediments and paleosol			
8.7	IA1b	78	10	12
		Vermiculite peak apparent.		
YARMOUTH-SANGAMON PALEOSOL in fine-textured sediments.				
13.2	IVA3b	Broad expandable peak; trace vermiculite; obscure illite peak.		
13.7	IVA3b	Broad expandable peak; no illite apparent.		
15.4	IVB2tgb	Broad expandable peak; no illite apparent.		
16.7	IVB2tgb	No illite apparent.		

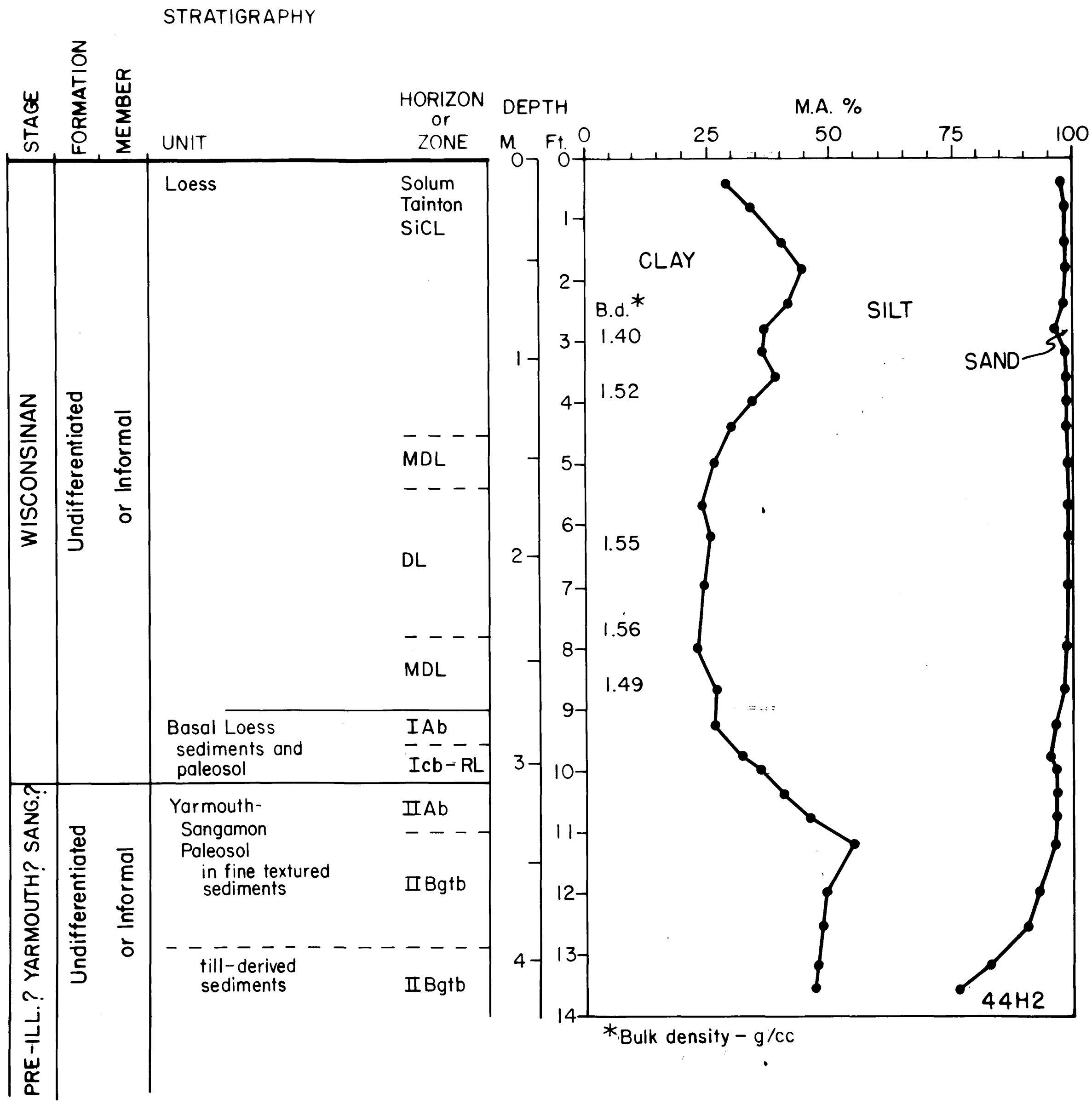

Figure 25. Stratigraphy and particle-size data, Core Site 44 H-2 The site is located on the broad, flat upland divide in the SE¼ of the SE¼ of the SE¼, of sec. 16, T 72N, R 5W, Henry County. It is 50 feet (15 m) north of the center line of the dirt road, in the SE corner of of the corn field. The elevation is approximately 733 feet.

Description 9. Schroder Section; in excavation for large pond on the Schroder Tree Farm, located in the SE¼ of the SE¼, of the NE¼, of sec. 4, T 70N, R 5W, Henry County; elevation 735 feet. Abbreviated description of section.

Depth-feet (meters)	Horizon or Zone	Description
		WISCONSINAN LOESS
0 - 6 (0 - 1.8)	DOL	Loess
		GLASFORD FORMATION - Kellerville Till Member
		SANGAMON PALEOSOL in upper part
6 - 11.2 (1.8-3.4)	Bb	Sangamon Paleosol in silty till or silty diamicton.
11.2 - 16.2 (3.4-4.9)	MOL-MRL	Silt loam till; some small inclusions of stratified materials; leached.
16.2 - 20.2 (4.9-6.2)	MOU-MRU	As above, no obvious inclusions; calcareous.
20.2 - 37.0 (6.2-11.3)	MRU-RJU	As above, more prominent joints lower in section.
		GLASFORD FORMATION - Undifferentiated sediments
		Early ("Pro") ILLINOIAN PEAT
37.0 - 39.0 (11.3-11.9)	IOeb	Peat, and mucky silt loam, common wood fragments, spruce undiff.
		WOLF CREEK FORMATION - Undifferentiated sediments
		YARMOUTH PALEOSOL
39.0 - 48.0 (11.9-14.6)	IIBtgb	Yarmouth Paleosol on fine-textured sediments and till.
		Hickory Hills Till Member
48.0+ (14.6+)	MRL	Loam till.

Table 25. Additional laboratory data for Schroder Section (44-55).

Depth	Clay Mineralogy EX.	ILL. - % -	K+C	Particle Size Clay	Silt - % -	Sand	Matrix Carbonate Ca	Do - % -	TC	C/D	Sand-fraction Lithologies C/D	T.C.	Sh.	T.S.	Q.-F.	T.X.
All Miscellaneous MRU-MRJU Kellerville Till samples	39	43	18	28.2	46.3	25.5	1.6	8.0	9.6	0.20						
	44	34	22	26.6	48.6	24.8	2.6	8.9	11.5	0.29						
				24.8	49.9	25.3	2.2	11.3	13.5	0.19						
	53	27	20	22.4	53.0	24.6	2.5	12.5	15.0	0.20	1.7	41	9	54	39	46
	46	31	24	20.2	50.5	29.3	2.5	15.2	17.7	0.16						
	37	34	29	32.0	44.4	23.6										

Table 26. Additional sections in Henry County.

Stratigraphy:		Depth-ft.	Sample Data: Depth (feet)	Clay Mineralogy-% EX.	Ill.	K+C	D	C	Particle Size-% Clay	Silt	Sand	Matrix CO_3-% C	D	TC	C/D	Sand-fraction Lithology-% C/D	TC	Sh	Sed	Qf	Tx	Notes
Site: 44 W-77-1; from road ditch, N. side U.S. 34. Location: NE¼, of SW¼, of NW¼, of NE¼, sec. 27, T.71N., R.5W., Henry County. Elevation: 765 feet																						
			GLASFORD FORMATION - Kellerville Till Member																			
In ditch: Wisconsinan loess	MOL	0 - 3																				
Sangamon Paleosol in GLASFORD FRM. Kellerville Till Mem.	Bb	3 - 6.5	12.0	42	32	26	C	NC	15.9	52.2	31.9					0.50	51	1	52	42	48	
	MOL	6.5- 9																				
	MOU	9 -14																				
Site: 44 W-77-2; from road ditch, south side of county road; below loess and paleosol. Location: NW corner of sec. 28, T.71N., R.5W., Henry County. Elevation: 680 feet																						
Stratigraphy:			WOLF CREEK FORMATION - Hickory Hills Till Member																			
WOLF CREEK FORMATION Hickory Hills Till Mem.	OU	0 - 5	3.0	58	19	23		NC	20.7	26.1	46.8					6.5	30	-	30	54	70	
Site: 44 W-77-3; stream cut bank. Location: NE¼, of SW¼, of SE¼, of SW¼, sec. 5, T.70N., R.5W., Henry County. Elevation: 630 feet.																						
Stratigraphy:			WOLF CREEK FORMATION - Winthrop or Aurora Till Member																			
WOLF CREEK FORMATION Winthrop (or Aurora) Till Member	OU	0 - 6	1.0	52	21	27		NC	29.5	40.5	30.0					8.0	18	1	19	71	81	S 2

Table 26 con't.

Site: 44 W-77-4; in east bank of gully on S. side of road.
Location: NE¼, of SE¼, of SW¼, of NE¼, sec. 27., T.70N., R.5W., Henry County.
Elevation: 640 feet

Stratigraphy:			WOLF CREEK FORMATION - Hickory Hills Till Member																		
Wisconsinan loess	MOL	0 - 2																			
Sangamon Paleosol	Btgb	2 - 9	16.0	59	19	22	NC	24.1	31.1	44.8					6.0	21	-	21	66	79	
WOLF CREEK FORMATION	MOL	9 -13																			
Hickory Hills Till Mem.	OU	13 -21																			

Site: 44 W-77-5; road cut, north side county road.
Location: NW¼, of SE¼, of NW¼, of SW¼ of sec. 15, T.70N., R.5W., Henry County
Elevation: 630 feet

Stratigraphy:																					
GLASFORD FORMATION			GLASFORD FORMATION - Kellerville Till Member																		
Kellerville Till Mem.	OU	0 - 8	6.0	52	26	22	NC	25.0	49.4	25.6					3.6	14	7	21	53	79	Coal

Site: Mount Union Cemetery Core Site (see Hallberg, et al., 1980).
Location: 255 ft. N. and 180 ft. W. of SE corner, sec. 4, T.72N., R.5W., Henry County.
Elevation: 740 feet

Stratigraphy:			WOLF CREEK FORMATION - Hickory Hills Till Member																		
Wisconsinan loess	MOL	0 - 7.8																			
basal loess paleosol	IAb	7.8- 8.1	34.8					22.7	33.3	44.0	3.6	5.2	8.8	0.69							
YARMOUTH-SANGAMON PALEOSOL			35.0	59	19	22		21.9	33.2	44.9	3.8	5.1	8.9	0.75	3.0	26	-	29	60	71	S 2
in undiff. sediments,		8.1-25.8																			
and																					
WOLF CREEK FORMATION																					
Hickory Hills Till Member -	Bb	25.8-29.5																			
	mol	29.5-32.8																			
		32.8-36.0																			

Table 27. Laboratory data and abbreviated descriptions for additional sections in Lee County.

Stratigraphy:		Depth-ft.	Sample Data: Depth (feet)	Clay Mineralogy-% EX.	ILL.	K+C	D C	Particle Size-% Clay	Silt	Sand	Matrix CO_3-% C	D	TC	C/D	C/D	Sand-fraction Lithology-% TC	Sh	Sed	Qf	Tx	Notes
Site: Gateway Terminal Section (Galland School # 2); excavations for barge terminal, overlooking Mississippi River. Location: SE¼, of SE¼, of SE¼, sec. 24, T.66N., R.5W., Lee County. Elevation: 672 feet																					
Wisconsinan loess	MOL	0 -14	WOLF CREEK FORMATION - Hickory Hills Till Member																		
Basal loess paleosol	IAb	14 -15																			
			24	56	22	22	NC	21.7	30.6	47.7	3.3	4.3	7.6	0.77							
Late-Sangamon Paleosol; with strong slope to	Btb	15 -19	* 24	49	26	25	*ILL				*4.4	5.1	9.5	0.86*							
river, stone-line and pedisediment are very			30	58	20	22	NC	24.4	30.4	45.2	2.7	4.1	6.8	0.66	2.7	28	1	29	68	71	
coarse.			* 30	57	20	23	*ILL				*4.3	5.3	9.6	0.81*							
WOLF CREEK FORMATION Hickory Hills Till Member	OL	19 -23																			
	OU	23 -35																			
Bedrock																					
Site: 56-61-78; road cut on east side U.S. Highway 61. Location: NW¼, of SW¼, of NE¼, sec. 16, T.66N., R.5W., Lee County. Elevation: 670 feet																					
Wisconsinan loess	MOL	0 - 4	WOLF CREEK FORMATION - Hickory Hills Till Member																		
YARMOUTH-SANGAMON PALEOSOL	Btgb	4 -14	30	61	18	21	NC	21.6	33.8	44.6	3.2	4.3	7.5	0.74	3.7	28	-	28	64	72	
WOLF CREEK FORMATION Hickory Hills Till Member	MOL	14 -25	40	56	20	24	NC	22.7	33.4	43.9	3.6	5.1	8.7	0.71	2.8	38	1	29	60	61	
	MOU	25 -44	* 40	53	24	23	*ILL														
Site: 56-79-2-1: borrow pit along south side of state highway 2. Location: N½, of NW¼, of SW¼, sec. 2, T.67N., R.5W., Lee County. Elevation: 640 feet																					
Wisconsinan loess	MOL	0 - 4	GLASFORD FORMATION - Kellerville Till Member, superglacial facies? or subglacial facies - basal till with sheared inclusions?																		
Late-Sangamon Paleosol developed in pedisediment and	Btb	4 - 8.5	12	59	26	15		24.5	43.8	31.7	4.5	3.6	8.1	1.3	?						
GLASFORD FORMATION Kellerville Till Member			13	59	22	19		21.4	75.6	3.0	4.0	8.3	12.3	0.48	?						(Density-g/cc)
Till with variable	OL	8.5-11.5	15					13.2	54.5	32.3	2.6	7.0	9.6	0.37							1.71
texture, and with	MOU	11.5-15.5	16	52	30	18		21.0	48.5	30.5	3.2	10.5	13.7	0.30							1.89
numerous large inclusions of sand and	MRU	15.5-16.5	- Kellerville Till Member, subglacial facies, basal till																		
gravel, silts, etc.			17	47	35	18		20.9	46.0	33.1	3.9	8.9	12.8	0.44							1.95

Table 27 con't.

Kellerville Till Member - basal till			24					21.1	44.7	34.2					
Uniform firm till	UJU	16.5-22.5	30	48	40	12		20.4	44.8	34.8	2.9	10.2	13.1	0.28	
Uniform texture till with sand and gravel	UJU	22.5-40.5	WOLF CREEK FORMATION - Hickory Hills Till Member												
inclusions (Iron oxides and gypsum in joints)			41					19.2	36.1	44.7	4.4	5.0	9.4	0.88	1.99
WOLF CREEK FORMATION			46	59	19	22		22.0	32.9	45.1	3.8	5.1	8.9	0.75	
Hickory Hills Till Member	UJU	40.5-48.5													

Site: 56-79-2-2-; road cut, north side state highway 2.
Location: NE¼, of SE¼, of SW¼, of NE¼, sec. 3, T.67N., R.5W., Lee County.
Elevation: 695 feet

Wisconsinan loess	MOL	0 -10	GLASFORD FORMATION - Kellerville Till Member											
Sangamon Paleosol	Btb	10 -14	18	51	31	18	NC	25.5	44.8	29.8	1.6	4.9	6.5	0.33
GLASFORD FORMATION Kellerville Till Member	MOL	14 -16	28	49	29	22	NC	17.0	48.7	34.3	2.4	15.8	18.2	0.15
some silt and sand lenses, within till.	OU	16 -29	WOLF CREEK FORMATION - Hickory Hills Till Member											
Sheared, contorted YARMOUTH PALEOSOL	Btgb	29 -37	39	59	19	22	NC	18.8	35.0	46.2	2.6	6.1	8.7	0.43
WOLF CREEK FORMATION Hickory Hills Till Member	RL	37 -38												
	RU	38 -41												

Site: 56-JTW-33-78; stream cut bank (described by J.T. Wickham).
Location: NW¼, of SE¼, of SW¼, of NE¼, sec. 10, T.68N., R.4W., Lee County.
Elevation: 595 feet

Covered		0 - 5	Colluvium, undifferentiated				
Silt, clayey; loess or or colluvium	DL	5 - 5.6	* 5.1	61	22	17	*ILL
Loamy colluvium	MOL	5.6- 7.2	* 5.7	61	20	19	* "
WOLF CREEK FORMATION							
Undiff. Till, silty, with gravel lens at top.	MOL	7.2-11.5	* 6.8	66	19	15	* "
			* 7.2	65	21	14	* "
ALBURNETT FORMATION			WOLF CREEK FORMATION - Undifferentiated Till				
Till, clay loam;	RU	11.5-13.1	* 7.6	66	17	17	*ILL
Silts,	MOU	13.1-15.0					
Till, loam	RJU	15 -20.0	* 9.8	66	15	17	* "
	UJU	20 -28.0	* 10.8	74	11	15	* "
Section B							
ALBURNETT FORMATION			ALBURNETT FORMATION - Undifferentiated				
Till, clay loam	MUJU	0 - 8.2	* 12.5	51	23	26	*ILL
			* 13.5	42	35	23	* "
			* 16.7	53	22	25	* "
			* 18.1	49	22	29	* "
			* 19.7	45	24	31	* "

Table 27 con't.

* 21.3	42	28	30	* "
* 23.0	44	24	32	* "
* 24.6	46	26	28	* "
* 26.3	46	26	28	* "
* 27.9	46	26	28	* "
Section B				
* 0.9	50	22	28	* "
* 2.0	46	24	30	* "
* 3.0	38	28	34	* "
* 4.0	45	27	28	C* "
* 5.0	39	25	36	* "

Site: 56W-79-1; Composite section from road ditch, core, and stream cut.
Location: SW¼, of SW¼, of SW¼, of sec. 5, T.69N., R.5W. On side of interfluve, on erosion surface, in front of Illinoian (GLASFORD FORMATION, Kellerville Till Member) terminus.
Elevation: 690 feet

Wisconsinan loess-truncated surface solum;		0 - 1.5
	MDL	1.5- 3.5
Basal loess paleosol	IAb	3.5- 4.2
Late-Sangamon Paleosol on pedisediment	II B1tb	4.2- 4.5
WOLF CREEK FORMATION Hickory Hills Till Member	IIIB2tb	4.5- 5.8
	IIIB3tb	5.8- 6.2
	MJOL	6.2- 9.7
Till with few thin sand beds	MJOU	9.7-10.0
MJOU Till with sheared inclusions of leached silts and sands, and		10.0-14.2
DYSART PALEOSOL *		
Aurora Till Member Few Pennsylvanian lithologies in pebble fraction- coal, black shale.)	MOL	14.2-14.8
	MOU	14.8-16.0
	MRU	16.0-20.0
	UU	20 -24.0

* Note: Dysart Paleosol is intact in exposures but is sheared in the core as described.

Wisconsinan loess																		
2.0					29.8	67.4	2.8											
3.0					29.5	63.9	6.6											
Basal loess Paleosol																		
4.0					31.6	45.0	23.4											
Late-Sangamon Paleosol																		
4.3					28.3	29.2	42.5											
5.0					32.6	33.0	34.4											
6.0					27.9	26.6	45.5											
WOLF CREEK FORMATION - Hickory Hills Till Member																		
7.0	63	15	22	NC	22.3	29.1	48.6											
9.7	60	18	22	NC	20.0	30.4	49.6	3.1	3.6	6.7	0.82							
- with sheared, leached, inclusions																		
10.0					16.3	33.0	50.7	1.1	1.4	2.5	0.79							
11.0					15.3	36.1	47.8	1.7	2.5	4.2	0.68							
13.0	59	17	24	NC	24.9	34.6	40.5	0.0	1.0	1.0	--							
WOLF CREEK FORMATION - Aurora Till Member																		
14.6					28.6	35.5	35.9	0.0	0.0	0.0	--							
15.0	58	19	23	NC	31.0	41.5	27.5	2.4	4.0	6.4	0.60	NoD	18	6	26	61	74	Coal
18.0					20.8	42.3	36.9	3.6	5.6	9.2	0.64	3.5	25	-	28	70	72	
21.0	58	20	22	NC	20.3	40.1	39.6	5.9	7.2	13.1	0.83	11.0	24	2	26	68	74	
22.0					20.3	41.8	37.9	1.9	4.9	6.8	0.39?							

Table 27 con't.

Site: 56W-79-2; cut in gully along dirt road.
Location: SE¼, of SW¼, of SW¼, of NW¼, sec. 9, T.69N., R.5W., Lee County
Elevation: 720 feet

GLASFORD FORMATION Kellerville Till Member	OU	0 - 6	5.0	52	30	18	NC	17.9	58.3	23.8	2.8	13.3	16.1	0.21	1.8	31	11	45	41	55	Coal

Site: 56-697R; Core taken during investigation of state highway 16 relocation.
Location: SE¼, of SE¼, of NE¼, of NE¼, sec. 7, T.69N., R.7W., Lee County.
Elevation: 693 feet

Road subgrade and fill		0 - 0.5	WOLF CREEK FORMATION - Hickory Hills Till Member																	
Late-Sangamon Paleosol in sediments.	Btb	0.5- 2.0	5.0	57	19	24	NC	21.6	31.0	47.4										
			9.0	60	18	22	NC	20.7	29.8	49.5	3.1	4.8	7.9	0.65	2.3	20	3	23	70	77
WOLF CREEK FORMATION Hickory Hills Till Member	MOL	2.0- 7.0	10.5	60	18	22	NC								2.7	26	-	26	62	74
	MOU	7.0-12.5	11.5	60	19	21	NC	20.0	33.1	46.9	2.7	4.6	7.3	0.59	2.1	28	-	28	66	72
	MRJU	12.5-20.0																		
Dysart Paleosol in undiff. seds.	Oeb	20.0-21.8	12.5	60	12	28	NC	21.8	31.7	46.5	2.9	3.7	6.6	0.78	2.4	24	-	24	71	76
	C-UL	21.8-27.5																		
Aurora Till Member	UL	27.5-																		

Site: 56-698R; Core taken during investigation of state highway 16 relocation.
Location: SE¼, of SE¼, of NE¼, of NE¼, of sec.7, T.69N., R.7W., Lee County.
Elevation: 685 feet

Road subgrade and fill		0 - 3.5	WOLF CREEK FORMATION - Hickory Hills Till Member																		
Late-Sangamon Paleosol in sediments	Btb	3.5- 5.5	8.5					21.9	29.5	48.6											
	MOL	5.5- 7.0	10.0	60	14	26	NC	25.9	27.5	46.6											
WOLF CREEK FORMATION			10.5	58	20	22	NC	21.5	30.6	47.9											
Hickory Hills Till Member	MRL	7.0- 9.9	11.5					21.8	29.9	48.3											
	MJRL	9.9-13.0	12.0					27.4	32.2	40.4											
DYSART PALEOSOL in undifferentiated sediments	Oeb	13.0-14.6						See figure 3.													
	Cb-MUL	14.6-21.3																			
Aurora Till Member	UL	21.3-22.5	WOLF CREEK FORMATION - Aurora Till Member																		
	UU	22.5-26.0	21.5	58	20	22	NC	18.6	44.1	37.3											
			22.5	58	18	24	NC	16.9	44.5	38.6	5.0	9.0	14.0	0.56	9.0	30	-	30	64	70	
			23.5	53	21	26	NC	23.8	40.2	36.0	6.5	3.8	10.3	1.71	1.9	26	1	28	58	72	Coal
			24.5	62	22	26	NC	17.2	42.8	40.0	5.5	9.8	15.3	0.56	3.7	40	2	42	52	58	
			25.5	54	21	25	NC	16.8	43.2	40.0	5.0	10.2	15.2	0.49	3.6	32	6	38	54	62	
			26.0	58	19	23	NC	18.0	44.3	37.7	8.0	9.1	17.1	0.88	14.0	22	4	26	68	74	

* Analyses by the Illinois State Geological Survey; Clay min.-H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.
U - Clay mineralogy uncalculable because of weathering effects.
    1. Broad diffuse expandable peak
    2. No illite peak apparent.
    (31) % clay mineral calculated from weathered sample for discussion purposes.
C - Chlorite peaks apparent.
t - trace
NC - not calculated

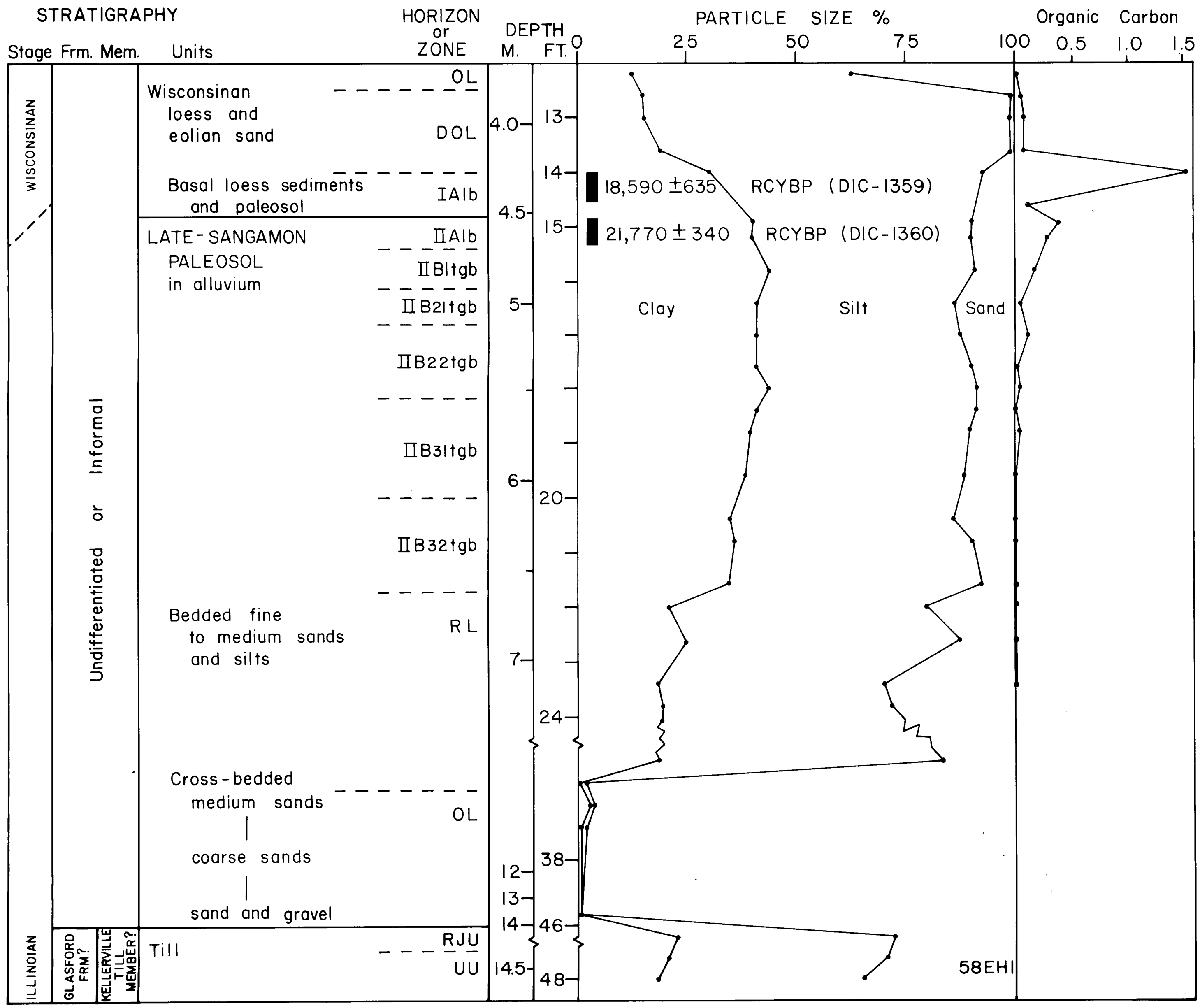

Figure 26. Stratigraphy and particle-size data, Wapello Bridge Cut (58 EH-1). See Table 28 for additional data.

Table 28. Additional sections in Louisa County.

Stratigraphy:		Depth-ft.	Sample Data: Depth (feet)	Clay Mineralogy-% EX.	ILL.	K+C	D	C	Particle Size-% Clay	Silt	Sand	Matrix CO_3-% C	D	TC	C/D	C/D	Sand-fraction Lithology-% TC	Sh	Sed	Qf	Tx	Notes
Site: 58-X37-1; road cut on north side county road X-37. (Description by Hallberg, Esling, Bicki, Nott). Location: SE¼, of SE¼, of NW¼, of SW¼, sec. 14, T.74N., R.4W., Louisa County. Elevation: 660 feet																						
Wisconsinan loess	OL	0 -10	GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																			
SANGAMON PALEOSOL	Btb	10 -14	18	49	30	21			21.1	49.6	29.3											
GLASFORD FORMATION			22						18.0	47.9	34.1					1.5	40	8	54	42	46	Coal, black Shale
Kellerville Till Member superglacial facies, loose friable till, varies in texture from loam to sandy loam; with few inclusions of stratified materials; some zones very pebbly.	OL OU	14 -16 16 -24	24	31	49	20		C	6.3	31.9	61.8	2.4	30.6	33.0	0.08							
			24	39	47	14			18.0	51.5	30.5	3.2	31.3	34.5	0.10							
Site: 58-CC-1; road cut and ditch south side of gravel road. Location: NW¼, of NE¼, of NW¼, of NE¼, sec. 30, T.74N., R.4W., Louisa County. Elevation: 705 feet																						
Wisconsinan loess	OL	0 - 2	GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																			
SANGAMON PALEOSOL	Btgb	2 - 8	10	58	30	12			17.0	48.7	34.3	2.2	17.2	19.4	0.13							
GLASFORD FORMATION Kellerville Till Member superglacial facies:			14						16.4	75.2	8.4											
Till	MRU	8 -12																				
Bedded silts	RU	12 -13.5																				
Silty diamicton	MRU	13.5-15.0																				
Site: 58-CC-2; road cut on east side gravel road. Location: SW¼, of NE¼, of NW¼, of SW¼, sec. 21, T.74N., R.4W., Louisa County. Elevation: 675 feet																						
Wisconsinan loess	OL	0 - 2	GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																			
LATE-SANGAMON PALEOSOL	Btb	2 - 6.5	8.5	44	36	20			6.5	40.5	53.0	2.2	23.3	25.5	0.09	0.9	42	9	56	36	44	Coal
GLASFORD FORMATION			10						20.2	49.6	30.2											
Kellerville Till Member superglacial facies till, highly variable in texture, some small gravel lenses. Abundant Pennsylvanian lithologies, including Mazon Creek-style fossiliferous siderite concretions.	OL OU	6.5- 8.0 8.0-11.5																				

Table 28 con't.

Site: 58-CJ-1; road cut south side state highway 92.
Location: NW¼, of SE¼, of SW¼, of SW¼, sec. 19, T.75N., R.4W., Louisa County.
Elevation: 640

Wisconsinan loess	OL	0 -12	WOLF CREEK FORMATION - Hickory Hills Till Member																		
Late-Sangamon Paleosol	Bb	12 -17	20	64	17	19		22.7	30.4	46.9											
WOLF CREEK FORMATION Hickory Hills Till Member	OL	17 -21.5	24	60	18	22		21.6	33.8	44.6	3.2	4.3	7.5	0.74							
Till	OU	21.5-36	28	62	19	19		22.6	32.9	44.5	3.0	6.5	9.5	0.46	1.1	21	1	23	66	77	
			* 28	64	18	18	*ILL														
			32	60	21	20		23.1	36.0	40.9											
			36	61	18	21		24.4	33.9	41.7	3.8	5.3	9.1	0.72	3.0	28	-	28	68	72	

Site: 58-JW-67; exposures in ditch along road to Lake Odessa.
Location: SW¼, of SE¼, of NW¼, of NW¼, sec. 20, T.74N., R.2W., Louisa County.
Elevation: 630 feet

Wisconsinan loess			WOLF CREEK FORMATION - Aurora or Winthrop Till Member.																		
Late- Sangamon Paleosol (?)			20	59	17	24		26.2	43.2	30.6	5.6	7.2	12.8	0.78	4.1	40	-	41	56	59	
WOLF CREEK FORMATION Till; Grab sample from			* 20	63	16	21	*ILL				*6.3	7.2	13.5	0.88*							
about 20 feet.	MOU	20																			

Site: 58-JW-68; slump scarp in bluff along Shirely Access Road.
Location: NW¼, of NW¼, of SW¼, of SE¼, sec. 20, T.74N., R.2W., Louisa County.
Elevation: 620 feet

WOLF CREEK FORMATION			WOLF CREEK FORMATION - Aurora Till Member																		
Aurora Till Member;																					
Till, with inclusions	OU	0 -10	* 3.5	57	22	21	*ILL				*8.3	9.3	17.6	0.89*							
of sands and silts.			3.5	58	20	22		20.8	42.9	36.3	4.8	9.7	14.5	0.49	1.7	38	-	38	55	62	
Base covered by slump.			* 7.0	50	26	24	*ILL				*6.1	10.0	16.1	0.61*							

Site: 58-JW-69; grab sample from grassed road cut on upland above terrace.
Location: NE¼, of SW¼, of NW¼, of NW¼, of sec. 23, T.73N., R.2W., Louisa County.
Elevation: 650 feet

Not sampled		0 -15	* 17	46	33	21	*ILL				*3.6	9.1	12.7	0.40*							
GLASFORD FORMATION Kellerville Till Member			17	44	35	21		22.4	44.7	32.9	2.5	9.8	12.3	0.26	1.4	39	3	42	50	58	Black shale.
Till, coal in pebble fraction.	OU	15 -25																			
Undifferentiated 5YR 5/8 sands	OL	25 -28																			

Table 28 con't.

Site: 58-JW-70; cut on east side gravel road, in bluffs along Iowa River.
Location: SE¼, of SW¼, of NE¼, of SW¼, sec. 29, T.73N., R.2W., Louisa County.
Elevation: 625 feet

(Wisconsinan loess; above)			GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																	
Late-Sangamon Paleosol developed in pedisediment (?) and		0 - 5	5	51	39	10		21.0	46.7	32.3										
			7					17.1	75.3	7.6										
GLASFORD FORMATION			8	44	40	16		15.2	49.5	35.3	6.9	16.0	22.9	0.43	0.94	68	1	69	24	31
Kellerville Till Member			* 8	25	63	12	*ILL				*11.0	13.3	24.3	0.83*						
superglacial facies; interbedded till, sand, mixed sand and gravel, silts, stratified silty diamictons. Coal and Pennsylvanian lithologies common in pebble fraction.	OL and OU	5 -12	10					7.8	4.4	87.8										

Site: Wapello Bridge Section, 58-EH-1; road cut for new bridge and highway alignment along U.S. 61.
Location: E½, of NE¼, of SE¼, sec. 9, T.74N., R.3W., Louisa County.
Elevation: 623 feet

			GLASFORD FORMATION - Kellerville Till Member, basal till.																		
Wisconsinan loess and eolian sand.		0 -14																			
Basal loess paleosol	IAb	14 -14.8	48	48	29	23		25.1	47.3	27.6											
Late-Sangamon Paleosol in alluvium	IIBb	14.8-21.7	50	54	24	22		25.5	48.9	25.6	1.0	7.1	8.1	0.14	1.2	26	2	28	69	72	
			* 50	54	24	22	*ILL				*4.7	6.9	11.6	0.68*							
Undifferentiated fluvial sediments.	OL	21.7-46.0	51	50	26	24									0.9	38	6	51	42	49	Coal
GLASFORD FORMATION			52	49	33	18	C	24.5	47.6	27.9	1.8	8.7	10.5	0.21	0.4	42	2	47	46	53	Coal
Kellerville Till Member Till, firm, with woood fragments, some coal and Pennsylvanian lithologies in pebble fraction.	UU	46 -55	55	44	36	20		26.3	47.7	26.0	1.6	6.9	8.5	0.23							

Site: 58-74-3; sample from drill hole for new water well.
Location: NE¼, of NE¼, of NE¼, of NW¼, of sec. 3, T.74N., R.3W., Louisa County
Elevation: 640 feet

Wisconsinan loess		0 -13	GLASFORD FORMATION - Kellerville Till Member								
Sangamon Paleosol in		13 -18	22	50	33	17		22.7	45.9	31.4	
GLASFORD FORMATION Kellerville Till Member	MOL	18 -20									
	MOU	20 -27									

Table 28 con't.

Site: 58-74-33; till augered from road ditch.
Location: SE¼, of SW¼, of SW¼, of SE¼, sec. 33, T.73N., R.2W., Louisa County.
Elevation: 680 feet

(Wisconsinan loess;			0-1	51	33	16	20.0	52.6	27.4
Sangamon Paleosol									
GLASFORD FORMATION Kellerville Till Member exposed but not measured.									
Till sample	OU	0 - 1							

* Analyses by the Illinois State Geological Survey; Clay min.-H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.
U - Clay mineralogy uncalculable because of weathering effects.
1. Broad diffuse expandable peak
2. No illite peak apparent.
(31) % clay mineral calculated from weathered sample for discussion purposes.
C - Chlorite peaks apparent.
t - trace
NC - not calculated

REEVALUATION OF THE YARMOUTH TYPE AREA

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ABSTRACT

The classic type location for the Yarmouthian Stage and Yarmouth soil was designated by Leverett in 1898 from his interpretation of the sediments in two dug wells, near Yarmouth, Des Moines County, Iowa. For this study, cores from the type location were obtained and analyzed. Leverett's "interglacial" deposits are composed of interbedded tills, diamictons, peats and bedded sands and silts, that are part of the superglacial facies of the Kellerville Till Member, Glasford Formation. These strata are interpreted as pro-glacial sediment flows, fluvial, and paludal sediments deposited along the early-Illinoian ice margin. Pollen samples and wood from these pro-Illinoian deposits indicate that the vegetation coeval with the sediments was a *Picea-Larix* forest, and that climate was full-glacial rather than interglacial. The type-section for the Yarmouth is redefined as the well-developed paleosol underlying these Illinoian pro-glacial sediments in the cores at Yarmouth. A stream cut near Mediapolis that exposes a Yarmouth Paleosol between the Illinoian and Pre-Illinoian tills is designated a principal reference section.

INTRODUCTION

The Yarmouth type section as originally defined by Leverett (1898) occurs in Des Moines County in the southeast Iowa study area. As part of the investigations reported in this volume, the authors reexamined and reevaluated the Yarmouth deposits of Leverett to place them into a modern stratigraphic framework. This report will deal only with the evaluation of deposits at the type locality at Yarmouth. The details of the lithostratigraphy and paleosols for the study area are reported in Hallberg, Wollenhaupt, and Wickham (this volume).

Standard lab procedures were used for the processing of the pollen samples (see Hallberg, Baker, and Legg, 1980). All wood identifications were made by Dr. Dwight Bensend, Department of Forestry, Iowa State University.

HISTORICAL PERSPECTIVE

Leverett (1898, 1899) concluded that a significant interglacial interval separated the Illinoian from the Kansan glacial episodes. His conclusions were based on: 1. the presence of a soil, peat, and/or sediments containing wood, between the Illinoian and Kansan tills; and 2. the generally weathered nature of the Kansan till (that is, the Kansan till was oxidized, leached, and in places had a "gummy gray leached clay" between it and the overlying Illinoian till). Leverett (1898) called this interglacial episode the Yarmouth because he based his initial observations and interpretations from two dug wells near Yarmouth in northwest Des Moines County (see figure 1, Hallberg, Wollenhaupt, and Wickham, this volume). The sections from these wells as reported by Leverett (1898, p. 239-240; 1899, p. 42) are given below.

Section from well of William Stelter, near Yarmouth, Des Moines County, Iowa.

	Feet
Soil and loam (Iowan loess)	4
Brownish yellow till (Illinoian)	20
Gray till (Illinoian)	10
Peat bed with twigs and bones (Yarmouth)	15
Gray or ashy sandy clay, containing wood (Yarmouth)	12
Fine sand (Yarmouth)	16
Yellow sandy till with few pebbles (Kansan)	33
Total depth	110

Section of Well at F. Smith's, near Yarmouth.

	Feet
Yellow till (Illinoian)	36
Sand with thin beds of blue clay and also of cemented gravel (Yarmouth)	73
Black muck containing wood (Yarmouth)	6
Sand and gravel, probably alluvial (Yarmouth)	8
Gray silt nearly pebbleless, apparently alluvial (Yarmouth)	15
Blue till (Kansan)	42
Total depth	180

Leverett did not view the materials as they came out of these wells. His logs were a composite description compiled from discussions with the well-driller or well-owner, and from examination of the material in the dump from the well.

Soil, in Leverett's time, was considered to be only the organic-rich portion of a soil profile as Follmer (1979a, b) noted in his discussion of the Sangamon Paleosol. Leverett's "Yarmouth soil" referred to the peats and mucks within what he interpreted as alluvial deposits. Later, Leverett (1899, p. 123) had wood identified from these "interglacial" deposits at Yarmouth. The wood was coniferous and led Leverett to postulate that some of these sediments were deposited during cooler climates as Illinoian ice advanced toward southeast Iowa. He considered this to be the later portion of the Yarmouth interval.

Leverett's "gummy gray clay" later became known as the Kansan gumbotil (Kay and Apfel, 1929; Kay and Graham, 1943), which (at least in part) became the Yarmouth Paleosol (Ruhe, 1969). The Yarmouthian Interglacial Stage has been considered as the longest interglacial period because of the great thickness of the Yarmouth Paleosol and the depth of weathering associated with it (see Willman and Frye, 1970).

The concept and the use of "Yarmouth" has evolved considerably since Leverett's definition. The deposits described by Leverett hardly seem compatible with the present concept of the Yarmouthian Stage. The intent of this study is to reexamine Leverett's Yarmouth and place it in a modern perspective.

Recent stratigraphic work has reclassified Leverett's Illinoian and Kansan tills. The Illinoian till is now considered to be the Kellerville Till Member, of the Glasford Formation, of Illinoian age (see Willman and Frye, 1970; Wickham, and Linebeck, this volume). The Kansan till of Leverett is classified as the Hickory Hills Till Member of the Wolf Creek Formation, of Pre-Illinoian age (Hallberg, 1980; see also Hallberg, Wollenhaupt, and Wickham this volume).

INVESTIGATIONS AT YARMOUTH, IOWA

The senior author attempted to locate the wells originally described by Leverett. Leverett did not, however, provide very accurate locations. The Stelter well was stated as being near the village of Yarmouth. A search of old plat books and land records failed to reveal any Stelter near Yarmouth. It is not clear from Leverett's (1898, 1899) discussions if Stelter owned the well or if he simply drilled the well.

Fortunately, the Smith well could be located. Leverett (1898) described the location as about one mile (1.6 km) south of Yarmouth, on the high point on the ridge marking the border of the Illinoian drift. Land records also located the F. Smith property and farmstead.

Drilling could not be done on the old Smith property. So, a transect of core-holes was drilled to the north of the Smith location across the terminal Illinoian ridge. A cross-section constructed from the cores is shown in figure 1. The Yarmouth Core (Y, figure 1) was the deepest core, which penetrated 149 feet (45 M) of Pleistocene sediments over Mississippian bedrock (Description 1; Table 1).

The sediments which make up the ridge are best illustrated from the detailed data from core site 29 WH-1, on the flanks of the ridge. Figure 2 summarizes the stratigraphy at the site, and documents the occurrence of Wisconsinan loess overlying the

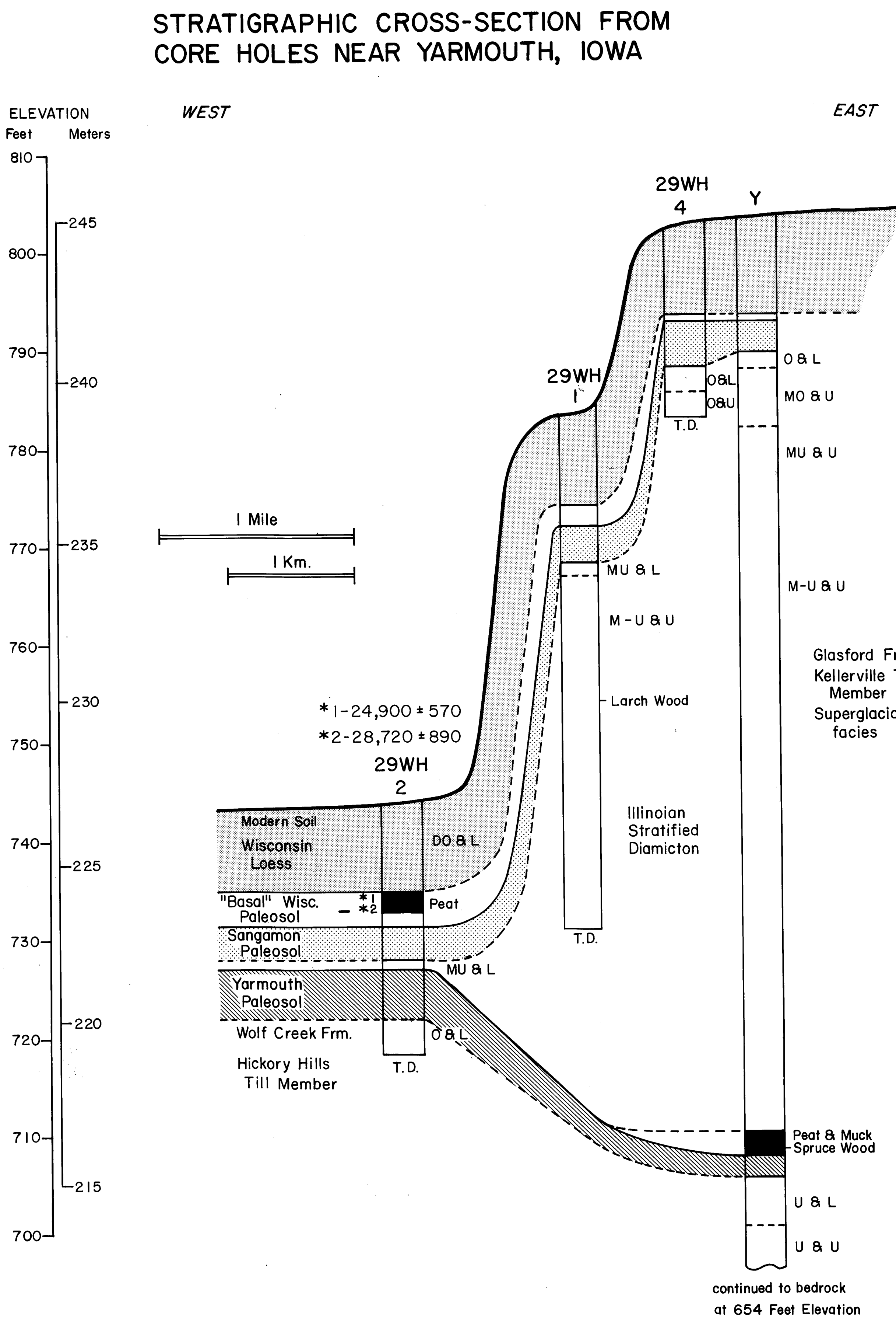


Figure 1. Cross section from Yarmouth coring transect.

Description 1. Summary description of Yarmouth core taken along the south section line of sec. 16, T 72N, R 4W, in the north shoulder of gravel road, 180 feet (55 m) west of center line of the paved road which forms the center line of sec. 16; elevation 808 feet.

Depth-feet (meters)	Horizon or Zone	Description
		WISCONSINAN Loess
0 - 5 (0 - 1.5)		Road bed and modern solum developed in loess.
5 - 10 (1.5 - 3.1)	DOL	Deoxidized and leached loess and some local alluvium.
		ILLINOIAN STAGE
		GLASFORD FORMATION - Kellerville Till Member; superglacial facies
		SANGAMON PALEOSOL in upper portion
10 - 12.9 (3.1 - 3.9)	Paleo-solum	Strongly mottled Sangamon Paleosol
12.9 - 14.0 (3.9 - 4.3)	MRL	Mottled, reduced (5Y4 and 5/1; 5BG4-5/1) and leached loam diamictons.
14.0 - 92.9 (4.3 - 28.3)	MRU-MUU	Reduced to unoxidized, commonly mottled, unleached diamictons of variable texture; variable thicknesses of soft till-like materials, thin peat beds, thin silt and few sand stringers, occasional boulders. Abundant coal in pebble fraction. Calcareous, but only slightly effervescent.
		GLASFORD FORMATION - Undifferentiated organic sediments. Complex early Illinoian - Late Yarmouth Paleosol
		(see detailed description)
92.9 - 93.6 (28.3 - 28.7)	IOab	Early or pro-Illinoian peat (formerly "Yarmouth"); IOab horizon of complex buried early Illinoian - late Yarmouth Paleosol.
93.6 - 95.1 (28.7 - 29.0)	IIAb	Early or pro-Illinoian mucky silt loam organic sediments, leached; with spruce wood; II Ab horizon of complex buried early-Illinoian-late Yarmouth Paleosol.
		PRE-ILLINOIAN
		WOLF CREEK FORMATION - Undifferentiated sediments; YARMOUTH PALEOSOL
95.1 - 96.3 (29.0 - 29.3)	IIIBtgb	Clay loam to silty clay loam, leached, gleyed till-derived sediments; IIIB1-B22tgb horizon of complex Yarmouth Paleosol.
		WOLF CREEK FORMATION - Hickory Hills Till Member YARMOUTH PALEOSOL in upper part
96.3 - 96.9 (29.3 - 29.5)	IVB3tgb	Clay loam to loam, weathered till; IVB3tgb horizon of complex Yarmouth Paleosol
96.9 - 102 (29.5 - 31.1)	IVCgb MRL	Loam till, very uniform, firm, mottled, reduced, leached.
102 - 115 (31.1 - 35.1)	MUU-UU	As above, unoxidized and calcareous

Description 1 con't.

	WOLF CREEK FORMATION - Undifferentiated sediments	
115 - 116 (35.1 - 35.4)	UU	Sand and gravel
116 - 120 (35.4 - 36.6)	UU	Bedded silts
	WOLF CREEK FORMATION - Aurora Till Member	
120 - 131 (36.6 - 39.9)	UU	Loam till, drak gray (5Y4/1), uniform texture
131 - 140	UU	As above, dark greenish gray (5GY4/1).
	ALBURNETT FORMATION - Undifferentiated till.	
140 - 143 (42.7 - 43.6)	UL	Loam till, dark gray (5Y4/1), uniform texture; leached.
143 - 149 (43.6 - 45.5)	UU	As above, dark greenish-gray (5GY and 5BG4/1), calcareous.
	MISSISSIPPIAN - BURLINGTON LIMESTONE	
149 plus (45.5 plus)		Bedrock

Sangamon Paleosol (see also Table 2). Description 2 and figure 3 show the details of the materials encountered for 2 other cores taken at core site 29WH-1. The sediments are a complex sequence of thin beds of: 1. tills; 2. diamictons; 3. organic horizons--peats, mucks, "organic silts", thin beds of organic debris, and even diamictons with abundant organic matter; 4. sorted deposits--sands and silts, a few thin gravel beds, and some finely laminated silts.

The tills and till-like deposits look like the typical till in this region, in that they are massive and rather uniform in particle-size distribution (see Hallberg, Wollenhaupt and Wickham, this volume). The diamictons, although poorly sorted like the till, are different in many gross characteristics. They often show some of the following characteristics:
1. inidivudal units may be very thin (10 in; 25 cm), and they may be stacked on top of one another; 2. there is often an obvious vertical variation in matrix texture; 3. they often

Table 1. Laboratory data, Yarmouth Core.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX. (%)	ILL. (%)	K+C (%)	D. (cps)	C. (cps)	I.D.	C/D	Sand-fraction Lithology T.C. (%)	Sh. (%)	Sed. (%)	Q.F. (%)	T.X. (%)	Notes	Matrix CO_3 Ca (%)	Do (%)	T.C. (%)	C/D	Particle Size Clay (%)	Silt (%)	Sand (%)
GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																						
UU	85.0	1553	48	35	17	C 90	20													17.5	63.9	18.6
UU	90.0	1535	34	43	23	20	t	410	1.1	49	1	54	41	46	Coal					21.5	54.6	23.9
UU	92.2	3130	34	44	22	C	NC													21.9	53.8	24.3
UU	* 92.2	ILL.	33	43	24	C																
UU	* 92.2	ILL.	32	44	24	C																
UU	92.5	1539	43	35	22	C 40	40									1.9	10.3	12.2	0.18	22.2	49.7	28.1
WOLF CREEK FORMATION - Hickory Hills Till Member																						
MRL	101	1540	64	17	19	-	-													23.0	31.4	45.6
MRL	* 101	ILL.	63	16	21	NC																
MUU	105	1542	62	18	20	80	120	941	4.8	27	-	28	65	72						22.4	31.5	46.1
UU	110	3145	60	19	21	NC		414	6.5	32	-	32	61	68		3.3	4.8	8.1	0.69	22.0	30.5	47.5
WOLF CREEK FORMATION - Aurora Till Member																						
UU	130	1543	66	16	18	t	180									4.5	8.5	13.0	0.53	21.3	42.1	36.6
UU	138	1544	62	18	20	t	160									5.6	7.7	13.3	0.73	20.1	43.1	36.8
ALBURNETT FORMATION - Undifferentiated till																						
UU	143	3154	46	23	31	NC		377	10.0	22	2	28	66	72								
UU	148	3147	41	28	31	NC		396	1.4	18	2	21	68	79						19.1	34.1	46.8

*ILL. - Analyses by Illinois State Geological Survey; clay min. by H.D. Glass.
t - trace

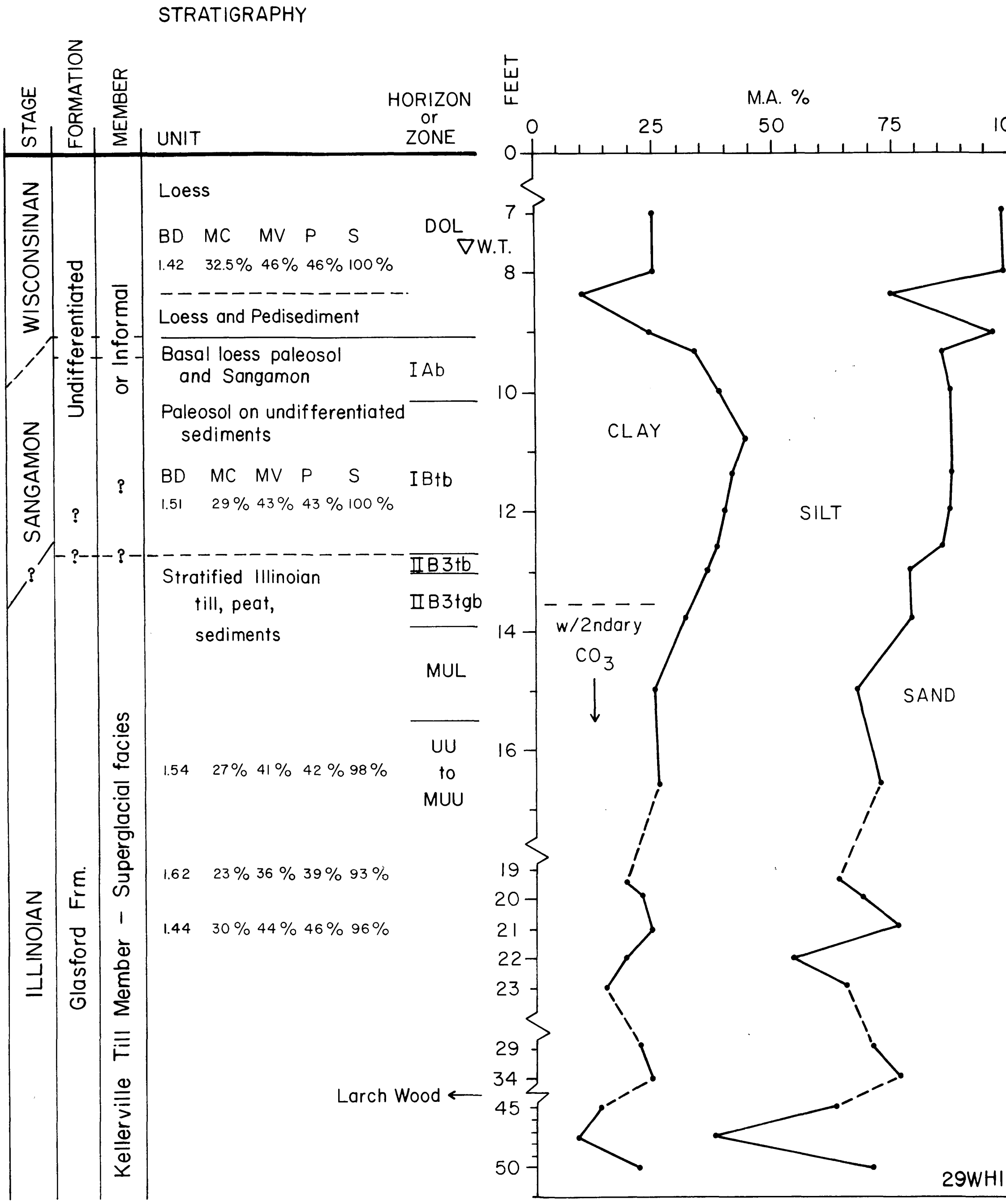


Figure 2. Stratigraphy and particle-size data, core site 29 WH-1. BD - bulk density; MC - moisture content by weight; MV - moisture content by volume; P - porosity; S - % saturation.

exhibit a vertical change in pebble content, instead of the uniform distribution of pebbles in the till; the pebble and matrix texture variation results in a grossly graded texture from coarse at the bottom to finer at the top; 4. between units there may also be an abrupt change in pebble content; 5. the

Table 2. Laboratory data Yarmouth Locality, core 29 WH-1.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX. - % -	ILL.	K+C	H.S.I.	D.I.	D. cps	C.	I.D.	C/D	Sand-fraction Lithology T.C. - % -	Sh.	Sed.	Q.F.	T.X.	Notes	Ca	Matrix CO_3 Do - % -	T.C.	C/D
Wisconsinan Loess																					
DOL	4.0	647	69	21	10	18	1.32											See figure 2 for data.			
DOL	6.0	648	71	20	6	21	1.29														
DOL	8.0	664	72	21	7	20	1.38		t												
SANGAMON PALEOSOL																					
IAb	10.0	649	U1	U2	U2	2.0	U2														
IB2tgb	11.0	665	U1	U2	U2	2.0	U2														
IB2tgb	11.3	656	U1	U2	U2	U1	U2														
IB2tgb	11.8	657	U1	U	U	U1	0.39														
IIB3gb	13.8	658	U1	U	U	U1	0.71														
MUL	14.9	659	U1	U	U1	1.0	0.58														
GLASFORD FORMATION - Kellerville Till Member; superglacial facies - samples from till-like sediments and other fine-textured diamictons.																					
MUU2	16.3	660	53	27	20 C	8	0.82														
MUU2	17.3	661	49	31	20	7	0.93														
MUU2	19.3	662	52	25	23	12	0.66														
MUU2 *	20.0	ILL.	63	23	14 C		1.07										*	4.8	5.2	10.0	0.92
MUU	22.0	650	53	28	19	13	0.74		t												
MUU	22.2	651	43	35	22 C	6	0.94	10		651	1.1	36	9	48	50	52					
MUU *	23.0	ILL.	57	26	17 C		0.96										*	3.6	8.6	12.2	0.42
MUU	25.0	652	47	34	19	4	0.91	t	40												
UU	36.0	653	52	28	20	10	0.69	t	20	653	0.5	39	8	49	48	51	Coal				
UU	48.0	654	34	43	23 C	3	0.95	30	40												
UU	48.0	654	33	41	25 C	7	1.0	30	40												
UU	50.0	655	48	35	17 C	3	1.0	25	20	184	0.8	28.0	5.2	34.1	50.4	66.0	Coal				
UU *	50.0	ILL.	31	41	28 C		1.0										*	2.7	9.3	12.0	0.29

* Analyses by the Illinois State Geological Survey; clay min. - H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.

U - Clay mineralogy uncalculable because of weathering effects.
1. Broad, diffuse expandable peak.
2. No illite peak apparent.

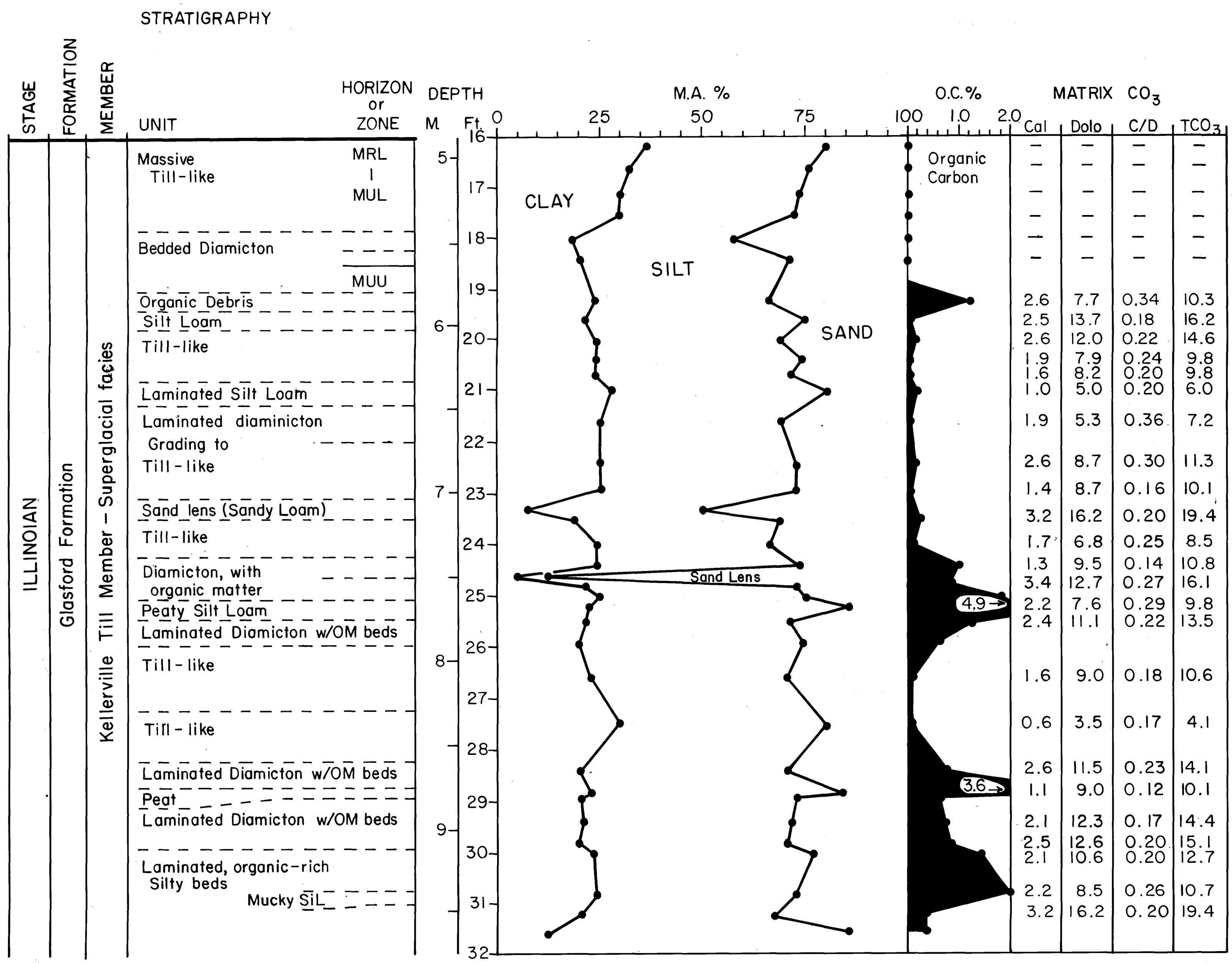
C - Chlorite peaks apparent.

t - trace

Description 2. Description of a short segment of core 29 WH-1; Yarmouth Ridge. Located NC point of north section line, sec. 22, T.72N., R.4W., Des Moines Co.; land elevation 785 feet. All units calcareous; coal fragments common in pebble fraction.

Depth-feet (meters)	Horizon or Zone	Description
GLASFORD FORMATION - Kellerville Till Member - Superglacial facies.		
23.5-24.5 (7.2-7.5)	M-UU	Dark greenish gray (5G 4/1) loam, with few pebbles; soft, slightly sticky; abundant organic carbon flecks, some recognizable, organic debris; massive; abrupt boundary; soft till-like diamicton.
24.5-25.3 (7.5-7.7)	M-UU	Dark greenish gray (5G 4/1) to dark gray (5Y 3/1); fine strata (1 to 4 cm) of silt loam, loam, and organic materials (less than 1 cm thickness).
25.3-25.5 (7.7-7.8)	M-UU	Peat band (5Y 3/1).
25.5-26.5 (7.8-8.0)	M-UU	Olive silt loam (5Y 5/3), massive, abrupt lower boundary.
26.3-26.5 (8.0-8.1)	M-UU	Olive, soft loam, till-like with few fine pebbles, gradual boundary.
26.5-30.5 (8.1-9.29)	M-UU	Dark greenish gray (5G 4/1) loam, with few pebbles; abundant organic carbon flecks, wood fragments, thin peaty laminae; large rock which appears to show "dropstone" type displacement of underlying beds (no displacement above); occasional snail shell below 29 feet; stratified till-like diamicton.
30.5-30.6 (9.29-9.32)	UU	Olive (5Y 5/3) medium sand.
30.6-30.8 (9.32-9.38)	UU	Fine laminated peat
30.8-31.4 (9.38-9.57)	M-UU	Dark greenish gray; till-like as above.
31.4-31.6 (9.57-9.63)	UU	Olive fine loamy sand.
31.6-32.5 (9.63-9.90)	UU	Fine laminated peak and olive silts.
32.5-36.0 (9.9-10.9)	M-UU	Dark greenish gray and olive loam and light clay loam, till-like material.

beds are often crudely stratified, or contain wavy flow structures; 6. some of the diamictons are rich with dispersed organic matter; 7. the contacts between the diamictons and other sediments range from sharp to diffuse, but on occasion coarse clasts protrude from the diamicton into the adjacent



Cal	Dolo	C/D	TCO3
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
2.6	7.7	0.34	10.3
2.5	13.7	0.18	16.2
2.6	12.0	0.22	14.6
1.9	7.9	0.24	9.8
1.6	8.2	0.20	9.8
1.0	5.0	0.20	6.0
1.9	5.3	0.36	7.2
2.6	8.7	0.30	11.3
1.4	8.7	0.16	10.1
3.2	16.2	0.20	19.4
1.7	6.8	0.25	8.5
1.3	9.5	0.14	10.8
3.4	12.7	0.27	16.1
2.2	7.6	0.29	9.8
2.4	11.1	0.22	13.5
1.6	9.0	0.18	10.6
0.6	3.5	0.17	4.1
2.6	11.5	0.23	14.1
1.1	9.0	0.12	10.1
2.1	12.3	0.17	14.4
2.5	12.6	0.20	15.1
2.1	10.6	0.20	12.7
2.2	8.5	0.26	10.7
3.2	16.2	0.20	19.4

Figure 3. Stratigraphy, particle-size, organic carbon, and matrix carbonate content, core site 29 WH-1.

sediment. Although the diamictons are difficult to describe, many of their gross characteristics resemble features from superglacial mudflows described by Lawson (1979).

In the Yarmouth Core (Core Y, figure 1) 93 feet (28.4 m) of these sediments were encountered. On the terminal ridge (Y and 29 WH-4, figure 1), however, the upper 20 feet (6 m) of these deposits were well-oxidized and though clearly stratified, they appeared more till-like than the sediments below, in their overall character. This may be in part because the bulk of the organic matter was destroyed by the oxidation.

All of the mineralogical properties analyzed clearly show that these sediments are related to the Kellerville Till Member (see Tables 1-3; figure 3; Hallberg, Wollenhaupt, and Wickham, this volume).

Many gross aspects of the deposits resemble water-laid till interbedded with other sediments (see Evenson, Dreimanis, and Newsome, 1977). However, there is no body of water for these sediments to be deposited in (nor any possibility of such a body). Our depositional model for these deposits is shown schematically in figure 4. It seems likely that the actual Illinoian age ice front stood some distance back from the terminus. As till reached the surface of the melting ice some of it, because of its high water content or steep slope, flowed down slope and out into the area of the terminal ridge. The change from till to a mudflow created some of the sedimentological characteristics described for the diamictons (see Lawson, 1979). Either some of these flows were little altered or coherent till was carried with some of the debris flows into the sequence. Some fluvial deposition also occurred in this ice marginal setting, but these deposits were of very minor importance in this area. Peats formed in some local depressions and organic debris accumulated in others. In small ponds laminated silts were deposited. Some of these pond deposits may also have formed on the ice, and then moved as a debris flow into the terminal ridge area as well. As ice blocks melted some of these materials may have been reworked several times.

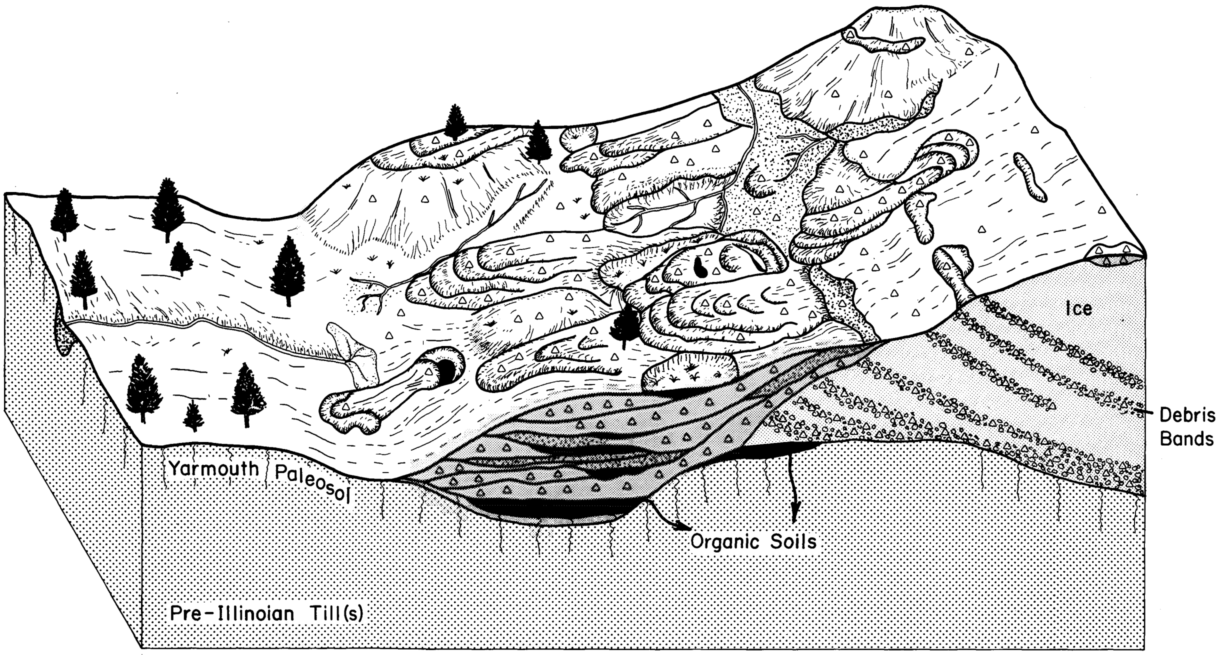


Figure 4. Schematic depositional model for the Illinoian deposits near Yarmouth (adapted from Evenson, Dreimanis, and Newsome, 1977).

All these subaerial processes acted to produce the complicated sequence of low-density, soft, interbedded deposits of flow-tills (diamictons and till-like sediments) paludal, and fluvial sediments described. When the ice finally melted these terminal deposits became a ridge by topographic inversion, as the topographically higher ice-front to the east disappeared.

These pro-Illinoian deposits left in the ridge are in the same position as Leverett's "nearly pebbleless" gray silts, gray clays containing wood, sand with thin beds of blue clay and also of cemented gravel, and peat and mucks containing wood. Leverett's "Yarmouth" sediments actually are these pro-Illinoian sediments that were deposited along the ice-front.

These deposits are an excellent representation of the superglacial facies of the Kellerville Till Member. The nature and properties of these deposits are more fully discussed in Hallberg, Wollenhaupt, and Wickham (this volume).

Table 3. Laboratory data, additional cores, Yarmouth Locality.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX. - % -	ILL.	K+C	H.S.I.	D.I.	D. cps	C.	Clay	Particle Size Silt - % -	Sand
CORE - 29 WH-2												
"Lower" WISCONSINAN Sediments - Basal loess paleosol												
IIA1b	11.3	666	U1	U2	U2	1.0	U2			See figure		
IICgb	12.0	667	U1	U1	U1	1.0	0.72					
GLASFORD FORMATION - SANGAMON PALEOSOL												
IIABgb	13.3	668	U1	U2	U2	U1	U2					
IIIB2tgb	14.0	669	U1	U1	U1	2.0	0.70					
IIIB23tgb	15.0	670	U1	U1	U1	2.0	0.81					
IIICgb-	16.2	671a	51	28	21 C	8.0	0.89	t				
MUL	16.4	671b	51	29	20	10.0	0.95	10	t			
WOLF CREEK FORMATION - Undifferentiated sediments YARMOUTH PALEOSOL												
IVA1b	16.9	672	U2	U2	U2	9.0	U2					
IVB1tgb	17.9	673	U2	U2	U2	10.0	U2					
IVB21tgb	18.6	674	U2	U2	U2	10.0	U2					
WOLF CREEK FORMATION - Hickory Hills Till Member												
IVCb-	24.8	675	63	11	25	23.0	0.3		t			
MOL												
MOL	26.0	984	62	14	24	21.0	0.36		t	22.1	32.3	45.6
MRL	28.0	985	61	18	21	21.0	0.50	t	t	21.9	31.4	46.7

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX. - % -	ILL.	K+C	H.S.I.	D.I.	D. cps	C.	I.D.	C/D	Sand-Fraction Lithology T.C.	Sh. - % -	Sed.	Q.F.	T.X.	Notes	Ca	Matrix CO_3 Do - % -	T.C.	C/D	Particle Size Clay	Silt - % -	Sand
CORE - 29 WH-3																								
GLASFORD FORMATION - Kellerville Till Member, superglacial facies. SANGAMON PALEOSOL																								
IIB1tgb	10	676	U1	U2	U2	2.0	U2																	
IIB2tgb	10.5	677	U1	U2	U2	2.0	U2																	
RL	13.0	678	50	28	22	7.0	0.87																	
CORE - 29 WH-4																								
Wisconsinan Loess																								
DOL	6.5	1178	78	15	7	30.0	1.42																	
GLASFORD FORMATION - Kellerville Till Member, superglacial facies.																								
MOL	15	1175	48	35	17	6.0	1.42																	
OU	18	1176	32	42	22	4.5	1.38	t		186	N.C.	41.0	2.9	44.8	50.9	55.1	Coal	3.5	12.6	16.1	0.28	19.9	43.1	37.0
OU	19	1177	40	43	17	7.5	1.71	10	20	188	1.6	41.3	--	42.2	53.2	57.7								
OU	* 19	ILL.	36	47	17		1.9											* 4.2	10.5	14.7	0.40			

* Analyses by the Illinois State Geological Survey; Clay min. - H.D. Glass; Matrix Carbonates of the < 0.74 mm fraction, J.T. Wickham.

U - Clay Mineralogy uncalculable because of weathering effects.
1. Broad diffuse expandable peak.
2. No illite peak apparent.

NC - Not calculated.

t - trace

Palynological Evidence

In the Yarmouth Core (Core Y, see Description 1) a peat and muck occurred at the base of these interbedded diamictons and sediments. This portion of the core is described in detail in Description 3 and figure 5. These organic sediments form the upper portion of a paleosol which is developed in the underlying Hickory Hills Till Member.

This basal peat and the thin peats in the interbedded deposits were processed for pollen. The deposits contained only modest amounts of pollen, but enough pollen was extracted from three levels for valid pollen counts. An additional count was obtained from the interbedded sediments from a depth of 25 feet (S-25; figure 6) in core 29 WH-1. The pollen percentages are shown in figure 6. The sequence is dominated by *Picea* (spruce) pollen throughout. *Larix* (larch) and *Picea* wood have also been identified from the peat and the diamictons (figures 2 and 6).

The vegetation is interpreted as a *Picea-Larix* forest. This forest type was dominant in all the full-glacial to late-glacial sequences of Wisconsinan sections in the midwest (e.g. - Van Zant, 1979). Wisconsinan interstadial deposits in Iowa often contain *Picea*, but most are dominated by *Pinus* (pine). Figure 7 shows the arboreal pollen percentages for a Farmdale age peat from core 29 WH-2 (see figure 1) as an example. No Holocene deposits in this region contain more than a trace of *Picea*, and most are dominated by Gramineae (grass) and other NAP (non-aboreal pollen) and/or pollen of deciduous trees.

Using the Wisconsinan and Holocene sequences as a model, the pollen sequences from the interbedded diamictons and peats, and from the basal peat at Yarmouth cannot represent an interglacial time, nor even an interstadial (e.g. - Farmdale). Rather, the pollen evidence, as well as the sedimentological evidence, indicate that these deposits represent pro-glacial deposits which formed along the ice front during early stages

Description 3. Detailed description of portion of Yarmouth Core Site; beginning at 92 feet (28.0 m)

Depth-feet (meters)	Horizon or Zone	Description
		ILLINOIAN STAGE
		GLASFORD FORMATION - Kellerville Till Member, superglacial facies.
92.0 - 92.4 (28 - 28.2)	UU	Dark greenish-gray (5 BG 4/1), silt loam with few pebbles; till-like, but with thin, 0.06 in (2 mm) bed of organic material.
92.4 - 92.9 (28.2 - 28.3)	UU	Dark greenish-gray (5GY 4/1) loam with pebbles; till-like, abrupt upper and lower contacts.
		GLASFORD FORMATION - Undifferentiated organic sediments Complex "Early" Illinoian - Late Yarmouth Paleosol
92.9 - 93.2 (28.35 - 28.42)	I Oa1b	Very dark gray (10YR3/1), silty peat; massive to weak thinly bedded; compact, leached, fine-grained organic debris; abrupt upper boundary, gradual lower boundary. "Early (pro)-Illinoian" peat.
93.2 - 93.6 (28.42 - 28.54)	I Oa2b	Very dark gray (10YR3/1) and dark brown (7.5-10YR3/2) peat; fine bedding or laminations; compact, leached, fine-grained organic debris; clear lower boundary. "Early (pro)-Illinoian" peat.
93.6 - 94.3 (28.54 - 28.73)	II A1b	Mixed black and very dark gray (10YR2/1 and 3/1), mucky silt loam; moderate very fine platy structure, some fine strata of fine sands and coarse silts; compact, leached, frequent macroscopic organic particles. "Early (pro)-Illinoian" organic silts.
94.3 - 95.1 (28.73 - 29.00)	II A3b	Black and very dark gray (10YR2/1 and 3/1) mucky silt loam (many very thin fine sand and coarse silt strata 28.75-28.81 m); strong thin platy structure breaking to weak very fine subangular blocky structure; compact, leached, more coarse organic debris than above, spruce wood fragments (<u>Picea</u> undifferentiated)*; gradual boundary. "Early (pro)-Illinoian" organic silts.
		PRE-ILLINOIAN
		WOLF CREEK FORMATION - Undifferentiated sediments YARMOUTH PALEOSOL
95.1 - 95.6 (29.00 - 29.15)	III B1gb	Very dark gray and black (10YR3/1 and 2/1, silty clay loam; moderate very fine angular blocky structure, weak thin platy; firm; some charcoal and wood fragments; leached, till-derived sediments.
95.6 - 96.0 (29.15 - 29.26)	III B21tgb	As above, heavier silty clay loam, with occasional pebble; common 1-2 mm oval to round dark greenish gray (5GY-5G4/1) inclusions; moderate very fine angular blocky structure; few fine vertical exped root tubules; few thin and moderate clay films; gradual upper, abrupt lower contact; leached till-derived sediments.
96.0 - 96.3 (29.26 - 29.35)	III B22tgb	Dark greenish gray (5G4/1) clay loam, with many dark greenish gray coatings and mottles (5GY4/1, 5BG4/1, 5Y4/1); strong to moderate very fine angular blocky structure; common thin and moderate clay films, continuous along fine to medium vertical root tubules; leached till-derived sediment.

Description 3 con't.

WOLF CREEK FORMATION - Hickory Hills Till Member

YARMOUTH PALEOSOL developed in upper part.

96.3 - 96.9 (29.35 - 29.52)	IV B3tgb	As above; clay loam grading to loam; moderate grading to weak very fine angular blocky structure; gradual boundaries; leached till.
96.9 - 102.0 (29.52-31.09)	IV Cgb-MRL to MUL	Dark greenish gray (5GY4/1) to dark gray (5Y4/1), loam with pebbles; massive with local weak to moderate medium angular blocky structure; reduced to mottled, unoxidized, and leached till.
102.0 - 115.0 (31.09-35.05)	UU	As above, unleached few mottles; unoxidized, unleached till.

* Wood identified by Dr. Dwight W. Bensend,Department of Forestry, Iowa State University

of the Illinoian glaciation. The basal peat and muck (figure 5) may have formed before the ice reached this position.

Other sections investigated have given similar results. The organic silts which underlie the Kellerville Till Member at the Nelson Quarry Section (Hallberg, Wollenhaupt, and Wickham, this volume) contained both *Picea* and *Larix* wood. The pollen at this site was not well-preserved enough to be counted. At the Schroder Section (Hallberg, Wollenhaupt, and Wickham, this volume) a peat again underlies the Kellerville Till Member, and overlies a thick, gleyed well-developed paleosol developed, in part, in the Hickory Hills Till Member. Preliminary work on this peat also show that its pollen spectrum is dominated by *Picea*.

REVISION OF THE YARMOUTH TYPE SECTION

The deposits originally defined by Leverett as indicative of the Yarmouth are actually pro-Illinoian sediments. Leverett's "soils" or the peats within these sediments, and even the peat at the base of these sediments are also pro-Illinoian and incompatible with the concept of the Yarmouth as an interglacial.

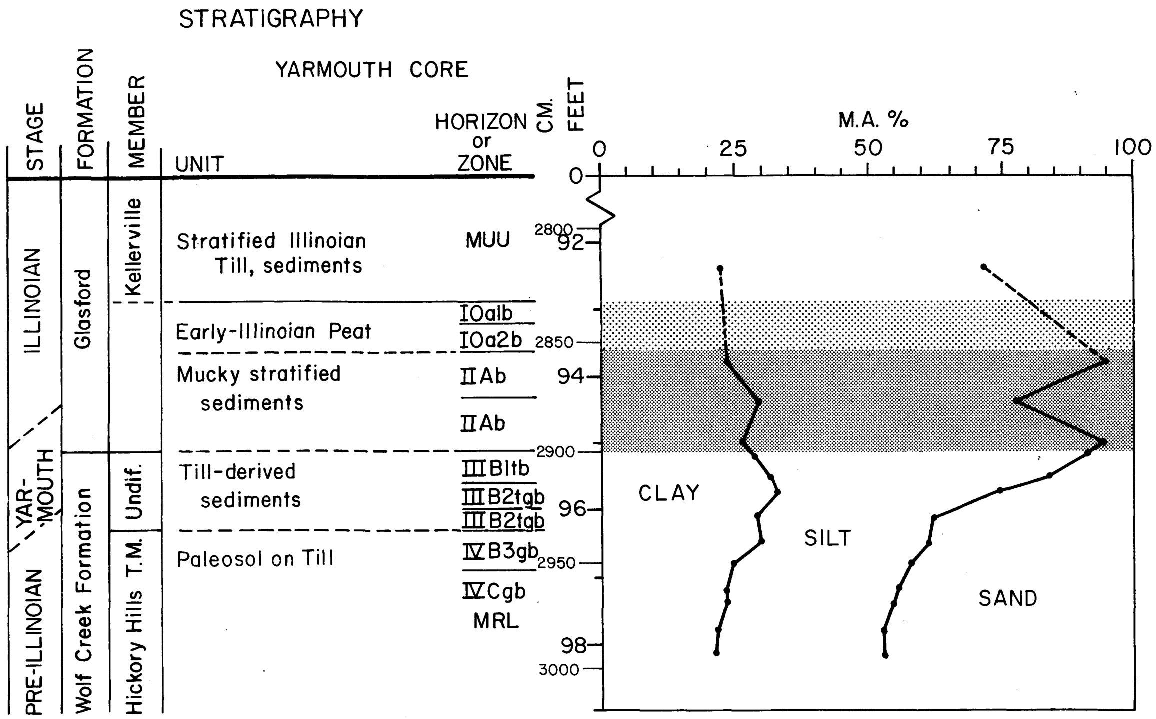


Figure 5. Stratigraphy and particle-size for a portion of the Yarmouth core.

Leverett also included the "deep weathering" of the underlying "Kansan" till. Fortunately, this allows rather easy redefinition of the Yarmouth. As described (Description 3, figure 5) the basal peat in the Yarmouth Core overlies a well-developed paleosol in slope wash sediments and the Hickory Hills Till Member. We here propose that the type-section for the Yarmouth Paleosol and Yarmouthian Stage be designated the Yarmouth Core Site as given in Descriptions 1 and 3. Further, the upper boundary of the Yarmouth Paleosol and Stage are considered to be the contact between the Early (or pro-) Illinoian peat and mucky stratified sediments and the underlying paleosol in till-derived sediments and the Hickory Hills Till Member of the Wolf Creek Formation (figure 5, Description 3). This well-developed paleosol is what "Yarmouth" has come to mean over time, since Leverett's original definition. Thus, in the

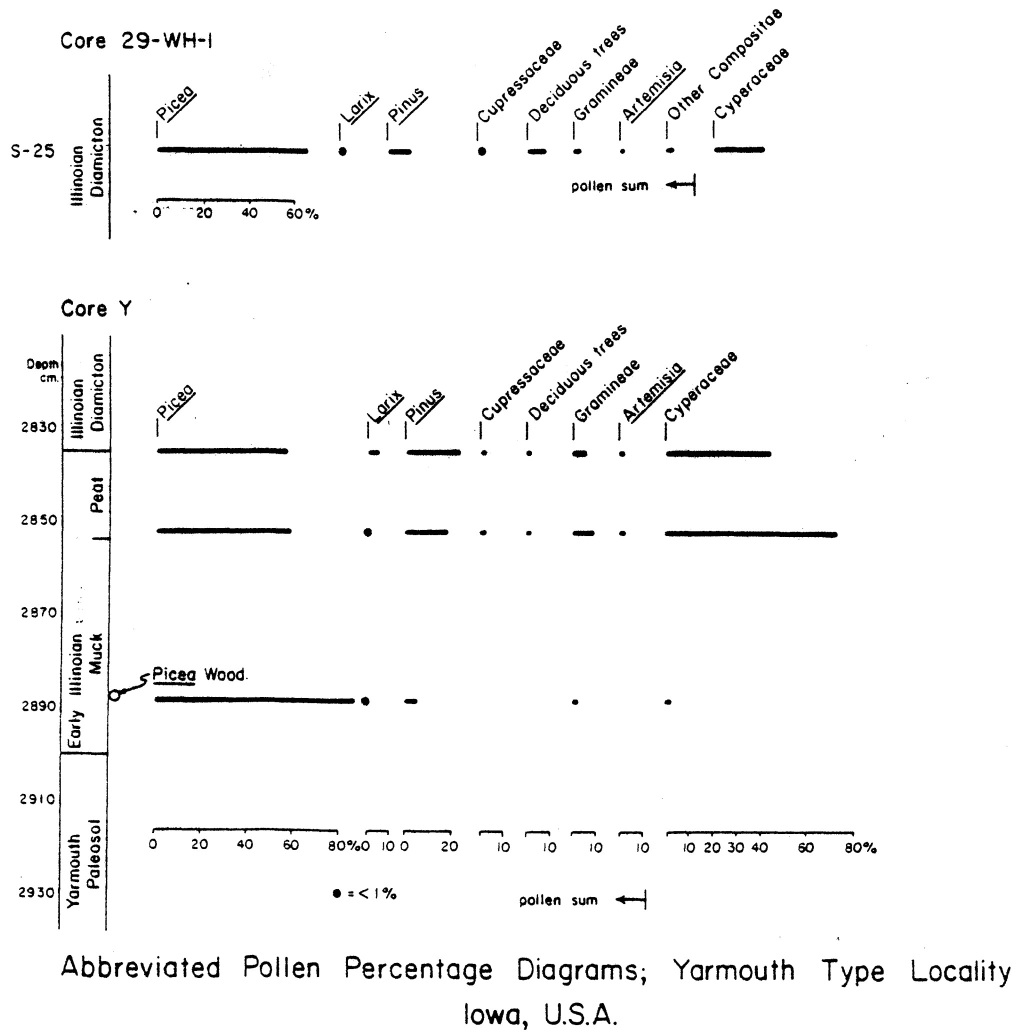


Figure 6. Pollen percentage diagram for peat deposits in Yarmouth Core and from Core 29 WH-1 (S-25, from 25 feet in depth).

type-section the Yarmouth Paleosol is a complex buried soil: the IOb and IIAb horizons are early-Illinoian organic sediments of the Glasford Formation (perhaps the equivalent of the Petersburg Silt), while the underlying well-developed mineral horizons are considered the Yarmouth Paleosol. The principle reference sections, which will be outlined, exhibit a clear contact between the Kellerville Till Member and the top of the Yarmouth Paleosol.

The type area remains as the region around the Yarmouth drilling transect (figure 1). Within the type area the sections from core site 29 WH-2 (the Brun Farm Section) are

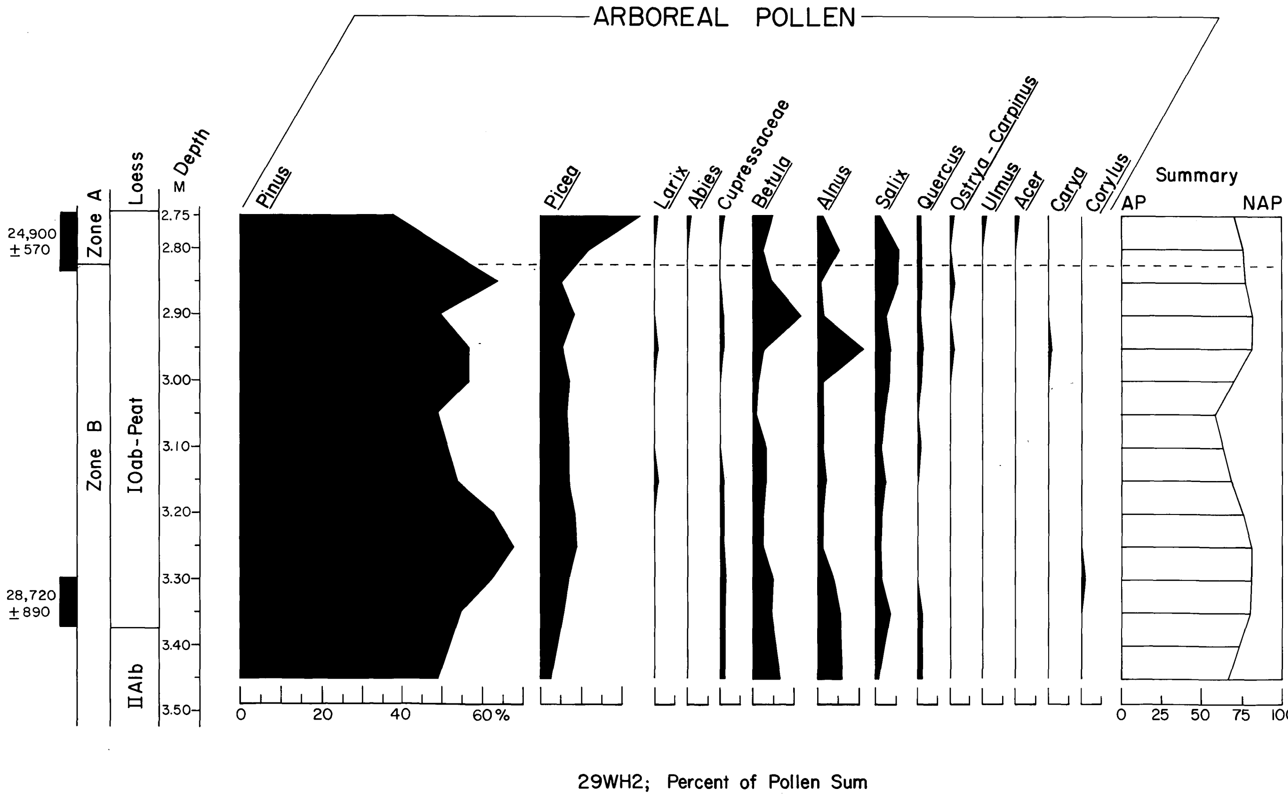


Figure 7. Arboreal pollen percentage diagram for Farmdale age peat from Brun Farm Section (29 WH-2; figure 1). From Hallberg, Baker, and Legg, 1980.

deemed reference sections. The cores from this area also illustrate some of the variations of the Yarmouth Paleosol and the local stratigraphy.

The Brun Farm Section occurs to the west, in front of the prominent terminal ridge. Sediments related to the Kellerville Till Member can be traced stratigraphically and mineralogically from the ridge out on to the tabular divide in front of the ridge. The general stratigraphy at the site is given in Description 4 and figure 8. The Yarmouth Paleosol is approximately 7 feet thick (2.1 m) and developed in unnamed fine-textured sediments and on the Hickory Hills Till Member of the Wolf Creek Formation. The Illinoian sediments are stratified and fine-textured, yet they contain some pebbles. It appears that some of the Kellerville sediment flows ran a considerable distance out from the terminal ridge at least locally. No

Description 4. Brun Farm Section; from core-hole (29 WH-2) on prominent tabular divide, stepped down from Yarmouth, Iowa; approximately 90 feet (27.4m) north of center line of east-west gravel road in the SE¼, of the SE¼, of sec. 18, T.72N., R. 4W., Des Moines County. Surface elevation 745 feet.

Depth inches-feet (meters)	Horizon or Zone	Description
WISCONSINAN LOESS		
0-108 (0-9) (0-2.7)	DOL	Modern solum and deoxidized and leached Wisconsin loess; silt loam to heavy silt loam.
Middle-WISCONSINAN Peat; Complex Basal Loess paleosol		
108-133 (9-11.1) (2.7-3.4)	IOab-IOeb	Black (10YR2/1) peat to silty peat; compact fibrous laminated zones, with some beds of fine grained organic debris; mineral fraction is silty clay loam; leached, middle Wisconsin peat (Farmdale). 108-111-24, 900±570 RCYBP (I-9357); 130-133-28, 720±890 RCYBP (I-9358).
"Lower"-WISCONSINAN Sediments; Complex Basal Loess paleosol		
133-143 (11.1-11.9) (3.4-3.6)	IIA1b	Very dark gray (10YR3/1) silty clay loam; weak very fine to fine granular and crumb structure; few thin clay films; weak stratification (1-2mm); some large pieces of charcoal and organic matter; leached "Basal Wisconsin" soil on sediments.
143-158 (11.9-13.2) (3.6-4.0)	IICgb-RL	Dark greenish gray (5GY4/1) silty clay loam with few greenish gray (5GY4/1) mottles; massive to very weak very fine subangular blocky; few fine vertical root tubules with coatings; clear upper, abrupt lower boundary; leached "Basal Wisconsin" sediment.
GLASFORD FORMATION - Kellerville Till Member?		
	SANGAMON PALEOSOL developed in sediments of the superglacial facies of the Kellerville Till Member, or stratified materials derived from them.	
158-162 (13.2-13.5) (4.0-4.1)	IIIABgb	Greenish gray (5GY4/1) silty clay loam (heavier than above) with common dark olive gray (5Y3/2) mottles and coatings on peds; weak very fine subangular blocky structure; common fine vertical and horizontal root tubules;charcoal and organic carbon flecks; very abrupt lower boundary; leached.
162-165 (13.5-13.8) (4.1-4.2)	IIIB1tgb	Greenish gray and gray (5GY-5Y4/1) silty clay (few pebbles); moderate fine subangular structure; common root tubules; many thin clay films and dark olive gray (5Y3/2) coatings; clear lower boundary; leached ; Sangamon paleosol on stratified Illinoian sediments or diamicton.
165-177 (13.8-14.8) (4.2-4.5)	IIIB2tgb	Dark greenish gray (5GY and 5G4/1) silty clay loam, with common bluish gray (5B5/1) mottles; strong fine subangular blocky structure; common fine and medium root tubules; continuous moderate clay films, with thick clay and dark gray (5Y4/1) coatings along prominent vertical faces and tubules; gradual lower boundary; leached; Sangamon paleosol on stratified Illinoian sediments or diamicton.
177-184 (14.8-15.3) (4.5-4.7)	IIIB23tgb	Dark greenish gray (5BG4/1) silty clay with many pebbles; moderate fine to very fine subangular blocky, many thin clay films with thicker coatings on prominent vertical faces and tubules; gradual lower boundary; leached as above.

184-192 (15.3-16.0) (4.7-4.9)	IIIB3tgb	As above, heavy silty clay, with occasional pebbles; common thin clay films; clear lower boundary; leached Sangamon paleosol of stratified Illinoian sediments or diamicton.
192-198 (16.0-16.5) (4.9-5.0)	IIICgb- MUL	Dark greenish gray (5BG4/1) silty clay loam with few (5GY4/1) mottles; massive to weakly stratified; I mm organic rich strata; few pebbles of coal; abrupt lower contact; leached stratified Illinoian sedmients or diamicton.

WOLF CREEK FORMATION - Undifferentiated Pre-Illinoian Sediments

YARMOUTH PALEOSOL

198-208 (16.5-17.3) (5.0-5.3)	IVA1b	Dark gray (5Y4/1) silty clay loam; very weak very fine subangular blocky or granular structure; organic carbon flecks (1-2 mm); leached Yarmouth paleosol on swale-fill sediments.
208-219 (17.3-18.3) (5.3-5.6)	IVB1tgb	Dark greenish gray (5GY4/1) silty clay; moderate fine to very fine subangular blocky structure; few thin and moderate clay films and greenish gray (5GY5/1) coatings; gradual upper diffuse lower boundary; leached, Yarmouth paleosol and swale-fill sediments.
219-240 (18.3-20.0) (5.6-6.1)	IVB21tb	As above, silty clay with occasional pebble; strong fine subangular blocky structure; firm; common fine and medium vertical root tubules; continuous thin many moderate and thick clay films and olive gray (5Y4/2-3) coatings; gradual lower boundary; leached Yarmouth paleosol on swale-fill sediments.
240-248 (20-20.7) (6.1-6.3)	IVB22tgb	As above silty clay, with common yellowish red (5YR4/8) and olive (5Y4/4) mottles.
248-260 (20.7-21.7) (6.3-6.6)	IVB23tgb	Dark gray (5Y4/1) clay, with common yellowish red (5YR4/6-8) mottles; strong to moderate fine (larger than above) subangular blocky structure; many thin and common moderate and thick clay films and olive coatings (5Y3/2; 4/4; 5/6) along vertical root tubules and prominent vertical faces; clear lower boundary; leached Yarmouth paleosol on swale-fill sediments.
260-268 (21.7-22.3) (6.6-6.8)	IVB3tgb	Olive (5Y4/3 and 4/1) clay with occasional pebbles and common yellowish red (7.5 YR 5/6; 5YR 4/8) mottles; moderate fine (larger than above) subangular blocky; very firm; common thin few moderate clay films; clear lower boundary; leached Yarmouth paleosol on swale-fill sediments.

WOLF CREEK FORMATION - Hickory Hills Till Member

(Yarmouth Paleosol)

268-282 (22.3-24.5) (6.8-7.2)	VB3tb	Yellowish brown (10YR5/4) clay with pebbles with common dark gray (5Y and 5GY4/1), olive (5Y 4/3), and strong brown (7.5YR5/6-5YR4/6) mottles; moderate fine to medium subangular blocky structure; common thin clay films, with thick olive (5Y4 and 5/3) coatings and slickensides on vertical joints; gradual lower boundary; leached Yarmouth paleosol on till.
282-300 (23.5-25) (7.2-7.6)	VCb MOL	Yellowish brown (10YR5/6) clay loam with pebbles and common grayish brown (10YR5/2) and few strong brown (7.5YR5/8) mottles; firm; massive; leached till.

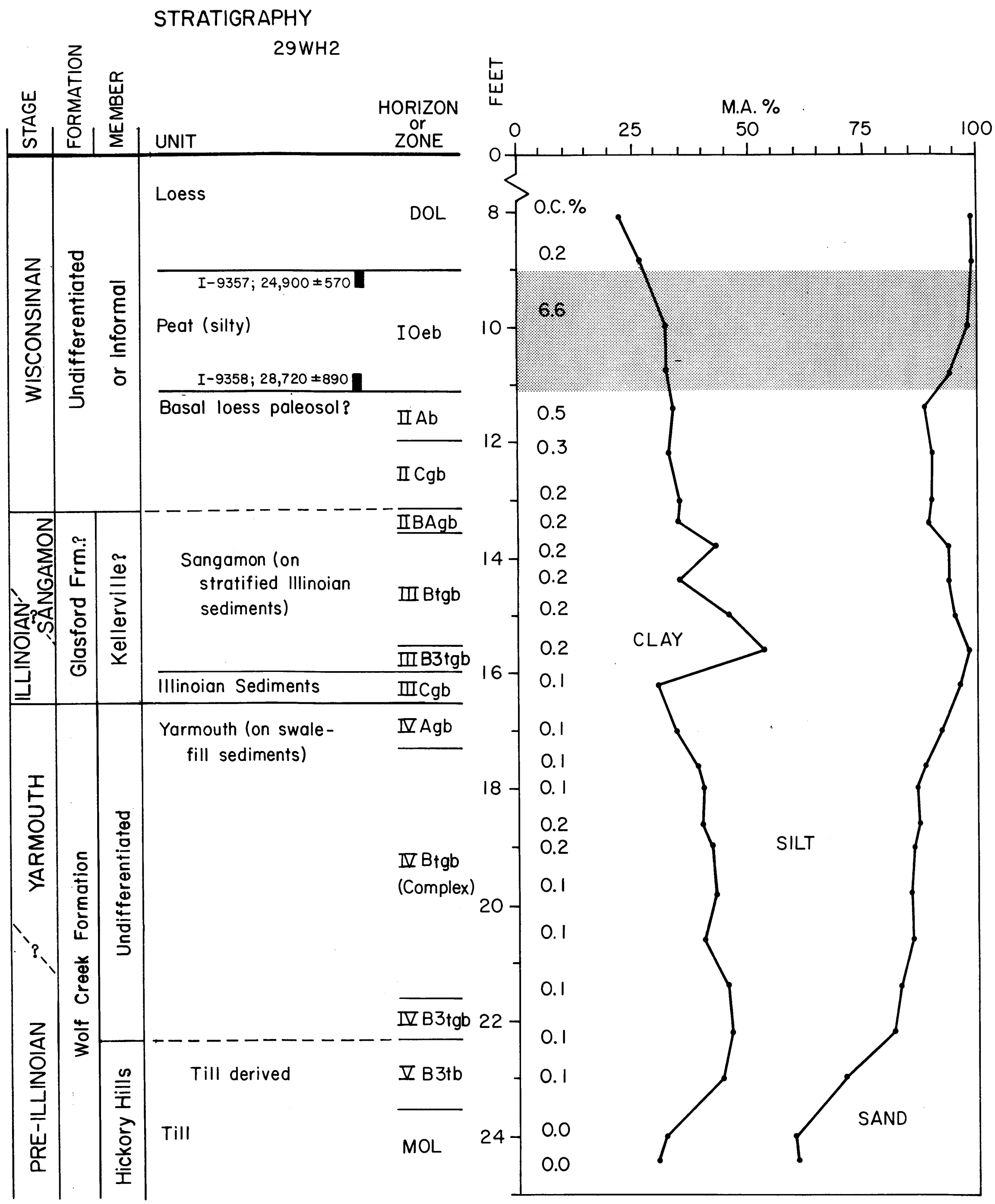


Figure 8. Stratigraphy and particle-size data for Core 29 WH-2, Brun Farm Section (Core 2-1 on figure 10).

trace of these sediments occurs 3/4 mile (1.2 km) north and west of this section (see 44 H-1 section; Hallberg, Wollenhaupt and Wickham, this volume).

The "early" Wisconsinan sediments and paleosol consist of loamy sediments which overlie the Sangamon Paleosol. An A/C soil profile occurs in the upper portion of the sediments, and is overlain by peat which is dated at 28,720 RCYBP immediately above the contact (figure 7). These sediments are mineralogically similar to those of the Illinoian Kellerville Till Member (Table 3), and they probably represent local erosion and redeposition of the Illinoian sediments in Wisconsinan time.

Several other cores were taken around the Brun Farm Site. Figure 9 shows the stratigraphy and data for another core about 50 feet from core 29 WH-2. At this site the Yarmouth Paleosol is developed entirely on local alluvium. Figure 10 shows the general relations between three cores in the Brun Farm location.

Other Reference Sections

The Yarmouth Paleosol in the type area is deeply buried and inaccessible. Consequently, additional reference sections are designated.

Reference sections, in exposures are difficult to find, and they are often short-lived. Two examples are worthy of mention for their future potential. Willman and Frye (1970) suggested that their Ft. Madison Section in Lee County, Iowa, could serve as a paratype for the Yarmouthian Stage and Yarmouth Paleosol. However, this section is no longer in existence, and the details of its stratigraphy in a modern context is also not known (see Hallberg, 1980). The Schroder Section (Hallberg, Wollenhaupt, and Wickham, this volume) exposes a stratigraphic sequence similar to Yarmouth and would be an excellent reference section. At the Schroder Section a thick sequence of the Kellerville Till Member overlies a pro-Illinoian peat, as at Yarmouth. This sequence overlies a very thick, gleyed, well-developed Yarmouth Paleosol. This section would also be good from an historical perspective in that it

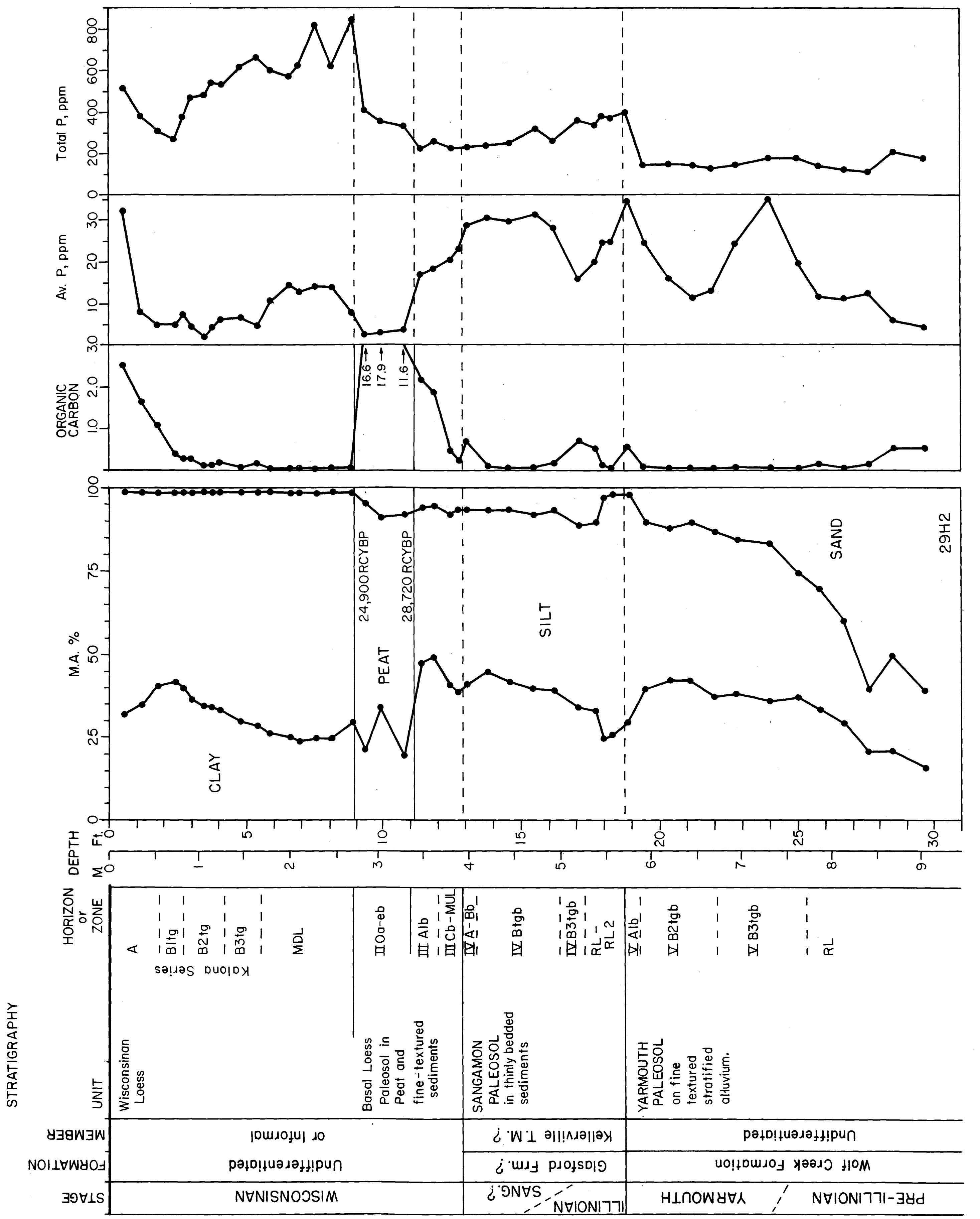


Figure 9. Stratigraphy and lab data for Core 29 H-2, Brun Farm Section (Core 2-2, on figure 10). Radiocarbon dates from 29 WH-2 (figure 8).

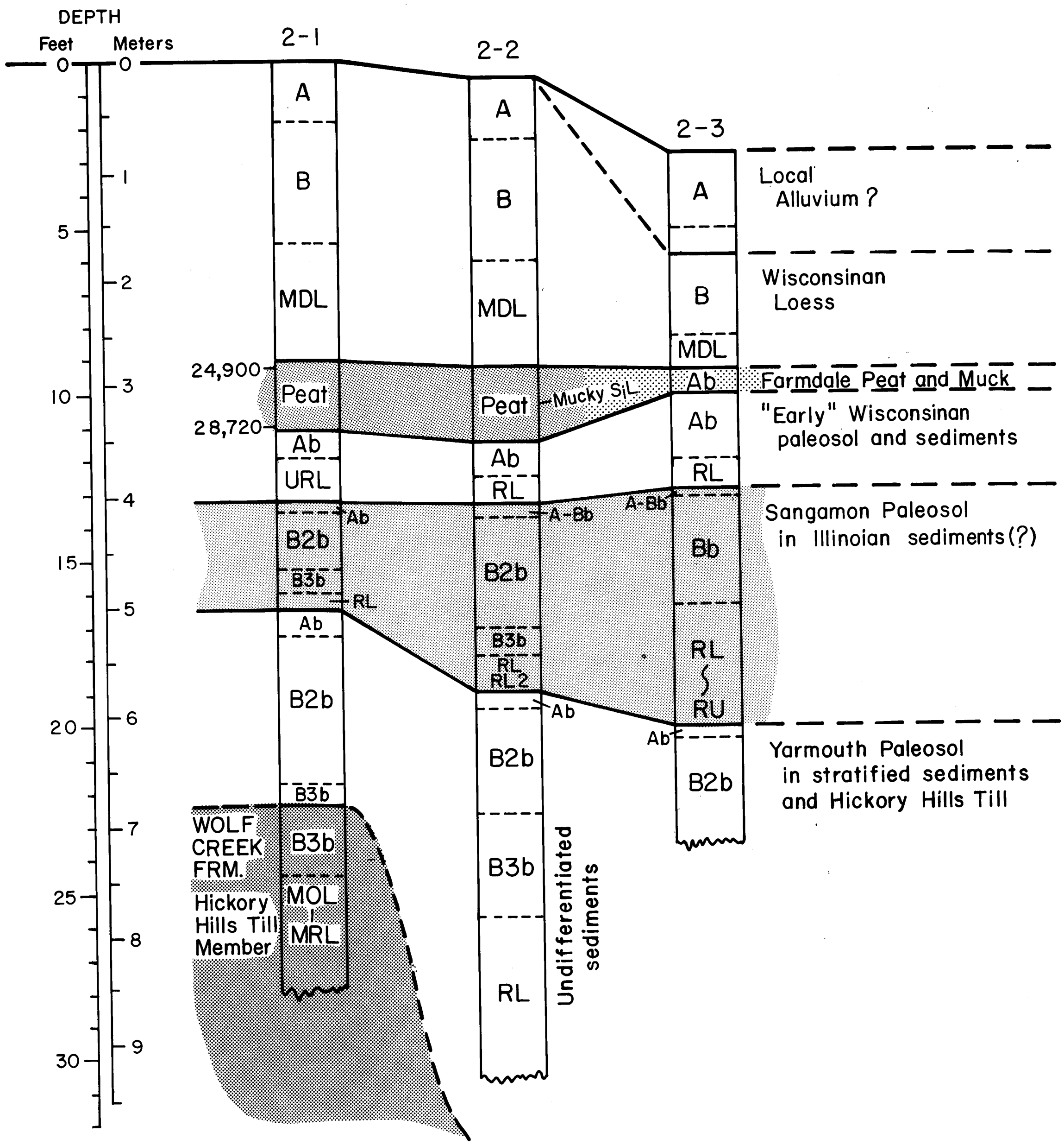


Figure 10. Schematic cross section from cores at Brun Farm Section (2-1 = 29 WH-2, figure 8; 2-2 = 29 H-2, figure 9).

is very close to a principle section of Kay and Apfel (1929, p. 228) that showed "Illinoian" till over 11 feet (3.4 m) of "Kansan gumbotil." Unfortunately, Kay and Apfel's section is overgrown, and the Schroder Section is exposed in the excavation for an artificial pond. It is likely under water even by this writing.

Description 5. Mediapolis outcrop section; taken in steep sloping stream cut, located in the SE¼, of the SE¼, of the NW¼, of sec. 36, T.72N., R.3W., Des Moines County. Elevation approximately 755 feet. (Description by T.E. Fenton, M. Collins, G.A. Miller, and G.R. Hallberg.)

Depth-Feet (m)	Horizon or Zone	Description
WISCONSINAN Loess		
0 - 0.3 (0 - 0.1)	A1	Dark brown (10YR 3/3) silt loam; with very dark grayish brown (10YR 3/2) coatings on peds; moderate fine granular structure.
0.3- 0.6 (0.1- 0.2)	A2	Brown (10YR 4/3), heavy silt loam; platy breaking to weak fine subangular blocky structure; dark brown (10YR 3/3) coats on ped faces, discontinuous light gray (10YR 7/1, dry) silt "grainy" coats; clear lower boundary.
0.6- 1.0 (0.2- 0.3)	B1	Dark yellowish brown (10YR 4/4) silty clay loam; moderate fine to medium subangular blocky structure; brown (10YR 4/3) coatings, few fine dark brown (10YR 3/3) soft (microbial?) pellets.
?GLASFORD FORMATION?	Undifferentiated Sediments? Hillslope sediments? or superglacial deposits? With exhumed SANGAMON or LATE-SANGAMON PALEOSOL	
1.0- 1.7 (0.3- 0.5)	IIB21t	Olive brown (2.5Y 4/3) silty clay; with continuous dark grayish brown (2.5Y 4/2) clay coatings; strong very fine subangular blocky structure.
1.7- 2.5 (0.5- 0.8)	IIB22t	Dark grayish brown (10YR 4/2) ped exteriors, with few pebbles; moderate medium prismatic breaking to strong fine to very fine subangular blocky structure, continuous 10YR 4/2 clay coatings.
2.5- 3.2 (0.8-0.9)	IIB23t	Grayish brown (10YR 5/2) silty clay, with few pebbles; many fine dark brown (10YR 4/3), and few fine yellowish red (5YR 4/6) mottles; moderate medium prismatic breaking to strong fine to very fine subangular blocky; yellowish brown (10YR 5/4) exterior clay coatings.
3.2- 3.5 (0.9-1.1)	IIB24t	As above, silty clay; with many fine to medium yellowish brown (10YR 5/6) mottles.
3.5- 4.0 (1.1- 1.2)	IIB31t	Mottled grayish brown (10YR 5/2) and yellowish brown (10YR 5/6) silty clay; structure as above, few coatings; common fine dark reddish brown (5YR 2/2) MnO concretions.
GLASFORD FORMATION -	Kellerville Till Member Superglacial facies; stratified sediments and diamictons.	
4.0- 4.5 (1.2-1.4)	IIIB32t	Grayish brown (2.5Y5/2), silty clay with few pebbles; many medium root channels with strong brown (7.5YR 5/6) coatings; structure as above.
4.5- 4.6 (1.4-1.4)	IIIB33	Band of dark gray (10YR 4/1) silty clay.
4.6- 5.2 (1.4-1.6)	IIIB34	Grayish brown (2.5Y 5/2) silty clay with pebbles; few fine yellowish red (5YR 4/6) and many fine yellowish red (5YR 5/6 and 8) mottles; structure as above.
5.2- 6.0 (1.6-1.8)	IIIB35	Mottled yellowish brown (10YR 5/6) and grayish brown (10YR 5/2) silty clay; moderate medium prismatic breaking to moderate medium and fine subangular blocky; many fine dark reddish brown (5YR 2/2) MnO concretions.
6.0- 6.4 (1.8-1.9)	IIIB36	Light brownish gray (2.5Y 6/2) silty clay; moderate medium to fine subangular blocky; common fine strong brown (7.5YR 5/6 and 8) mottles.

Description 5 con't.

6.4- 7.0 (1.9-2.1)	IIIC-MOL	Mottled yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) silty clay loam with pebbles; massive with some horizontal cleavage planes with 10YR 7/1 grainy coats; common fine dark reddish brown (5YR 2/2) MnO concretions; silty diamicton.
	Abbreviated description to depth.	
7.0- 8.1 (2.1- 2.5)	MOL	Loam till with some silty and sandy zones.
8.1- 9.6 (2.5- 2.9)	OU	As above, calcareous.
WOLF CREEK FORMATION - Undifferentiated sediments; YARMOUTH PALEOSOL (See Mediapolis-2 for detailed description.)		
9.6-17.1 (2.9-5.2)	I-IIIBtgb	Truncated, gleyed sediments; Yarmouth Paleosol.
WOLF CREEK FORMATION - Hickory Hills Till Member		
17.1-19.4 (5.2-5.9)	MOL	Loam till.
	Section ends at creek level; see Mediapolis cores 1 and 2.	

An outcrop south and east of Mediapolis, Des Moines County, is here designated a principle reference section for the Yarmouth Paleosol and Yarmouthian Stage. The Mediapolis Outcrop Section is in a steep streambank, and will be accessible for some time to come. The outcrop section (Description 5, figure 11) exposes Wisconsinan loess, over a Sangamon Paleosol developed in the superglacial facies of the Kellerville Till Member (see data in Table 4). This is underlain by till (basal till facies?) of the Kellerville Till Member which exhibits an abrupt lower contact with the Yarmouth Paleosol. The Yarmouth Paleosol is truncated at this location and begins in the B-horizon. The remaining paleosolum is about 7.5 feet (2.3 m) thick. The upper 6 feet (1.8 m) is developed in fine-textured, gleyed, swale-fill materials (Hallberg, 1980); the lower 1.5 feet (0.5 m) of the paleosol is developed in the Hickory Hills Till Member just as at Yarmouth.

Cores were also taken from sites around the stream cut to provide further information on this principle reference section. The cores reveal complexities in the sub-Kellerville Till Member surface. The Mediapolis-2 Core Site (figure 12, Description 6) is similar to the outcrop section and provides more complete

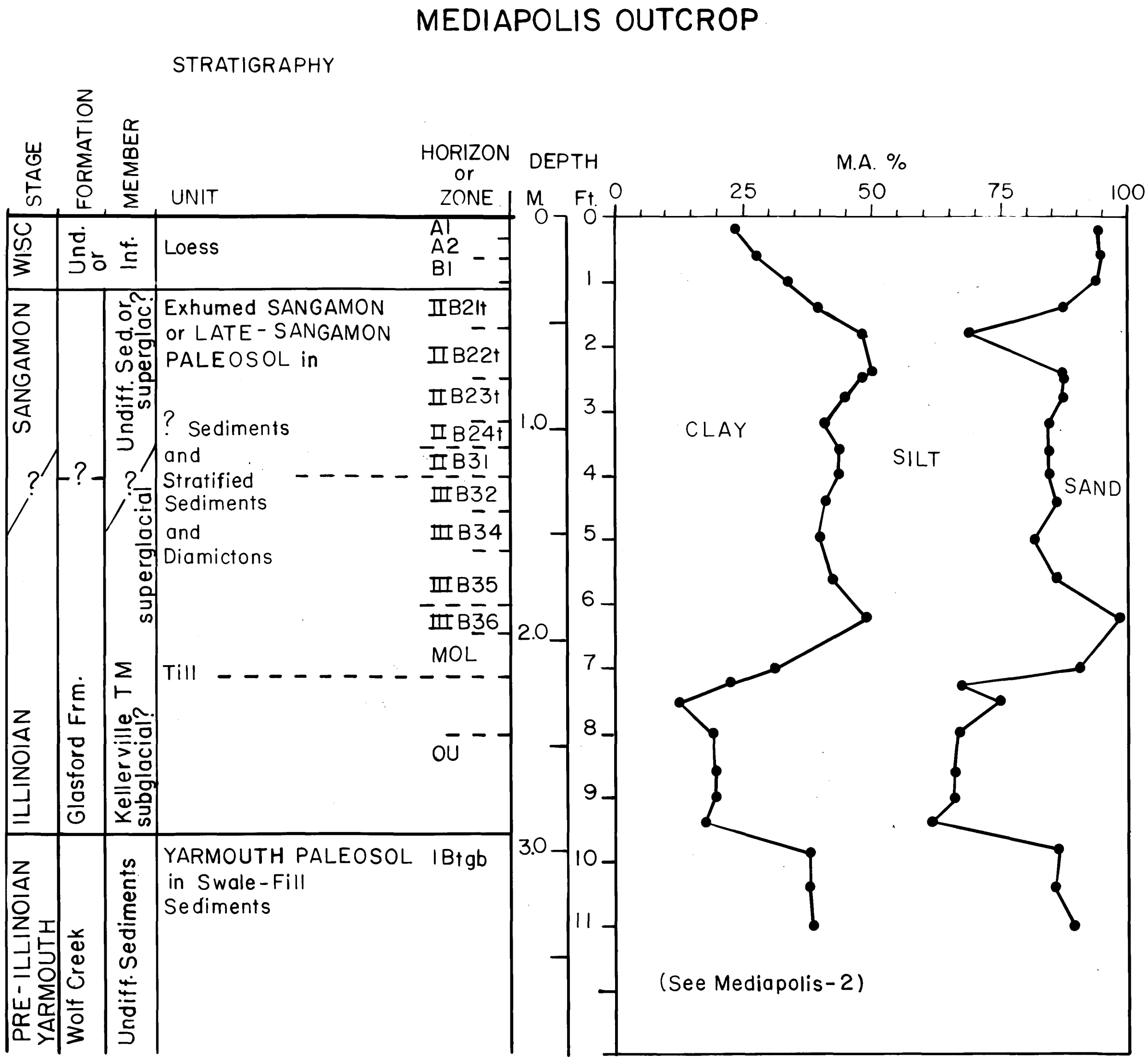


Figure 11. Stratigraphy and particle-size data Mediapolis Outcrop Section.

data on the Yarmouth Paleosol and the Hickory Hills Till Member. The Mediapolis-1 Core Site was drilled to bedrock to characterize the complete stratigraphic sequence (Description 7; Table 4). The Mediapolis-1 Core Site was located between the Mediapolis Outcrop Section and another outcrop of the Yarmouth Paleosol (figure 13). However, the Yarmouth Paleosol was not present, and the Kellerville Till Member rests directly on the oxidized and leached Hickory Hills Till Member (figure 14). Interpretation of the sub-Kellerville paleo-landscape from the outcrop

Table 4. Laboratory data Mediapolis locality.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX.	ILL. (- % -)	K+C	H.S.I.	D.I.	D.	C. (cps)	I.D.	C/D	Sand-Fraction Lithology T.C.	Sh.	Sed. (- % -)	Q.F.	T.X.	Notes	Ca	Matrix CO_3 Do (- % -)	T.C.	C/D	Particle Size Clay	Silt (- % -)	Sand
Mediapolis Outcrop Section.																								
GLASFORD FORMATION - Kellerville Till Member																								
OU	9.0	1531	50	31	19	10.0	1.11	t	20		1.1	23	12	35	55	65						30.6	36.4	33.0
OU	9.6	1182	65	18	17	21	0.73																	
(Note: sample at 9.6 ft. comes from contact with underlying sediments and shows some mixing or inclusions.)																								
WOLF CREEK FORMATION - Undifferentiated sediments; YARMOUTH PALEOSOL																								
IBtgb	9.7	1183	(78)	(11)	(11)	30.0	0.65																	
IBtgb	9.8	3163	(80)	(5)	(15)	NC	NC		t															
IBtgb	12.0	1538	(71)	(10)	(19)	26.0	0.37																	
IIBtgb	14.0	1545	(79)	(10)	(11)	28.0	0.63																	
WOLF CREEK FORMATION - Hickory Hills Till Member																								
MOL	19.2	1184	61	19	20	21.0	0.63															24.5	30.5	45.0
Mediapolis - 1 Core Site.																								
GLASFORD FORMATION - Kellerville Till Member, superglacial facies - ablation till.																								
OL	14.0	1546	62	20	18	14.0	0.80	t	-															
subglacial facies - basal till.																								
OU	* 16.7	ILL.	60	21	19	NC	NC										*	1.7	4.8	6.5	0.35			
OU	* 17.0	ILL.	54	27	19	NC	NC										*	2.7	7.2	9.9	0.38			
OU	17.0	3117	54	28	18	NC	NC			405	0.6	26	-	28	63	72		1.9	8.2	10.1	0.23	22.9	42.4	34.7
OU	17.0	1532	53	32	15	14.0	1.32	20	t															
OU	18.0	3116	41	38	21 C	NC	NC			415	14.0	41	2	43	49	57	Coal	2.8	9.1	11.9	0.31	21.7	43.5	34.8
OU	* 20.0	ILL.	55	26	19	NC	NC										*	1.5	6.3					
OU	20.0	3112	50	30	20	NC	NC			393	11.0	39	5	44	49	56	Pyrite							
OU	20.0	1541	51	33	16	12.0	1.08	30	50															

Table 4 con't.

OU	20.2	1533	41	52	17	C	14.0	1.25	20	30	531	1.1	44	5	49	49	51	Coal							
WOLF CREEK FORMATION - Hickory Hills Till Member																									
MOJL	21.0	3165	56	18	26		NC		-	-															
MOJU	23.0	3149	60	15	25		NC		NC		401	6.5	29	-	29	64	71								
MOJU	23.8	1534	57	19	24		NC		NC																
MOJU	* 25.0	ILL.	57	20	23		NC		NC									*	4.2	5.3	9.5	0.79			
MOJU	26.0	3120	56	20	24		NC		NC		416	5.6	26	-	26	69	74								
MOJU	* 31.0	ILL.	55	21	24		NC		NC									*	5.1	5.5	10.6	0.93			
MOJU	32.0	3114	55	20	25		NC		NC		389	6.5	21	2	25	65	75								
MOJU	33.0	1527	58	18	24		16.0	0.40	80	110									3.3	4.2	7.5	0.79	20.5	33.7	45.7
MOJU	* 35.0	ILL.	58	20	22		NC		NC									*	5.3	5.5	10.8	0.96			
MOJU	36.0	3133	55	21	24		NC		NC		400	3.5	28	-	28	58	72								
MRJU	37.0	1528	58	20	22		18.0	0.60	50	80															
MRJU	38.0	3142	61	18	21		NC		NC		421	4.0	30	-	30	65	70		4.2	5.0	9.2	0.84	21.1	32.8	45.1
MRJU	* 39.0	ILL.	56	20	24		NC		NC																
MRJU	40.0	3146	64	16	20		NC		NC		529	2.1	19	2	21	71	79								
MRJU	40.0	1529	59	20	21		18.0	0.60	60	140															
WOLF CREEK FORMATION - Aurora Till Member																									
OU	40.5										390	14.0	29	6	36	60	64						3.5	14.4	82.1
MOJU	43.0	1547	63	15	23		20.0	0.44	t	200	444	6.1	21	4	25	68	75						20.1	40.1	39.8
MOJU	47.0	3161	60	15	25		NC		NC														20.8	37.9	41.3
MOJU	52.0	1530	63	15	22		22.0	0.47	t	300	413	12.0	33	-	34	62	66						22.7	37.2	40.1
ALBURNETT FORMATION - Undifferentiated till																									
MRU	54.0	1537	42	28	30		15.0	0.63	30	120															
MUU	59.0	3144	39	29	32		NC		NC		528	6.0	17	1	19	74	81						20.4	32.0	47.6
UU	70.0	3155	39	23	38		NC		NC		397	14.0	24	-	28	65	72						16.8	34.3	48.9

* Analyses by the Illinois State Geological Survey; Clay min.-H.D. Glass; Matrix carbonates of the <.074 mm fraction J.T. Wickham.
U - Clay mineralogy uncalculable because of weathering effects.
1. Broad diffuse expandable peak
2. No illite peak apparent.
(31) % clay mineral calculated from weathered sample for discussion purposes.
C - Chlorite peaks apparent.
t - trace
NC - not calculated

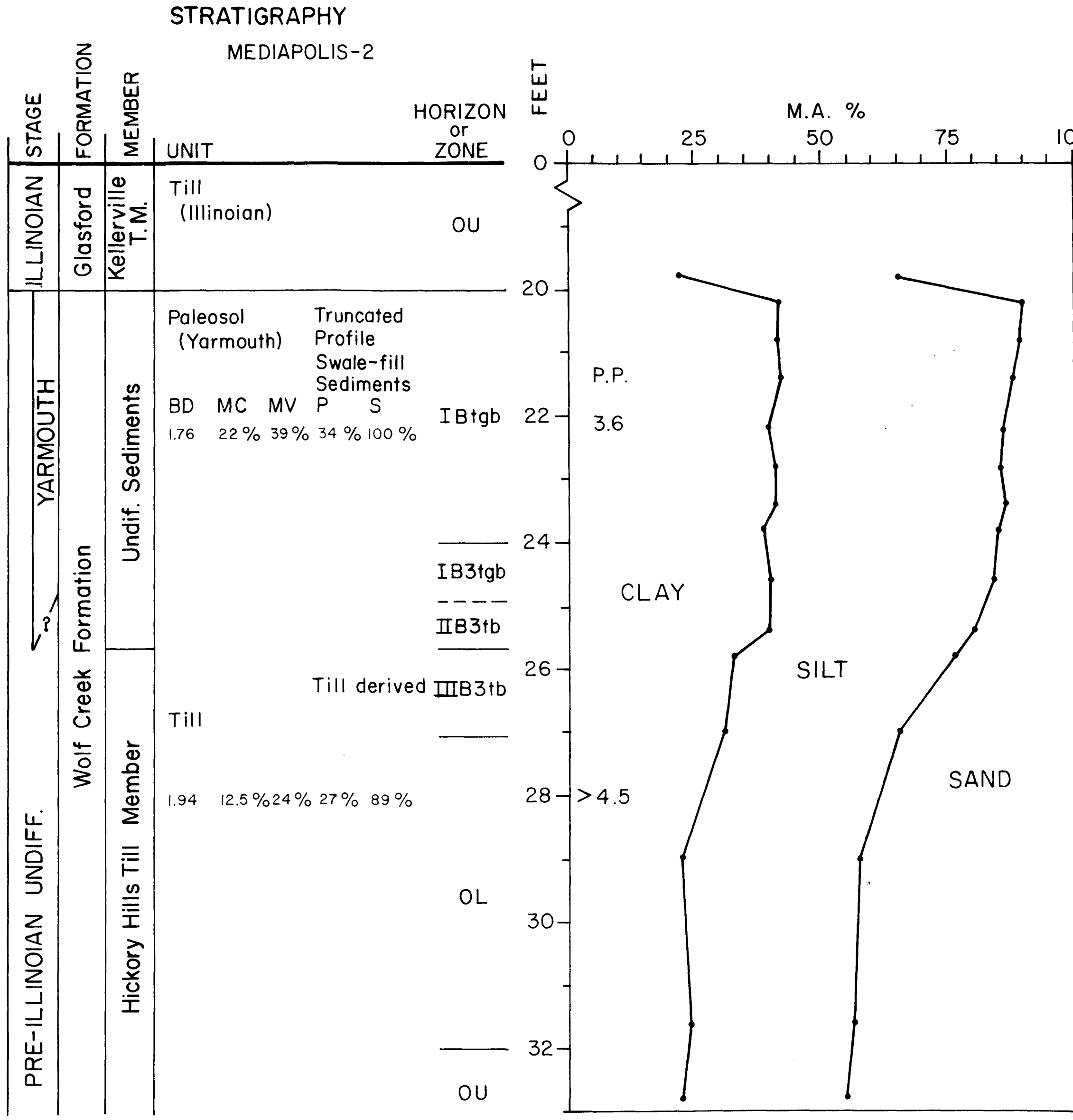


Figure 12. Stratigraphy and particle-size data Mediapolis-2 Core Site.

and core data (see leached-unleached boundary in the Hickory Hills Till, figure 13) indicate that the Mediapolis-1 Core Site was probably located on a topographic high in the paleo-landscape. The preservation of the Yarmouth Paleosol in this area is similar to the occurrence of sub-till paleosols in other parts of Iowa (Hallberg, 1980). The poorly-drained swale-fill sites are commonly preserved, while the higher, Description 6. Mediapolis-2 core site; in road bed on south side of east-west gravel road which forms center line of sec. 36, T.72N., R.3W., about 1,000 feet west of center of section, at about 762 feet elevation; Des Moines County.

Depth-Feet (m)	Horizon or Zone	Description
WISCONSINAN Loess		
0-9.5 (0-2.9)	DOL	Road bed and deoxidized and leached loess.
9.5-10.0 (2.9-3.0)	IAlb	Basal loess paleosol.
GLASFORD FORMATION - Kellerville Till Member; superglacial facies? SANGAMON PALEOSOL in upper part (see Mediapolis Outcrop and Core 1 section)		
10.0-15.1 (3.0-4.6)	IIAb-IIIBtb	Sangamon paleosol in fine-textured sediments and Illinoian till.
15.1-17.0 (4.6-5.2)	MOL	Oxidized and leached, loam-textured Illinoian till.
17.0-19.0 (5.2-5.8)	OU	Oxidized and unleached, stratified loam-textured till-like materials and sorted silts and sands.
19.0-19.5 (5.8-5.9)	OU	Oxidized and unleached sand and gravel.
WOLF CREEK FORMATION - Undifferentiated sediments; Truncated YARMOUTH PALEOSOL		
19.5-21.2 (5.9-6.5)	IB2?tgb	Gray and olive (5Y5-6/1 and 5Y4/3) silty clay; weak to moderate fine subangular blocky structure; very firm; common thin to moderate clay films, continuous coatings on medium tubules; abrupt upper boundary, diffuse lower boundary; leached swale-fill sediments, truncated Yarmouth paleosol.
21.2-22.6 (6.5-6.9)	IB2?tgb	As above, with common olive (5Y5/4) mottles; weak to moderate fine to very fine subangular blocky; very firm; few thin clay films, continuous moderate to thick coatings on vertical cleavage planes and around medium root tubules, few grainy (silt) coats; gradual lower boundary; leached swale-fill sediments.
22.6-24.0 (6.9-7.3)	IB2?tgb	Light olive brown to olive brown (2.5Y 5/4 and 4/4) silty clay, with few olive (5Y4/3) and yellowish brown (10YR5/4-6) mottles; weak to moderate fine subangular blocky structure; common fine and few medium structure; root tubules; near vertical joints with gray coatings (2.5Y6/0), some slickensides on large pressure faces along angular planes; gradual boundaries; leached swale-fill sediments.
24.0-24.9 (7.3-7.6)	IB3tgb	Grayish brown and olive (2.5Y 5/2 and 5Y5/3) silty clay loam with common yellowish brown (10YR 5/6) mottles; weak to moderate fine subangular to angular blocky structure; very firm; common thin clay coatings and grainy (silt) coats, with continuous gray coatings on vertical joints; common fine horizontal and vertical exped tubules with iron oxide and clay coatings, gradual boundaries; leached swale-fill sediments.
24.9-25.7 (7.6-7.8)	IIB3tb	Yellowish and dark yellowish brown (10YR5/6, 5/8, 4/6) silty clay with few pebbles, and common olive gray (5Y5/2) mottles; moderate fine angular to subangular blocky; very firm; clay coatings along and adjacent to vertical joints; leached till-derived sediment.

Description 6 con't.

WOLF CREEK FORMATION - Hickory Hills Till Member

25.7-27.0 (7.8-8.2)	IIIB3tb	As above, clay loam; with prominent greenish gray (5Y5-6/1) joint filling; gradual upper, diffuse lower boundary; leached till.
27.0-32.0 (8.2-9.8)	MOL	Yellowish brown (10YR5/6-8) loam till, with common fine gray 2.5Y6/1-2) mottles continous along joints; fine iron-oxide concretions; few vertical root tubules with iron-oxide stains; leached till.
32.0 - 36.0 (9.8-11.0)	MOU2	As above; with few large hard secondary carbonate concretions; very firm; unleached till.
36-38 (11.0-11.6)	MOU	As above; very few small secondary carbonate concretions.

better-drained positions of the paleo-landscape are not preserved, having been planed off by glacial erosion.

SUMMARY

No type section for the Yarmouthian Stage or Paleosol is exposed at Yarmouth, Iowa. Leverett's original designation of the Yarmouth was from interpretations of the sediments from two dug wells. Since Leverett originally defined the Yarmouth interglacial episode the concept of Yarmouth has undergone considerable evolution. Yet, his original sections at Yarmouth are still considered as the type section for the Yarmouthian Stage and the Yarmouth Paleosol.

Using drill-cores the authors have reexamined Leverett's Yarmouth deposits. The sediments and "soils" Leverett described are composed of interbedded till, flow-till (mud-flows), stratified silts, sands, and minor gravel, and peats and mucks. The deposits represent superglacial and/or proglacial sediment flows, fluvial and paludal deposits, of the Kellerville Till Member which accumulated at the terminus of the early Illinoian ice front.

The pollen from the peats (considered the "Yarmouth soil" by Leverett) is dominated by *Picea*. *Picea* and *Larix* wood has also been identified from the deposits. The vegetation is

Description 7. Mediapolis-1 core site; located in road bed 20 feet south of intersection of gravel roads 550 feet east of the center of sec. 36, T.72N., R.3W., at 760 feet elevation, about 2 feet below natural land surface; Des Moines County.

Depth-Feet (m)	Horizon or Zone	Description
WISCONSINAN LOESS		
0-3.5 (0-1.1)	MOL-DOL	Road bed and mottled to deoxidized and leached loess (silt loam).
3.5-6.9 (1.1-2.1)	DOL	Deoxidized and leached loess (silt loam).
Basal Loess sediments and paleosol		
6.9-7.4 (2.1-2.3)	IAb	Very dark grayish brown (10YR3/2) silty clay loam; moderate medium to coarse angular blocky struture; few fine yellowish brown mottles (10 YR5/6) and coatings on root tubules; leached; abrupt upper contact, gradual lower contact.
7.4-7.7 (2.3-2.4)	ICb-MDL	Dark grayish brown (2.5Y4/2) silty clay loam, common fine grayish brown (2.5Y5 and 6/2) mottles; massive; few vertical root tubules; leached.
GLASFORD FORMATION - Undifferentiated Sediments		
SANGAMON or LATE SANGAMON PALEOSOL		
7.7-8.0 (2.4-2.5)	IIAb	Dark grayish brown (10YR4/2) silty clay loam, with few fine yellowish and grayish brown mottles and coatings (10YR4/4 and 5/2); weak very fine subangular blocky structure; common fine, few medium exped root tubules; clear upper, gradual lower boundary; leached, swale-fill or side-valley sediments?
8.0-8.7 (2.5-2.7)	IIBtb	Dark grayish brown (10YR4/2) silty clay loam (heavier than above), with common dark yellowish brown and gray mottles and coatings (10YR4/4 and 6/1); weak to moderate very fine subangular blocky structure; common fine, few medium exped root tubules, common thin clay films and coatings; diffuse lower boundary; leached sediments as above.
8.7-11.6 (2.7-3.5)	IICb(CBb?) MDL	Grayish brown (10YR5/2) silty clay loam, with many light olive brown (2.5Y5/4) and yellowish brown (10YR5/6) mottles; few very fine manganese and iron oxide concretions; massive to very weak, very fine, subangular blocky structure near vertical cleavage faces and medium vertical root tubules, which show continuous coatings of clay and some iron oxide stains (10YR5/6); friable to slightly sticky; clear lower boundary; leached sediments as above.
GLASFORD FORMATION - Kellerville Till Member; Superglacial facies		
11.6-12.6 (3.5-3.8)	IIIBb? Beta-B? MOL	Grayish brown and dark gray (10YR5/2 and 4/2) clay loam with some pebbles, with many distinct yellowish brown mottles (10YR5/6); moderate to weak very fine subangular blocky structure; abundant fine to medium vertical root tubules with coatings of clay and iron oxides; few thin clay films; gradual lower boundary; leached till or till-like diamicton.

Description 7 con't.

12.6-13.8 (3.8-4.2)	MOL	Yellowish brown and light brownish gray (10YR 5/6 and 2.5Y6/2) clay loam to loam with few light olive brown (2.5Y5/4) mottles; massive; common fine vertical root tubules; varies from sticky to loose consistence; leached diamicton.
13.8-15.9 (4.2-4.8)	MOL	Yellowish brown (10YR 5/6 and 5/8) loam and sandy clay loam with few light grayish brown (2.5-5Y6/2) mottles; massive; loose to slightly sticky; diffuse upper boundary, clear lower boundary; leached, loose (low density), weakly stratified silty and sandy zones, but till-like throughout; Illinoian diamicton.

GLASFORD FORMATION - Kellerville Till Member; Subglacial facies; basal till

15.9-16.7 (4.8-5.1)	MOL	Yellowish brown (10YR5/6-8) loam till with common strong brown (7.5YR5/8) mottles; massive; slightly firm to friable; clear upper boundary, gradual lower boundary; abrupt increase in density and consistence from unit above; not stratified; leached Illinoian till.
16.7-20.3 (5.1-6.2)	MOJU	As above, with continuous strong brown iron oxide coatings along near vertical joint; slightly firm; calcareous but only slightly effervescent; abrupt lower contact unleached Illinoian till; all of the Illinoian diamicton and till units from 11.6 to 20.3 feet show abundant coal in the pebble fraction.

WOLF CREEK FORMATION - Hickory Hills Till Member

20.3-22.0 (6.2-6.7)	MOJL	Yellowish brown (10YR5/6) loam till, with many grayish brown streaks and mottles, and manganese and iron oxide stains; massive, jointed; very firm; abrupt upper, gradual lower boundary; abrupt increase in density and consistence from above unit; leached till; no coal is present in pebble fraction from this unit down.
22.0-27.0 (6.7-8.3)	MOJU2	As above, but calcareous (strong effervescence), till, with secondary carbonate coatings in joints and few medium concretions.
27.0-29.7 (8.3-9.1)	MOJU2	Till as above with large secondary carbonate concretions, and gray to olive gray (5Y5/1-2) along joints.
29.7-40.0 (9.1-12.2)	MOJU-MRJU	Till as above without carbonate concretions; gray mottles increase with depth.

WOLF CREEK FORMATION - Aurora Till Member

40.0-41.0 (12.2-12.5)	OU	Oxidized, unleached medium sand.
41.0-53.0 (12.5-16.2)	MOJU	Oxidized, mottled, jointed, till, with numerous sand and gravel breaks; abrupt lower contact.

ALBURNETT FORMATION - Undifferentiated till

53.0-58.0 (16.2-17.7)	MRU	Gray to olive (5Y5/1 to 4) mottled, unleached, texturally uniform till, gradational with lower unit.
58.0-72.0 (17.7-21.9)	UU	Dark gray to dark greenish gray (5Y-5GY 4/1) unleached till, with few gravel breaks 68-72 feet.

ST. LOUIS LIMESTONE; Mississippian; Weathered bedrock.

72.0 to depth (21.9 to depth)

Sketch of stratigraphic relationships near Mediapolis, Iowa.

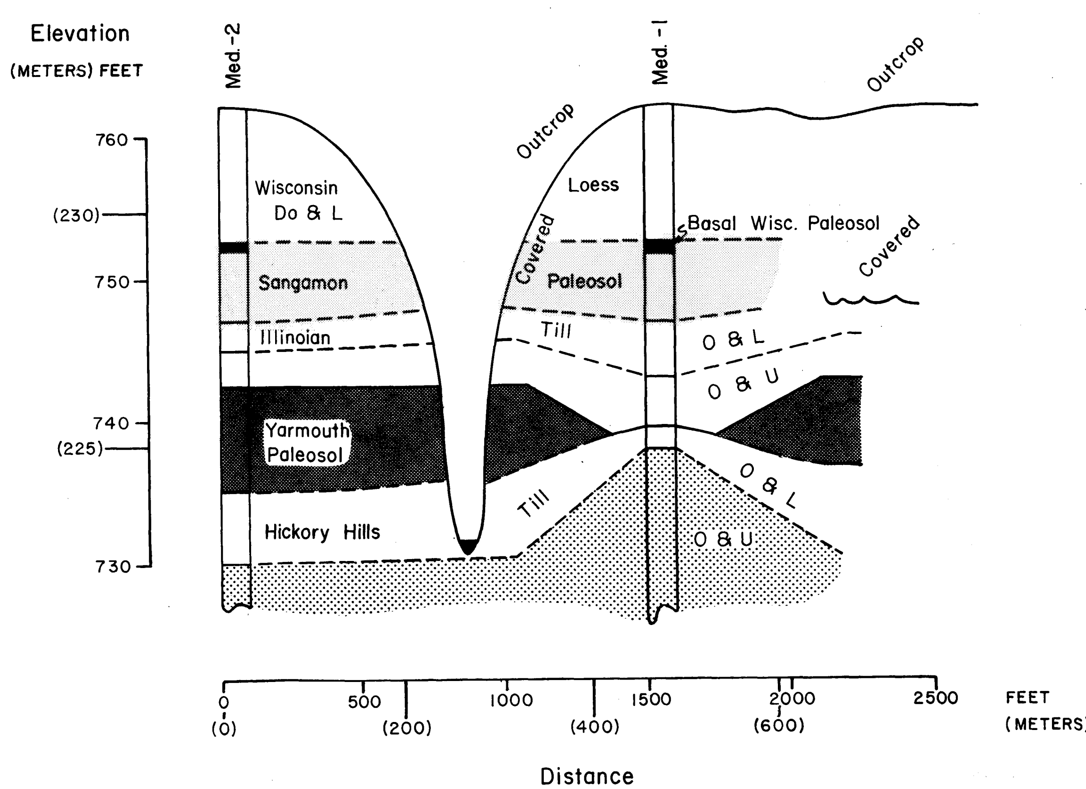


Figure 13. Schematic cross section from cores and outcrops at Mediapolis Section.

interpreted as a *Picea-Larix* forest. By analogy with Wisconsinan and Holocene sections this is likely a full-glacial pollen assemblage, and is not compatible with inclusion in the Yarmouth.

In the Yarmouth transect a well-developed paleosol underlies these early Illinoian sediments. This paleosol is compatible with the modern concept of the Yarmouth. It is proposed that: 1. the type-area for the Yarmouth Paleosol Stage remain the same, i.e. - the region around Yarmouth, Iowa; 2. the type-section be designated the Yarmouth-Core Site; and 3. that the upper boundary for the Yarmouth Paleosol and Stage be defined as the contact between the early-Illinoian peat (perhaps the equivalent of the Petersburg Silt) and the underlying paleosol developed in till-derived sediments and the Hickory Hills Till

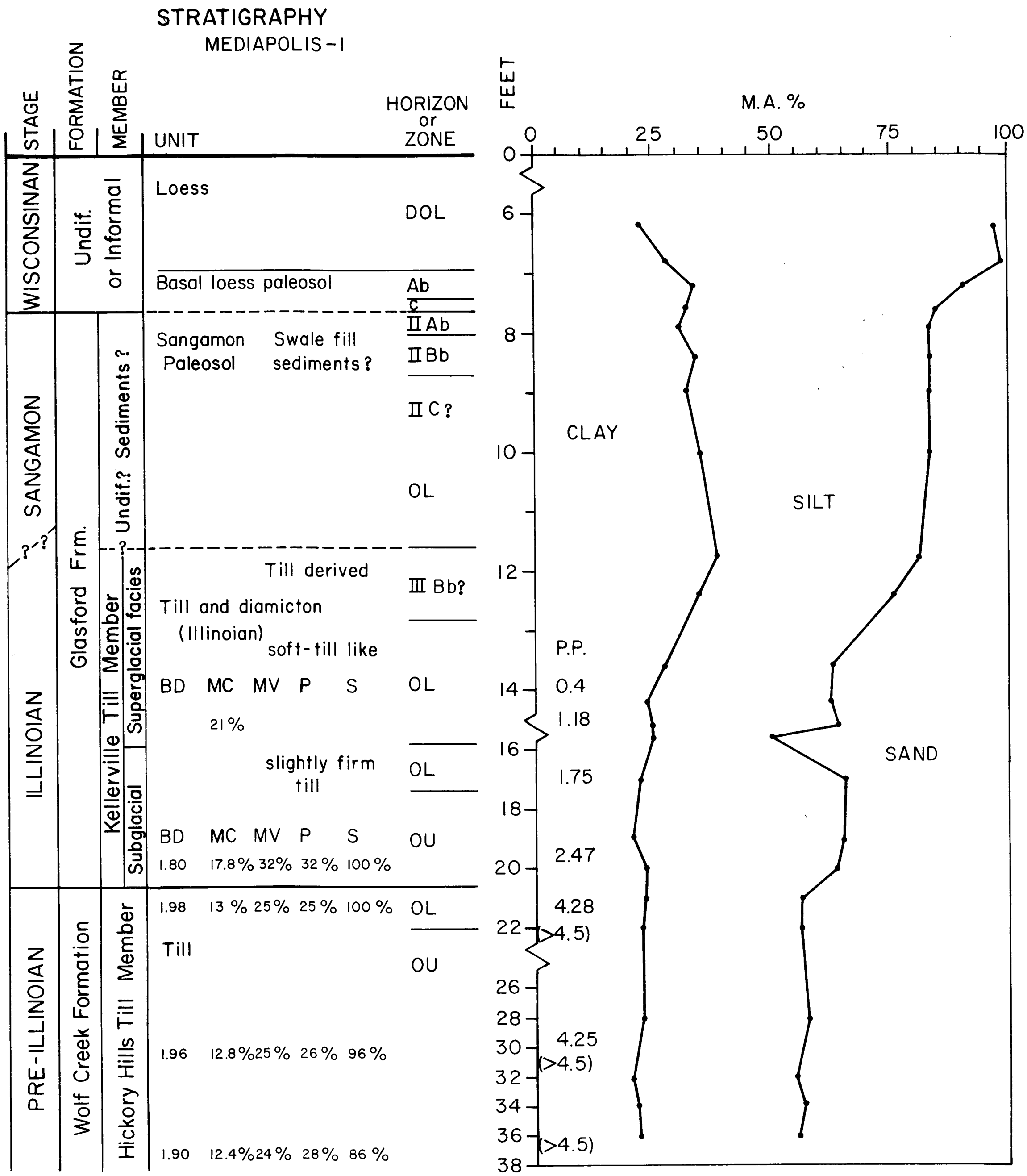


Figure 14. Stratigraphy and particle-size data for Mediapolis-1 Core Site (P.P. - calibrated penetrometer data, in tons/sq. ft.; other abbreviations see figure 2).

Member. In the type section the Yarmouth Paleosol is a complex buried soil in that the IOb and IIAb horizons are the early-Illinoian organic sediments. In the principle reference sections (Brun Farm and Mediapolis Sections) the Yarmouth Paleosol is overlain abruptly (and simply) by the Kellerville Till Member.

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STATUS OF THE KELLERVILLE TILL MEMBER IN WESTERN ILLINOIS

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ABSTRACT

The Kellerville Till Member of the Glasford Formation is the westernmost Illinoian till unit in western Illinois and extends into southeast Iowa. The till was deposited by the Lake Michigan Lobe which advanced across western Illinois from the northeast. The composition of the Kellerville Till is similar to other Lake Michigan Lobe tills and reflects incorporation of Paleozoic bedrock in the Lake Michigan Basin and adjacent areas. In vertical profiles, the till sometimes varies in texture and mineralogy because of sedimentologic breaks and/or weathering effects. In its lateral extent, the Kellerville Till has regional variations in composition. However, the regional variations do not fit a simple trend and localized changes are also evident. Based on available data in the study area, the Kellerville Till Member is a single stratigraphic unit and should not be subdivided as previously proposed.

INTRODUCTION

The purpose of this contribution is to evaluate the Kellerville Till Member in Illinois as a rock-stratigraphic unit and also to discuss its genesis and geologic history. Till research in Illinois has concentrated mostly on subdivision of tills into rock-stratigraphic units on the basis of observable physical characteristics, texture, mineralogy, and stratigraphic position (Willman and Frye, 1970). Recently studies have examined and described the composition of particular till units and any variations in the composition. Only a limited number of studies in Illinois have discussed till genesis.

Problems in constructing rock-stratigraphic classifications for tills in Illinois have developed. Specific problems are, of course, different for each geologic setting, however some overall conceptual problems are clear. The stratigraphic approach works best in those areas where the tills can be separated into distinctive units that have uniform physical properties. In those situations, the rock-stratigraphic subdivisions are clear and the units can be easily traced. Most of the problems in developing a rock-stratigraphy for till stem from spatial changes within till units. Whenever a change in till composition from one location to another is noted, the question arises "Should this change be considered a lateral variation within one till unit or should the compositional change be considered a separate stratigraphic unit?" The question directly addresses the definition of a stratigraphic unit.

One problem is that individual workers have different concepts of what constitutes a till member, formation, or group. Another problem is that different workers emphasize different characteristics of the tills. For example, some investigators may depend very heavily on till mineralogy for characterizing till units. Changes in the composition may be considered criteria for recognizing separate till units. At the opposite end of the spectrum, some workers may ignore compositional changes and use only gross physical properties and stratigraphic position to recognize till units. Stratigraphic classifications derived from different approaches may not result in the same units and may have a great deal of overlap between units.

Discrepancies in till stratigraphy cannot be solved by a rigid approach. Till units should conform to the American Stratigraphic Code. To go beyond that, to a standardized or "cookbook" approach to classifying till units, seems undesirable at this point. Instead, all the available data should be considered rather than focusing on only one or two criteria for stratigraphic subdivision. The parameters that appear to be diagnostic in a given geologic setting may not be meaningful at other locations. Recognizing those parameters that make a till unit distinctive within a given area requires the consideration of a large number of factors and should be a goal of stratigraphic studies.

Consideration of the sedimentology and geologic history of the till, although not a prerequisite to stratigraphic studies, is certainly an aid in recognizing the character and distribution of the deposits. In evaluating the Kellerville Till Member as a rock-stratigraphic unit, some of the factors which have been assessed are the distribution, thickness, texture, mineralogy, vertical and lateral variability of the till, stratigraphic position, its occurrence in different landscape positions, weathering effects, environment of deposition, and the distribution and quality of available data. The data base is the major factor which in many cases determines the detail and accuracy of the stratigraphic classification. The data base for the Kellerville Till is limited mostly to surface exposures with some engineering and control borings. The study area does not include the complete extent of the Kellerville Till Member but instead covers only the area outlined in figure 1.

HISTORY OF INVESTIGATIONS OF ILLINOIAN TILL IN WESTERN ILLINOIS

Leverett (1899) first applied the term Illinoian Stage to the interval of glaciation represented by the Illinoian drift sheet. He used the term Illinoian for both the interval of glaciation and the drift sheet. Leverett did not subdivide the drift sheet and he described the drift as follows: "Throughout the area occupied by the Illinoian drift till predominates, there being but a small amount of sand and gravel except in deeply buried valleys (Leverett, 1899, p. 27)." The upper and lower boundaries of the Illinoian drift sheet were marked by the presence of weathered zones, which Leverett (1898a and 1898b) termed the Sangamon Soil and Yarmouth Soil respectively.

Leverett (1899) also noted physical differences between the Illinoian and older drifts. He cited red jasper conglomerate and quartzite boulders as indicators of Illinoian drift. Leverett suggested that red jasper conglomerate and quartzite were derived from outcrops north of Georgian Bay and were transported southwest by the advance of "Labradorian" (Leverett, 1899, p. 41) ice during the ILlinoian. Cherty material derived from Burlington Limestone found in southeastern Iowa also indicated to Leverett transport westward by Illinoian ice. Leverett described physical differences between the Illinoian and Kansan till as follows: "The Illinoian may be denoted a friable or crumbling till, while the Kansan is a caking till where characteristically developed (Leverett, 1899, p. 4)."

T.E. Savage, in reports on the Edgington and Milan Quadrangles (Savage, 1921a) and La Harpe and Good Hope Quadrangles (Savage, 1921b), described a single Illinoian till sheet with no subdivision into smaller units. Savage noted the prsence of widespread beds of sand and gravel at the base of the Illinoian drift. Based on pebble counts of the Illinoian till, Savage (1921b) suggested that pebbles of local origin were predominant and that the Illinoian drift "was here probably derived for the most part from local beds of shale and sandstone which were deeply weathered when the ice sheet moved over them (Savage, 1921b, p. 58)."

Horberg (1956) examined Pleistocene deposits along the Mississippi River Valley in two separate areas, the Rock Island-Mercer Counties region and the Adams-Hancock Counties region. He interpreted the total succession of Pleistocene deposits in terms of cyclical processes related to glacial advances and retreats.

Within the Illinoian succession, Horberg recognized a basal eolian and fluvial unit, proglacial outwash, a main body of till with sand lenses, retreatal outwash, and loess. Horberg interpreted only one major glacial advance and retreat accompanied by deposition of a continuous till complex during the Illinoian.

Leighton and Brophy (1961) characterized the Illinoian glaciation in Illinois as a rapid and far-reaching ice advance

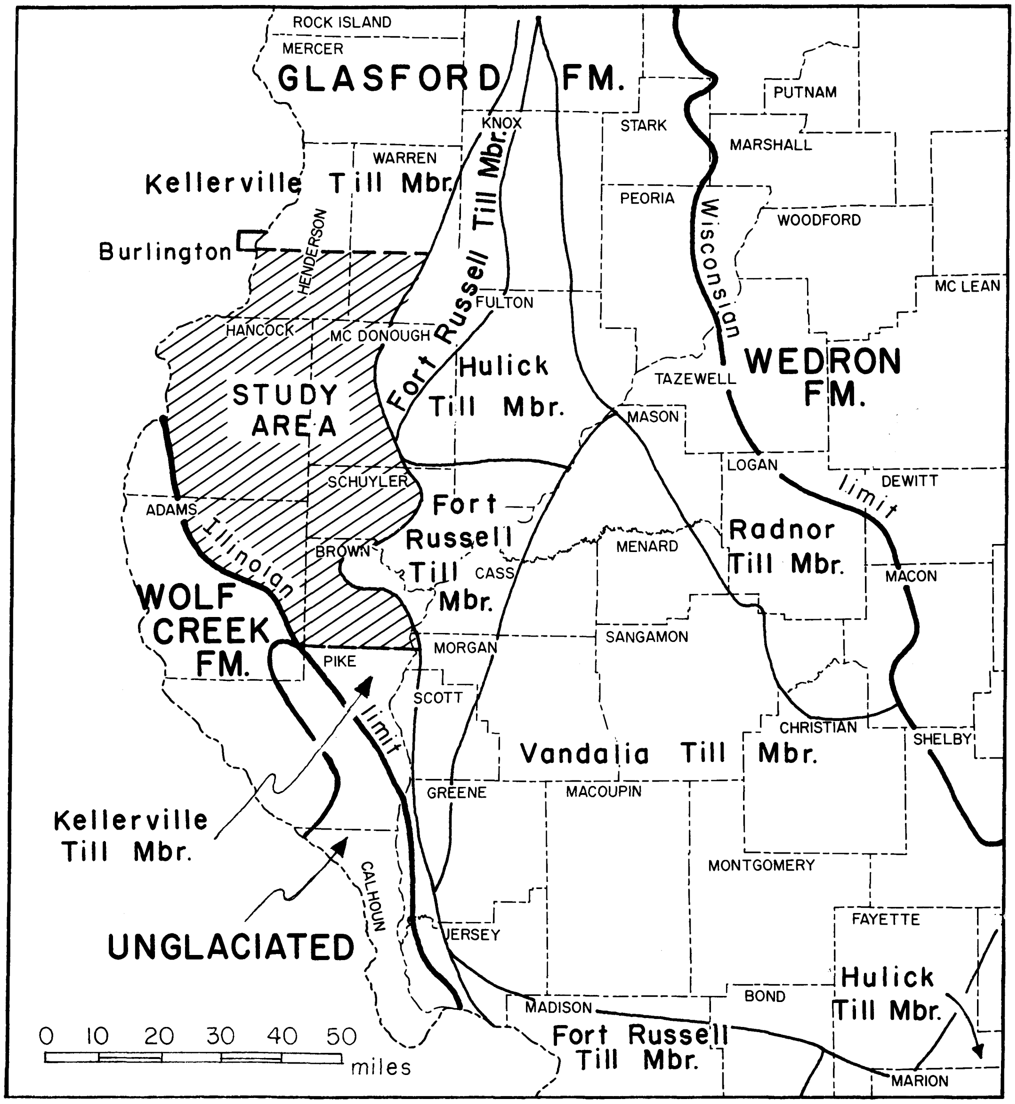


Figure 1. Surficial till members of the Glasford Formation and location of the study area. Modified after Lineback (1980).

that was followed by stagnation of the entire ice mass. The relatively abrupt change in glacial regime was attributed to climatic change. Leighton and Brophy (1961) identified a large region of stagnant ice features mainly within the Kaskaskia River Basin in south-central Illinois. In western Illinois, Leighton and Brophy (1961) interpreted the northeast-southwest trend of many streams to be related to the former orientation of crevasses in the stagnant Illinoian glacier. The Illinoian glacier was presumed to have remained active for a longer time in western Illinois than in southern Illinois but still under-went widespread stagnation throughout. Leighton and Brophy (1961) suggested that retreat of the stagnant Illinoian glacier was interrupted by only a minor interval of renewed glacial activity represented by the Buffalo Hart Moraine.

In their study of the mineralogy of glacial tills throughout Illinois, Willman, Glass, and Frye (1963) recognized three tills with different mineralogic compositions. They attributed the different mineral assemblages to separate pulses of the Illinoian glacier and related the three tills to three end moraines. These three end moraines and associated deposits were the basis for the three substages within the Illinoian Stage. Willman, Glass, and Frye (1963) demonstrated the contrast in mineralogy between the western-derived Kansan till and the Lake Michigan Lobe Illinoian till in western Illinois. They also suggested that the first till deposited by the Illinoian glacier had a wide range in its clay mineral composition. Willman, Glass, and Frye showed a progressive westward increase in the amount of montmorillonite within the "Payson till" (Kellerville equivalent). They interpreted the apparent increase in montmorillonite to be the result of incorporation of underlying montmorillonitic material by the westward flowing glacier.

Frye, Willman, and Glass (1964) changed the Illinoian glacial boundary from its position at the "Payson Moraine" to the Mendon Moraine. They also further described the mineralogy of the Illinoian glacial deposits and the Cretaceous deposits in western Illinois.

Willman and Frye (1970) established the multiple stratigraphic classification used in Illinois today. Based on their work in western Illinois, Willman and Frye (1970) named the Kellerville Till Member of the Glasford Formation from roadcut exposures in western Illinois. They defined the Kellerville Till Member as a highly variable unit. Willman and Frye's diagrammatic cross-section showing the relations of the Kellerville Till within the Illinoian succession is reproduced in figure 2.

Lineback (1979) suggested that the Illinoian Stage may include several major glaciations. He proposed an expanded Illinoian stratigraphy for western Illinois that included eight till units (now reduced to six, Lineback, 1980, and this volume), several of them separated by paleosols. The paleosols were interpreted as interglacial or major interstadial soils. An unnamed till member A was recognized by Lineback in the area of the Kellerville Till mapped by Willman and Frye (1970).

GLACIAL STRATIGRAPHY OF WESTERN ILLINOIS

A stratigraphic column for the study area is shown in figure 3. Within the study area, the Kellerville Till Member is the only Illinoian till unit present. West of the Illinoian glacial boundary (figure 1), the Pre-Illinoian Wolf Creek Formation (Hallberg, 1980) occurs near the surface. The Wolf Creek Formation (figure 3) consists of tills and associated deposits that accumulated during two or possibly three glaciations. During each of the glaciations represented by the Wolf Creek Formation, the ice sheets apparently advanced from the northwest. The till units within the Wolf Creek Formation have similar physical properties but can be distinguished by (differences in their) texture and mineralogy. Paleosols are found between the three till members (figure 3). The Wolf Creek Formation has a widespread occurrence beneath the Illinoian Stage deposits in western Illinois. Its eastern limit is approximately 85 km east of the Illinoian glacial boundary.

Underlying the Wolf Creek Formation is the Alburnett Formation (figure 3). The Alburnett Formation is stratigraphically the lowest till unit found in western Illinois and may consist of a number of unnamed till members (Wickham, 1979). The Alburnett Formation probably has a source to the northwest, however, its mineralogy is distinctly different from that of the Wolf Creek Formation. It is very thick (>30 m) in some of the buried bedrock valleys but is exposed at the surface only along a few stream valleys in western Illinois.

An expanded rock-stratigraphic column for the Illinoian

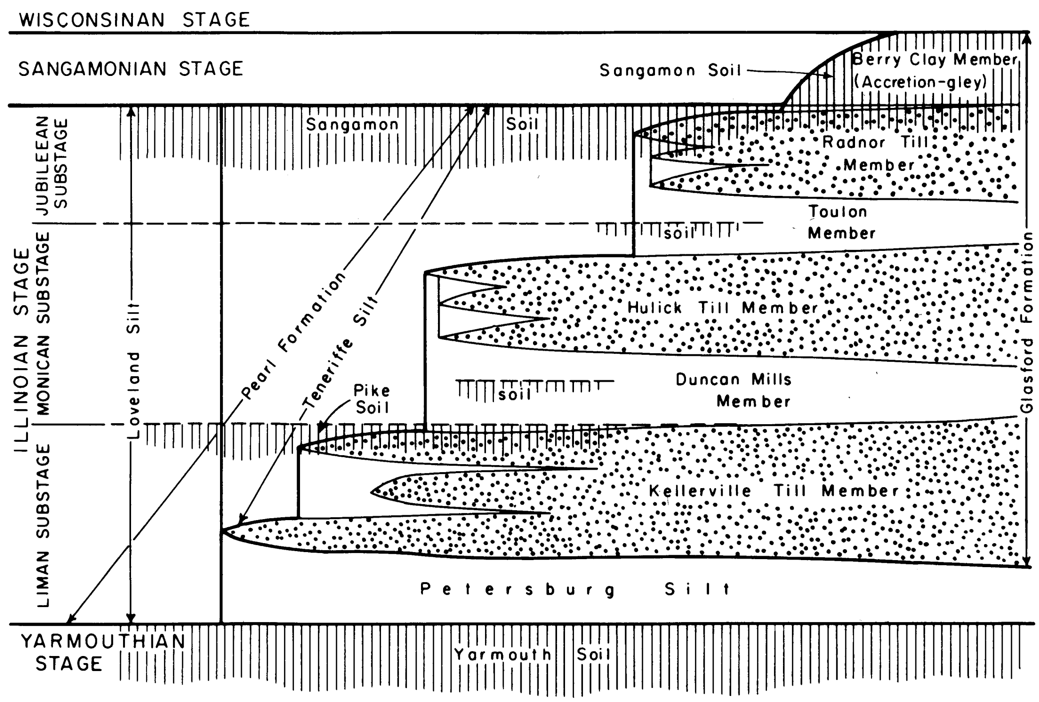


Figure 2. Diagrammatic cross-section showing the relations of formations and members of Illinoian age in western Illinois.

Stage deposits in western Illinois was developed by Lineback (1979, and this volume). This represents a major change from the long-established view that the Illinoian was one major glaciation. Lineback (1979, and this volume) suggests that possibly four major glacial episodes separated by weathering episodes of inter-glacial or major interstadial rank occurred during the Illinoian Stage. Lineback (this volume) cites the presence of paleosols between till units that have been assigned to the Illinoian Stage as evidence that multiple glaciations may be represented by the body of sediments representing the Illinoian Stage.

Considering the extent of previous investigations of Quaternary deposits which have taken place in Illinois, it is perhaps surprising that such major conceptual changes should now occur. In partial explanation, two factors seem important. The first factor is the very limited occurrences of the unnamed

TIME-STRATIGRAPHY	TILL STRATIGRAPHY		SOIL-STRATIGRAPHY
Wisconsinan Stage			
Sangamonian Stage			Sangamon Soil
Illinoian Stage	Glasford Fm.	*unnamed till member A Kellerville Till Member	
Yarmouthian Stage			Yarmouth Soil
Pre-Illinoian Stages	Wolf Creek Fm.	Hickory Hills Till Mbr.	
		Aurora Till Mbr.	Dysart Soil
		Winthrop Till Mbr.	unnamed soil
	Alburnett Fm.	unnamed till members	Westburg Soil

* **Unnamed till member A is included within the Kellerville Till Member in this report.**

Figure 3. Stratigraphic column for the study area.

soils identified within the Illinoian Stage. Apparently the presence of these soils separating the respective tills is not a typical situation. More commonly, the soils have been eroded and the till contacts show no sign of weathering (Lineback, personal communication).

The second factor is an increase in the amount of laboratory data available for stratigraphic studies. The use of analytical data is an aid in till correlation and helps in tracing the stratigraphic position of the intra-Illinoian soils. The limited extent of the paleosols makes regional till correlations critical.

Many questions concerning the Illinoian Stage deposits are still unanswered. A major question is "Why are the intra-Illinoian soils absent over such large areas?" In comparison, the Yarmouth Soil while absent in many places is a marker horizon over much of western Illinois. The Yarmouth Soil is better developed i.e., thicker than any of the unnamed intra-Illinoian soils (Lineback, personal communication). However, it seems unlikely that greater thickness alone would account for the much greater preservation of the Yarmouth Soil. A satisfactory explanation is not obvious.

STRATIGRAPHIC RELATIONSHIPS OF THE KELLERVILLE TILL*

Stratigraphic Nomenclature

The Kellerville Till Member of the Glasford Formation was named from roadcut exposures in the Washington Grove School Section by Willman and Fyre (1970). The type section is located in southeastern Adams County, Illinois, approximately 100 km south of Burlington, Iowa. Kellerville Till Member replaces the terms Mendon till (Frye, Willman, and Glass, 1964; Frye, et al., 1969) and Payson till (Leighton and Willman, 1960; Wanless, 1958).

The Kellerville Till Member was subdivided into two till members by Lineback (1979). The lower unit was correlated to the type Kellerville and the upper till unit was termed unnamed till member A (Lineback, 1979). In this report, the two units will be collectively referred to as the Kellerville Till Member. the reasons for this are discussed in a later section on vertical variability.

Stratigraphic Positions, Distribution, and Thickness

The Kellerville Till forms the western boundary of the Illinoian glaciation in southeastern Iowa and western Illinois. Stratigraphically, the Kellerville is the lowermost Illinoian till unit and overlies the Petersburg Silt or more commonly where the Petersburg Silt is absent, the Yarmouth Soil. Its upper limit is the contact with either the "Fort Russell" Till Member, the Teneriffe Silt, or younger stratigraphic units.

The Kellerville Till ranges from less than 1 m to 25 m thick over most of western Illinois but may be as much as 50 m thick in deep bedrock valleys. The Kellerville Till apparently

*includes unnamed till member A

correlates to the Smithboro Till which extends to the eastern boundary of Illinois (Lineback, 1980, and this volume).

"TYPICAL" TEXTURE AND MINERALOGY

The gross textural and mineralogic composition of the Kellerville Till reflects its Lake Michigan Lobe source. The Lake Michigan Lobe advanced southward down the axis of the Lake Michigan Basin and spread radially outward from the basin. Within the Lake Michigan Basin, the Lake Michigan Lobe traversed Paleozoic sedimentary rocks; predominantly shales, dolomites, and limestones. As the lobe advanced across Illinois into western Illinois, the glacier crossed regions of Silurian, Ordovician, and Pennsylvanian rocks. The Silurian and Ordovician strata border Lake Michigan in northeastern Illinois and consist of dolomites with some limestones. A large expanse of Pennsylvanian strata in central and western Illinois is predominated by shale with lesser amounts of sandstone and limestone. Along the Mississippi Valley, the Lake Michigan Lobe locally overrode Mississippian limestones, however, these limestones do not appear to be extensively incorporated into the Kellerville Till.

Lake Michigan Lobe tills characteristically have a high illite content in the clay fraction, a low ration of calcite to dolomite in the <74 μm fraction, and a >1 ratio of garnet to epidote in the heavy minerals. Pebbles with a Pennsylvanian lithology, particularly coal fragments are conspicuous features within the Kellerville. The high illite content may be derived from the illitic Pennsylvanian shales in Illinois. The high proportion of dolomite in the carbonates is probably a reflection of incorporation of Silurian and Ordovician dolomites by the Lake Michigan Lobe in northeastern Illinois.

In comparison, the Wolf Creek Formation which is derived from a source to the northwest, has a high content of expandables in the clay fraction, a calcite to dolomite ration of roughly one, and more epidote than garnet in the heavy minerals.

This sharp contrast between the mineralogy of the Lake Michigan Lobe Illinoian tills and the northwestern source Pre-Illinoian tills is evident in different physical properties and weathering characteristics of the tills.

Mean values for the texture and mineralogy of the Kellerville Till Member based on available data are indicated in Table 1. Typical values cited by other workers are also presented in Table 1.

VERTICAL VARIABILITY

Till is often not a homogeneous deposit in vertical profiles. The first factor that introduces vertical variability is till sedimentation. Till can be deposited by a number of different mechanisms and in a number of different environments. In Illinois and Iowa, two distinct elements are frequently recognized within the till members (Kemmis, Hallberg, and Lutenegger, 1979). The lower element is subglacially deposited till and includes all till deposited from the base of the glacier. The upper element is supraglacially deposited material and includes all till and associated deposits that accumulate by surface melting or debris flows. These two elements are not continuously present in till members but instead the relative proportions of each element in vertical sections varies.

Subglacially deposited till tends to be comparatively uniform in its texture and mineralogy and generally occurs in nearly continuous bodies, although its thickness varies. Supraglacially deposited till is more variable in texture and mineralogy and is commonly interbedded with stratified deposits. Supraglacial till has a highly irregular distribution and may be absent over large areas.

In addition to deposition in the two fundamental glacial environments, deposition of till by different processes can be a source of vertical variation. Recent advances in galciology have expanded our knowledge of the mechanisms of till deposition

Table 1. Average textural and mineralogical data for the Kellerville Till Member in a portion of western Illinois.

	Matrix Texture[1] (% of <2mm)			Carbonate Content (% of <75μm)		Clay Mineral[2] Composition (% of <2μm)		
	Sand	Silt	Clay	Calcite	Dolomite	Expandables	Illite	Chlorite & Kaolinite
This Study								
mean	33	39	28	3.0	8.2	34	44	22
standard deviation	5.2	4.4	4.4	0.8	2.5	9.8	9.3	3.3
number of samples	106	106	106	53	53	7	7	7
Lineback (1979)[3]								
unnamed till member A	(sandy)			(3)	(10)	(65)	(25)	---
Kellerville Till	(silty)			(3-5)	(10-15)	(40)	(40)	(20)
Willman and Frye (1970)								
"typical values"	28	45	27	---	---	39	40	21
type section	--	--	--	---	---	38	44	18

[1] The clay percentage is for .004 mm clay.
[2] The clay mineral composition was determined for this study from only unoxidized calcareous samples.
[3] Insufficient data to provide meaningful averages.

to include the following processes; regelation deposition, subglacial stagnation and melt-out of debris-rich basal ice, frictional lodgement, basal melt-out, surface melt-out, supraglacial debris flow, and ice slope failure (Kemmis, 1978). A combination of these processes occurring at a site can result in vertical changes in the texture, mineralogy, and physical properties of the till deposit. For detailed discussions of these mechanisms, the reader is referred to the following references: Boulton (1970a, 1970b, 1971, 1972a, 1972b), Dreimanis (1976), and May and Dreimanis (1976).

A second factor that certainly induces vertical differences within a succession of till is weathering effects. A till member that is situated partly or totally within a weathering profile will undergo alterations that affect the homogeneity of the unit. The weathering effects are greatest in the upper part of the solum but physical and chemical changes in the till may extend deeply into the unit.

In the study area, the weathering of the Sangamon Soil typically affects a large portion of the Kellerville Till. In some cases, the Sangamon Soil is developed in the upper part of the Kellerville Till. Within the solum, which generally has a thickness of 1 to 1.5 m in till, sharp textural and mineralogic changes occur in the till. Below this, the weathering effects include leaching of carbonates and oxidation or reduction of the till matrix. In a well-drained Sangamon profile on till, leaching of carbonates typically extends to a depth of about 2 m. The depth of oxidation is dependent on local water table conditions but may be as great as 10 m in the Kellerville Till.

The effects of weathering on the till matrix must be considered in any correlation relying on quantitative mineralogic data. Clay mineral percentages for unoxidized till in one section should not be correlated to clay mineral percentages for oxidized till in another section. It is possible to compare two weathering profiles if the geologic setting for the two profiles are similar. However, mean values for till mineralogy derived from a weathering profile are not useful for regional correlations.

The Kellerville Till Member is perhaps an illustrative but not typical example of vertical variability in a till member. The unit has sedimentologic breaks and also shows definite alterations within the weathering profile. However, the degree of variation may be greater than the changes observed in other Illinoian and Wisconsinan till members. Lineback (1979, and this volume) has found little vertical variability other than weathering effects in other Illinoian till units in western Illinois. Examples of significant vertical variations in the Kellerville Till can be seen in a number of sections in the study area.

The most distinct vertical change within the Kellerville Till was observed in boring EL-33-77 in northeastern Hancock County, Illinois (figure 4). At a depth of about 10.2 m, a break in the texture, clay mineral content, and carbonate content occurs (figure 5). The upper till zone, referred to as unnamed till member A by Lineback (1979), is sandy and contains a relatively high percentage of expandable clay minerals. The till is oxidized and unleached in the upper 0.8 m. From 6.4 to the base of the upper till zone at 10.2 m, the till is gray (5Y 3/1) with olive green zonations. Apparently, most of the till is oxidized but there are many interspersed partly oxidized zones. The matrix texture of the upper till is consistent, having a maximum range of only 4% or less in the grain-size fractions of the six samples analyzed.

The percent expandable clays increases upward from 49% at the base of the upper till to 71% at the 6.5 m sample. Between the 6.5 m sample which is in a partly oxidized zone and the 6.3 m sample located in an oxidized zone, a significant change in clay mineral composition occurs (figure 5). Interspersed in the till matrix are coal and wood fragments.

The lower zone from 10.2 to 17.0 m is termed till in this report; however, the deposit does not conform to a strict tech-

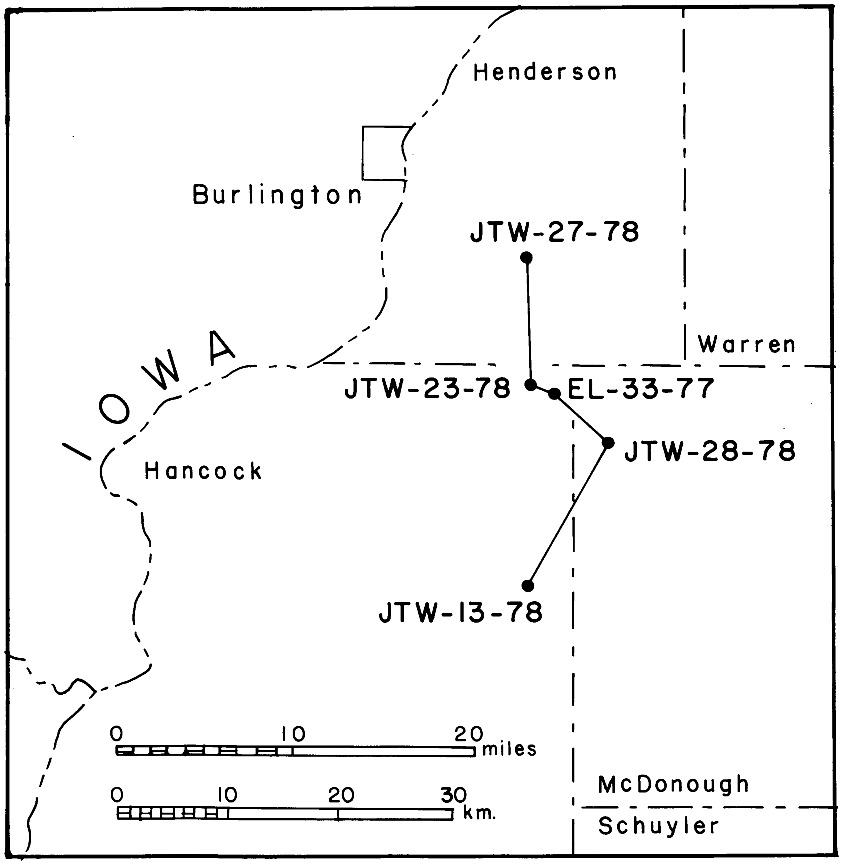


Figure 4. Index map for locations of referenced sections.

nical definition requiring no stratification or sorting. The lower till zone is silty and lacks the massive structure usually associated with till. Faint stratification is present in the upper 2 m of the lower till. The stratification becomes prominent in the basal 5 m of the till, consisting of fine to very fine laminae. Thin silt beds are present at depths of 10.8 m, 12.6 m, and 17 m. The lower till has fewer pebbles than the upper till and contains pebble-size pods of silt incorporated in the till matrix. Wood fragments are very abundant and coal fragments are common.

Texturally, the till matrix is fairly consistent throughout the lower till zone, having a range of 6 percent or less in the grain-size fractions. The clay mineral composition of the lower till exclusive of the silt beds, shows little vertical variation. A sharp contrast in the clay mineral composition is evident in the upper two silt beds.

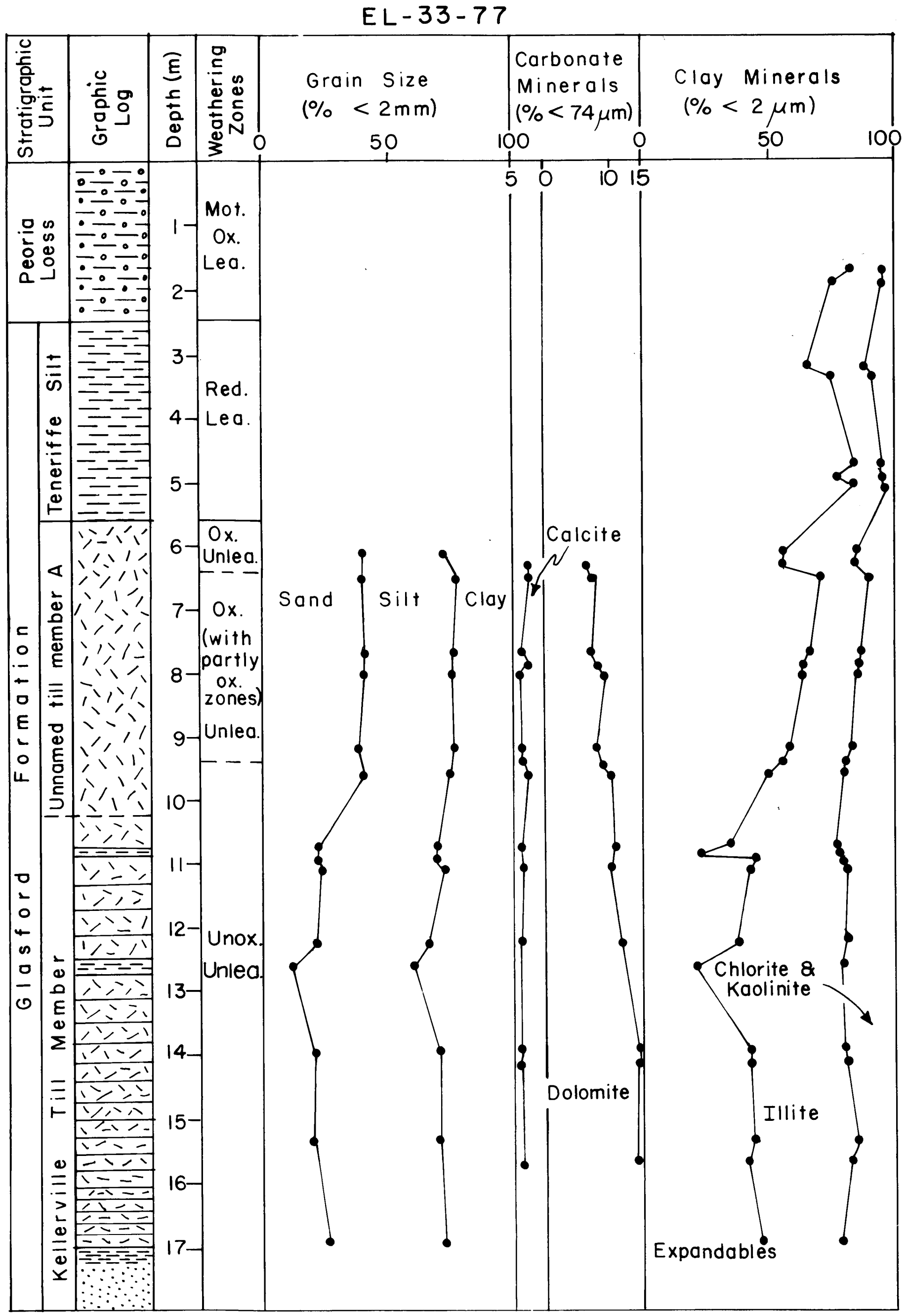


Figure 5. Grain sizes, carbonate-mineral content, and clay mineralogy of EL-33-77 (SE¼, NE¼, SE¼, Sec. 11, T.7N., R.5W., Hancock County, Illinois).

The lower till zone is underlain by about 0.4 m of finely laminated silt and clay layers with organic zones. Below this fine-grained layer is a ten-meter succession of medium- to coarse-grained sand with some pebbly layers. The boring ended in a thin layer of wood fragments.

Lineback (1979) suggested that the two till zones in EL-33-77 could be considered different rock-stratigraphic units. The lower zone was correlated to the Kellerville Till Member and the upper zone was termed unnamed till member A. The usefulness of this two-fold subdivision depends to a great extent on the lateral continuity of the two zones and how they relate to the Kellerville Till regionally. If the two till zones have widely distinguishable, mappable physical properties, they can be considered useful rock-stratigraphic units. However, if one of the zones lacks continuity, the usefulness of differentiating two till members is minimal.

The genesis of the two till zones is a controlling factor in how widely the zones are distributed. If the lower stratified zone and the upper till zone were deposited during the same ice advance, their distribution as two distinct entities may be limited. Stratigraphic differences that result from variations in till sedimentation are not expected to have the same continuity and widespread areal extent as stratigraphic differences that result from different glacial advances. Local conditions have considerable control over glacial processes whereas major events such as glacial advances are not controlled by local conditions.

This author suggests that both till zones in EL-33-77 were deposited during the same glacial advance. The thick succession of sand in the lower part of the boring is interpreted as a proglacial or possibly subglacial channel deposit. A small east-west trending valley located about 100 m north of EL-33-77 may have been much larger during glaciation and carried large amounts of outwash. The finely laminated silty zone overlying the sand at 17 m is interpreted as a glaciolacustrine deposit that accumulated in ponded meltwater within the valley. The lower till zone from 10.2 to 17.0 m is interpreted as a water-lain till deposited incrementally by mass movement of till into a glacial lake. Becuase the lower till zone is probably a water-lain till (Dreimanis, 1979), its distribution is of course restricted to the extent of the glacial lake. In this case, the areal extent of the glacial lake and water-lain till is probably confined to the east-west trending glacial valley. Silt layers and organic clays interbedded with the water-lain till probably represent intermittent periods of normal glaciolacustrine sedimentation from turbidity currents and suspension. The upper till zone is interpreted as a subglacially deposited till. The till is massive, compact, and has a uniform texture. Within EL-33-77, it is this zone of subglacially deposited till that should have the greatest lateral continuity.

One of the factors suggesting that both the upper and lower till zones in EL-33-77 were deposited during the same ice advance is the similarity of the incorporated material within both zones. In comparison to the surrounding Kellerville Till, both zones contain unusually large quantities of wood and coal fragments. This indicates a high degree of local incorporation for both zones. It is more likely that the fragments reflect localized incorporation of wood and coal during one advance rather than repeated incorporation during two advances. Deposition from the first advance would change the local glacier bed and erosional conditions for later advances.

The textural difference between the upper and lower till zones reflects a change in depositional processes. Dreimanis (1976) found that water-lain tills along the north shore of Lake Erie were richer in silt and fine sand than related subglacial tills. Apparently, water-lain till undergoes a sorting process.

The break in clay mineral composition between the two till zones can be related to both weathering and sedimentation. Clay mineral composition is affected by the depositional processes which sort the sediments as is well illustrated in the lower till by the sharp differences in clay mineral composition between the till and interbedded silt layers. Compounding the primary differences are weathering effects in the upper till. The lower till is unoxidized but almost all of the upper zone is within the weathering profile. Alteration of the clay minerals within the profile is suggested by the trend in figure 5.

A number of sections in the immediate vicinity of boring EL-33-77 can be compared to figure 5 to evaluate the continuity and variability of the till (figure 4). Section JTW-27-78 (figure 6) is a small roadcut exposure in which the Kellerville Till directly overlies bedrock. The lowest sample may reflect very localized incorporation of the bedrock. Texturally, the till is intermediate between the two zones in boring EL-33. The clay mineral composition shows a trend of steadily increasing percentages of expandables upward in the weathering profile (figure 6). This weathering is apparently the lower part of a well-darined Sangamon Soil. The clay mineral data for Section JTW-27-78 cannot be used for regional correlation purposes due to the weathering. The till is massive and compact and has no obvious physical breaks other than the basal zone of incorporation.

Section JTW-23-78 (figure 7) is a stream cut located only 3 km northwest of boring EL-33. The section exposes over 5.5 m of Kellerville Till, however, the base of the Kellerville is not exposed. The till is massive, jointed, and except for the weathering profile, uniform throughout. Only the lowermost sample is unoxidized. Note the increased percentage of chlorite/kaolinite for the unoxidized sample. Chlorite is one of the clay minerals that is easily altered in a weathering profile. The percentage of expandable clay minerals increases from 34 percent at the base to 52 percent in the uppermost sample. The till is relatively sandy with a mean matrix texture of 37% sand, 44% silt, and 19% clay. This is somewhat sandier than the till in JTW-27-78 and is siltier than the upper till in EL-33-77. The weathering profile is very comparable to JTW-27-78, both sections showing a progressive increase in expandables upward in the sections.

Section JTW-28-78 (figure 8) is a stream cut located about 7 km southeast of boring EL-33-77. Over 9 m of Kellerville Till

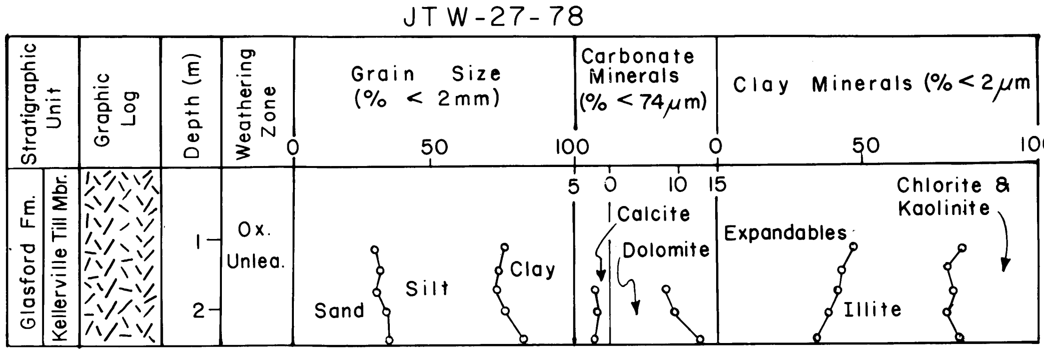


Figure 6. Grain sizes, carbonate-mineral content, and clay mineralogy of JTW-27-78 (SW¼, SW¼, NW¼, Sec. 3, T.8N., R.5W, Henderson County, Illinois).

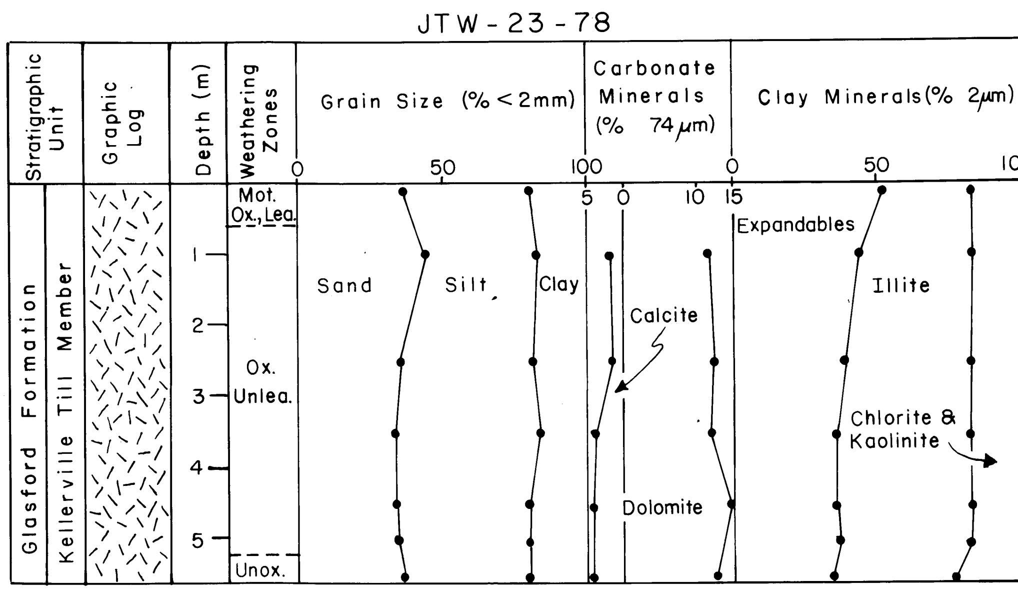


Figure 7. Grain sizes, carbonate-mineral content, and clay mineralogy of JTW-23-78 (NE¼, NW¼, NW¼, Sec. 10, T.7N., R.5W., Hancock County, Illinois).

are present with no upper or lower boundary exposed. The till is leached in the upper 1.3 m of the exposure and is oxidized to a depth of about 7.3 m below the top of the exposure. At 7.6 m, the till has a greenish yellow color and is apparently in a partly oxidized condition. This partly oxidized condition is probably related to the finer texture of the 7.6 m sample (figure 8). The textures of the remaining samples plot in a nearly straight vertical line with a mean of 35% sand, 39% silt, and 26% clay and standard deviations of 0.9%, 1.1%, and 1.5%, respectively. The clay mineral composition of the partly oxidized sample at 7.6 m distinctly differs from the clay mineral composition of the surrounding samples. This difference is probably related to the chemical environment rather than reflecting the original composition. The oxidized samples show a steady upward increase in the percentage of expandable clays from 39% at 7.0 m to 57% at the top of the section (figure 8). Similar trends for the Kellerville Till were seen in JTW-23-78 and JTW-27-78.

The final section descirbed is JTW-13-78 (figure 9). It is a stream cut exposing 10.2 m of Kellerville Till. The Kellerville Till is the only unit present in the section and consists of oxidized till down to 9.2 m and unoxidized, unleached till from 9.2 to 10.2 m. A thin reduced zone within the till occurs between 3.3 and 3.9 m. This zone is similar to the partly oxidized zone present in JTW-28-78 in having less sand and more clay than the surrounding till. As in JTW-28-78, the percent expandable clays increases and the percent chlorite/ kaolinite decreases within the partly oxidized zone. The two lowermost unoxidized samples also have a higher clay content than the overlying oxidized till samples.

Texturally, the till in JTW-13-78 is more variable than till in the previously discussed sections, having a mean matrix texture of 36% sand, 36% silt, and 28% clay with standard deviations of 3.6%, 3.6%, and 3.4%,respectively. The till also contains numerous sand lenses throughout the section.

In general, the clay mineral composition of the till in JTW-13-78 shows an upward increase in the percent expandable clays through the weathering profile, similar to the trends seen in previously discussed sections. However, the changes are more irregular and the upper two samples show a reversal in the trend. The upper part of the till contains secondary carbonates and more oxidized segregations.

The sections presented in this report are all good examples

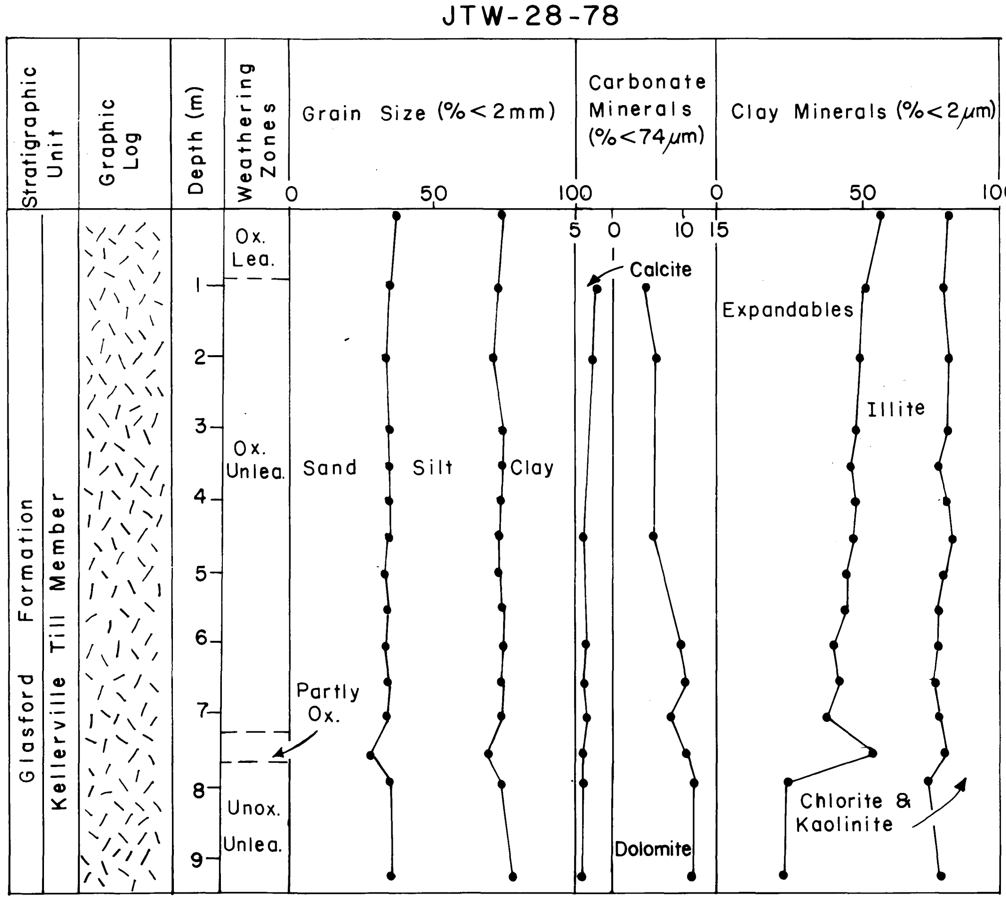


Figure 8. Grain sizes, carbonate-mineral content, and clay mineralogy of JTW-28-78 (NE¼, NE¼, NE¼, Sec. 29, T.7N., R.4W., McDonough County, Illinois).

of vertical variability within a till. The major source of vertical variability for most of the sections is weathering effects. In each section, there is a discernible trend in the clay mineral composition within the weathering profile. The trends were continuous enough through the oxidation zone that they could not be confused with stratigraphic breaks. There is some question whether the lowermost unoxidized samples in JTW-13-78 and JTW-28-78 belong to the same stratigraphic unit as the overlying oxidized till. It is possible that the clay mineral changes may be primarily depositional differences but are coincident with boundaries between weathering zones. However, no physical breaks were obvious in the field and the textural change is negligible in JTW-28-78 and only minor in JTW-13-78. The sharp vertical break within the Kellerville Till in boring EL-33-77 is probably

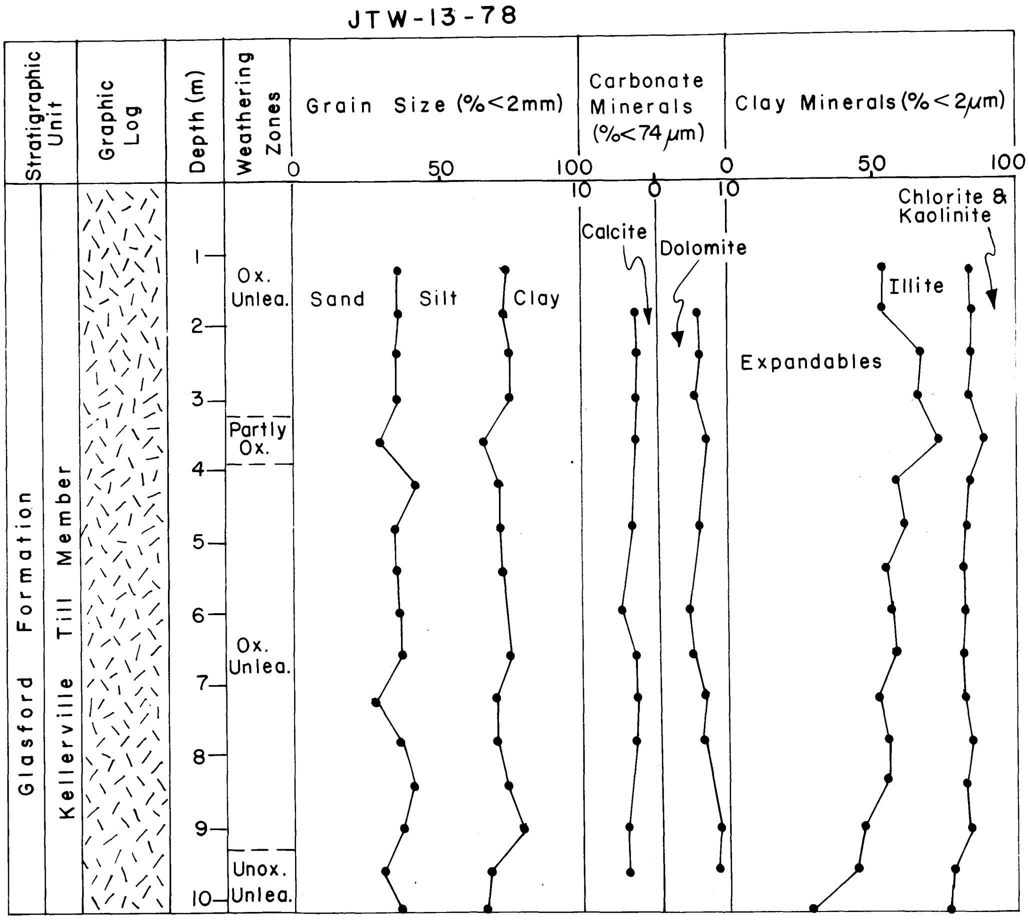


Figure 9. Grain sizes, carbonate-mineral content, and clay mineralogy of JTW-13-78 (NE¼, NW¼, NE¼, Sec. 3, T.5N., R.5W., Hancock County, Illinois).

only a sedimentologic break relfecting two different processes of deposition occurring during one glacial advance.

LATERAL VARIABILITY

In addition to vertical variability, till also normally has some lateral variability. Lateral change in the relative thicknesses of supraglacial and subglacial till is one type of lateral variation that is usually obvious. In Iowa, supraglacial deposits on the Kellerville Till are widespread and sometimes very thick (Hallberg, et al., this volume). Supraglacial deposits on the Kellerville Till in western Illinois are absent over many areas and where present are usually one 1-2 m thick. In this report, the more subtle lateral variations in the texture and mineralogy of subglacially deposited

Kellerville Till in the study area will be discussed.

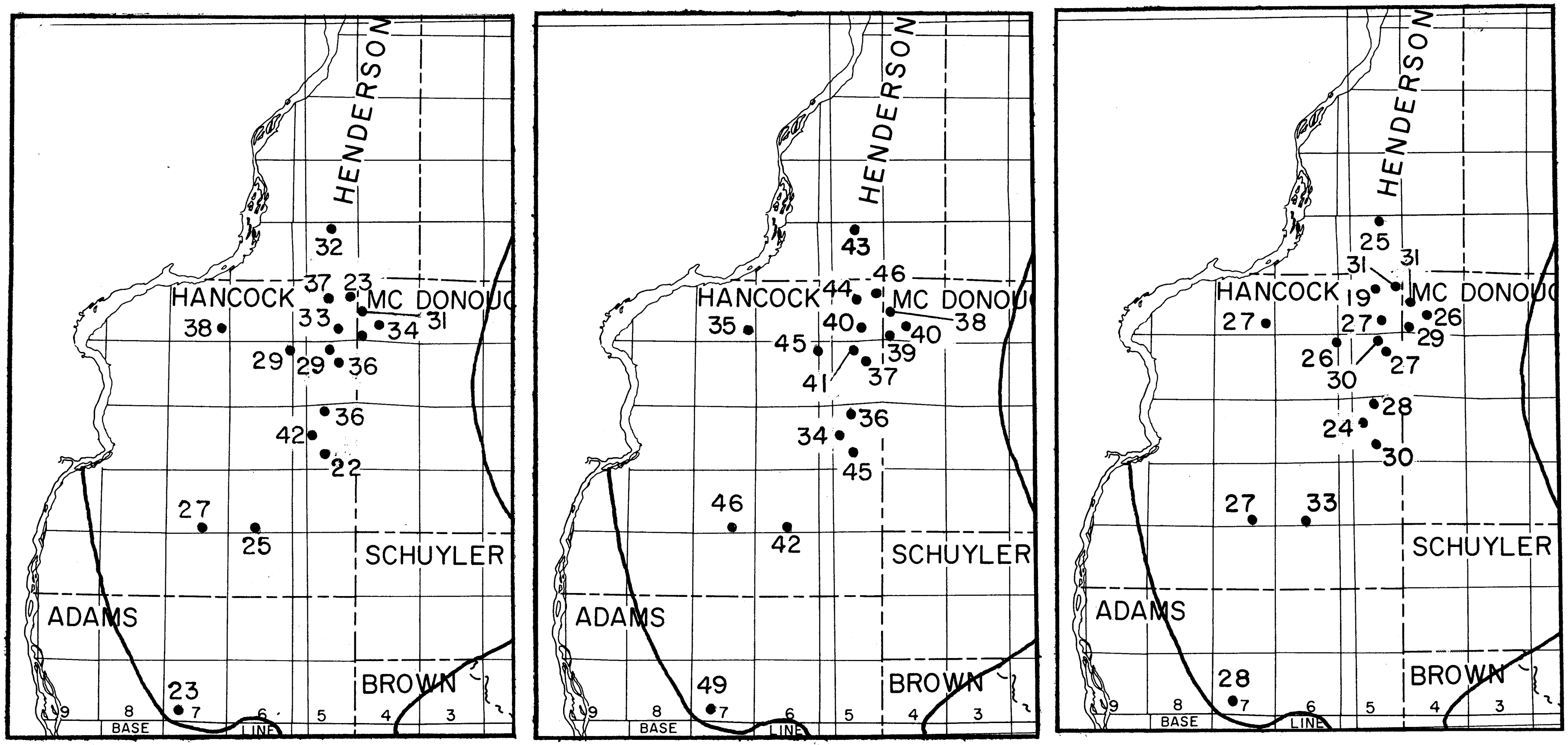
Willman, Glass, and Frye (1964) suggested that the montmorillonite content of the Payson till (Kellerville equivalent) progressively increased in a smooth trend towards its western limit. For western Illinois, their contour map of the montmorillonite content showed nearly equally-spaced countour lines increasing in value to the west. The increase was attributed to incorporation of mortmorillonite-rich deposits.

Within the study area, the number of sites with clay mineral analyses of unoxidized till is too small to establish a regional trend. However, in the cross-section discussed in the previous section, the expandables content ranged from 23 to 45 percent for unoxidized samples of subglacial till. Also, the variations in values were closely-spaced and did not fit a trend of increasing expandable clays to the west, suggesting that the lateral changes within the Kellerville Till are more complex than indicated on the contour map of Willman, Glass, and Frye (1964).

In comparison to the few clay mineral data, much more data on the matrix texture of the Kellerville Till can be utilized for evaluation of lateral variation. Although oxidation induces alteration of the clay minerals, oxidation does not affect texture. Therefore, all textural data for samples below the pedological zone of clay accumulation can generally be utilized.

Percentages of sand, silt, and clay in the Kellerville Till matrix are shown in figure 10. With some exceptions, the Kellerville Till has a high sand content in the vicinity of northeastern Hancock County. Near the Illinoian margin in Adams and southern Hancock Counties, the till is silty. This general pattern is interrupted by scattered sampling sites in northeastern Hancock County that have silty till.

The area of sandy till roughly correspondes to the distribution of unnamed till member A shown by Lineback (1980). However, sandy subglacial till has not bee found overlying silty subglacial till. Therefore, the higher sand content of the Kellerville Till in northeastern Hancock County is here inter-



SAND SILT CLAY

Figure 10. Mean percentages of sand, silt, and clay for the Kellerville Till Member in the study area.

preted to be a lateral variation of the silty type Kellerville Till located to the southwest. Subglacially deposited Kellerville Till in Iowa generally has a high silt content. Along with these broad lateral variations, there are also the localized variations noted previously.

SUMMARY

The Kellerville Till Member of the Glasford Formation, as it is defined by Willman and Frye (1970), is a useful rock-stratigraphic unit. The Kellerville Till in the Hancock County area appears to be a single stratigraphic unit which has recognizable genetic subdivision in places. At present, the available data in the area does not support the proposed stratigraphic subdivision of the Kellerville Till by Lineback (1979) into a restricted Kellerville Till (lower part) and unit A (upper part). Instead, it suggests that unnamed till member A is a lateral variation of the type Kellerville Till. Unnamed till member A has not been found in superposition with the lower part of the Kellerville Till.

The Kellerville Till varies texturally and mineralogically in vertical profiles because of variations in till sedimentation and weathering effects. The weathering effects occur in almost all stratigraphic sections of the Kellerville Till. Lateral variations within the Kellerville Till are apparent on a regional scale but localized changes also occur.

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THE GLASFORD FORMATION OF WESTERN ILLINOIS

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The Glasford Formation (Illinoian) is a distinctive bundle of silty to sandy, friable, illitic, and dolomitic glacial tills and related deposits. Matrix mineralogy, clasts, and fabrics indicate that the tills of the Glasford were deposited by the Lake Michigan Lobe of the continental ice sheet rather than the Des Moines (western) or Huron-Erie (eastern) Lobes. In many respects, the Glasford resembles the Wedron Formation (Wisconsinan), which was also deposited by a Lake Michigan Lobe glacier. The Glasford Formation includes most of the Illinoian of Leverett (1899) and was used as the basis for the Illinoian Stage of Willman and Frye (1970).

Wickham (this volume) has described the lithology, stratigraphy, and origin of the Kellerville Till Member and unnamed unit A of the Glasford Formation in western Illinois. Lineback (1979a) indicated that these two units might have underlain the Smithboro Till Member of central Illinois. Subsequent work, however, indicates that the Kellerville probably correlates directly with the Smithboro (Lineback, 1980). For convenience, the name Kellerville is used west of the Illinois River and the Smithboro elsewhere. The Smithboro-Kellerville is widespread in Illinois and, except for unit A, is generally a silty, low illite, low carbonate, dolomitic till (table 1). The Smithboro-Kellerville (and unit A) is the oldest known till of the Glasford Formation. These units rest on the Wolf Creek Formation (Des Moines Lobe)(Wickham,

1979) in western Illinois and on Lake Michigan and Huron-Erie Lobe tills of the Banner Formation in central, southern and eastern Illinois. A paleosol (the Yarmouth Soil) is present below the Smithboro-Kellerville and, although not present at most sites, is found at more locations than any other paleosol below the Sangamon Soil.

Work conducted during 1979 failed to produce any additional data on unnamed unit B of Lineback (1979a). It is possible that this unit may be stratigraphically below the Glasford. Until more data are developed, placement of this unit in the Glasford must be considered tentative.

The Smithboro-Kellerville is overlain by the relatively sandy and illitic till of the "Fort Russell Till Member" (table 1). The name Fort Russell was informally proposed by McKay (1979) and is to be formally proposed by McKay (in preparation). The "Fort Russell" is the unnamed unit C of Lineback (1979a). The "Fort Russell" is perhaps the most widespread till member of the Glasford (Lineback, 1980) and can be correlated from western Illinois to Indiana and south to near the glacial limit.

In western Illinois, the "Fort Russell" has been traced across Knox County, the eastern half of McDonough County, and through Schuyler County before the boundary curves southward along the Illinois River (Wickham, this volume, fig. 1). This boundary is not marked by any recognizable terminal moraines. Examination of boreholes indicates that there was a topographic lowland in eastern McDonough County at the end of Wolf Creek deposition. The Kellerville, "Fort Russell," and Hulick Till Members filled in this lowland. Small topographic highs in the vicinity of Vermont and Table Grove in Fulton and McDonough Counties and northward have been mapped as morainic features (Lineback, 1979b), but these may be related to bedrock topography or to deposition of the younger Hulick Till Member.

The Hulick Till Member of the Glasford differs from the "Fort Russell" by having more illite and having more calcite

TABLE 1: Characteristics of till members of the Glasford Formation.

Members	Grain size	Illite	Calcite/dolomite	Total carbonate
Radnor	Silty	High	Dolomitic	High
Vandalia	Sandy	High	Dolomitic	High
Hulick	Sandy	High	Relatively less dolomitic	High
"Fort Russell"	Sandy to silty	Intermediate	Dolomitic	Intermediate
Unit A	Sandy	Low	Dolomitic	Low
Kellerville-Smithboro	Silty	Low to intermediate	Dolomitic	Low

relative to dolomite than have other Glasford tills (table 1). The Hulick Till Member is wide-spread across Illinois in the subsurface (Lineback, 1980) and is present in western Illinois as far west as eastern Knox and Fulton Counties (Wickham, this volume, fig. 1). It may extend farther westward, but becomes difficult to distinguish from the "Fort Russell." The Hulick is separated from the "Fort Russell" at the Lewistown Section by an accretion gley and a thin leached zone with clay mineral alteration in the "Fort Russell" (Lineback, 1979a). This paleosol has not yet been found elsewhere.

The Vandalia Till Member lies between the Hulick and Radnor Members east of the Illinois River (Wickham, this volume, fig. 1). The Vandalia differs from the Hulick by being slightly sandier, slightly more illitic, and by being dolomitic (table 1), and it is sandier than the Radnor. The Vandalia's distribution is less extensive than that of the Hulick and it is not known west of the Illinois River.

The Radnor Till Member is a silty, dolomitic till that is the youngest known till of the Glasford Formation. The

Radnor extends as far west as eastern Knox County where it overlies the Hulick; a paleosol is present in places between the two. The Radnor is very similar to the Vandalia mineralogically (Lineback, 1979a), but may have more apparent illite in oxidized samples and is almost everywhere more silty than the Vandalia. Both the Vandalia and Radnor may contain more than one bed of till (Lineback, 1979a).

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MATRIX CARBONATE DATA FOR TILLS IN SOUTHEAST IOWA

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ABSTRACT

The percentage calcite, dolomite and total carbonate in the < 2 mm size matrix of Illinoian and Pre-Illinoian tills in SE Iowa were measured using a Chittick apparatus. The matrix carbonate data were found to be useful for characterizing and differentiating the till units. Using C/D (calcite/dolomite) ratios the eastern-derived, Illinoian Kellerville Till Member of the Glasford Formation can be differentiated from the western-derived Pre-Illinoian tills. The Kellerville Till Member exhibits C/D ratios less than 0.40, whereas 95% of the Pre-Illinoian till samples have C/D ratios greater than 0.40.

All of the tills studied exhibit a very well-defined linear, inverse relationship between the percentage of total matrix carbonate and the percentage of clay (or conversely, a direct relationship with percentage sand plus silt). Analysis of this relationship aids in understanding and evaluating the wide range in total carbonate values from individual samples or locations. Using the linear relationship between the total matrix carbonate and the clay content, the till members of the Pre-Illinoian Wolf Creek Formation may generally be discriminated.

As in previous studies which used different particle size fractions, the eastern-derived Kellerville Till Member has higher dolomite (or dolostone) contents than the western-derived Pre-Illinoian tills. However, unlike in these previous studies, the western-derived tills generally exhibit more dolomite than calcite.

INTRODUCTION

Carbonate content of tills has routinely been used for till correlation and differentiation. This paper will discuss the synthesis and overall significance of this data for Illinoian and Pre-Illinoian age tills in the southeast Iowa study area. The percent calcite, dolomite, and total carbonate in the < 2 mm size fraction were measured using a Chittick apparatus (Walter and Hallberg, this volume). Data for individual samples or particular sections are presented in Hallberg, Wollenhaupt, and Wickham (this volume). The occurrence of carbonate materials in the matrix of tills results from the incorporation and comminution of calcareous rock materials in the till. The nature and amount of carbonate materials present is dependent upon many complex factors (Dreimanis and Vagners, 1969, 1971a, b), but the provenance of the tills is a major determinant. Consequently, tills in the midcontinent frequently can be characterized and differentiated on the basis of their carbonate content or on the basis of some relationship between carbonate and another parameter, such as matrix texture (see for example Johnson, Gross, and Moran, 1971; Kemmis, 1978; and Hallberg, 1980). In the SE Iowa study area C/D (calcite/dolomite) ratios and the textural dependence of matrix carbonate, as indicated by the inverse relationship between total carbonate and percentage clay in the matrix, are useful for characterizing and differentiating the till units.

C/D RATIOS

The C/D ratio data provide excellent discrimination between the Illinoian and Pre-Illinoian tills (figure 1). The western-derived Pre-Illinoian tills do show consistently higher proportions of calcite. About 95% of all the Pre-Illinoian tills have C/D ratios higher than 0.40 and 99% are higher than 0.35. By contrast all of the Illinoian age Kellerville Till samples show C/D ratios lower than 0.40, and 95% are lower than 0.35. There is only a very limited overlap between the tills of different provenance.

Previous studies have indicated that the eastern-derived Illinoian tills in this region, such as the Kellerville,

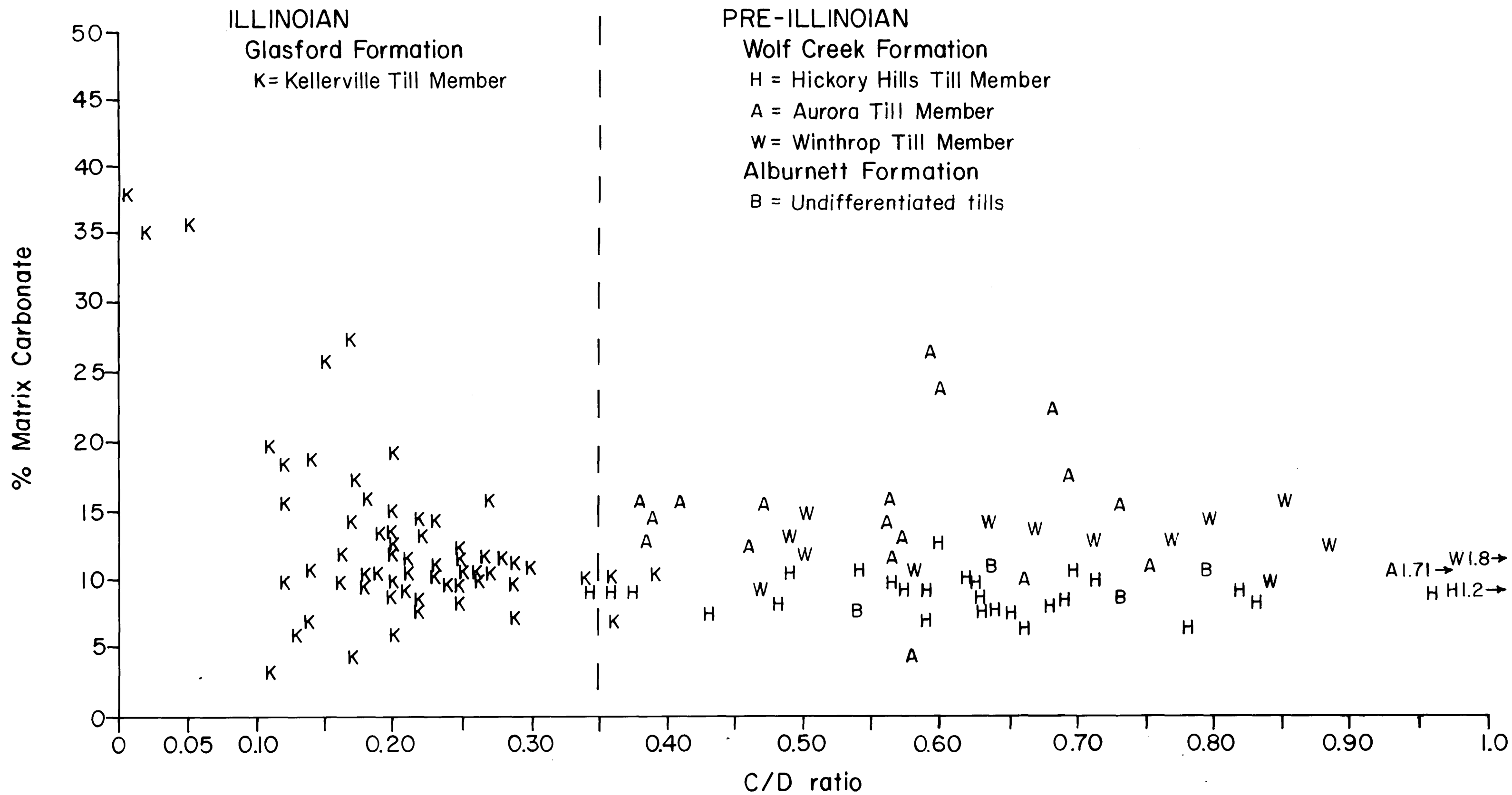

Figure 1. Plot of total matrix carbonate vs. C/D ratio for the tills in eastern Iowa.

exhibit more dolostone than limestone in pebble counts and analysis of the coarse or very coarse sand fraction (Horberg, 1956; Anderson, 1957; Wanless, 1957; Hallberg, Wollenhaupt, and Wickham, this volume). X-ray analysis of the clay fraction generally shows more dolomite than calcite (in counts-per-second) as well (Willman, Glass, and Frye, 1963; Hallberg, Wollenhaupt, and Wickham, this volume). Conversely, these same studies showed that the western-derived Pre-Illinoian tills (classic Kansan and Nebraskan), which came south through Iowa generally exhibit more limestone (or calcite) than dolostone (or dolomite).

The analysis of the total matrix carbonates does not entirely parallel the findings of these previous investigations. As discussed, and shown on figure 1, the Kellerville Till Member does exhibit a very low C/D ratio (high dolomite content). As also shown, only about 5% of the western-derived Pre-Illinoian till samples have a C/D ratio greater than one (indicating more calcite than dolomite). This is in marked contrast with the previous studies. However, the same general trend is present; the western-derived tills do show consistently higher proportions of calcite than the eastern tills.

TEXTURAL DEPENDENCE OF MATRIX CARBONATE

It is evident from figure 1 that the range of total matrix carbonate content is similar for all of the tills studied. The total carbonate values are of little value, by themselves, for till discrimination in this area. It has recently been recognized, however, that texture may influence matrix carbonate values (Kemmis, 1978, in prep.; Hallberg, 1980). The wide range of textures exhibited within the superglacial facies of the Kellerville Till Member provide an excellent example of this relationship. The percentage of total matrix carbonate for the Kellerville Till Member samples were plotted vs. the percentage sand (2-0.062 mm size), the percentage silt (0.062-0.002 mm size), and the percentage clay (< 0.002 mm size) (shown in figures 2, 3, and 4 respectively). The samples shown here are dominantly from the basal till and the diamicton (till-like materials) of the superglacial facies, although a few samples of stratified sediments contained within the superglacial facies have also been included. Figure 4 shows that there is a strong, inverse linear relationship between the matrix carbonate and the clay content. This relationship would be the same as a direct relationship between total percent of matrix carbonate and percent sand and silt. This textural dependence, as pointed out by Kemmis (1978, in prep.), is likely because the glacially comminuted debris of similar lithology and provenance becomes concentrated in certain terminal grade particle sizes (Dreimanis and Vagners, 1969; 1971a, b). For the data presented here the terminal grades for the carbonate rock fragments must be spread throughout the sand and silt fractions. This must be the case because there is a direct relationship between total matrix carbonate and the total percentage of sand plus silt. Yet neither sand or silt individually exhibit much influence on the total carbonate content.

In contrast with the total carbonate data, there is no apparent relationship between texture and the C/D ratio. As shown in figure 5, the C/D ratio data exhibit a rather "normal" distribution. This perhaps should be expected because the relative proportion of calcite and dolomite should be more closely related to the provenance of the tills.

An understanding of the textural dependence of the matrix carbonates is necessary to understand, and more importantly to utilize the data for discrimination of the till units. Figure 6 shows the relationships between the total carbonate percentage and the clay content for the Pre-Illinoian tills of the Wolf Creek and Alburnett Formations. This figure combines data from east-central Iowa (Hallberg, 1980) and the data from this study in southeast Iowa. The data from the two geographic areas is very consistent, and show three discrete envelopes which separate the Hickory Hills, Aurora, and

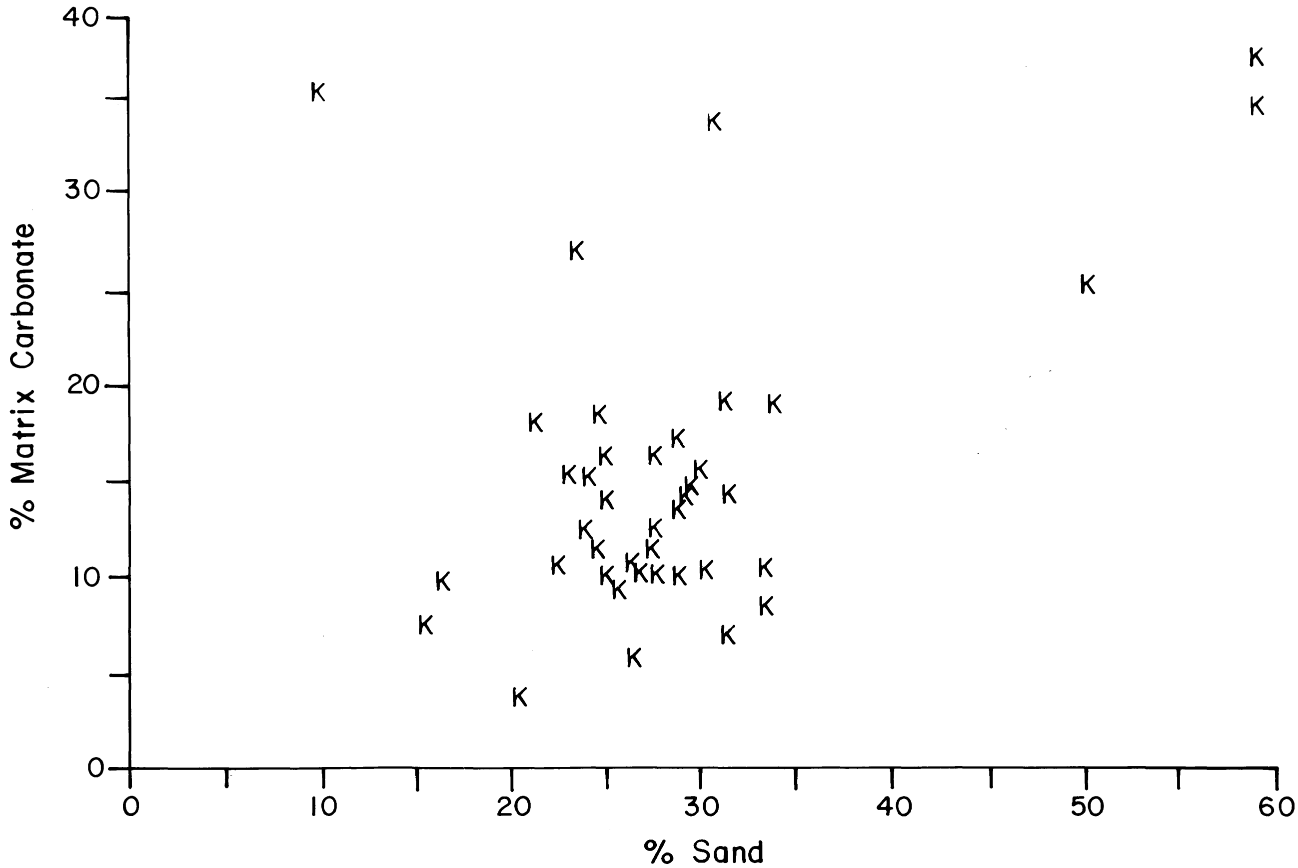

Figure 2. Total matrix carbonate vs. sand content, Kellerville Till Member.

Winthrop Till Members of the Wolf Creek Formation.

This relationship allows an added dimension for using both the textural data and the matrix carbonate data for discrimination of these till deposits. As shown in figures 1 and 6 the range of both the total carbonate percentages and the C/D ratios are very similar for all the tills of the Wolf Creek Formation. This makes the carbonate data of little value for discrimination, when used by itself. The mean textures of these tills are indeed different, but again their range in textures overlap (Hallberg, Wollenhaupt, and Wickham, this volume), making discrimination based on texture difficult in some cases. The Aurora Till Member does tend to range to higher total carbonate values than the other tills (figure 6) but where it does so, its texture is more like that of the Hickory Hills. The linear combination of this data,

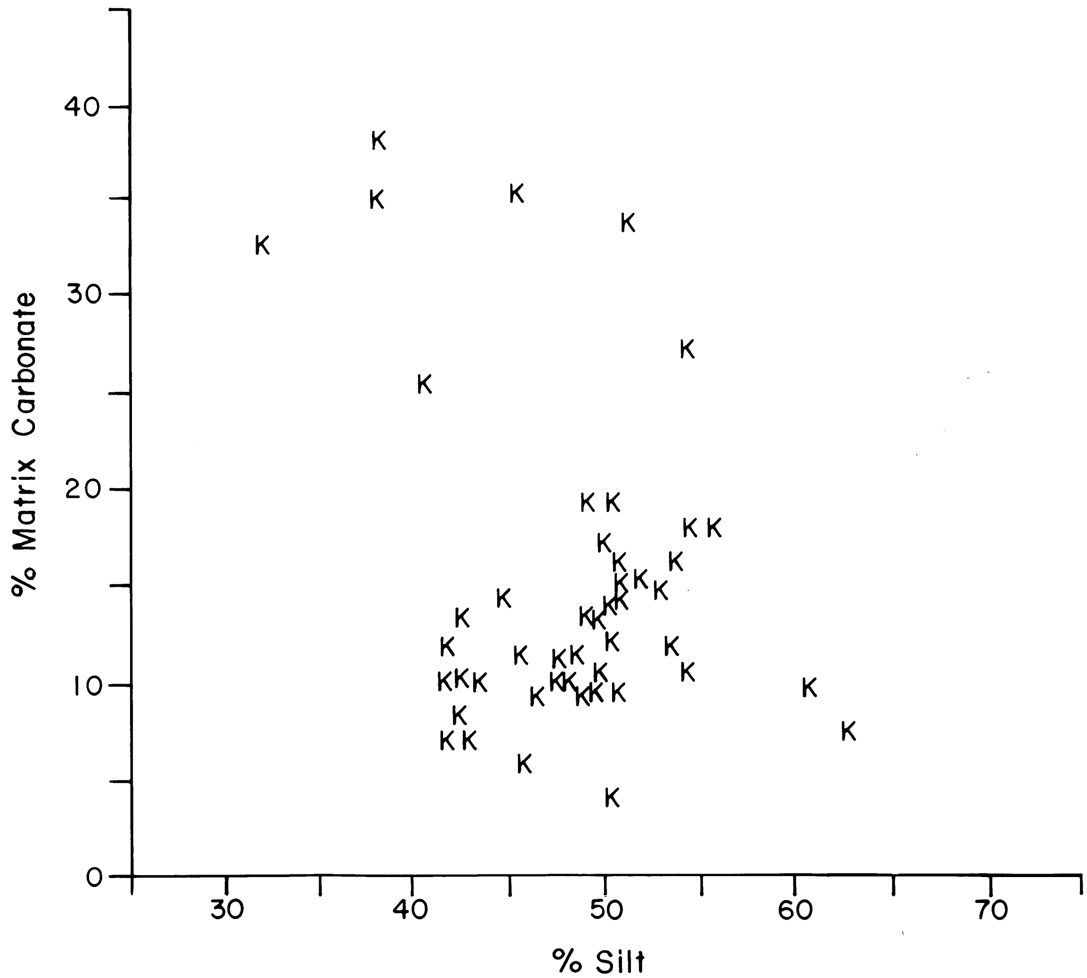

Figure 3. Total matrix carbonate vs. silt content, Kellerville Till Member.

as in figure 6, improves the utility of both the carbonate and the textural data and provides an effective tool for discrimination.

Figure 7 shows the data envelopes of the matrix carbonates vs. clay content for the principal tills in the southeast Iowa study area. The Kellerville Till Member overlaps the Aurora Till Member, and overall exhibits a very similar relationship to the Aurora. As discussed, the Kellerville can be readily separated by the C/D ratios.

The textural dependence of the matrix carbonates produces a very useful relationship in the eastern Iowa region. However, not all tills exhibit such clear relationships

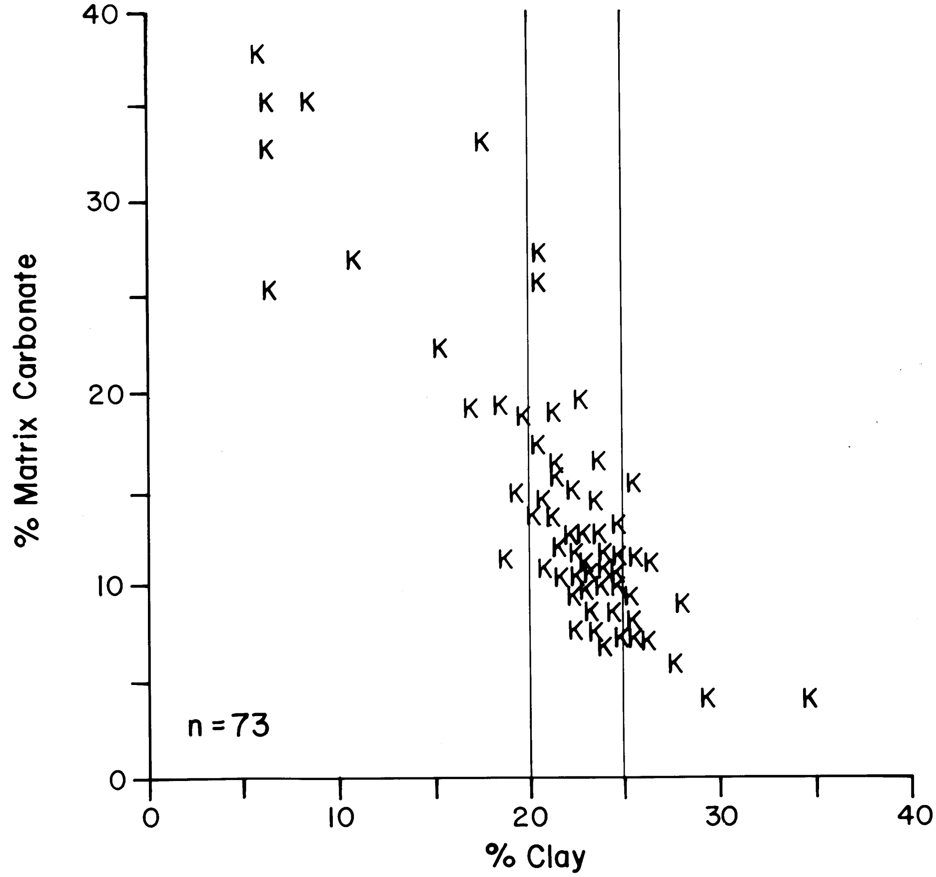

Figure 4. Total matrix carbonate vs. clay content, Kellerville Till Member.

(Kemmis, in prep.). It seems likely that the relationship (or the lack of) may relate to the distance of transport of the comminuted debris. Where local carbonate rocks have been incorporated in the tills,they may not be comminuted to the point that they have reached their "terminal grades." In such cases, aberrations from the textural trends illustrated here will likely occur. Although the tills, diamictons, and the stratified debris included within the tills in this study all seem to follow the same linear trend of carbonates vs. clay content, this may not be the case for stratified sediments exclusive of the tills. A few samples of fluvial sands and silts from between tills did not conform to the textural relations shown in figure 7. The C/D ratios were similar to the associated tills, however. The differences in the

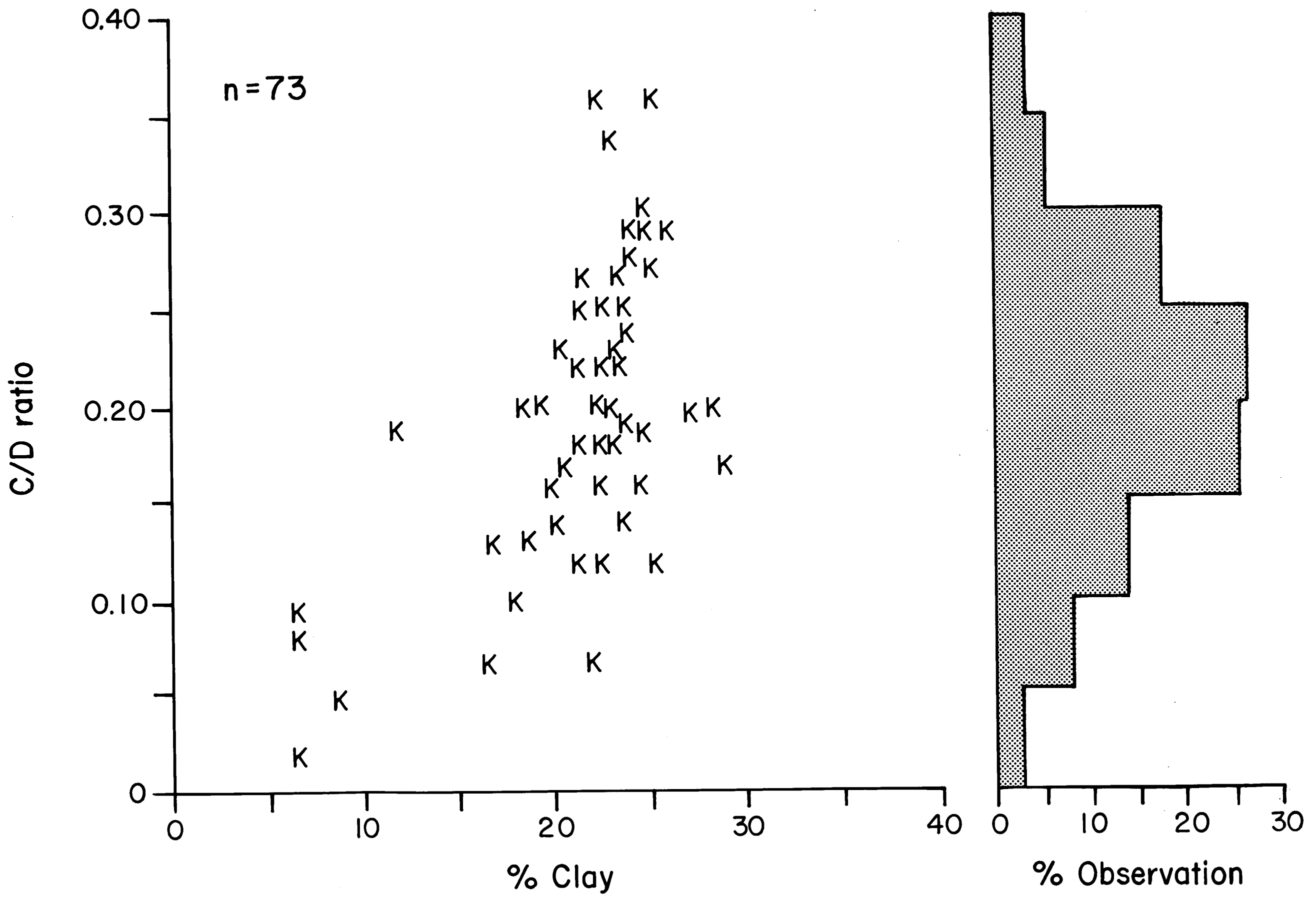

Figure 5. C/D ratio vs. clay content, and histogram of percent of observations by 0.05 increments of C/D ratio; Kellerville Till Member.

textural relations are probably related to the fluvial processes altering the sorting of the sediments.

ADDITIONAL COMMENTS

As discussed in other parts of this report (see Hallberg, Wollenhaupt, and Wickham, this volume) the carbonate content of the very coarse sand fraction of these tills has been evaluated from grain counts. It is interesting to note that although the relationship of the sand-fraction carbonate data between the Wolf Creek Formation tills changes from the northern east-central Iowa area to the southeast Iowa area, the matrix-carbonate relations are essentially identical (figure 6). The C/D ratios of the very coarse sand fraction

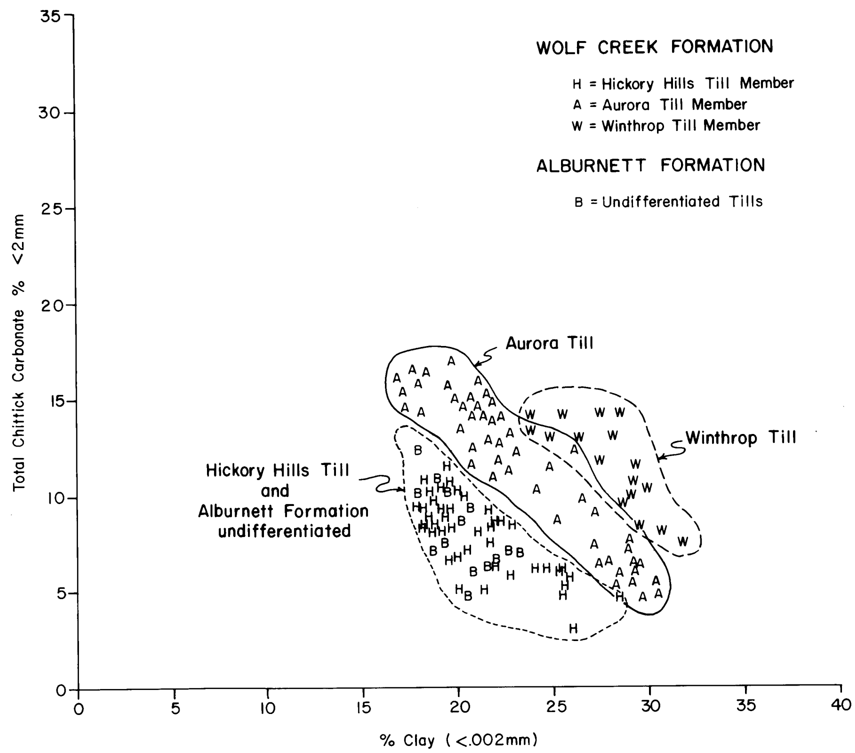

Figure 6. Total matrix carbonate vs. clay content for Pre-Illinoian till samples in eastern Iowa.

are also much higher than the matrix carbonate C/D ratios. This may seem problematical at first, particularly because the total carbonate content of the very coarse sand fraction varies from 10 to 40%. However, the very coarse sand fraction generally constitutes less than 4% of the total sample. Consequently, the carbonate fraction of the very coarse sand generally constitutes only 1-2% of the total matrix carbonate and consequently variations within this size fraction have little overall effect on the total matrix carbonate values.

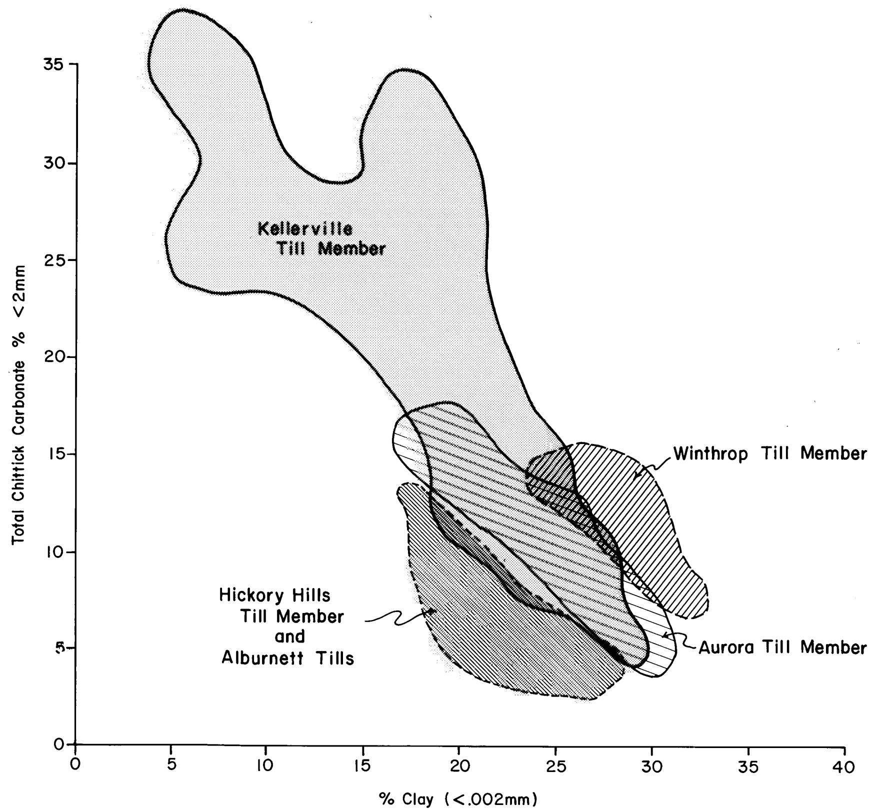

Figure 7. Data envelopes summarizing the relationship between total matrix carbonate content and clay content for tills in eastern Iowa.

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ANALYSIS OF MATRIX CALCITE AND DOLOMITE BY THE IOWA STATE UNIVERSITY SOILS LAB

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ABSTRACT

Matrix calcite and dolomite are analyzed by the Iowa State University Soils Lab on the < 2 mm size fraction of pedologic and geologic soil samples. The analysis uses the Chittick apparatus, with slight modifications of the procedure by Dreimanis (1962). The percentages of calcite and dolomite are calculated from empirical graphs relating the volumes of CO_2 that are evolved from known amounts of calcite and dolomite. The procedure is outlined and discussed. Caution must be used in comparing matrix carbonate data between labs because of differences in sample preparation or calculation method.

INTRODUCTION

Matrix calcite and dolomite content is determined for soil and sediment samples by the Soil Survey Laboratory, Department of Agronomy, Iowa State University. The Chittick apparatus (Fig. 1) was used, following a modified version of the procedure of Dreimanis (1962). The general principle of the procedure is that calcite and dolomite dissolve at different rates in dilute HCl. The volume of CO_2 evolved at two different times is measured. The percentages of calcite and dolomite are calculated from empirical graphs relating the volumes of CO_2 that are evolved from known amounts of calcite and dolomite.

PROCEDURE

Air dry and grind the samples to pass a 2 mm sieve being careful not to crush any pebbles larger than 2 mm. Weigh out exactly 1.70 g sample into the reaction flask (Fig. 1,B). Place a stirring bar in the flask and fit the flask snugly onto the stopper assembly (Fig. 1,H). A slight water film on the stopper enhances a snug fit.

Open the leveling stopcock (Fig. 1,F) to the atmosphere and adjust the leveling bulb (Fig. 1,D) until the level of the displacement solution is at 20 ml above the 0 ml mark in the measuring burette (Fig. 1,E). Close the leveling stopcock and lower the leveling bulb 2-3 cm. The level of the displacement solution should fall slightly and then stabilize. If it continues to fall, there are gas leaks in the system.

Fill the pipette (Fig. 1,C) with 6N HCl. Begin to add HCl from the pipette into the reaction flask. Start a timer capable of showing seconds. Turn on the magnetic stirrer (Fig. 1,A). Dispense exactly 20 ml of HCl into the flask. During the time the acid is being dispensed into the reaction flask, the level of the displacement solution in the leveling bulb must be kept at least 2-3 cm below the level of the fluid in the measuring burette. This prevents CO_2 from being forced back into the pipette containing HCl.

Shortly before 30 seconds of reaction time have elapsed, level the displacement solution in the leveling bulb and measuring burette. At 30 sec. of reaction time, read the level of the displacement solution in the measuring burette. Record the temperature from the thermometer (Fig. 1,G) that is inserted into the reaction flask. Also record the barometric pressure.

Periodically lower the leveling bulb as CO_2 evolves to keep the level of displacement solution at least 2-3 cm lower than the level in the measuring burette. When CO_2 ceases to be evolved, record the volume of CO_2, temperature and barometric pressure. For samples low in dolomite, CO_2 ceases to

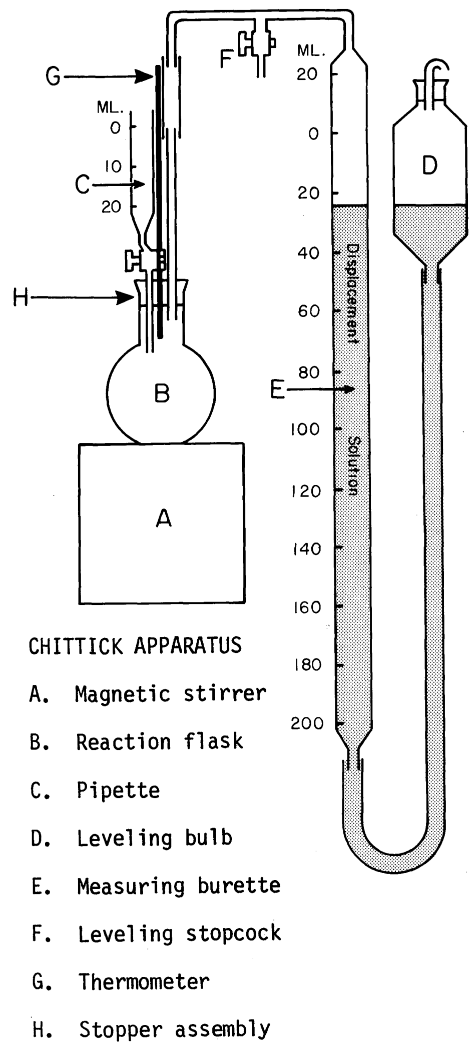

Figure 1. Chittick apparatus as used by Iowa State University Soils Lab

be evolved by 20 min. of reaction time. For samples high in dolomite, reaction time often exceeds 20 min.

Results: Comments and Calculations

According to Dreimanis (1962), all of the calcite and 2-5% of the dolomite present are dissolved by the 30 second reaction time reading. When CO_2 evolution stops, 5-7% of the dolomite is still unreacted. At least 6-24 hours are required to dissolve all of the dolomite. Dreimanis' Figure 5 graph automatically accounts for this 5% of unreacted dolomite. The graph seems reliable since it represents 75 analyses. This graph is used in calculating results since it is incorrect to assume all carbonates have dissolved after CO_2 evolution stops. In following the calculation steps of Dreimanis (steps A-F, p. 525), the 2-5% of dolomite that dissolves within the first 30 sec. is also accounted for.

Dreimanis' Figure 5 graph is too small to be used conveniently. Regression equations can be developed representing the two lines of Figure 5. The following equations were calculated by Dr. Reuben E. Nelson, USDA National Soil Survey Laboratory, Lincoln, Nebraska. Do all steps per Dreimanis' paper, p. 525, steps A through F, then

$$\% \text{ calcite} = F\ (0.232)$$

$$\% \text{ dolomite} = E\ (0.223) + 0.3.$$

All values are calculated on a percentage by weight basis. The correlation coefficient between values picked off the graph and those calculated by these regression equations is 0.99998. Regression equations make the calculations of results faster and may avoid errors in reading points off the graph.

The correction factor table from the A.O.A.C. (Association of Official Agricultural Chemists) Manual (1950) is used to correct all CO_2 volumes to a volume at a standard temperature and pressure. The table is far more accurate than necessary, considering the overall accuracy of the Chittick apparatus. The senior author made a study of the derivation and development of the table and concluded that there were several erroneous assumptions made in applying the table to the Dreimanis carbonate procedure. These assumptions crept in over the years as the procedure was adapted. The errors are important only if one is concerned with the precise physical chemistry of the system. They are not significant for calculating the percentages of calcite and dolomite using the Dreimanis (1962) procedure. The A.O.A.C. correction factor table should still be used because Dreimanis used it in developing his Figure 5 graph. If one uses the graph he should use the correction table.

Notes on the Procedure

The range of samples analyzed by the Soil Survey Laboratory often includes surface horizons of soils high in organic matter. HCl and MnO_2 present in the soil can react to oxidize organic matter and thus release CO_2. An easily oxidizable ion such as Fe^{++} present in the HCl will prevent such reactions (Allison and Moodie, 1965). The 6N HCl is routinely prepared containing 0.15 M Fe^{++}. Soils high in organic matter and carbonates often froth excessively upon addition of the HCl. The frothing can produce slightly erroneous results because it keeps some carbonates from contact with the HCl during the first 30 second reaction period. One or two drops of octyl alcohol added to the sample effectively prevents frothing (Bundy and Bremner, 1972).

The heat from the electric motor of the magnetic stirrer will produce a slight increase in the second reading for CO_2 because of thermal expansion. One should insulate the surface of the magnetic stirrer well. To correct for this run several blanks of 20 ml of HCl solution to see how much expansion occurs after 20-30 min. of stirring. Subtract this correction (usually 1-2 ml) from the second CO_2 volume reading. An air driven magnetic stirrer is ideal since it produces no heat.

COMPARISON OF DATA WITH OTHER LABS

Some caution must be used in comparing calcite-dolomite data between labs. First, the exact methods of the procedure and calculations may differ (even though all may use the Chittick apparatus). Particular attention should be payed to the particle size analyzed. Dreimanis (1962) took a sample of dry till, disintegrated the till lumps gently, and then sieved them on a 200 mesh sieve (< 0.074 mm). The sample analyzed was a small subsample of the matrix, consisting of particles < 0.074 mm. No grinding occurred. The Illinois State Geological Survey (pers. commun. Dr. E. Donald McKay) also analyzes the < 0.074 mm size fraction, without grinding.

Analyzing just the < 0.074 mm size fraction is not acceptable for the work in Iowa. Essentially all work in soil science is done on the < 2 mm fraction. Anything > 2 mm is considered gravel, and is not included in standard pedologic analyses. The < 2 mm fractions entails all sand, silt, and clay. The standard analyses, both chemical and physical, are performed on this size fraction. These include: particle size, pH, amounts of various forms of carbon, cation exchange capacity, exchangeable cations (Ca, Mg, Na, K, H, etc.), plant available N, P, and K, amounts of iron, total elemental analysis, as well as carbonate content. Past work with soil carbonates was done on the < 2 mm fraction.

The Soil Survey Lab feels that analyzing the < 2 mm fraction is preferred for its use so that current data can be compared with past data, current data can be compared with pedologic data from other states, and the calcite-dolomite data can be compared to other soil properties of the < 2 mm fraction. Because of the nature of the cooperative work between the Iowa Geological Survey and the Iowa Cooperative Soil Survey all geologic samples are analyzed in this manner as well. The consistent methods used enable the joint utilization of the matrix carbonate data for pedologic and geologic studies.

Another source of difference between data run by Iowa and Illinois is in the method of calculation. Iowa uses the graph of Dreimanis, Figure 5, as stated previously. This graph automatically accounts for the 5-7% dolomite that is still undissolved when CO_2 evolution stops. Illinois (pers. commun., Dr. E. D. McKay) uses a calculation equation based on mole ratios that does not account for the unreacted dolomite.

The Nebraska Geological Survey also analyzes for total matrix carbonates rather than just the < 0.074 mm fraction (see Boellstorff, 1978). Their procedure states, "Gently crush approximately 10 grams of this (bulk) sample by hand and remove all granules larger than about 1.0 mm. Grind this sample in a mechanical shatter box for 5 minutes and then sieve through a U.S. Standard Sieve No. 200 (200 mesh)." The Dreimanis' graph is not used. The calculations at Nebraska are based on graphs developed from analyzing samples of known amounts of calcite and dolomite on their Chittick apparatus.

The Iowa Soil Survey Lab analyzes the matrix calcite-dolomite on the sieved, but unground, < 2 mm fraction. The effects of fine grinding was investigated and it was concluded that although it was not necessary, it may be desirable to promote complete reaction.

Several samples were analyzed using splits of the < 2 mm fraction. One sample was processed as usual, and the other was ground in a mechanical grinder to try to pass a 200 mesh sieve. It was impossible to get the total sample to pass the sieve. Even though the particles were ground fine enough, electrostatic forces held the particles together and prevented them from passing the 200 mesh sieve. A 100 mesh sieve (0.149 mm) was then used. No consistent or significant differences were found between the ground and unground samples.

If fine grinding had given higher calcite values, then one would suspect the large calcite particles were not reacting within 30 sec. The reaction times of various sizes of calcite particles were also studied. Only the 1.0-2.0 mm size fraction had not completely reacted at the end of 30 sec. However, the amount of CO_2 evolved from a 1.70 g sample after 30 seconds was negligible. It is possible that less dolomite reacts in the first 30 seconds if the sample is not ground. It also may take longer for all of the dolomite to react. As long as the reaction is allowed to continue until CO_2 evolution stops, this should present no problem.

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