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27th Field Conference
MIDWEST FRIENDS OF THE PLEISTOCENE
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YARMOUTH REVISITED

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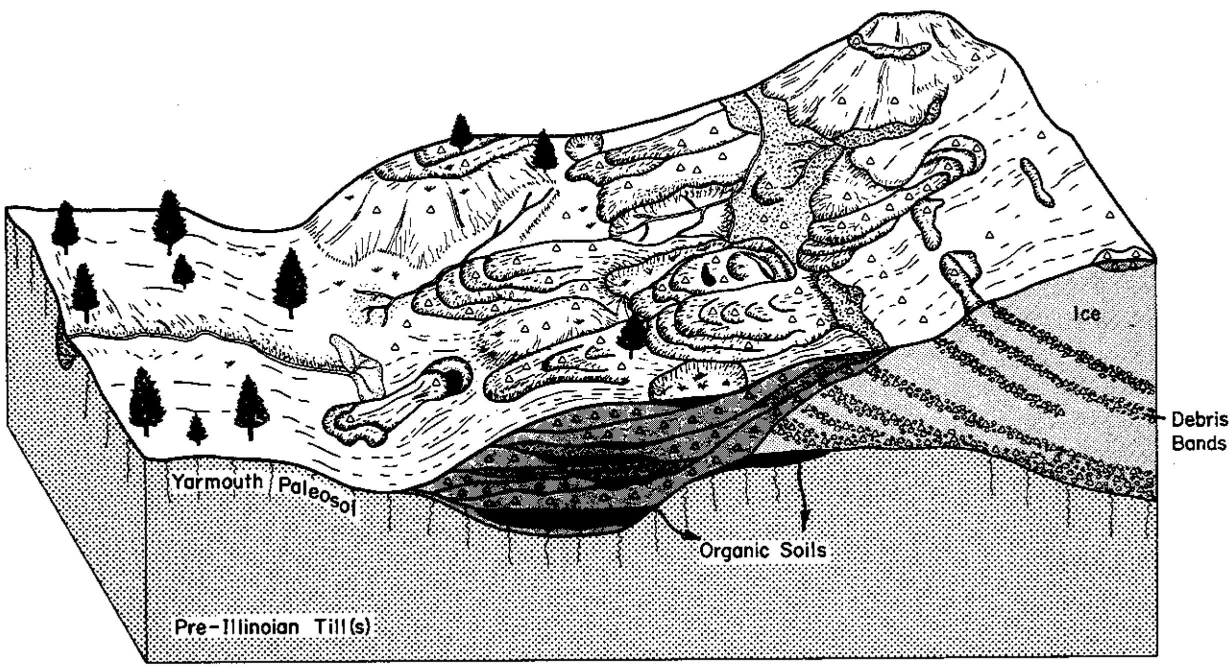

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Guidebook #3

YARMOUTH REVISITED

IOWA GEOLOGICAL SURVEY GUIDEBOOK FOR THE 27TH FIELD CONFERENCE MIDWEST FRIENDS OF THE PLEISTOCENE

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Listing of Midwest Friends of the Pleistocene Meetings

No.	Year	Date	Author, Affiliation; Location
1	1950	-	S. Judson, Univ. wisc.; eastern Wisconsin
2	1951	-	H.E. Wright, Univ. Minn. and R.V. Ruhe, Iowa St. Univ.; southeastern Minn.
3	1952	May 10-11	P.R. Shaffer, Ill. Geol. Surv. and W.H. Scholtes, Iowa St. Univ.; western Ill. and eastern Iowa.
4	1953	May 23-24	F.T. Thwaites, Univ. Wis.; northeastern Wis.
5	1954	May 29-30	H.E. Wright, Univ. Minn.; central Minn.
6	1955	May 20-22	R.V. Ruhe, Iowa State Univ.; southwestern Iowa
7	1956	May 11-13	J.H. Zumberge et al., Univ. Mich.; northwestern part of southern Michigan
8	1957	Apr. 26-28	W.D. Thornbury, Ind. Univ. and W.J. Wayne; south-central Indiana
9	1958		W. Laird et al. N.D. Geol. Survey; eastern N. Dakota
10	1959		R.F. Black, Univ. Wis.; western Wisconsin
11	1960	May 14-15	F.V. Steece, M.J. Tipton and A.F. Agnew, S.D. Geological Surv.; eastern S. Dakota
12	1961		C. Gravenor et al., - ; eastern Alberta
13	1962	May 12-13	R.P. Goldthwait et al., Ohio State Univ.; western Ohio
14	1963	May 11-12	J.C. Frye and H.B. Willman, Ill. Geol. Surv.; western Illinois
15	1964	May 16-17	H.E. Wright, Univ. Minn.; eastern Minnesota
16	1965	May 15-16	R.V. Ruhe et al., Iowa State Univ.; northeastern Iowa
17	1966	May 21-22	E.C. Reed et al., Neb Geol. Surv.; eastern Nebraska
18	1967	May 19-21	L. Clayton and T.F. Freers, N.D. Geol. Surv.; south-central N. Dakota
19	1969		W. Kupoch, Univ. Saskatchewan; Cypress Hills, Sask. and Alberta
20	1971	May 15-16	C.K. Bayne et al., Kansas and Mo. Geological Surveys; Kans. and Mo. Border
21	1972	May 12-14	W.H. Johnson et al., Ill. Geol. Survey; east-central Illinois
22	1973	June 1-3	E.B. Evenson et al., Univ. Mich.; Lake Michigan Basin
23	1974	Aug. 8-10	W.H. Allen et al., Mo. Geol. Survey; western Mo.
24	1976	April	C.K. Bayne, et al., Kansas Geol. Survey; southwestern Kansas
25	1978	May 19-21	R.V. Ruhe and C.G. Olson, Ind. Univ; southwestern Indiana
26	1979	May 4-6	L.R. Follmer et al., Ill. Geol. Survey; central Illinois
27	1980	May 31-June 1	G.R. Hallberg et al., Iowa Geol. Survey; southeast Iowa

Compiled by Leon Follmer

We are not toally sure of the accuracy of the list. Anyone wishing to make corrections or additions (or add titles) please forward comments to the next convener of the Friends.

G.R.H.

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The illustrating and artwork which makes this report comprehensible was done by Mr. John Knecht and Ms. Pat Lohmann of the Iowa Geological Survey. The cover figure was drawn by Ms. Charmaine Shreve.

Our thanks also to Ms. Chris Crowley, Ms. Holly Kemmis, Ms. Barbara Miller, and Ms. Rosemary Regan for all their work in preparing manuscripts and their assistance in organizing this affair.

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Last, but not least, we must acknowledge Frank Leverett, the original visitor to Yarmouth.

INTRODUCTION

This field conference marks the culmination of a long series of cooperative investigations in southeast Iowa which began in 1974. Staff of the Iowa Geological Survey, Iowa Cooperative Soil Survey, Departments of Agronomy and Engineering, Iowa State University, U.S.D.A. Soil Conservation Service, Department of Geology, University of Iowa, and the Illinois State Geological Survey have all contributed to this work. The results of these investigations are described in detail in the various papers included in Iowa Geological Survey Technical Information Series No. 11 (Hallberg, ed., 1980). This guidebook is a supplemental part of this report. As such, the detailed findings and review of previous investigations will not be elaborated on here, except for a few pertinent points.

The field trip itself will not attempt to completely review the stratigraphy of the area. Rather the trip will focus on a few key points: 1. a review of the Yarmouth type area, including Leverett's original definition, and our present reevaluation (see Hallberg and Baker, 1980); 2. the relationships of the Yarmouth and Sangamon Paleosols; and 3. a depositional model for the deposits of the early Illinoian Kellerville Till Member, of the Glasford Formation in southeast Iowa. As promised a limited amount of time will be spent discussing minor Wisconsinan units.

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; see Appendix also). 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 (1980). 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 <0.004mm, 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.

Stratigraphy

The Pleistocene stratigraphic framework for this area is outlined in Table 1. (The general surficial geology is shown in figure 3.) This trip will principally be concerned with the pre-Wisconsinan Pleistocene stratigraphy. These deposits are formally 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. 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.

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, 1980). The clay mineralogy of these deposits is also a useful parameter for differentiation at the formation level. Table 2 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 kaolinite 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) and in 8.3% of the Alburnett

Table 1. 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. *	
PLEISTOCENE SERIES	SANGAMON STAGE	Yarmouth-Sangamon Sediments undif. *	Unnamed sediments; * includes Sangamon and Late Sangamon Pedi-sediment and Alluvium; and undifferentiated sediments.	Sangamon and Late-Sangamon Paleosols	YARMOUTH-SANGAMON Paleosol
PLEISTOCENE SERIES	ILLINOIAN STAGE	Yarmouth-Sangamon Sediments undif. *	GLASFORD FORMATION Kellerville Till Member superglacial and sub-glacial-basal till facies.		YARMOUTH-SANGAMON Paleosol
PLEISTOCENE SERIES	YARMOUTH STAGE	Yarmouth-Sangamon Sediments undif. *	WOLF CREEK FORMATION (including unnamed, undifferentiated sediments)	YARMOUTH Paleosol	YARMOUTH-SANGAMON Paleosol
PLEISTOCENE SERIES	PRE-ILLINOIAN STAGES undifferentiated		Hickory Hills Till Member Aurora Till Member Winthrop Till Member	Dysart Paleosol Franklin Paleosol Westburg Paleosol	
PLEISTOCENE SERIES			ALBURNETT FORMATION unnamed sediments, unnamed till members.		

* Informal names.

Formation samples (5.6% of the ISGS analyses). Also, chlorite peaks are frequently apparent in the Kellerville Till Member samples (determined as chlorite by H. D. Glass, see Willman, Flass, 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.

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

Table 2. 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

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 2. 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 incorporation 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.

This field conference will not attempt to review the complete stratigraphy of this area. Very little of the stratigraphic section can be seen at any one locality, and the demonstration of the stratigraphic relations is dependant upon deep, and detailed core drilling (which is too expensive to repeat) and on the quantitative characterization of the deposits (Hallberg, Wollenhaupt, and Wickham, 1980). The trip leaders feel there is little to be gained by attempting this. Rather, we feel that all parties involved can participate and learn more effectively (editor's translation--jump and shout more vigorously) by reviewing in detail only certain problems whose field relations can readily be examined in exposures and cores. As discussed, the principal focus will be on the relationships of the Yarmouth, and only two tills will be viewed on the trip. These are the Hickory Hills Till Member of the Wolf Creek Formation (Hallberg, 1980) which constitutes the youngest Pre-Illinoian till (Hallberg, Wollenhaupt, and Wickham, 1980), and the Kellerville Till Member of the Glasford Formation which is the oldest Illinoian till (see Wickham, 1980; Lineback, 1980 for discussion).

Hickory Hills Till Member - Wolf Creek Formation

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 in which the Yarmouth-Sangamon or Late-Sangamon Paleosols formed.

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; (2) a direct contact with the Aurora Till Member; (3) a contact with undifferentiated fluvial sediments, which separate it from the Aurora Till Member; or (4) a contact with the Paleozoic bedrock.

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 (stops 1-3); (2) the contact with overlying early-Illinoian silts or organic silts; or (3) a till-till contact between the Kellerville Till Member and the Hickory Hills Till Member (Pleasant Grove Section, stop 4). Till-till contacts where the intervening paleosol is missing are much more common than sections where the paleosol is preserved.

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 (stops 7 and 8).

All the tills of the Wolf Creek Formation average 58-60% expandable clays (Table 3). The data is presented to demonstrate the 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). In combination with stratigraphic position the particle-size data, and this data combined with the matrix carbonate data provide the principal means of discriminating the Hickory Hills and other till members of the Wolf Creek Formation.

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 4; figure 1). There is again an excellent correspondence in the particle-size distributions of the

Table 3. 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 4. 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).

three till members between southeast Iowa and the type area. The Hickory Hills Till Member is relatively sandy, the Aurora and Winthrop are relatively silty, but the Winthrop 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 1.

The particle-size data combined with the matrix carbonate 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 (1980). Again, the matrix carbonate data from southeast Iowa is very consistent with the data from the type area (Hallberg, 1980, figure 38).

The Hickory Hills Till Member is considered to be a basal till (in the generic sense of Dreimanis, 1976), based on its very uniform properties vertically and laterally, its sedimentologic features, and its consolidation characteristics and density (see Hallberg, 1980; Hallberg, Wollenhaupt, and Wickham, 1980).

Kellerville Till Member - 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

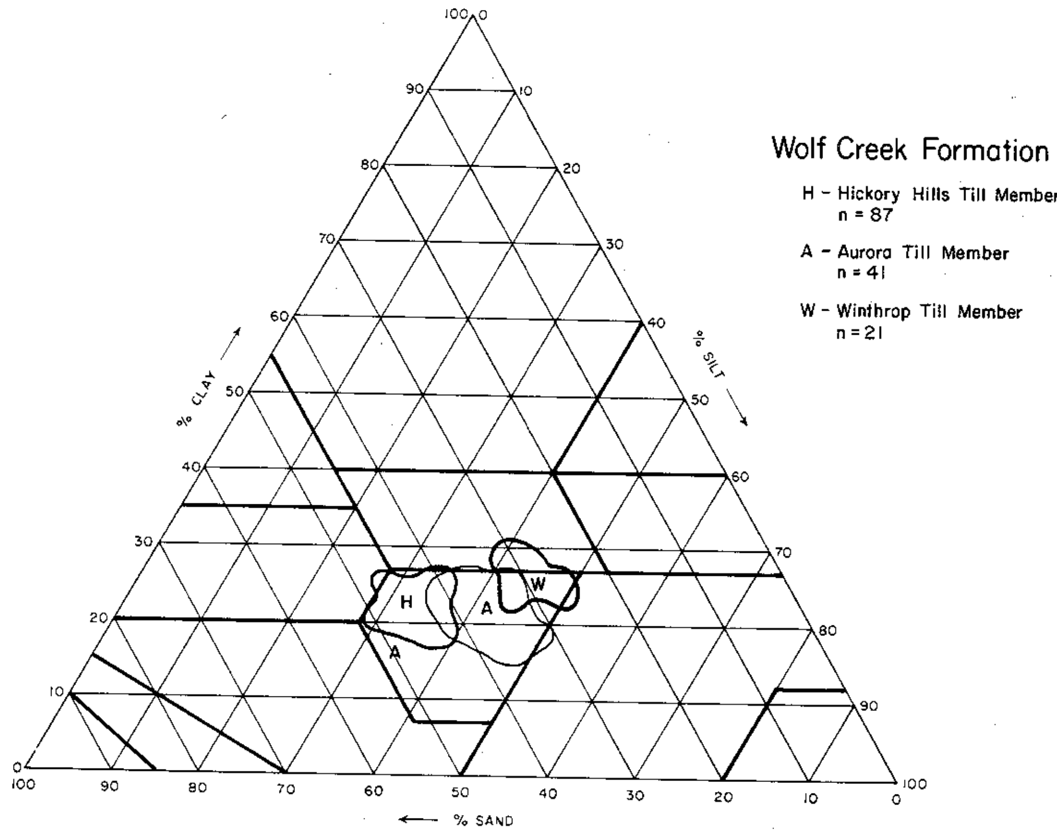


Figure 1. Range of textures in the Wolf Creek Formation tills in southeast Iowa.

the top of the Sangamon Paleosol. Current work on the Glasford Formation is reviewed by Lineback (1980).

In southeast Iowa the Glasford Formation is comprised of the Kellerville Till Member, and some thin units of undifferentiated sediments which 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 (stop 1) which may be the equivalent of the Petersburg Silt.

The Kellerville Till Member is the oldest till member of the Glasford Formation (Willman and Frye, 1970; Lineback, 1980). 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 (1980).

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 Petersburg Silt of Illinois; or (2) the Yarmouth Paleosol; or (3) the Hickory Hills Till Member of the Wolf Creek Formation, where the Yarmouth Paleosol has been eroded. The lower contact can be complex where glacial deformation has occurred.

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 have removed the paleosols the top of the Kellerville Till Member may be marked by a stone line which is overlain by Wisconsinan loess.

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. The basal till facies is subjacent to the superglacial facies and is composed of dense, uniformly-textured till.

The laboratory data for the Kellerville Till Member are summarized in Table 5 and figure 2. 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 2a).

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 2b). 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 2b) from sand, and sand and gravel, to silt, to a very heavy clay in matrix texture. As noted in Hallberg and Baker (1980) 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 5 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 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

Table 5. 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

characteristic which often allows recognition of the Kellerville in the field.

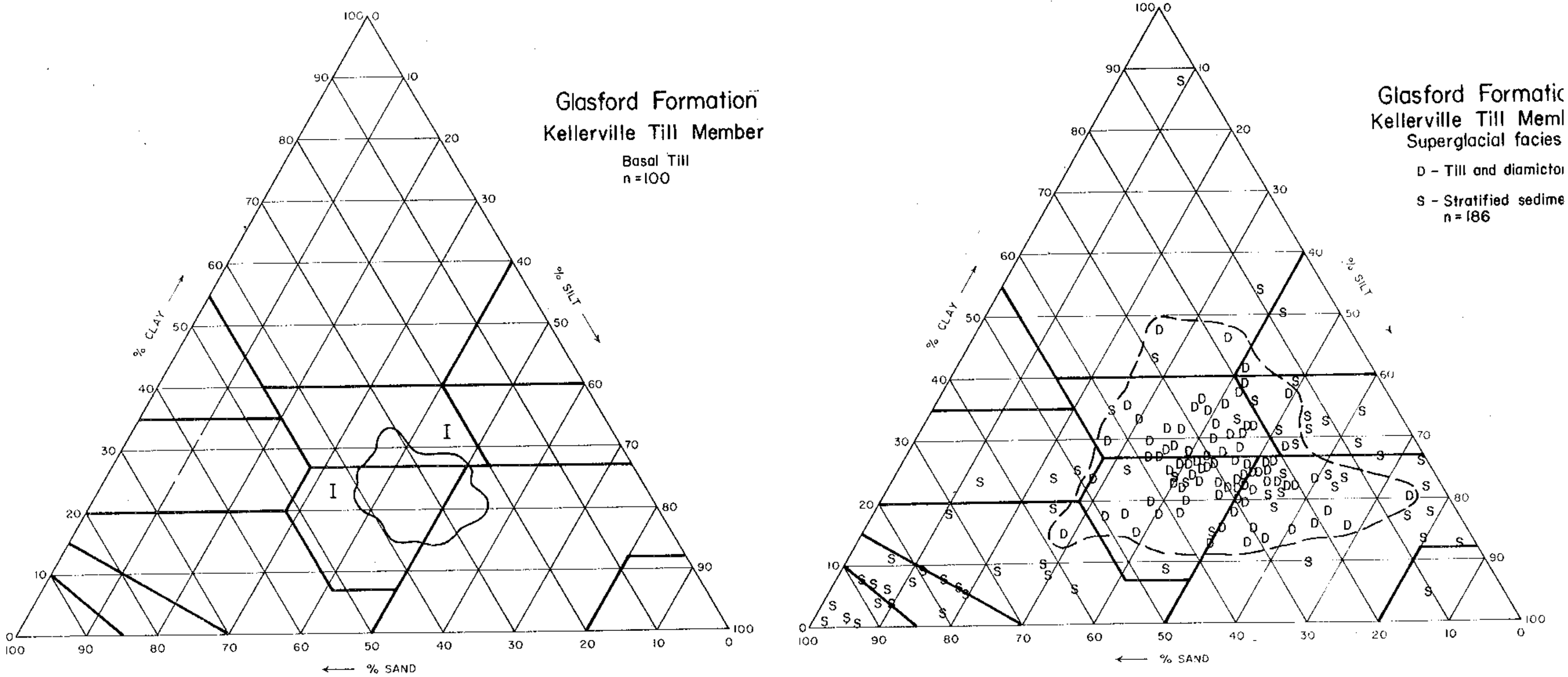
As discussed, perhaps the most distinguishable characteristic of the Kellerville Till Member is its high dolomite content in the matrix carbonates (Kemmis and Hallberg, 1980). The Kellerville exhibits matrix carbonate C/D ratios less than 0.40, whereas 95% of all the Pre-Illinoian deposits have C/D ratios greater than 0.40.

Density - Consolidation Characteristics

In addition to the contrast in texture and sedimentology there is a pronounced difference in density between the superglacial and subglacial facies. Table 6 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 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.

Table 6 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 considered to be basal tills (Hallberg, 1980). Table 6 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 and which may be moderately overconsolidated.



A. B.

Figure 2. Textural distribution for the Kellerville Till Member: A. Basal till facies; B. Superglacial facies.

Table 6. Summary of bulk density measurements for Pleistocene deposits in the southeast Iowa study area.

Wisconsinan loess *

n	density - g/cc (pcf) mean	s.d.	range
31	1.50 (94)	0.06 (4.0)	1.39-1.59 (87-99)

GLASFORD FORMATION - Kellerville Till Member

superglacial facies

n	mean	s.d.	range
21	1.59 (99)	0.12 (7.5)	1.42-1.83 (89-114)

subglacial facies - basal till

n	mean	s.d.	range
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

n	mean	s.d.	range
11	1.98 (124)	0.07 (4.4)	1.91-2.16 (119-135)

Where surficial till unit. **

n	mean	s.d.	range
105	1.79 (112)	0.08 (4.8)	1.61-1.96 (101-122)

- Aurora Till Member **

(overlain by Hickory Hills Till Member)

n	mean	s.d.	range
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.

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 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 (see Hallberg, Wollenhaupt, and Wickham, 1980; Hallberg, 1980).

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.

Soil-Stratigraphic Units

Many of the stops on this trip will concentrate on the Yarmouth and Sangamon Paleosols or combinations or variations of these paleosols. Thus, only a brief mention of them will be made here (see also Hallberg, Wollenhaupt, and Wickham, 1980; Hallberg and Baker, 1980).

The Yarmouth Paleosol is overlain by the earliest Illinoian age Kellerville Till Member (or related pro-glacial silts) 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 because they are clearly defined, in space and in time, by the overlying Kellerville Till Member.

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

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 Paleosol is developed in undifferentiated fine-textured 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 uncertainty of their temporal relations.

The Late-Sangamon Paleosol also is recognized in the area developed in both the Kellerville and Hickory Hills Till Members. The Late-Sangamon Paleosol is also overlain by the Wisconsinan loess, and where recognizeable the basal loess sediments and paleosol. 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).

Wisconsinan Loess

The loess is not a focal point for this field trip, but it is present at every locality. All the deposits in the area are mantled by loess, except late Wisconsinan to Holocene slopes and alluvial deposits (see figure 3). The loess varies in thickness from about 8 to 20 feet. It is thickest near the Mississippi and Iowa Rivers where it also includes variable amounts of eolian sand.

At the base of the loess occur the basal loess sediments and basal loess paleosol. The sediments are generally very thin, are mineralogically similar to the loess, but generally are higher in clay and sand than the loess. The sediments grade into peat in swales on the sub-loess surface. The basal loess paleosol varies from a buried A horizon or an A/C soil profile, to a buried O horizon (peat), which complex with or mark the top of the various Sangamon, Yarmouth-Sangamon Paleosols.

Basal dates on the basal loess paleosol and peat range from ca. 18,500 to 24,000 RCYBP (see Ruhe, 1969; Hallberg, Wollenhaupt, and Wickham, 1980) in this immediate area. (See note by Lutenegger, this volume, also.)

THE FIELD TRIP

Saturday

The route for Saturday is shown in figure 3. Driving north from Burlington on U.S. 61 we will drive through an area which is highly dissected because of its proximity to the Mississippi River. In this area the Westlake Section, a steep stream and roadcut on the west side of U.S. 61, exposes a very thick section of the Kellerville Till Member (see Table 7). Proceeding northward the route rises on to the very flat "tabular" divide in central Des Moines County. Wisconsinan loess varies from 8-10 feet (2.5-3.0 m) in thickness and overlies the Sangamon Paleosol which is developed in a variety of sediments and the Kellerville Till Member.

As we approach the towns of Sperry and Mediapolis, the large industrial plant to the west is the U.S. Gypsum Sperry Mine. This is an underground operation which mines Devonian gypsum deposits.

Figure 3. (facing page). Generalized surficial geologic map of study area showing Saturday's route and stops. All units loess-mantled except late-Wisconsinan to Holocene slopes and alluvium.

Stratigraphic Sections shown with symbols indicating surficial till unit (see Hallberg, ed., 1980).

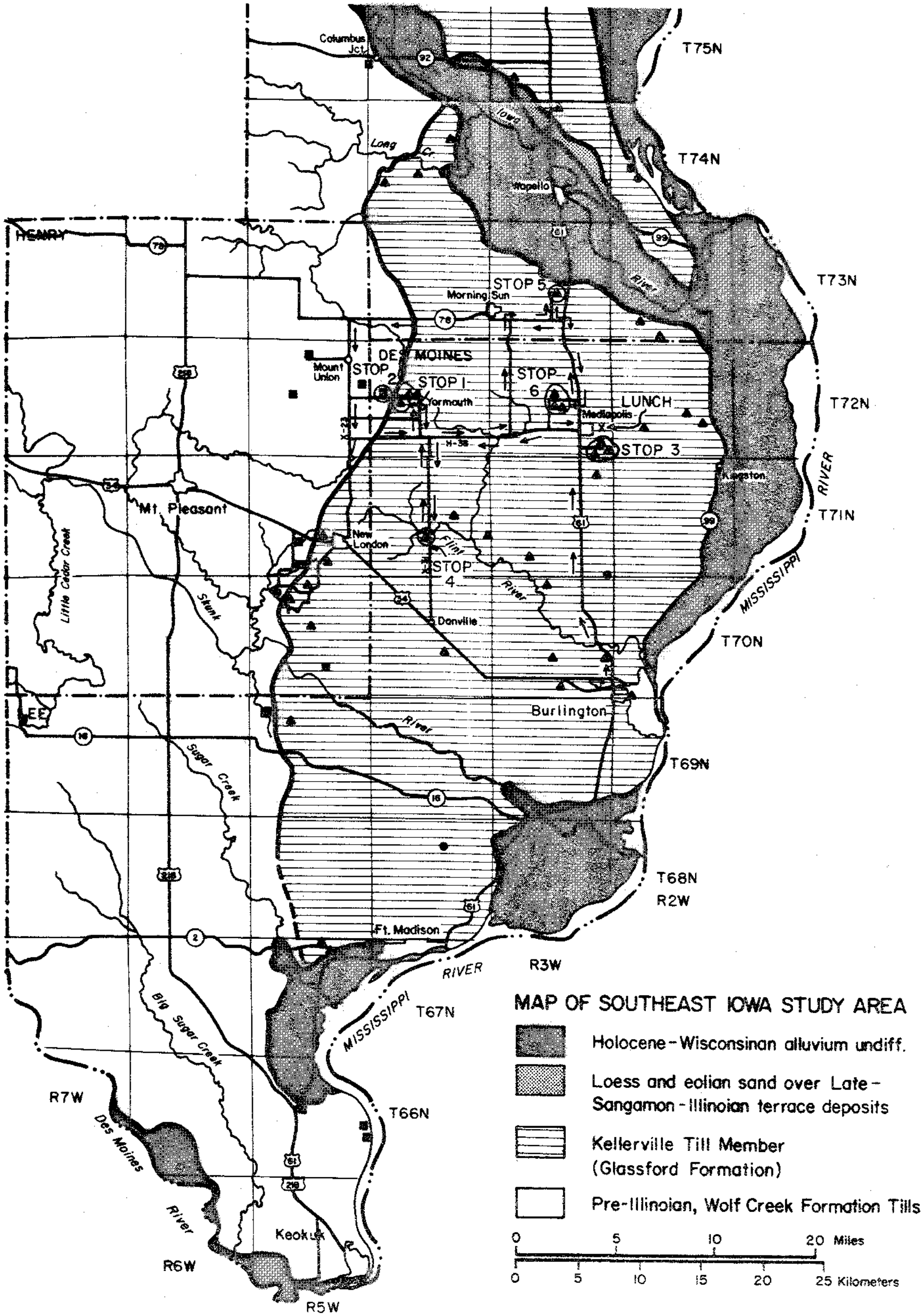
Illinoian - GLASFORD FORMATION

▲ Kellerville Till Member

Pre-Illinoian - WOLF CREEK FORMATION

■ Hickory Hills Till Member

● Other WOLF CREEK or ALBURNETT FORMATION tills



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
HENRY
Morning Sun
STOP 5
DES MOINES
Mount Union
STOP 2
STOP 1
Yarmouth
STOP 6
LUNCH
Mediapolis
STOP 3
Kingston
Mt. Pleasant
New London
STOP 4
Danville
Burlington
LEE
Ft. Madison
Keokuk
Long Cr.
Iowa River
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
R2W
R3W
T67N
T66N
R7W
R6W
R5W

Table 7. 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.

The route will turn west to traverse the terminal ridge of the Illinoian deposits. A scenic vista will befall even the most casual observer as we descend from the terminus of the Illinoian onto the lower elevation tabular divides on the loess-mantled Pre-Illinoian deposits.

The route turns south and looking back to the west the Illinoian terminus will be evident for much of the route. A brief stop will be made for pictures and discussion. This prominent ridge marks the approximate limits of the Illinoian deposits, and has been traced in detail to map the limits of the Kellerville Till Member as shown in figure 3.

STOP 1. Yarmouth, Iowa; the Yarmouth Transect, Core Site 29 WH-1.

The objectives of this first stop are to look at the materials in the subsurface which Leverett originally interpreted as indicative of the Yarmouth interglacial; and to review our work and reinterpretation of these deposits, and our redefinition of the Yarmouth type section.

A brief historical note is in order. 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 has a "gummy gray leached clay" between it and the overlying Illinoian till). Leverett (1898) called this interglacial epsiode the Yarmouth because he based his initial observations and interpretations from two dug wells near Yarmouth. The sections from these wells as reported by Leverett (1898, p. 239-240; 1899, p. 42) are given below.

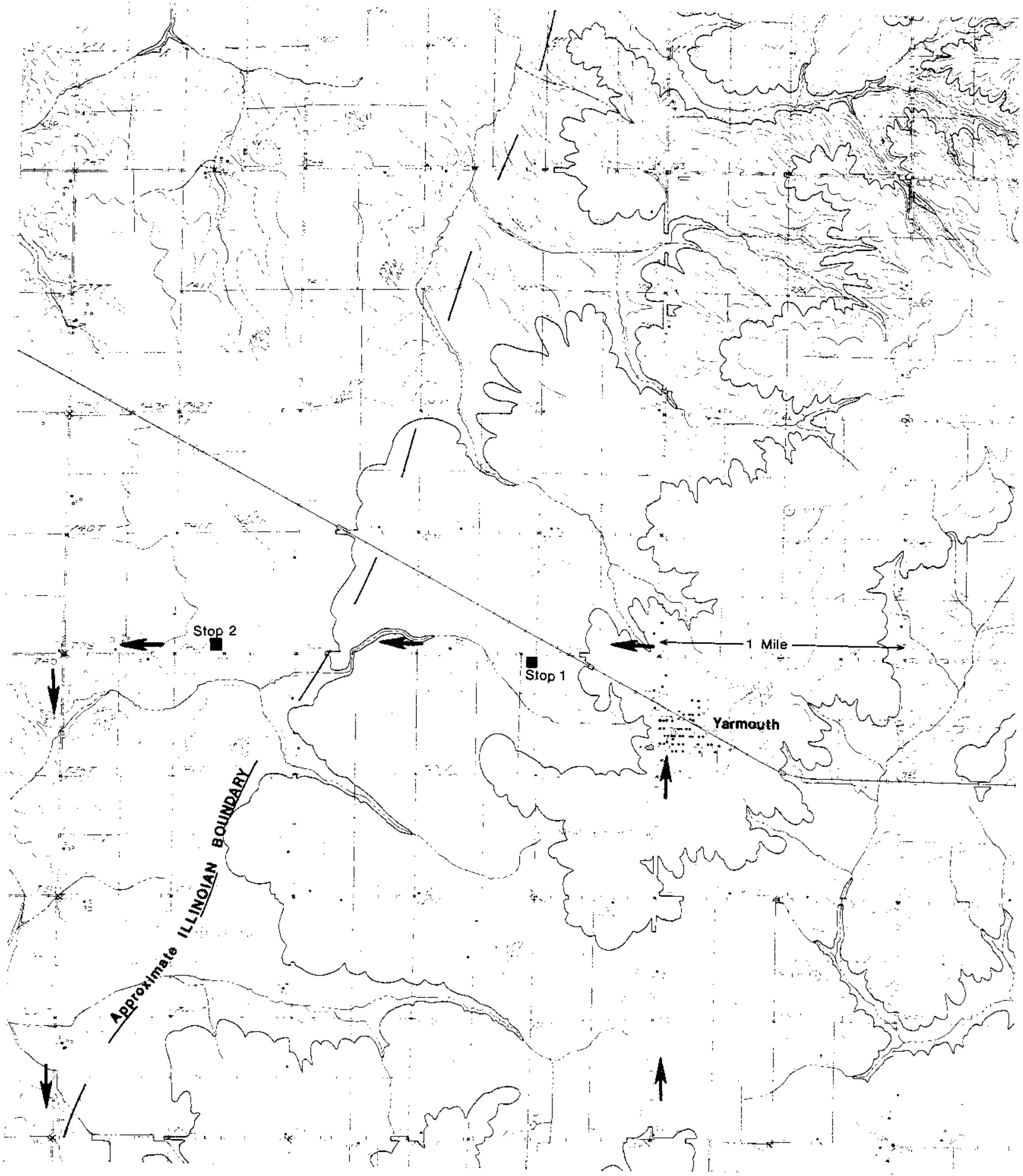


Figure 4. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stops 1 and 2.

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 was to reexamine Leverett's Yarmouth and place it in a modern perspective.

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. The location of the Smith site can be seen to the south from stop 1.

Drilling could not be done on the old Smith property. So, a transect of core-holes was drilled to the north along this road across the terminal Illinoian ridge. A cross-section constructed from the cores is shown in figure 5. The Yarmouth Core (Y, figure 5) was the deepest core, which penetrated 149 feet (45 m) of Pleistocene sediments over Mississippian bedrock (Description 1; Table 8).

The sediments which make up the terminal ridge are best (and most easily) illustrated from the detailed data from core site 29 WH-1, on the flanks of the ridge; the site of stop 1. Figure 6 summarizes the stratigraphy at the site, and documents the occurrence of Wisconsinan loess overlying the Sangamon Paleosol (see also Table 9). Description 2 and figure 7 show the details of the materials encountered for 2 other cores taken at core site 29 WH-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, 1980). The diamictons, although poorly sorted like the till, are different in many gross characteristics. They often show some of the following characteristics: 1. individual 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 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 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 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 5) 93 feet (28.4 m) of these sediments were encountered. On the terminal ridge (Y and 29 WH-4, figure 5), 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 8-10; figure 3; Hallberg, Wollenhaupt, and Wickham, 1980).

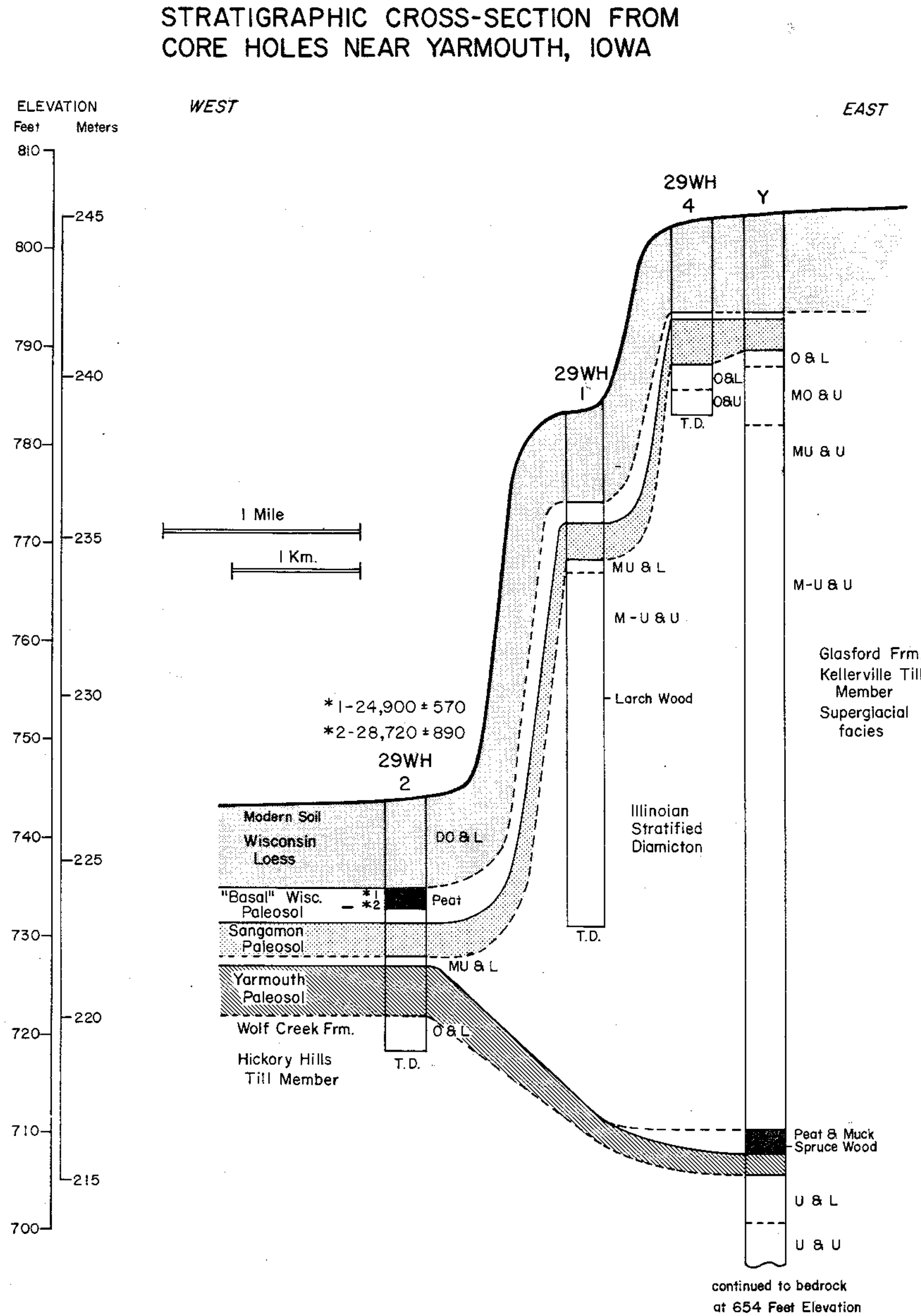


Figure 5. Cross section from Yarmouth coring transect.

Table 8. Laboratory data, Yarmouth Core.

Sample Horizon or Zone	Depth (feet)	I.D.	Clay Mineralogy EX.	ILL. (- % -)	K+C	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
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

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 8. 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. 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.

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. 15; 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
		WOLF CREEK FORMATION - Undifferentiated sediments
115 - 116 (35.1 - 35.4)	UU	Sand and gravel
116 - 120 (35.4 - 36.6)	UU	Bedded silts

Description 1 con't.

	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

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 (1980).

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 9. 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 10) in core 29 WH-1. The pollen percentages are shown in figure 10. The sequence is dominated by *Picea* (spruce) pollen throughout. *Larix* (larch) and *Picea* wood have

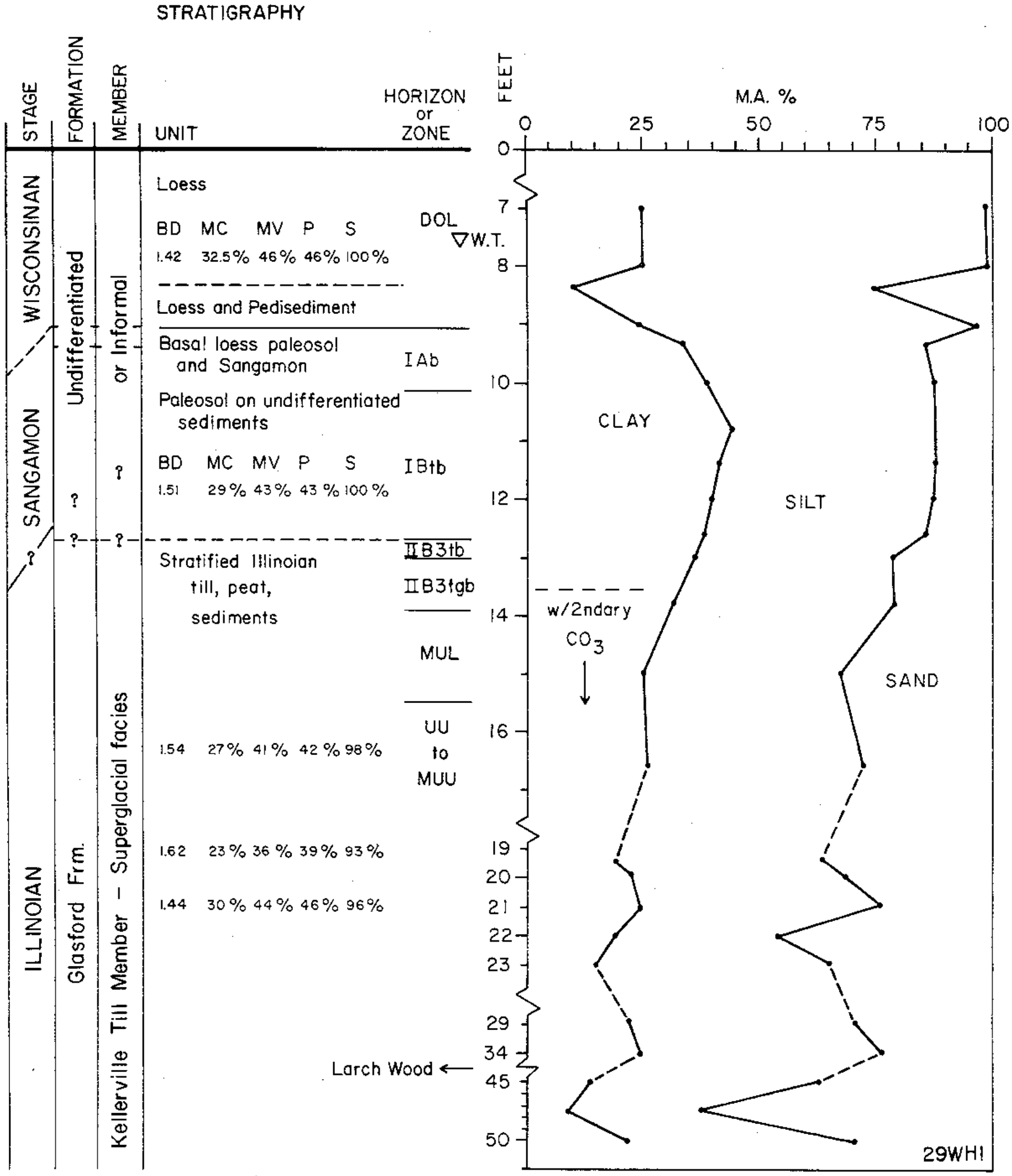


Figure 6. Stratigraphy and particle-size data, core site 29 WH-1. BD-bulk density; MC-moisture content by weight; MV-moisture content by volume; P-porosity; S-% saturation.

also been identified from the peat and the diamictons (figures 6 and 10).

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

Table 9. 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 7 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.
(31) % clay mineral calculated from weathered sample for discussion purposes.
C - Chlorite peaks apparent.
t - trace
NC - not calculated

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.

Iowa often contain *Picea*, but most are dominated by *Pinus* (pine). Figure 11 shows the arboreal pollen percentages for a Farmdale age peat from core 29 WH-2 (stop 2; see figures 4 and 5) as an example. No Holocene deposits in this region contain more than a trace of *Picea*, and most are dominated by

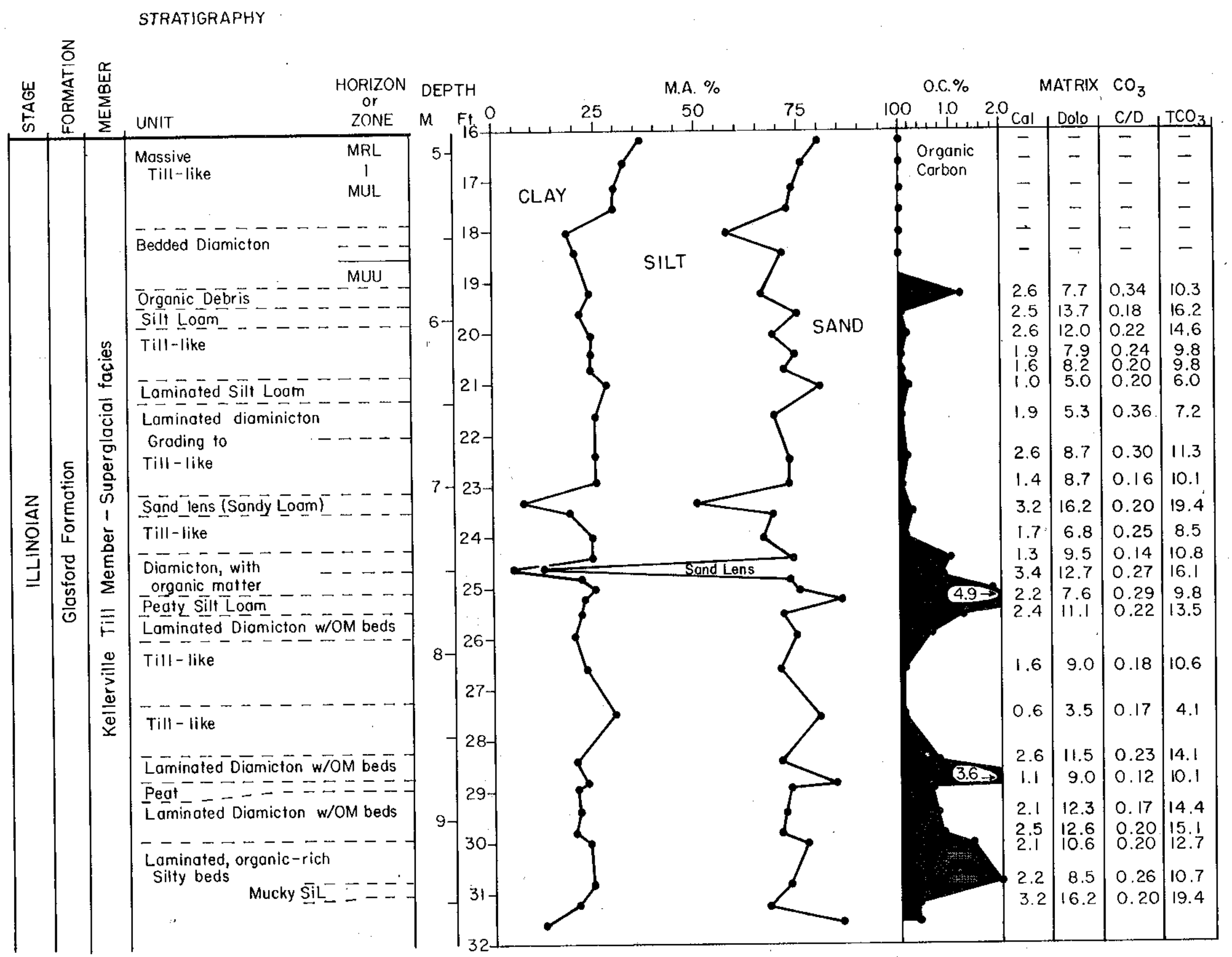


Figure 7. Stratigraphy, particle-size, organic carbon, and matrix carbonate data, Core Site 29 WH-1.

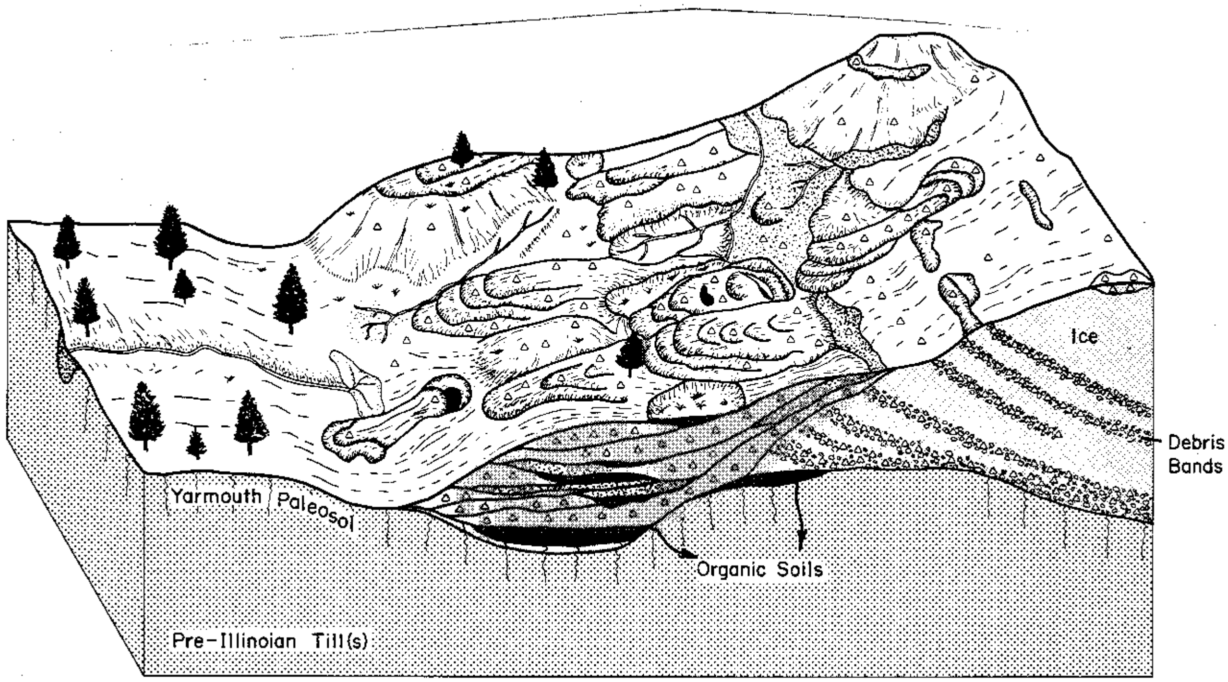


Figure 8. Schematic depositional model for the Illinoian deposits near Yarmouth (adapted from Evenson, Dreimanis, and Newsome, 1977).

Gramineae (grass) and other NAP (non-arboreal 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 of the Illinoian glaciation. The basal peat and muck (figure 9) may have formed before the ice reached this position.

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

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 13.		
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- MOL	24.8	675	63	11	25	23.0	0.3		t			
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

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

at the base of these sediments are also pro-Illinoian and incompatible with the concept of the Yarmouth as an interglacial.

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 9) the basal peat in the Yarmouth Core overlies a well-developed paleosol in slope wash sediments and the Hickory Hills Till Member. We have proposed (Hallberg and Baker, 1980) 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 of the Glasford Formation and the underlying paleosol in till-derived sediments and the Hickory Hills Till Member of the Wolf Creek Formation (figure 9, Description 3). This well-developed paleosol is what "Yarmouth" has come to mean over time, since Leverett's original definition. Thus, in the 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

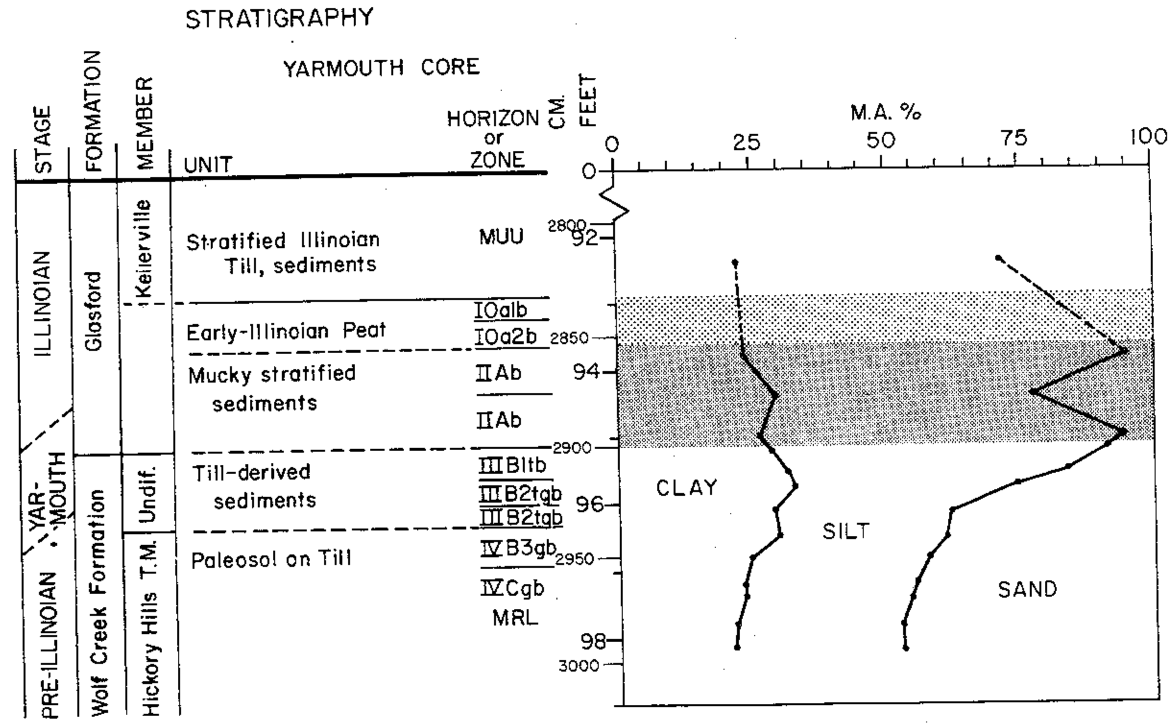


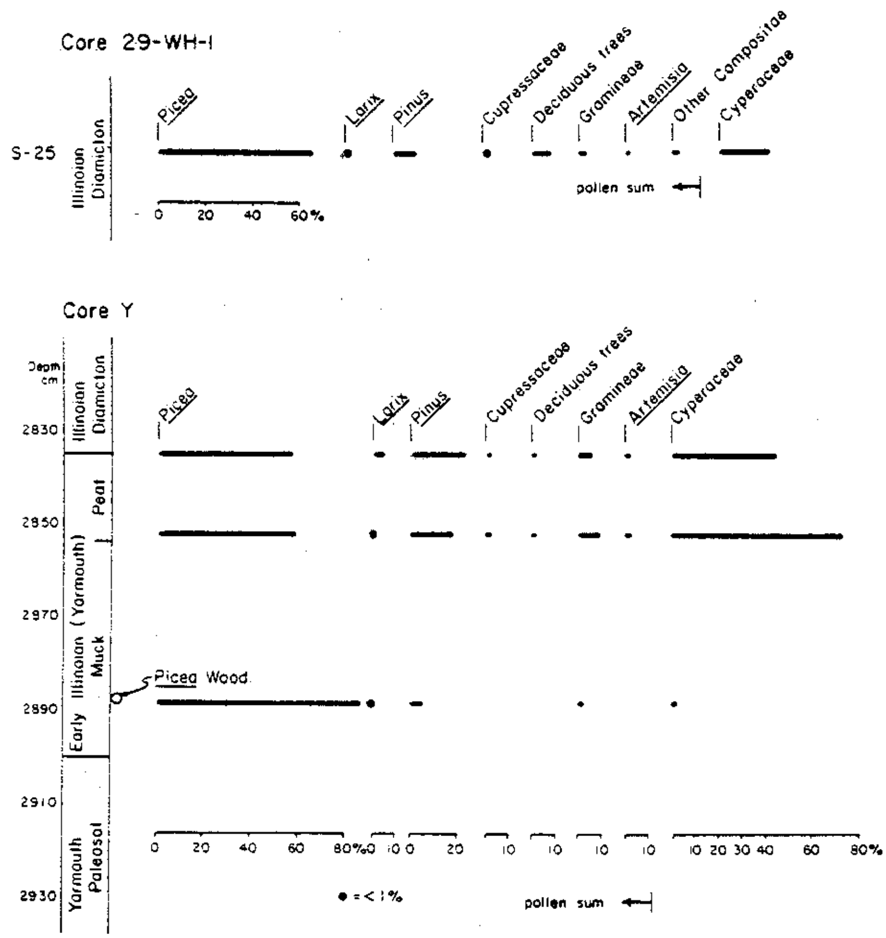
Figure 9. Stratigraphy and particle-size for a portion of the Yarmouth core.

Yarmouth Paleosol. The principle reference sections, which will be seen at stops 2 and 3, exhibit a clear contact between the Kellerville Till Member and the top of the Yarmouth Paleosol.

Discussion: Stop 1.

At stop 1 we will view the materials at Core Site 29 WH-1 as shown in figures 6 and 7. Principal points for discussion are the origin of the deposits, the proposed depositional model, their relation to Leverett's Yarmouth, and our redefinition of the Yarmouth.

Other times to note at stop 1 are the landscape relationships. Stop 1 occurs on a gently sloping surface, stepped down from the crest of the terminal ridge. This surface has all the characteristics of an erosion surface or pediment cut in Pleistocene deposits (see Ruhe, 1969; 1975a, b; Hallberg, et al., 1978). The setting of this erosion surface is somewhat unique, however.



Abbreviated Pollen Percentage Diagrams; Yarmouth Type Locality
Iowa, U.S.A.

Figure 10. Pollen percentage diagram for peat deposits in Yarmouth Core and from Core 29 WH-1 (S-25, from 25 feet in depth).

The ridge form at Yarmouth was originally a constructional feature, which has undergone modification from early Illinoian time until burial by Wisconsinan loess ca. 20-25,000 RCYBP. Beneath the loess, on both the ridge and the surface at stop 1 a great variety of "Sangamon" Paleosols are found. In some instances moderately well-developed, poorly-drained paleosols are found, such as shown in figure 6, and some of the cores at stop 1. These buried soils exhibit moderate to strong structural and textural B-horizons, with common clay films, etc. However, in other settings, on the same loess-mantled geomorphic surface

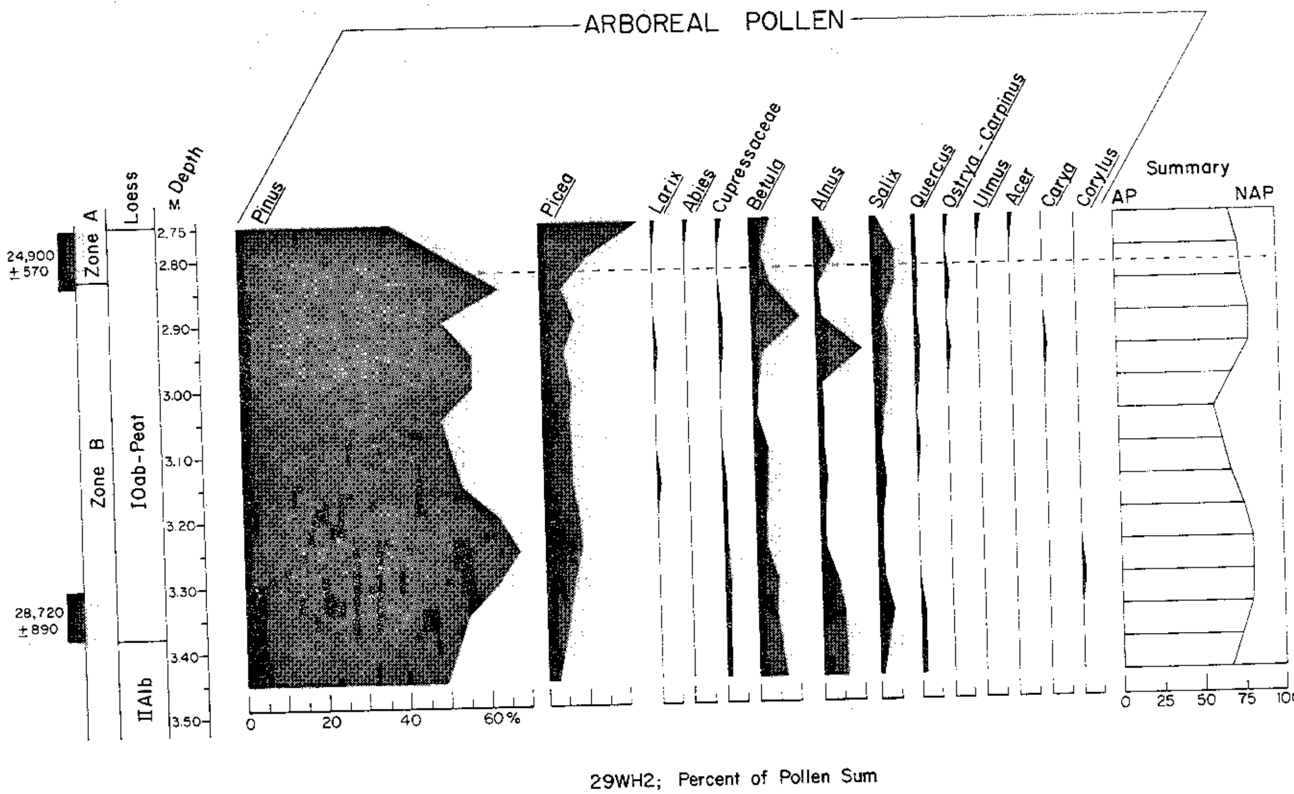


Figure 11. Arboreal pollen percentage diagram for Farmdale age peat from Brun Farm Section (29 WH-2; figure 5). From Hallberg, Baker, and Legg, 1980.

better-drained paleosols show very minimal development, exhibiting only a color or weak structural B-horizon and no clay films. Figure 12 shows the "Sangamon" Paleosol from Core Site 29 WH-4 (see figure 5) which shows a "minimal" well-drained Sangamon Paleosol. The apparent clay enrichment in 29 WH-4 is from stratification of the sediments, as hardly any clay films were present. In some cores along the terminus no paleosol is found beneath the loess, even though these surfaces descend to the lower Pre-Illinoian till plain to the west, which exhibit very highly developed Yarmouth-Sangamon Paleosols below the loess. Some of these variations will be evident in the cores at stop 1.

We would offer the following explanation. From the depositional model outlined, it is likely that the terminal ridge originally consisted of a very irregular, hummocky,

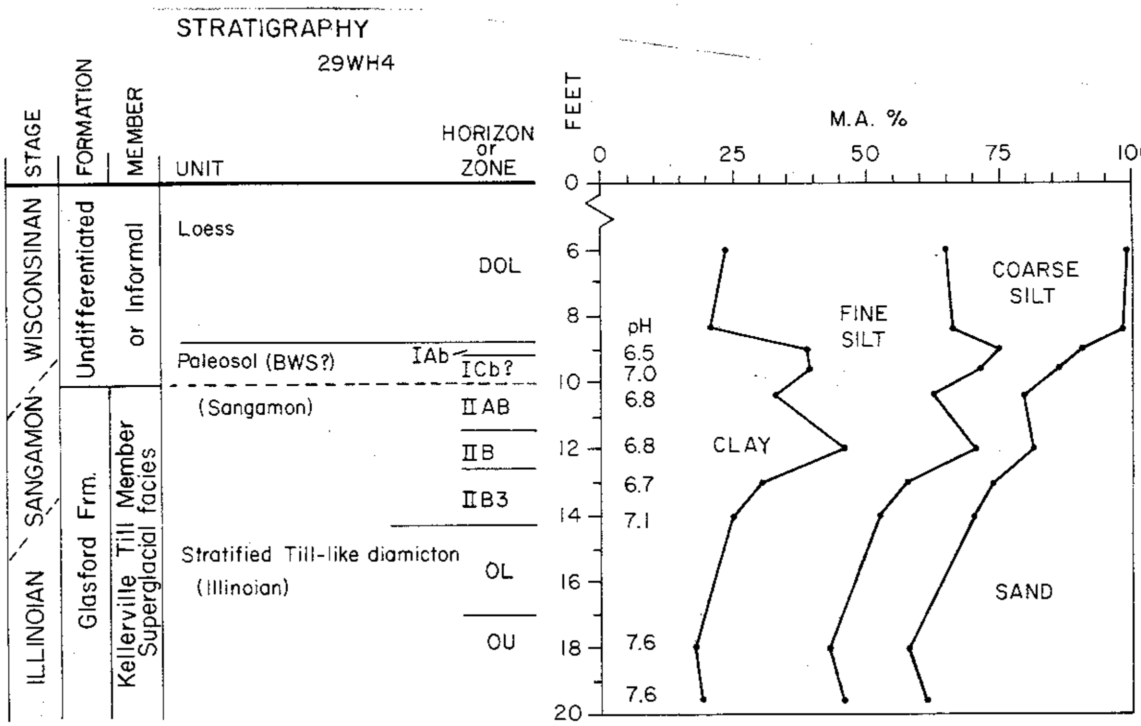


Figure 12. Stratigraphy and particle-size data for a portion of core 29 WH-4 (see figure 5 for location).

unstable landscape. Erosion of this landscape over time produced the much smoother landscape we now see. Erosion of the higher portions of this landscape continually eroded the better-drained soils leaving only rather minimally developed paleosols. In the swales, sediment slowly accumulated and better-developed paleosols were formed. This process was continuing on this paleo-landsurface until its burial by the loess, as indicated by sites where loess overlies nothing but a stone-line and oxidized and leached sediments of the Kellerville Till Member. Thus, these processes have left these "severely-eroded" landscape positions on a beveled surface which does indeed descend to the loess-mantled Yarmouth-Sangamon surface below. These variations are analogous to the range of soils that can be found on modern landscapes. It is not clear at this time though if the buried pediment surface at stop 1 is a modification of an original deposition surface, or if it was cut in response to other factors (such as a lowering of base-level). The former idea is favored because the surface descends to the stable, tabular divides of the loess-mantled Yarmouth-Sangamon surface.

STOP 2. Old Brun Farm Section (Core Site 29 WH-2). See figure 4.

At this stop we will look at cores from the western end of the Yarmouth Transect, which reveal a complex sequence of sediments and paleosols. We also consider this to be a principal reference locality for the Yarmouth Paleosol.

The type area for the Yarmouth Paleosol (and Stage) remains as the region around the Yarmouth drilling transect (figure 5). Within the type area the sections from core site 29 WH-2 (the Old Brun Farm Section) are deemed reference sections. The cores from this site 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 13. 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 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, 1980).

The "early" Wisconsinan sediments and paleosol consists 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 13). These sediments are weathered and the percentage clay minerals have not been calculated (Table 10). However, in the Cb horizon these sediments show

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.

Description 4 con't.

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.

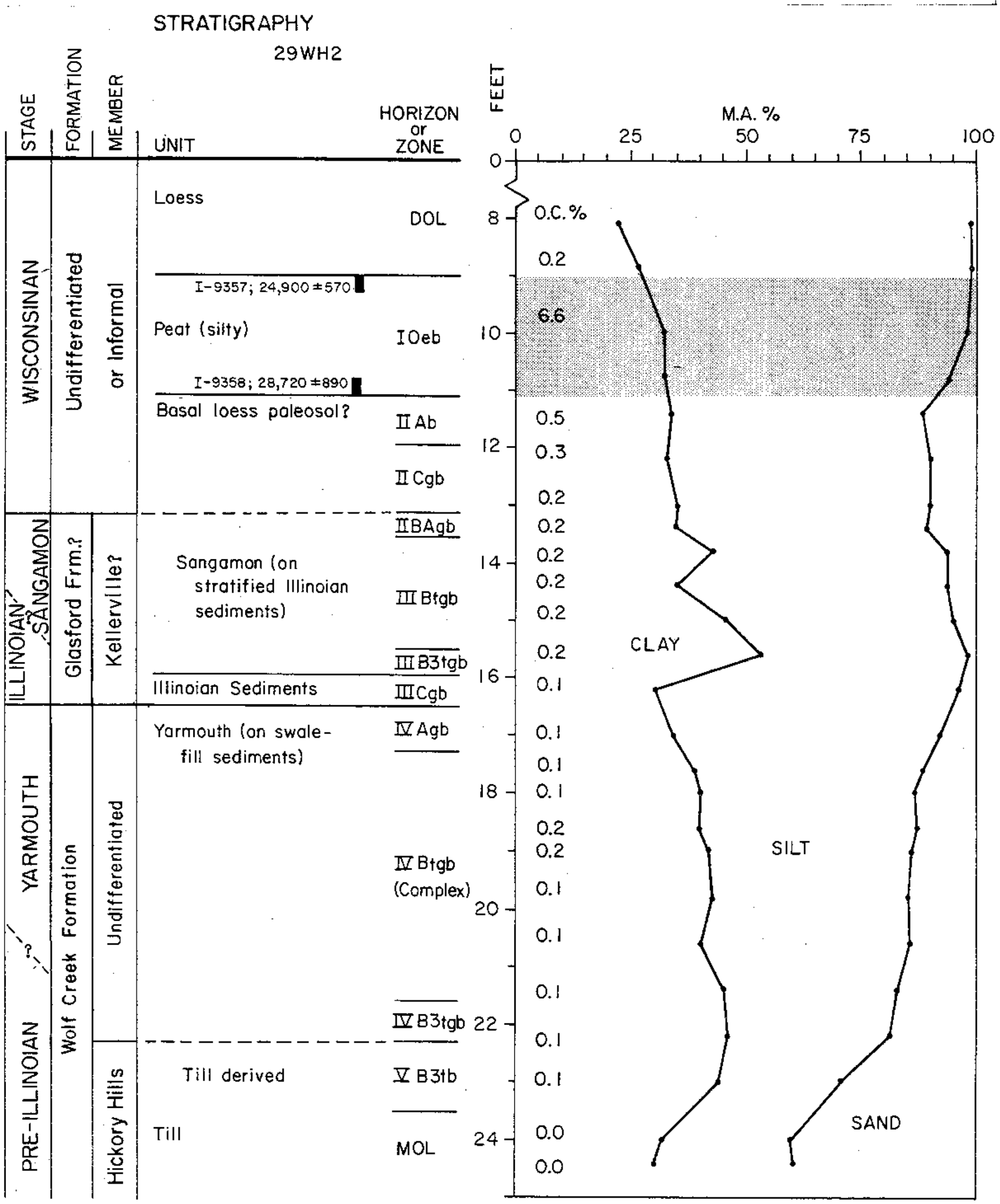


Figure 13. Stratigraphy and particle-size data for Core 29 WH-2, Old Brun Farm Section (Core 2-1 on figure 15).

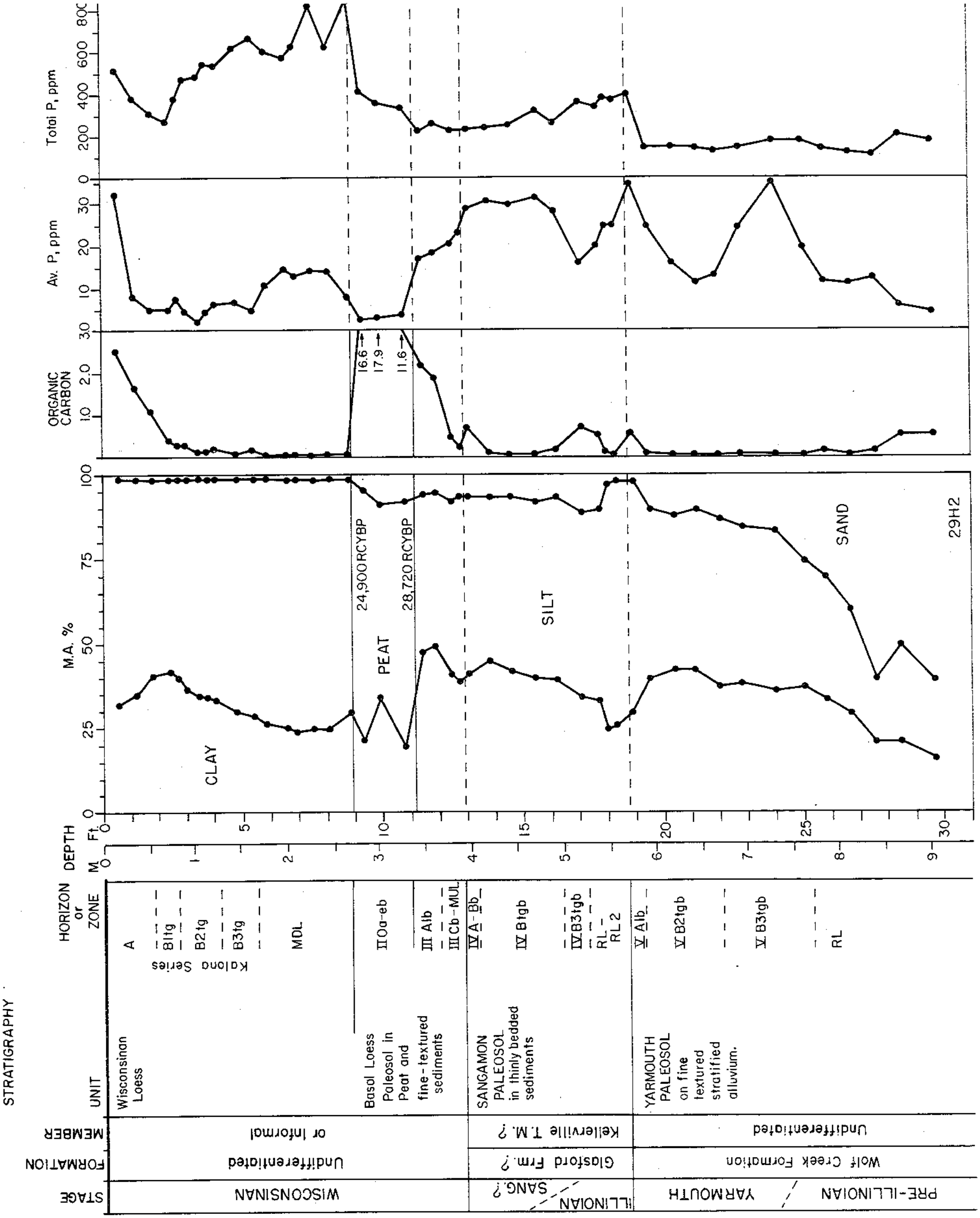


Figure 14. Stratigraphy and lab data for Core 29 H-2, Brun Farm Section (Core 2-2, on figure 15). Radiocarbon dates from 29 WH-2 (figure 13).

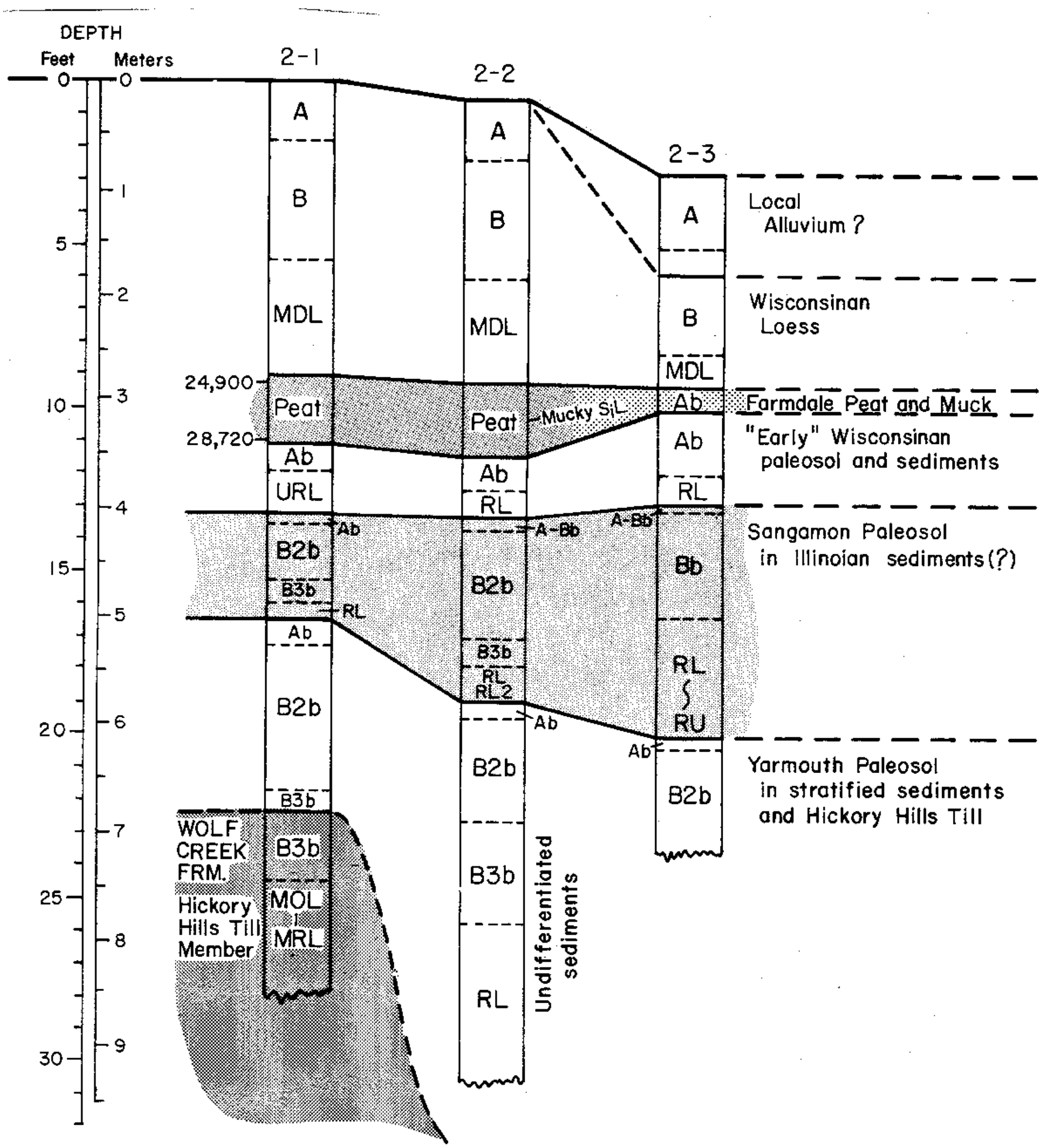


Figure 15. Schematic cross section from cores at Brun Farm Section (2-1 = 29 WH-2, figure 13; 2-2 = 29 H-2, figure 14).

good, relatively high illite peaks, similar to those of the Illinoian Kellerville Till Member deposits. (See also the total phosphorus data in figure 14.) These "early" Wisconsinan sediments probably represent local erosion and redeposition of the Illinoian sediments in Wisconsinan time.

These "early" Wisconsinan deposits are older than 28,720 RCYBP, but younger than the Sangamon Paleosol. There is only evidence of minor soil development within them. These sediments were deposited during the Altonian Substage of Illinois terminology (Willman and Frye, 1970), and may be the equivalent of the colluvial phase of the Roxana Silts (Heaven Forbid!). These very localized deposits are the only sediments of this age recognized in southeast Iowa.

The typical thin basal loess sediments (which will be seen in other stops) are mineralogically similar to the loess. If these sediments are to be equated rock-stratigraphically with the Roxana, then it must be admitted that the Roxana sediments transgress the Farmdalian and even into the early Woodfordian in this region.

Several other cores were taken around the Brun Farm Site. Figure 14 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 15 shows the general relations between three cores in the Brun Farm location.

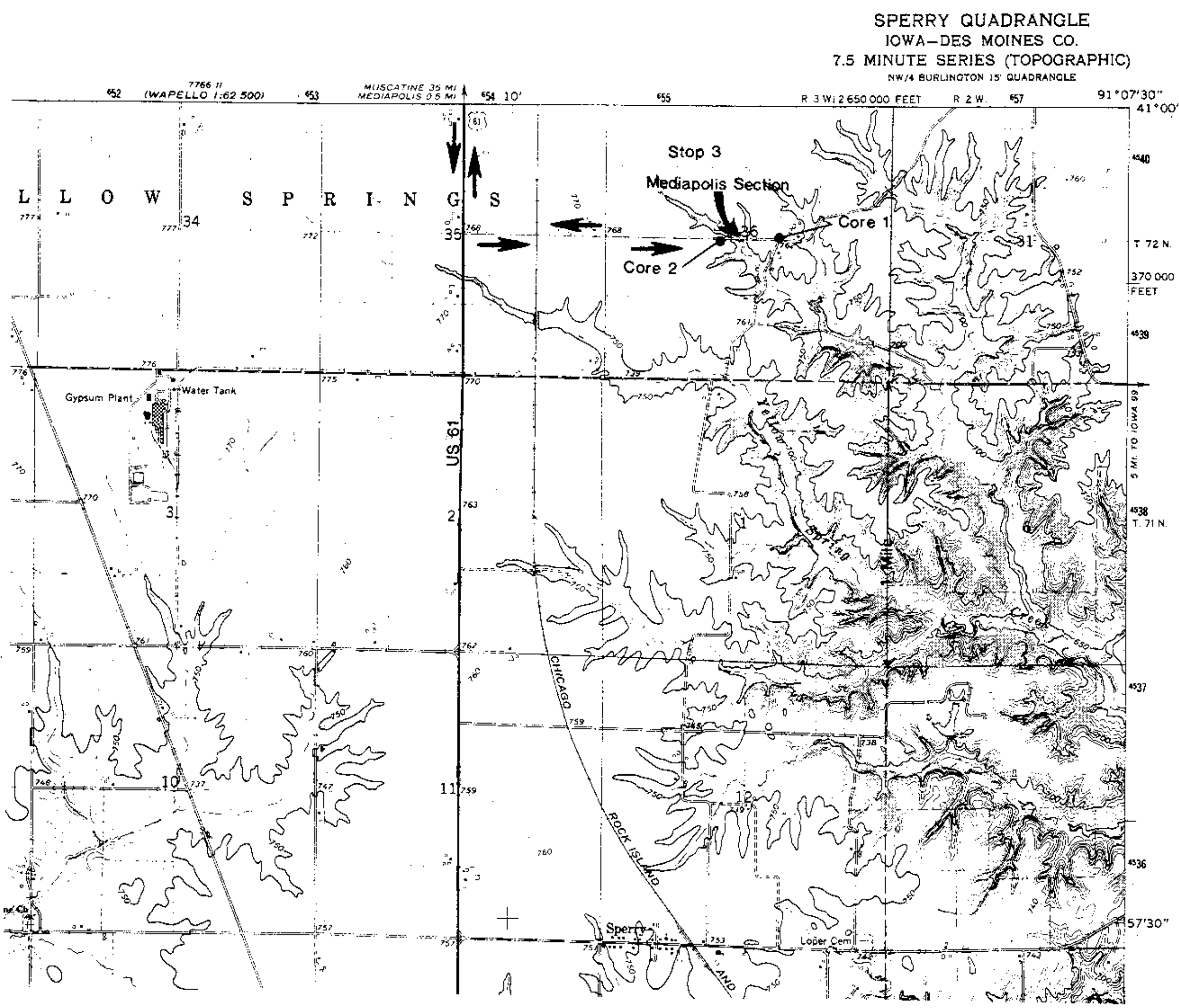


Figure 16. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stop 3.

STOP 3. The Mediapolis Section.

The Yarmouth Paleosol in the type area is deeply buried and inaccessible. Consequently, additional reference sections in outcrop have been designated (Hallberg and Baker, 1980). At stop 3 (figure 16) we will visit an outcrop south and east of Mediapolis, Des Moines County, which is designated a principle reference section for the Yarmouth Paleosol and Yarmouthian Stage. We will also review our deep core-drilling in the area to demonstrate the complexity and problems with paleolandsurfaces buried by till.

The Mediapolis Outcrop Section was designated as a principle reference section because it occurs in a steep streambank, and will likely be accessible for some time to come. The outcrop section (Description 5, figure 17) exposes Wisconsinan loess, over a Sangamon Paleosol developed in the superglacial facies of the Kellerville Till Member (see data in Table 11). 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 18, Description 6) is similar to the outcrop section and provides more complete 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 11). The Mediapolis-1 Core Site was located between the Mediapolis Outcrop Section and another outcrop of the Yarmouth Paleosol

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.

Description 5 con't.

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.
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.	

(figure 19). However, the Yarmouth Paleosol was not present, and the Kellerville Till Member rests directly on the oxidized and leached Hickory Hills Till Member (figure 20). Interpretation of the sub-Kellerville paleo-landscape from the outcrop and core data (see leached-unleached boundary in the Hickory Hills Till, figure 19) 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, better-drained positions of the paleo-landscape are not preserved, having been planed off by glacial erosion.

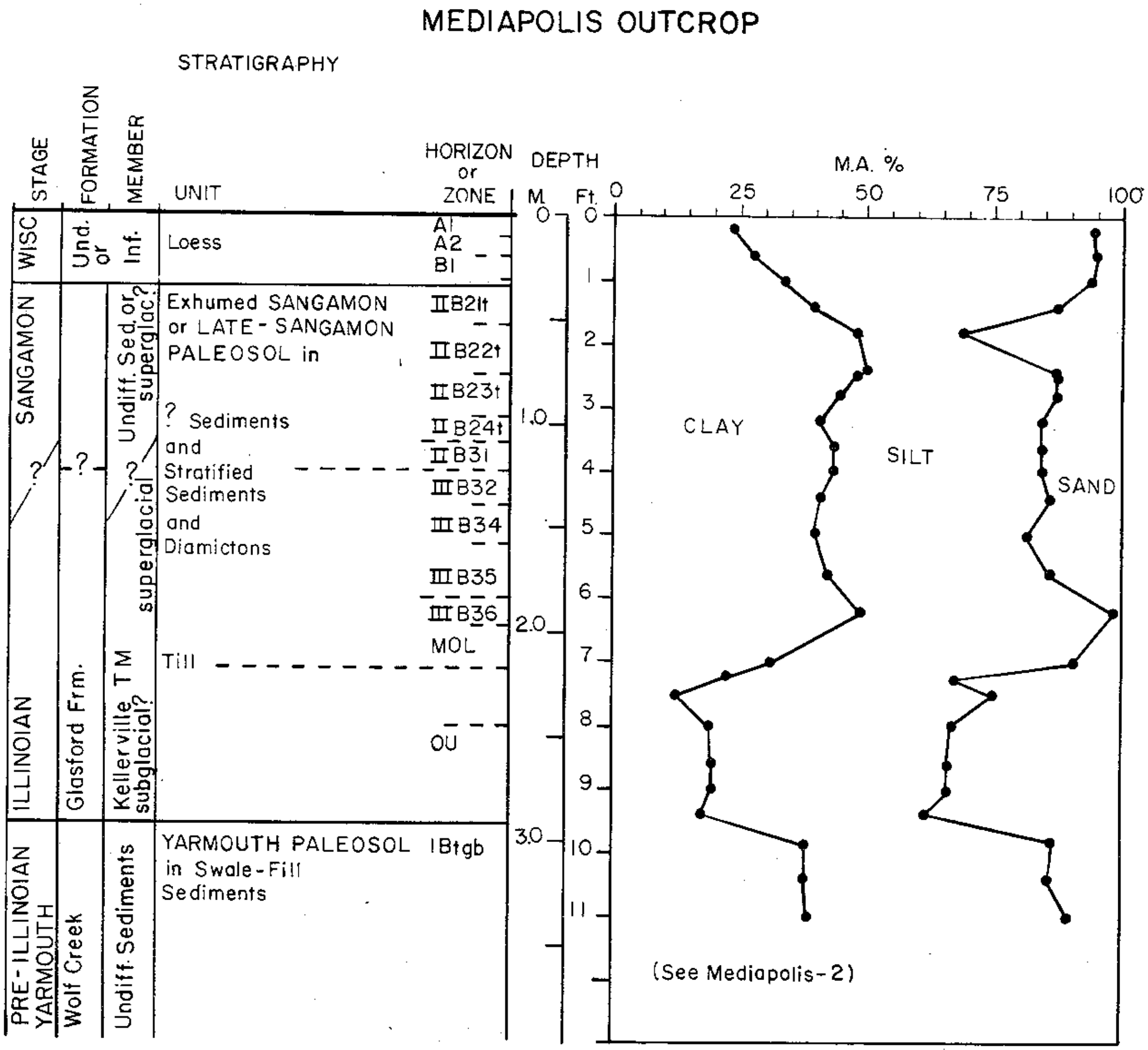


Figure 17. stratigraphy and particle-size data Mediapolis Outcrop Section.

Table 11. Laboratory data Mediapolis locality.

Sample Horizon or Zone	Depth (feet)	I.D.	EX. - % -	ILL.	Clay Mineralogy 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
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	3.9	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 11 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

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)	IA1b	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.

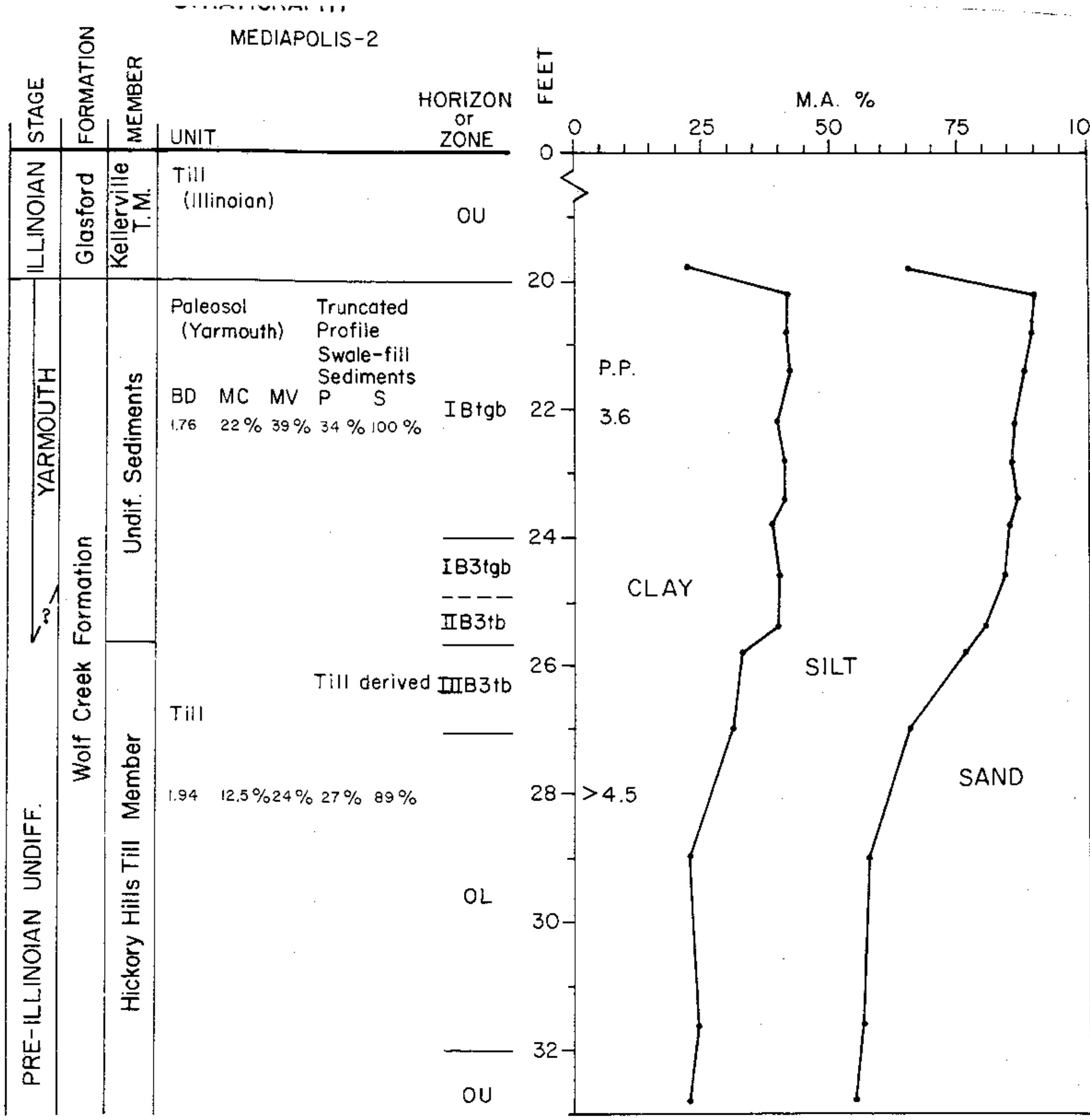


Figure 18. Stratigraphy and particle-size data Mediapolis-2 Core Site.

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.

Description 7 con't.

12.6-13.3 (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.
13.3-15.9 (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)		

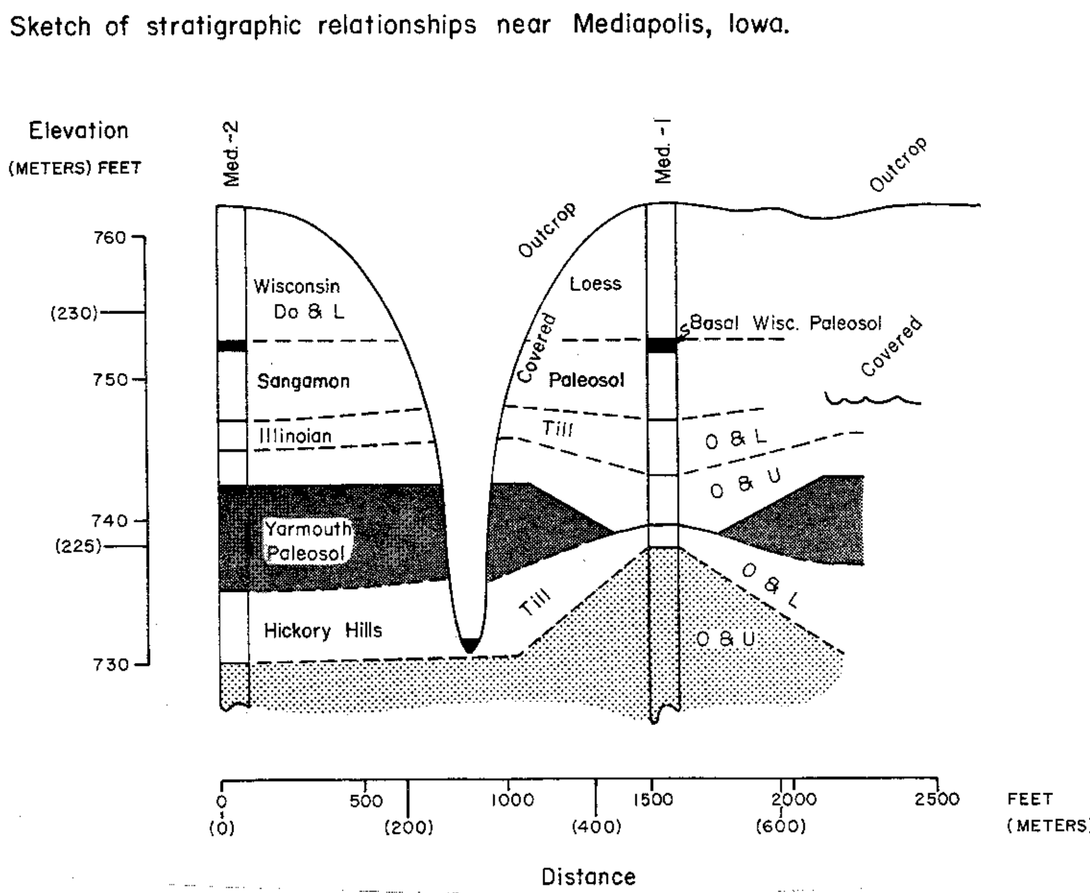


Figure 19. Schematic cross section from cores and outcrops at Mediapolis Section.

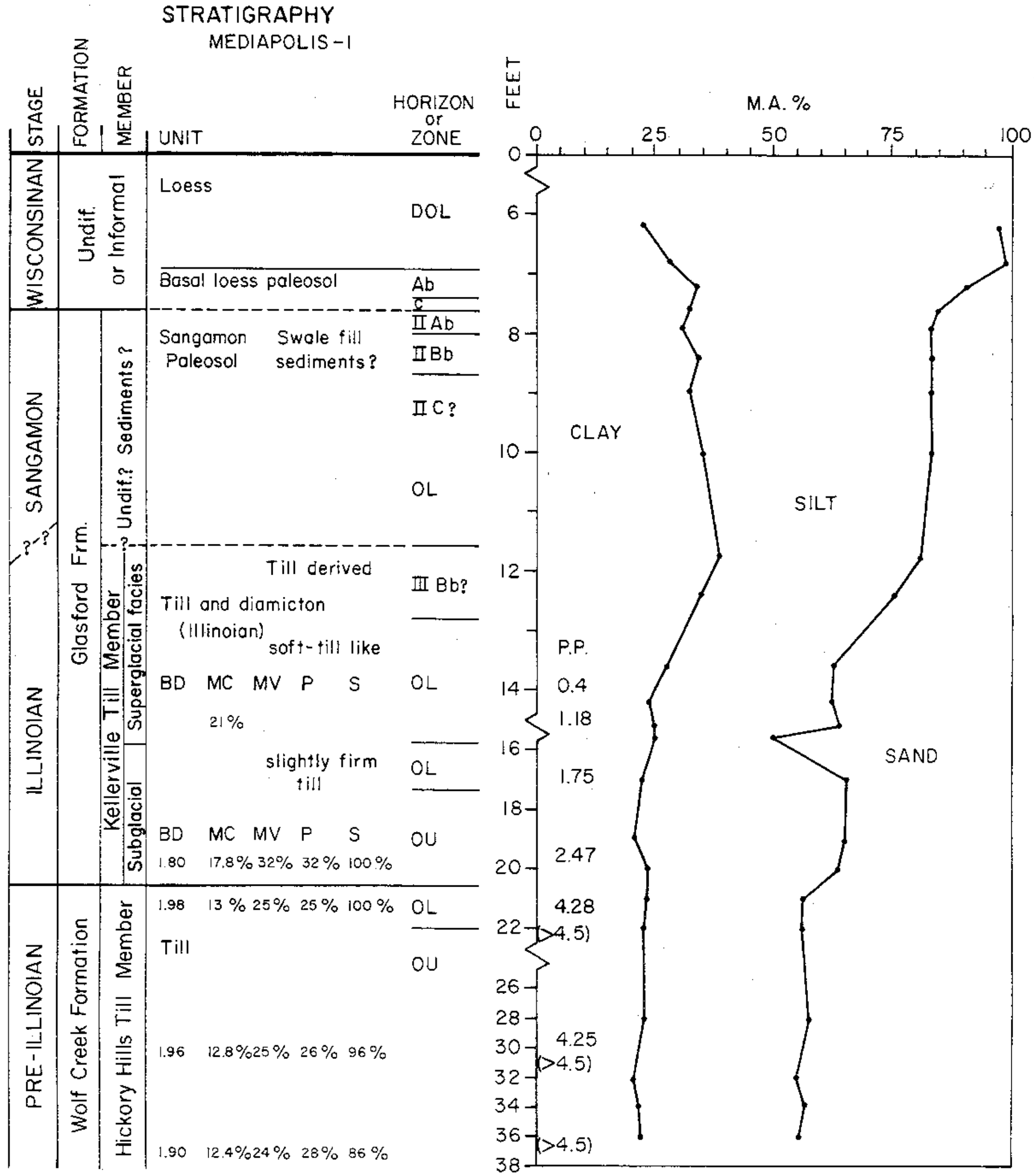


Figure 20. Stratigraphy and particle-size data for Mediapolis-1 Core Site (P.P. - calibrated penetrometer data, in tons/sq. ft.; other abbreviations see figure 6).

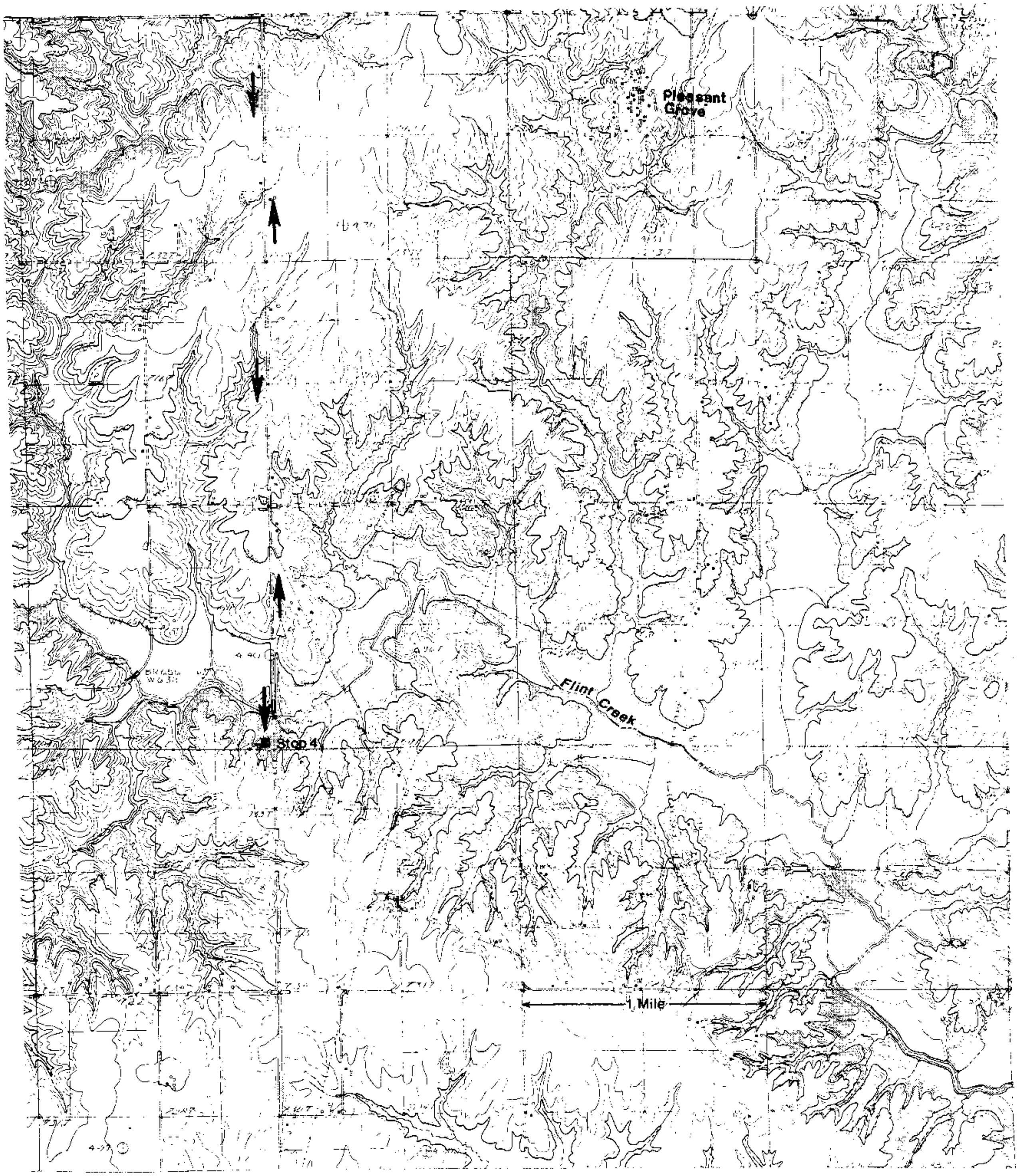


Figure 21. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stop 4.

STOP 4. The Pleasant Grove Section (29-PG-21) - Iowa Style.

Till-till contacts between the Kellerville and Hickory Hills Till Members, where the intervening Yarmouth Paleosol is missing, are quite common. This was inferred at stop 3. The Pleasant Grove Section in Des Moines County is an excellent example of such a contact. As shown in Description 8 and Table 12, 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.

At this site the two tills can be easily compared. Feel the textural difference, the difference in consistency (density) and look at the differences in pebble lithologies.

Description 8. 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.

Table 12. Laboratory data Pleasant Grove Section (29-PG-21).

Sample Horizon or Zone	Sample Depth (feet)	Clay Mineralogy ID.	Clay Mineralogy EX. (%)	Clay Mineralogy Ill. (%)	Clay Mineralogy K+C (%)	Sand-fraction Lithologies C/D	Sand-fraction T.C. (%)	Sand-fraction Sh. (%)	Sand-fraction T.Sed. (%)	Sand-fraction Q.F. (%)	Sand-fraction Tx. (%)	Notes	Matrix CO_3 Ca (%)	Matrix CO_3 Do (%)	Matrix CO_3 TC (%)	Matrix CO_3 C/D	Particle Size Clay (%)	Particle Size Silt (%)	Particle Size Sand (%)	Density g/cc	Atterberg Limits L.L.	Atterberg Limits P.L.	Atterberg Limits 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.

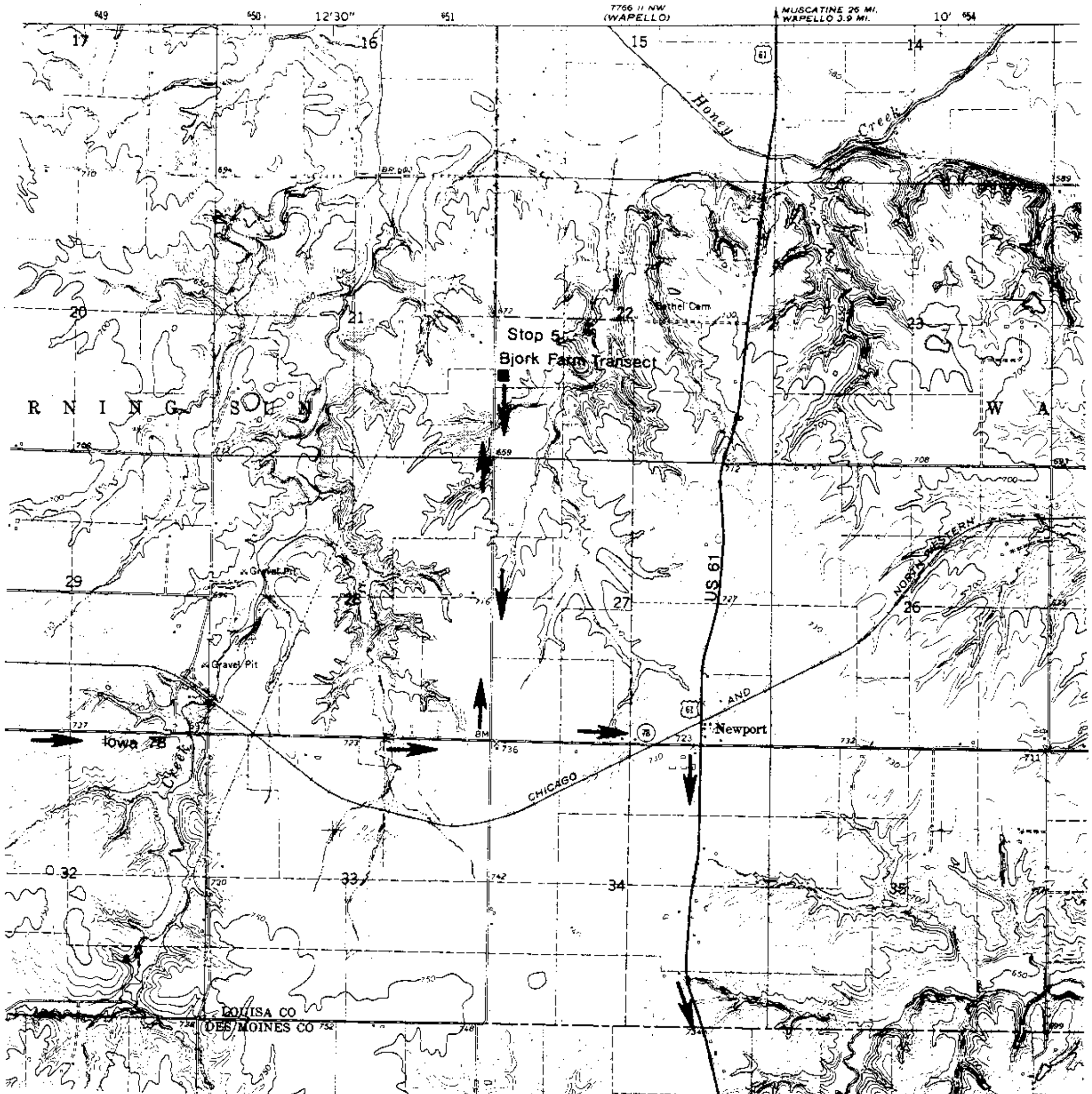


Figure 22. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stop 5.

STOP 5. The Bjork Farm Transect.

At the Bjork Farm Transect we will view a series of core-holes and 2 outcrops. The purposes of this stop are 1. to look at the relationships between the superglacial and subglacial facies of the Kellerville Till Member; and 2. to examine the landscape relationships of the Sangamon or Late-Sangamon Paleosol; and 3. to observe a local late-Wisconsinan or Iowan erosion surface developed on the Illinoian deposits.

In a series of core-holes, beginning on the divide (figure 23; Description 9; Tables 13 and 14), below the Wisconsinan loess a Sangamon or Late-Sangamon Paleosol is developed in the

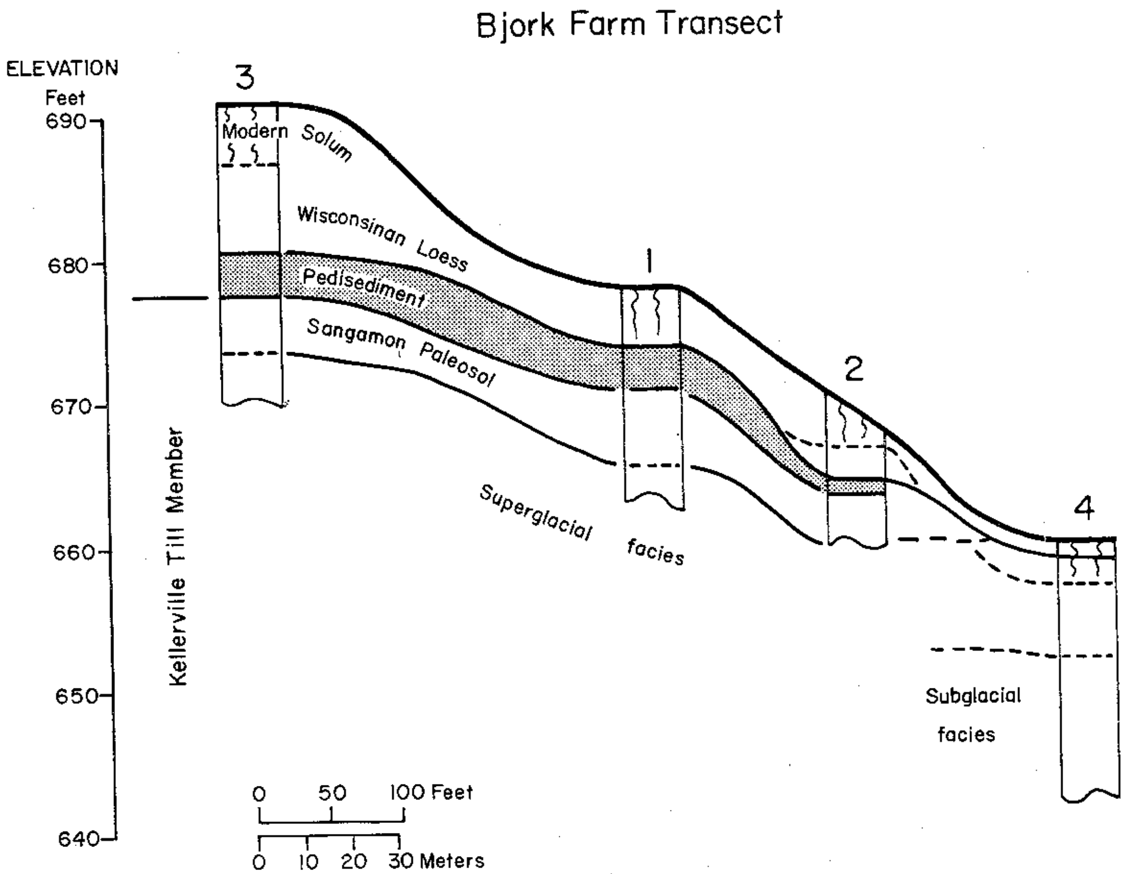


Figure 23. Schematic cross section of the Bjork Farm Transect (outcrop sections adjacent to core -4). Note that the transect cuts across the interfluves from 58H-3 to -1, and from 58H-2 to -4.

Table 13. 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 present.		
15.4	IIIB31tb			
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.		

Table 14. Additional laboratory data, Bjork Farm Section.

Sample Depth (feet)	Sample Horizon or Zone	Material	Particle-size Clay	Particle-size Silt - % -	Particle-size Sand	Matrix Carbonates Ca	Matrix Carbonates Do	Matrix Carbonates Tc	C/D	Density g/cc	Clay Mineralogy EX.	Clay Mineralogy ILL - % -	Clay Mineralogy K+C	C/D	Sand-fraction Lithologies 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 14 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.

superglacial facies of the Kellerville Till Member. The Kellerville consists of interbedded silty diamictons and some sorted sediments (figure 25). This can be traced down through the landscape to site 58 H-4 (figure 23; figure 27) 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 27). 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 58 H-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 28 is a photograph of a portion of this exposure showing the contorted, intercalated mixture of sediments which occur (see Table 15 also). To the east in a larger exposure (figure 29) 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.

While examining the outcrop sections, also note that bedrock outcrops in the base of the hillslope on the south side of the valley.

As summarized in figure 30 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 2). 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 1.80 g/cc (Table 14; figure 27). 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.

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

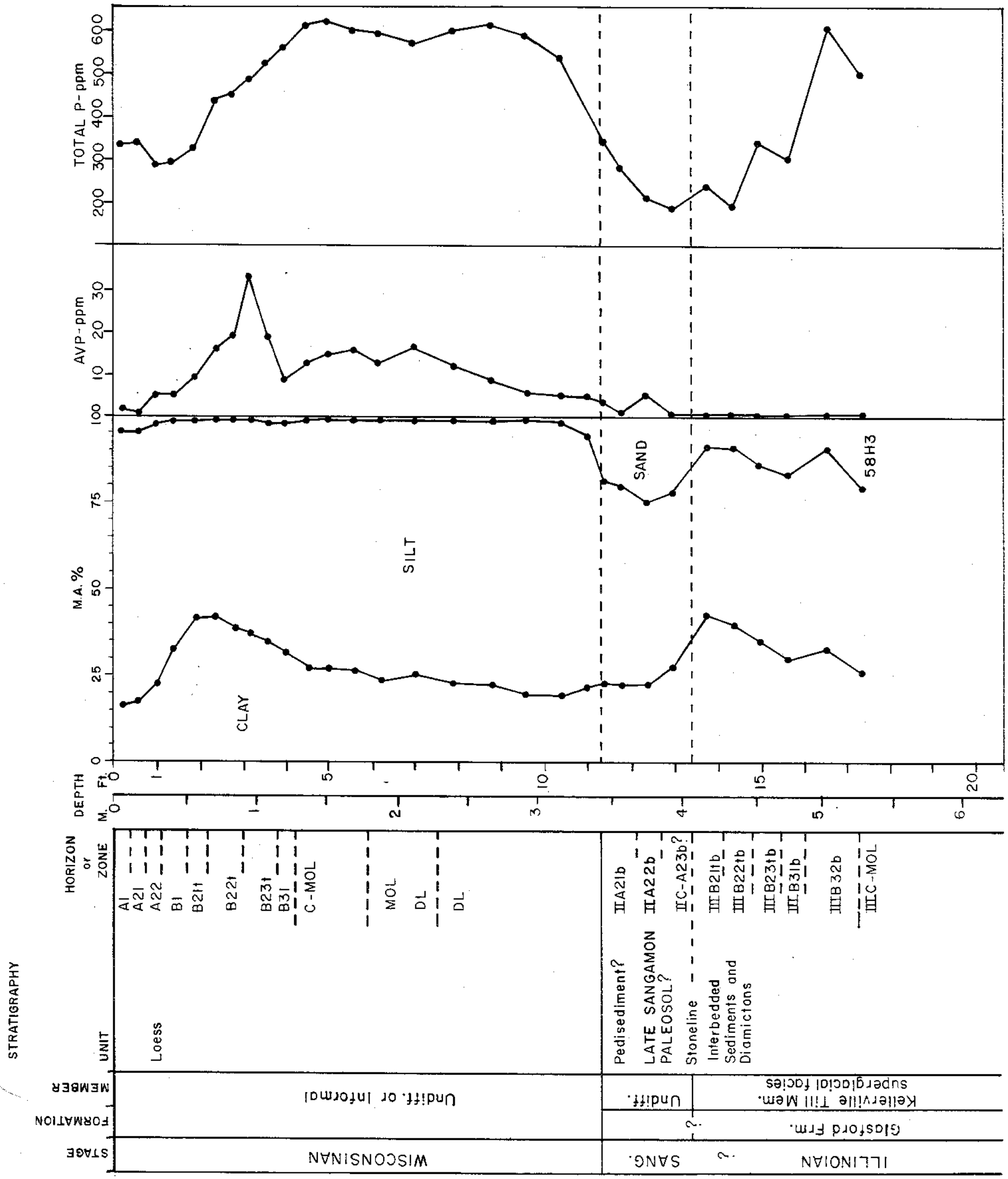


Figure 24. Stratigraphy, particle-size, and phosphorus data for Core Site 58H-3, Bjork Farm Transect (Description 9).

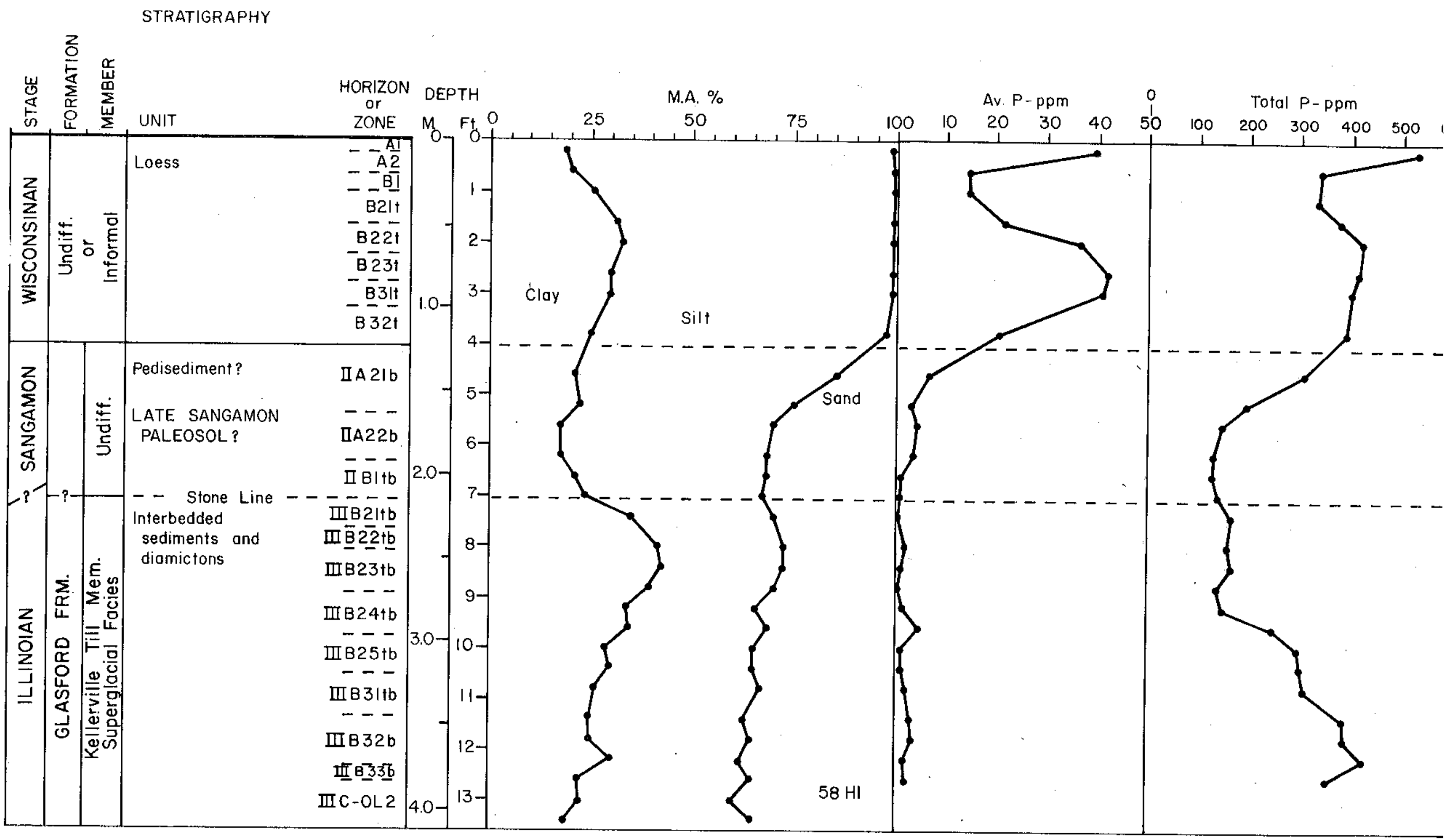


Figure 25. Stratigraphy, particle-size, and phosphorus data for Core 58H-1, Bjork Farm Transect.

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.

Description 10. 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 10 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.

contorted sediments, while at other sites (Mediapolis Core-1) it is made up entirely of soft to friable till-like deposits.

The nature of the Sangamon surfaces and paleosols are also of interest at this site. Core Site 58 H-3 is located on the gently-sloping narrow divide. Sites 58 H-1 and -2 are on

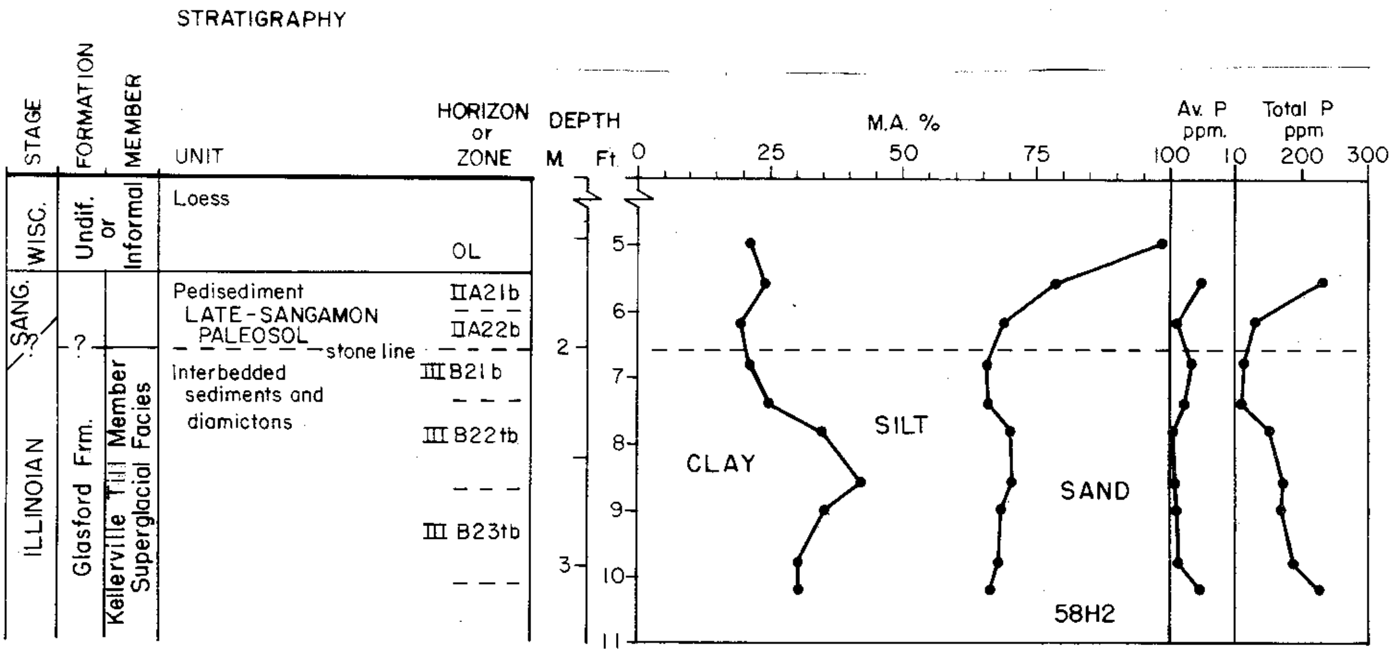


Figure 26. Stratigraphy, particle-size, and phosphorus data, Core Site 58 H-2, Bjork Farm Transect.

interfluve surfaces branching off from the divide. Site 58 H-4, is on a pediment, cut into the interfluve forming a lower-lying erosion surface and interfluve.

To place the setting of the Bjork Transect in perspective we must start at the primary divide. The Mediapolis flats area, which we have driven across and where stop 6 will be located (figure 31), is the primary divide. As will be shown, these broad tabular primary divides, in the area of the Illinoian deposits preserve modified, but undissected remnants of the constructional surface of the Kellerville Till Member, beneath the loess. These 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 Sangamon Paleosols encountered beneath the Wisconsinan loess on these long divides have all been similar, and have all resembled the paleosols from core sites 58 H-3 and -1 (see Hallberg, Wollenhaupt, and Wickham, 1980). All the paleosols on these types of divides have had the appearance of

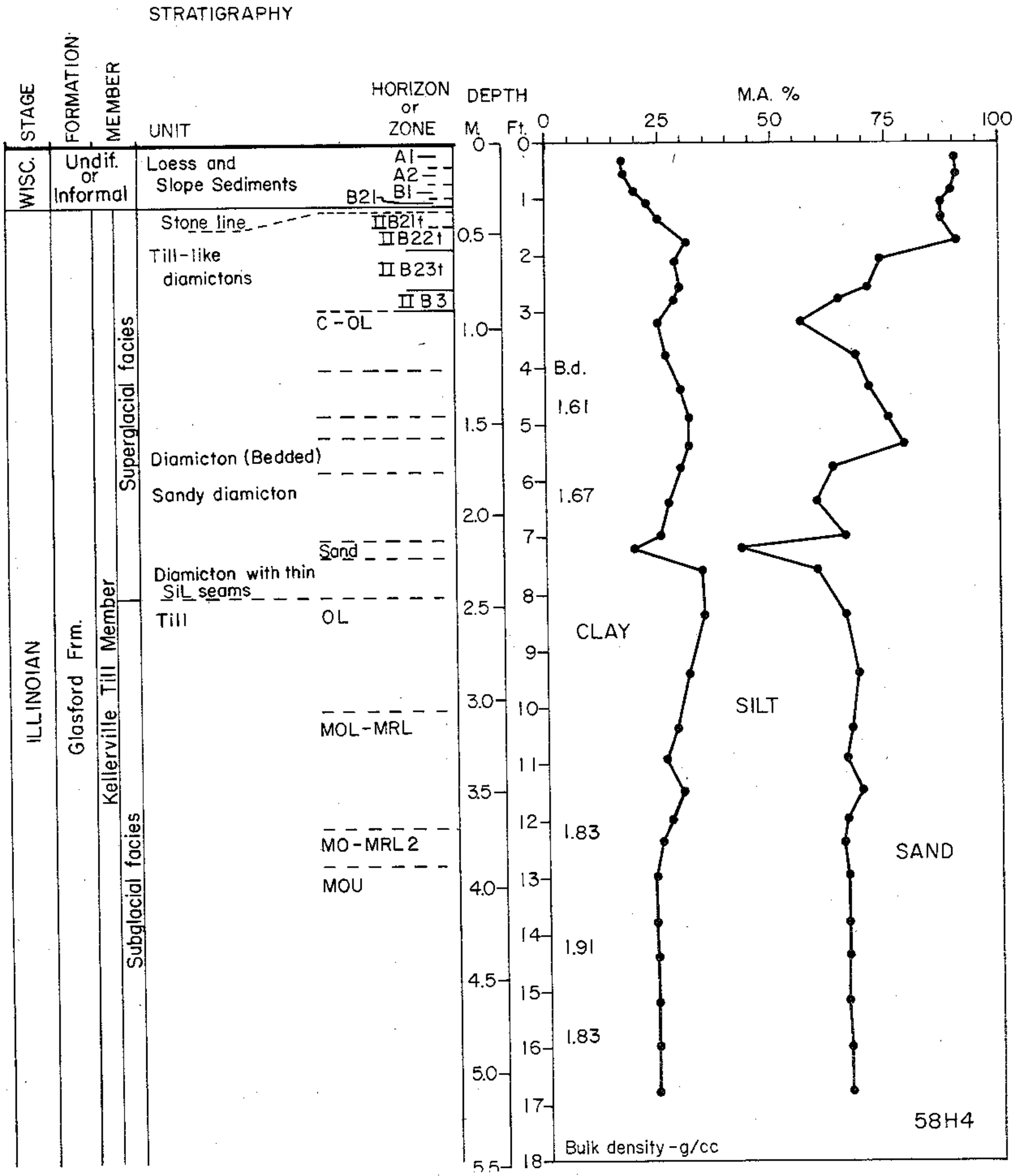


Figure 27. Straigraphy and particle-size data, Core Site 58H-4, Bjork Farm Transect.

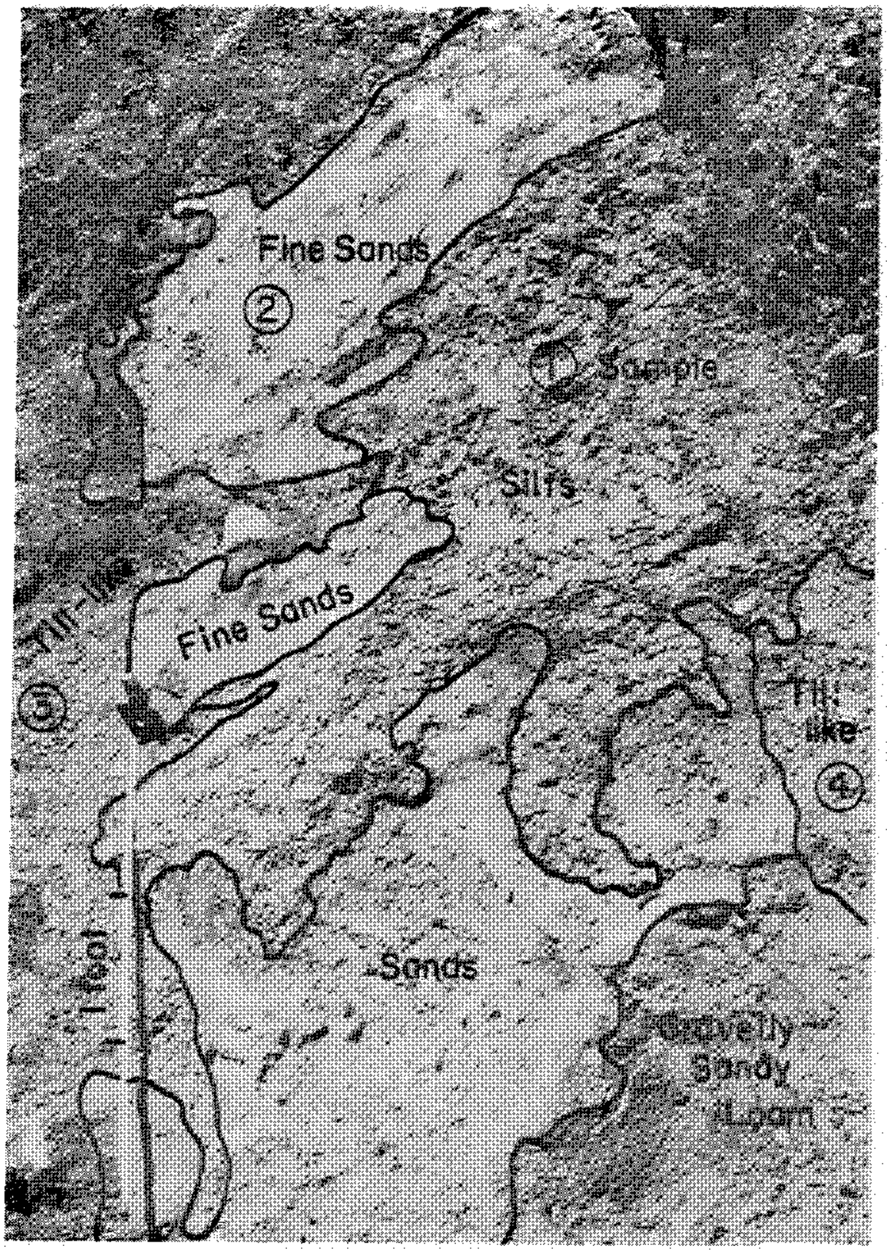


Figure 28. Photograph of portion of west exposure, Bjork Farm Transect, showing superglacial facies sediments.

Table 15. Particle-size data for samples in figure 28.

	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

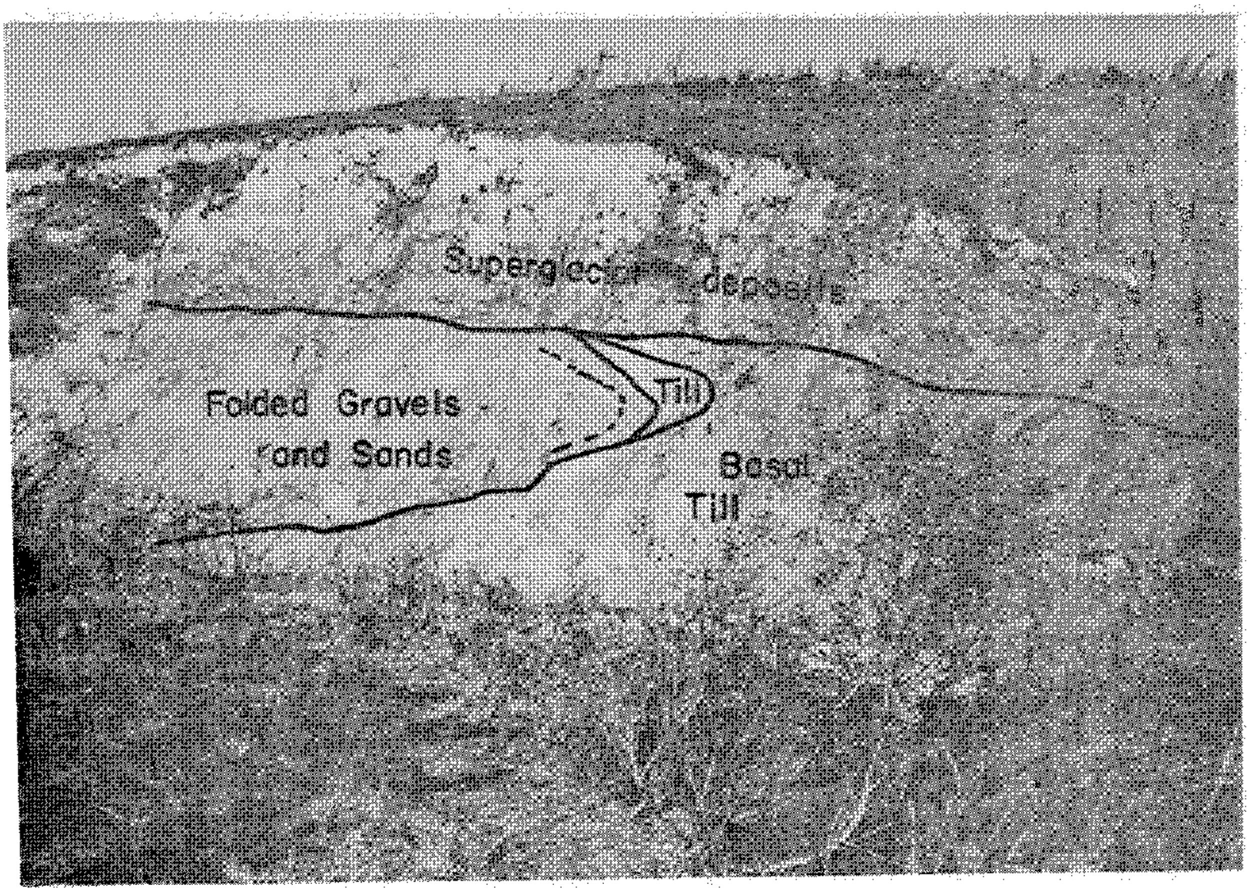


Figure 29. Photograph of east exposure at Bjork Farm Transect.

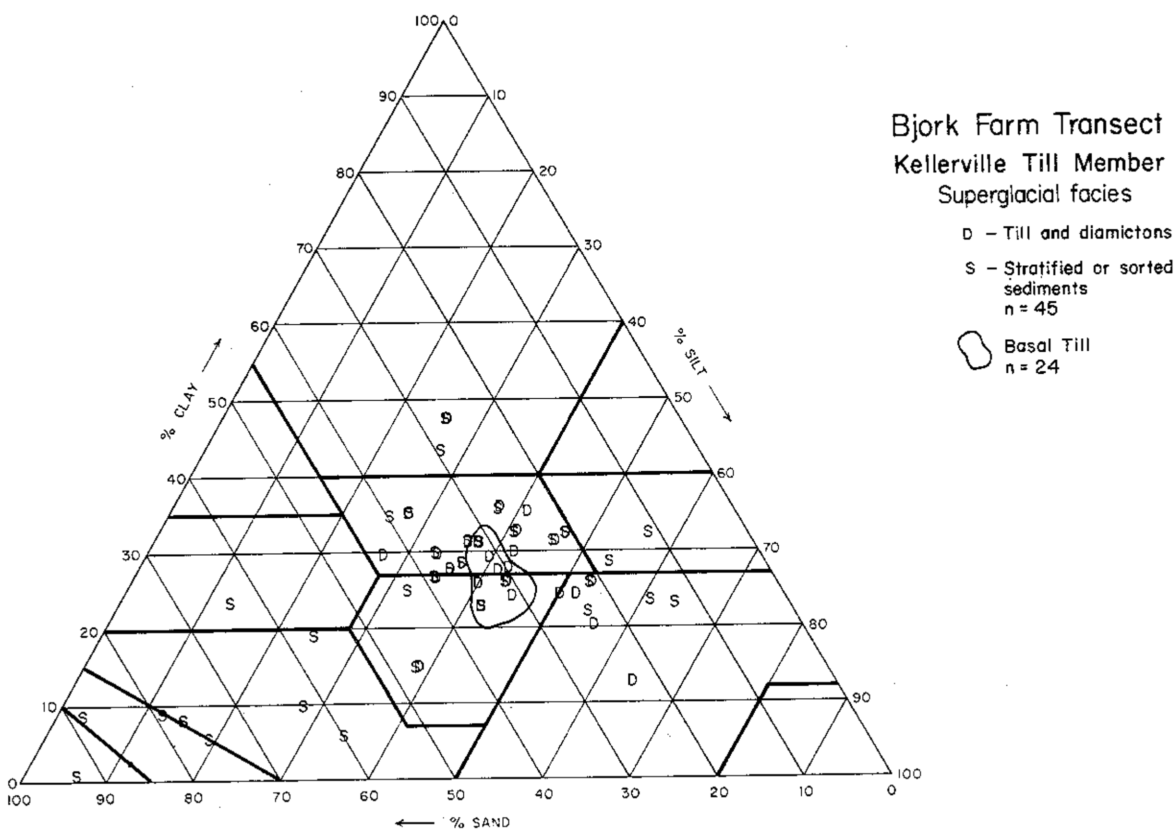


Figure 30. Summary of textural data, Bjork Farm Transect.

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. The paleosurfaces upon which these paleosols developed are not entirely 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.

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 58 H-1 (figure 25) is a good example of this type of Sangamon Paleosol on an interfluve. It can be compared with 58 H-3 (figure 24) which occurs on the adjacent divide surface.

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; and (2) in areas where the superglacial facies is thin or absent, and the erosion surface is cut into the basal till facies (Hallberg, Wollenhaupt and Wickham, 1980).

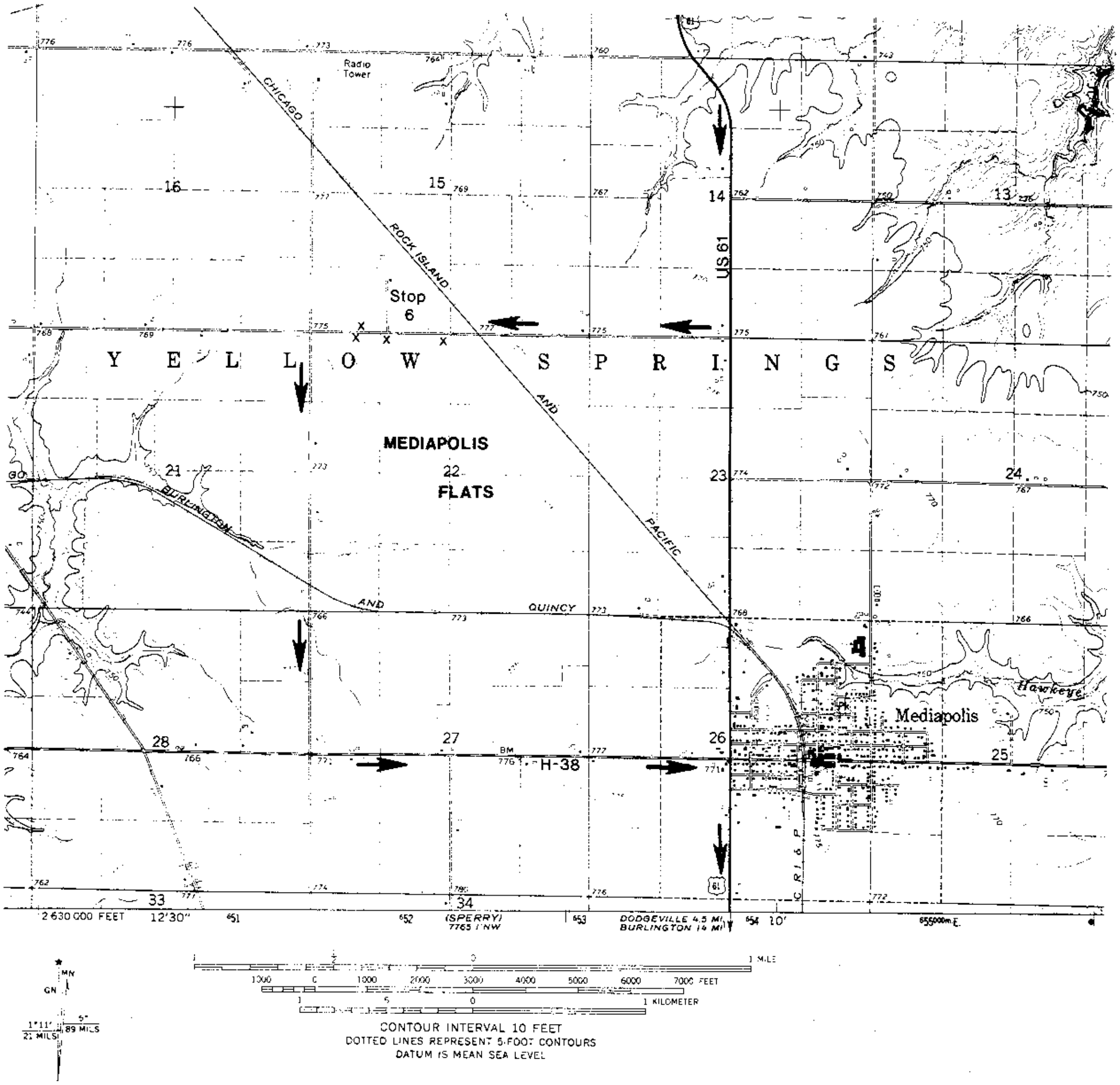


Figure 31. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stop 6.

STOP 6. Mediapolis Flats (Core Sites 29 WH-7 and -8).

The objectives of stop 6 will be to view a paleo-drainage sequence of Sangamon Paleosols on a modified but undissected remnant of the original surface developed on the superglacial facies of the Kellerville Till Member.

Several cores will be laid out to examine. Beginning on the west at Core Site 29 WH-8 (figure 32) we will examine a well-drained Sangamon Paleosol on a remnant knob on the Kellerville surface. On and around this knob the Sangamon Paleosol exhibits a reddish-colored, well-developed B-horizon, within the superglacial facies of the Kellerville Till Member. The superglacial facies is relatively thin across this area varying from 8 to 10 feet in thickness. It abruptly overlies the dense (1.80-1.89 g/cc; compare with figure 33) texturally uniform basal till.

In other cores in the vicinity of this knob a thin increment of hillslope sediments is incorporated in the paleosolum above a weakly-developed stone-line (Description 11; figure 33). In this core the complex relationships between the basal loess sediments and paleosol, and the underlying hillslope sediments (or pedisediment?) within the Sangamon Paleosol, can be examined.

The basal loess sediments and paleosolum are thin and form part of the complex A2b horizon of the composite paleosolum. The contact between the basal loess sediments and the hillslope sediments with the A2b is seen by the abrupt change in texture and total phosphorus (figure 33; see Bicki, this volume, also) and in clay mineralogy (Table 16). As typical the basal loess sediments are higher in clay and in sand content than the overlying loess. Both the total phosphorus content and the clay mineralogy are more like the loess than the underlying sediments in which the Sangamon Paleosol formed. In the hillslope sediments in the upper portion of the Sangamon the total phosphorus content decreases and the illite content increases to values typical of the Kellerville Till Member and related sediments.

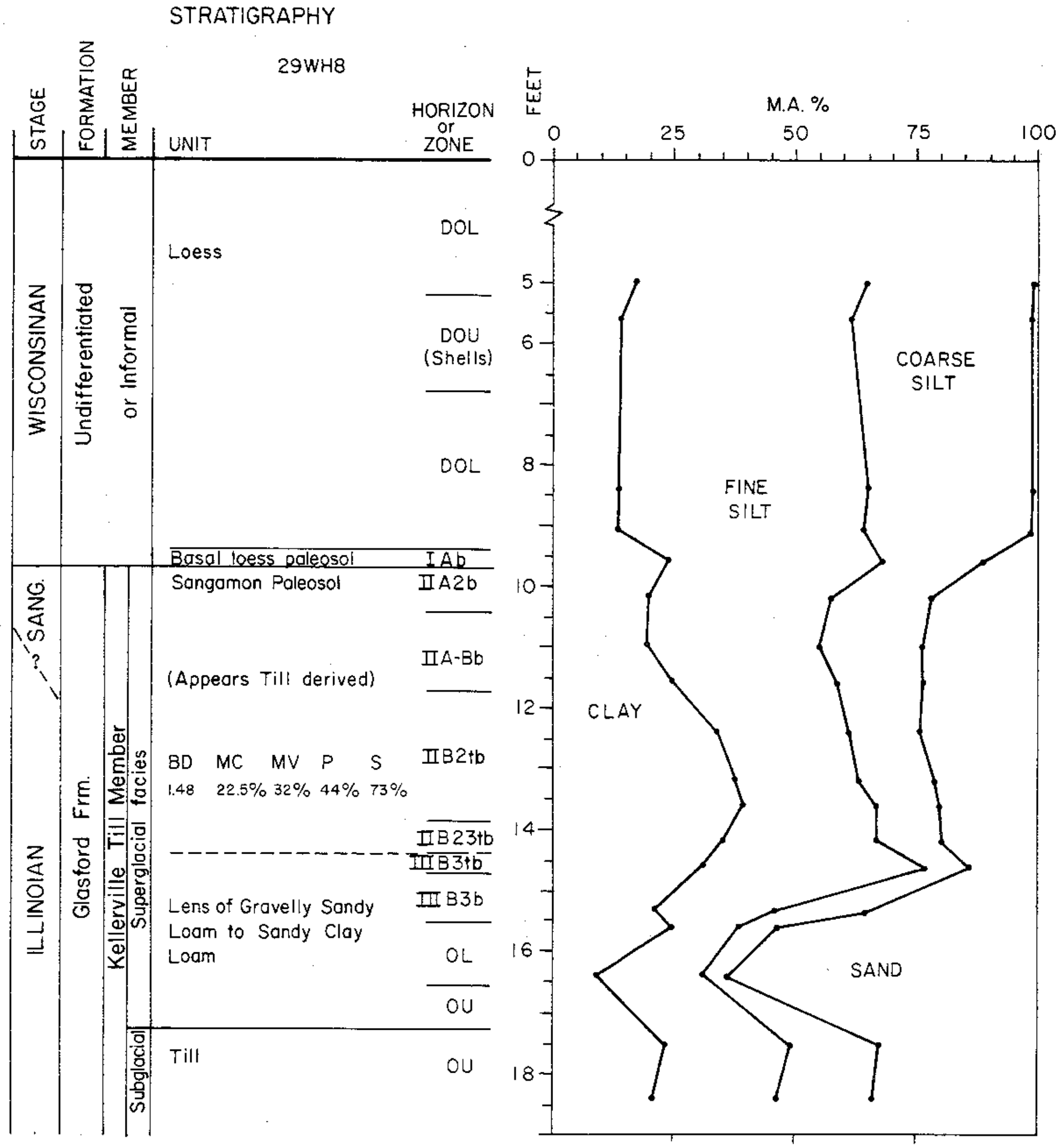


Figure 32. Stratigraphy and particle-size data, Core Site 29WH-8.

Cores 29WH-7 and -8 are located on the broad, relatively flat, upland divide northwest of Mediapolis. 29WH-7 (figure 34) was taken in a low position on the upland surface in the NE¼, of the NE¼, of the NE¼, of the NW¼, of sec. 22, T.72N., R.3W., Des Moines County; elevation approximately 777 feet. Core 29WH-8 (figure 32) was taken on a higher knob on the upland, just to the west of 29 WH-7, located in the NW¼, of the NE¼, of the NW¼, of the NW¼, of sec. 22; elevation 785 feet. Additional data in Hallberg, Wollenhaupt, and Wickham (1980).

Description 11. Mediapolis flats 29 WH-8-79 Core Site; the core is located on a low ridge on the broad upland divide northwest of Mediapolis, in the NW¼, of the NE¼, of the NW¼, of the NW¼, of sec. 22, T.72N., R.3W., Des Moines County; elevation 780 feet.

Depth-inches (feet) (meters)	Horizon or Zone	Description
WISCONSINAN Loess		
0- 8 (0 - 0.6) (0 -0.2)	Ap	Black (10YR 2/1) light silty clay loam; moderate fine granular structure.
8- 12 (0.6- 1.0) (0.2-0.3)	A12	Very dark brown (10YR 2/2; 3/2 kneaded) light silty clay loam; structure as above.
12- 18 (1.0- 1.5) (0.3-0.5)	A3	Very dark grayish brown (10YR 3/2) light silty clay loam; moderate fine and medium granular.
18- 24 (1.5- 2.0) (0.5-0.6)	B1	Dark grayish brown (10YR 4/2) medium silty clay loam; common fine yellowish brown (10YR 5/6) mottles; moderate fine subangular blocky; discontinuous dark brown (10YR 3/3) coatings.
24- 30 (2.0- 2.5) (0.6-0.8)	B21t	Mottled grayish and dark grayish brown (10YR 4 and 5/2) medium to heavy silty clay loam; common fine yellowish brown (10YR 5/6) mottles; moderate medium prismatic breaking to moderate medium and fine subangular blocky structure; continuous dark grayish brown (10YR 4/2) clay coatings on prisms; few fine dark reddish brown (5YR 2/2) Mn oxides.
30- 38 (2.5- 3.2) (0.8-0.9)	B22t	Grayish brown (2.5Y 5/2) medium silty clay loam; many fine to medium yellowish brown (10YR 5/6) mottles; moderate medium prismatic breaking to moderate medium and coarse subangular blocky; dark grayish brown (10YR 4/2) clay films continuous on prisms,discontinuous on smaller peds.
38- 48 (3.2- 4.0) (0.9-1.2)	B3t	Grayish brown (2.5Y 5/2) light silty clay loam; many fine and medium yellowish brown (10YR 5/6 and 8) mottles; moderate medium prismatic breaking to weak medium and coarse subangular blocky; discontinuous clay films on prisms, thick very dark grayish brown (10YR 3/2 some 4/2) clay coatings in root channels; common fine dark reddish brown (5YR 2/2) Mn oxides.
48- 70 (4.0- 5.8) (1.2-1.8)	C-MOL	Light brownish gray (2.5Y 6/2) light silty clay loam to silt loam; many fine and medium strong brown (7.5YR 5/6 and 8) mottles and segregations; massive, with some horizontal bedding; few very dark gray (10YR 3/1) clay-organic fillings in root tubules and as fine spherical masses; common fine dark reddish brown (5YR 2/2) Mn oxides.
70- 93 (5.8- 7.8) (1.8-2.4)	MDL	As above,silt loam; few zones of medium strong brown (7.5YR 5/6) Fe oxide concretions; gradual lower boundary.
93-104 (7.8- 8.7) (2.4-2.6)	MDL	As above, but medium to heavy silt loam.

	Basal loess sediments.	
	Basal loess paleosol.	
104-112 (8.7- 9.3) (2.6-2.8)	I A21b	Dark yellowish brown (10YR 4/4) medium to heavy silt loam; common fine grayish brown (10YR 5/2) mottles; weak coarse platy breaking to moderate fine granular; few discontinuous very dark brown root tubule fillings; discontinuous brown (10YR 4/3) coatings; few charcoal flecks.
GLASFORD FORMATION - Undifferentiated sediments.		
	SANGAMON PALEOSOL	
112-124 (9.3-10.3) (2.8-3.1)	II A22b	As above, but silt loam, high in sand, few pebbles at 124 inches; weak coarse platy; few fine dark reddish brown (5YR 2/2) Mn oxide segregations; pedisediment.
124-131 (10.3-10.9) (3.1-3.3)	II A23b	Yellowish brown (10YR 5/4) silt loam to loam; weak coarse platy breaking to weak fine subangular blocky and moderate fine granular; few fine dark reddish brown (5YR 2/2) Mn oxides; few charcoal flecks.
131-132 (10.9-11.0) (3.3-3.4)	STONE LINE	
GLASFORD FORMATION - Kellerville Till Member		
		Superglacial facies
	SANGAMON PALEOSOL	
132-136 (11.0-11.3) (3.4-3.5)	III B1b	Brown (7.5YR 4/4) heavy loam; weak fine subangular blocky structure.
136-147 (11.3-12.3) (3.5-3.7)	IV B21tb	Brown (7.5YR 4/4) light clay loam, with occasional pebbles; common coarse yellowish red (5YR 4/6) mottles; discontinuous dark brown (10YR 3/3) clay films; moderate medium prismatic breaking to moderate medium and coarse subangular blocky; few medium dark reddish brown (5YR 2/2) Mn oxides; crudely stratified (?) till-like material.
147-156 (12.3-13.0) (3.7-4.0)	IV B22tb	As above; clay films more continuous.
156-172 (13.0-14.3) (4.0-4.4)	IV B31tb	Brown (7.5YR 4/4) light clay loam to loam; few medium brown (10YR 5/3) mottles; discontinuous dark brown (7.5YR 4/2) clay films; moderate medium prismatic breaking to weak medium and coarse subangular blocky.
172-187 (14.3-15.6) (4.4-4.8)	V B32b	Mottled strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) loam with few pebbles; common fine yellowish red (5YR 4/6) mottles; moderate medium prismatic breaking to weak medium and coarse subangular blocky; few fine (5YR 2/2) Mn oxides; till-like, but with few pebbles (diamicton).
187-196 (15.6-16.3) (4.8-5.0)	V Cb MOL	Mottled yellowish brown (10YR 5/6) and light grayish brown (10YR 6/2) loam, with few pebbles; common fine and medium (5YR 2/2) Mn oxides.
197-200 (16.3-16.7) (5.0-5.1)	VI Cb MOL	Sandy loam, stratified, no pebbles; glaciofluvial sediments.

Observations from a number of cores show that stratified silts, sands, and/or sand and gravel occur to a depth of about 17.5 feet (5.3 m). These overlie oxidized and unleached very firm, uniform till; the subglacial, basal till facies, of the Kellerville Till Member. Density measurements in the basal till range from 1.79-1.86.

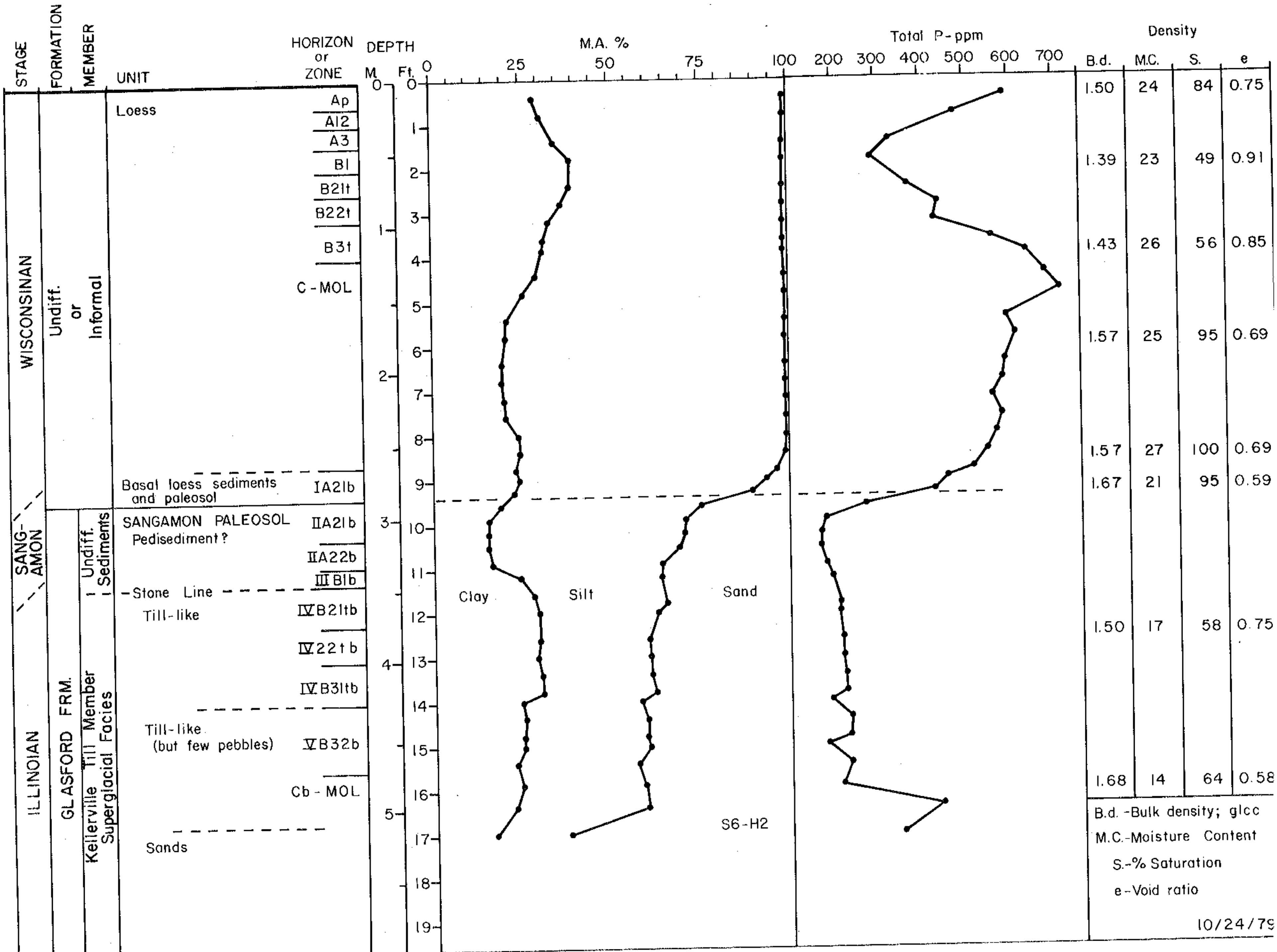


Figure 33. Stratigraphy and lab data for Core 29WH-8-79 (S6-H2).

Table 16. Clay Mineralogy for core 29 WH-8-79.

Depth (Feet)	Horizon or Zone	Clay Mineralogy EX.	ILL. %	K+C
WISCONSINAN Loess				
7.0	MDL	65	29	6
8.5	MDL	68	20	12
		Basal loess sediments		
		Basal loess paleosol		
8.8	IA21b	(64)*	(16)*	(20)*
9.0	IA21b	(59)*	(17)*	(24)*
		Both samples show 1) a broad expandable peak; 2) a vermiculite peak; and 3) a very low illite peak.		
GLASFORD FORMATION - Undifferentiated sediments				
SANGAMON PALEOSOL				
9.6	IIA22b	(51)*	(28)*	(21)*
10.4	IIA23b	(56)*	(25)*	(19)*
- Kellerville Till Member, superglacial facies.				
SANGAMON PALEOSOL				
11.2	IIIB1b	(48)*	(32)*	(20)*
		The three samples above show 1) broad expandable peaks; 2) vermiculite or chlorite peaks; and moderate to low illite peaks.		
11.7	IVB21tb	(42)*	(33)*	(25)*
12.1	IVB21tb	(45)*	(31)*	(24)*
13.3	IVB31tb	(49)*	(29)*	(22)*
		Chlorite or vermiculite peak apparent.		
		The three samples above show broad expandable peaks; moderate to high illite peaks; other peaks as noted.		
15.0	IVB32b	(42)*	(35)*	(23)*
16.2	IVC - MOL	44	32	24
18.5	MOU	48	32	20
		(Chlorite peak apparent.)		

()* - Weathered samples; numbers in parantheses for discussion purposes only.

In a locality in Louisa County where these Ab horizons contained more organic matter the basal loess paleosol dated 18,590±635 RCYBP, and the underlying Ab horizon of the Sangamon Paleosol dated 21,770±340 RCYBP (see Hallberg, Wollenhaupt, and Wickham, 1980).

The elevation of both the present land surface and the Sangamon surface declines slightly in all directions from 29 WH-8. In a low position to the east, Core Site 29 WH-7 (figure 34) shows a Sangamon Paleosol developed on swale-fill sediments in a depression on the Kellerville Till surface. The data for 29 WH-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. Several cores will be provided for examination. Note that the basal loess sediments and paleosol grade downslope into a peat. Although this peat has not yet been analyzed other peats in the area have dated from 19,130±450 RCYBP to 24,900±570 RCYBP at their upper contact with the loess (see figure 13 and Hallberg, Wollenhaupt, and Wickham, 1980, p. 96). Also, note that the thin veneer of hillslope sediments have thickened to at least 12 feet (3.7 m) of gleyed sediments in this old depression on the Kellerville Surface. At 29 WH-7 the entire Sangamon Paleosolum is developed in these local erosional sediments.

There is nothing unusual, magical or mystical about these variations in the Sangamon Paleosol. This is to be expected. To demonstrate, cores from analagous landscape positions from the modern landsurface on the Des Moines lobe will be presented with the Sangamon Paleosols. The Des Moines lobe till dates ca. 14,000 RCYBP (Ruhe, 1969). The toposequence includes a well-drained Clarion soil through a very-poorly drained Okoboji soil.

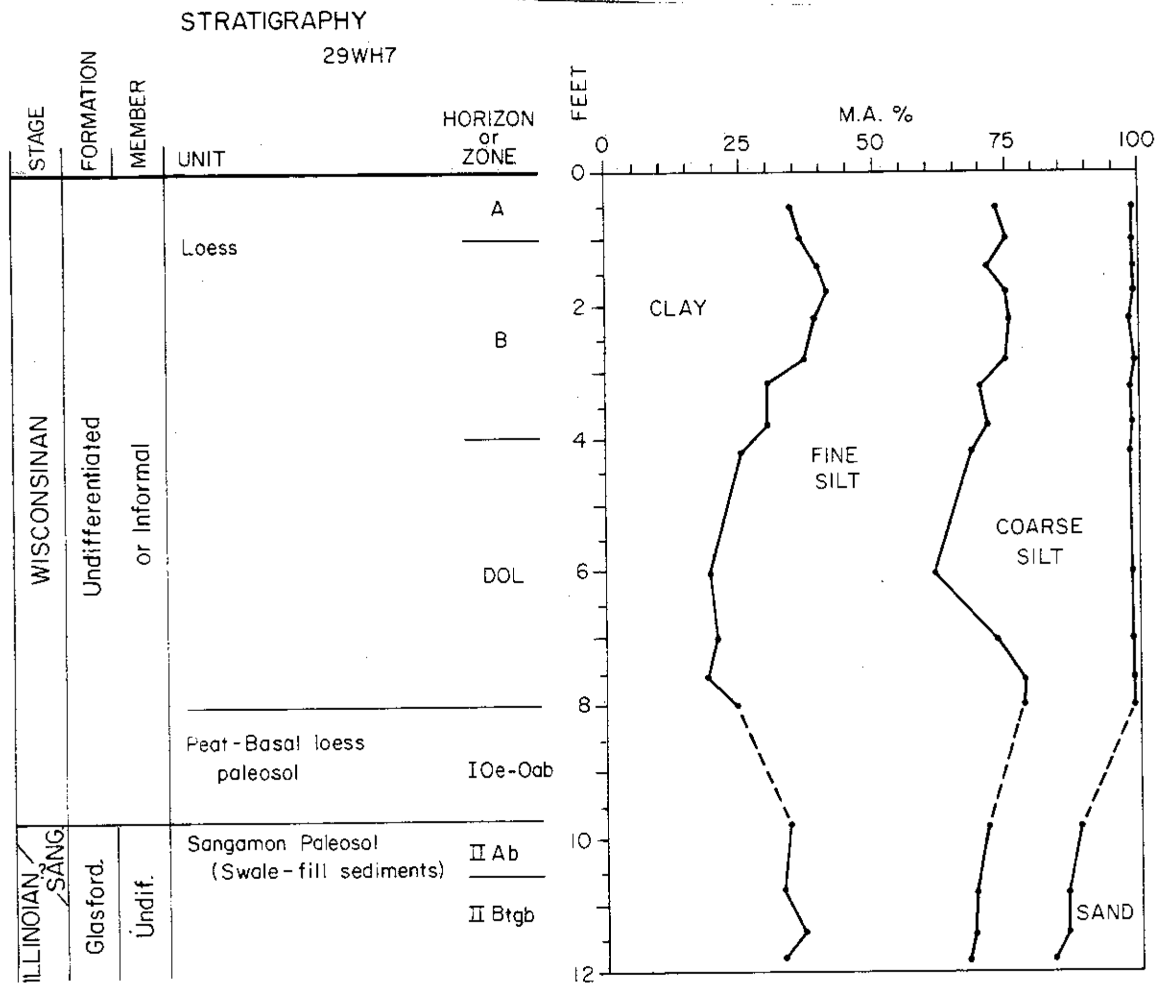


Figure 34. Stratigraphy and particle-size data, core site 29 WH-7; see figure 32 for location; additional data in Hallberg, Wollenhaupt, and Wickham, 1980.

On the Des Moines lobe a variable thickness of hillslope sediments also occur even on knobs analagous to figure 33. In this setting these sediments are clearly Holocene in age and relate to the erosion and modification of the original constructional topography. In similar fashion, there is no need to consider the hillslope sediments on the well-drained Sangamon position anything but Sangamon in age.

Sunday

We will drive west out of Burlington on U.S. 34 (figure 35). At Danville we will turn north. Flag men will be present when we are entering or leaving major highways. Please drive carefully.

Figure 35. (facing page). Generalized surficial geologic map of study area, showing Sunday's route and stops. All units loess-mantled except late-Wisconsinan to Holocene slopes and alluvium.

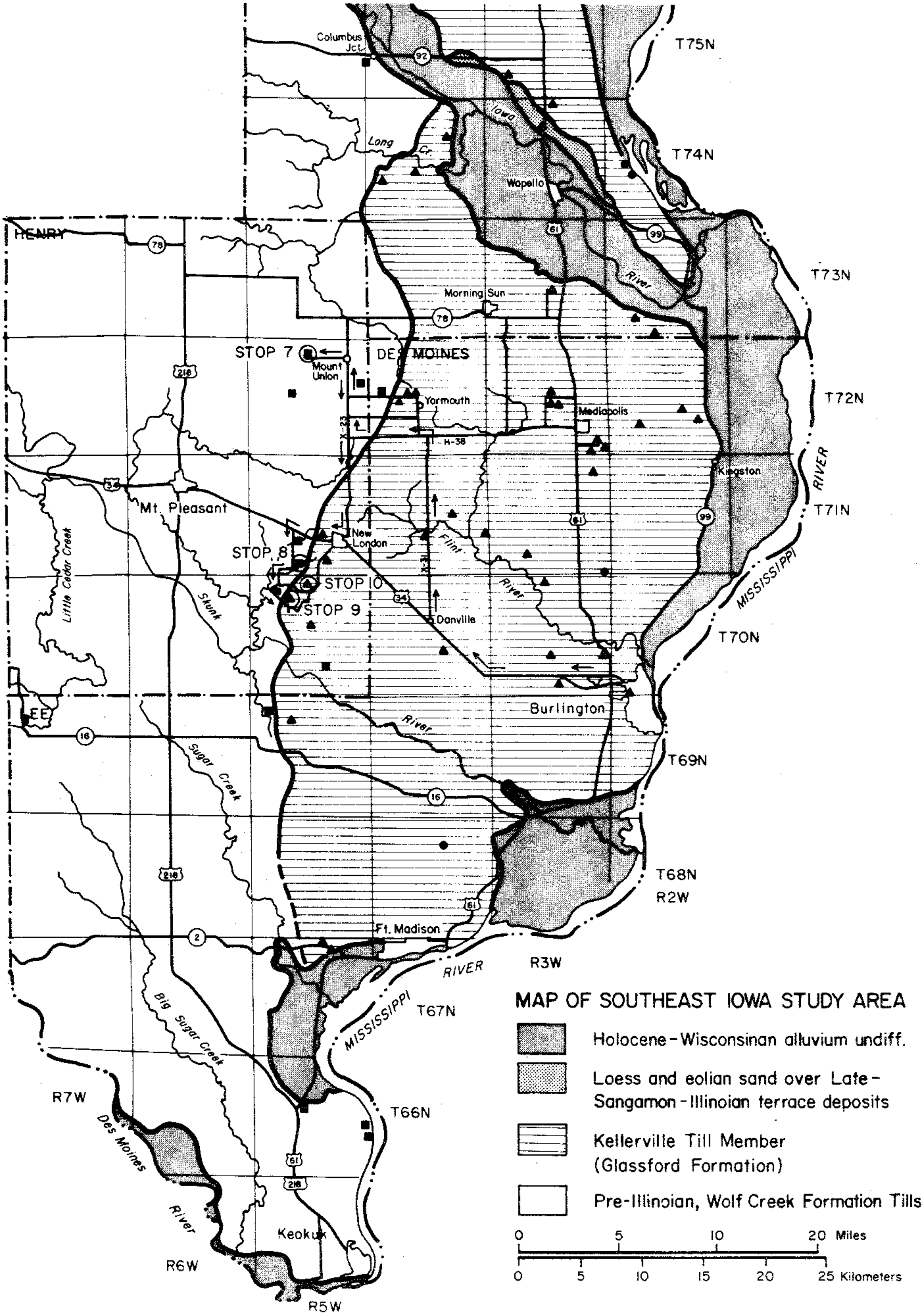
Stratigraphic Sections shown with symbols indicating surficial till unit (see Hallberg, ed., 1980).

Illinoian - GLASFORD FORMATION

- ▲ Kellerville Till Member

Pre-Illinoian - WOLF CREEK FORMATION

- ■ Hickory Hills Till Member
- ● Other WOLF CREEK or ALBURNETT FORMATION tills


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
Mount Union
Yarmouth
Mediapolis
Kingston
Mt. Pleasant
New London
Danville
Burlington
Ft. Madison
Keokuk
HENRY
LEE
STOP 7
STOP 8
STOP 9
STOP 10
Long Cr.
Iowa River
Little Cedar Creek
Skunk River
Flint River
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

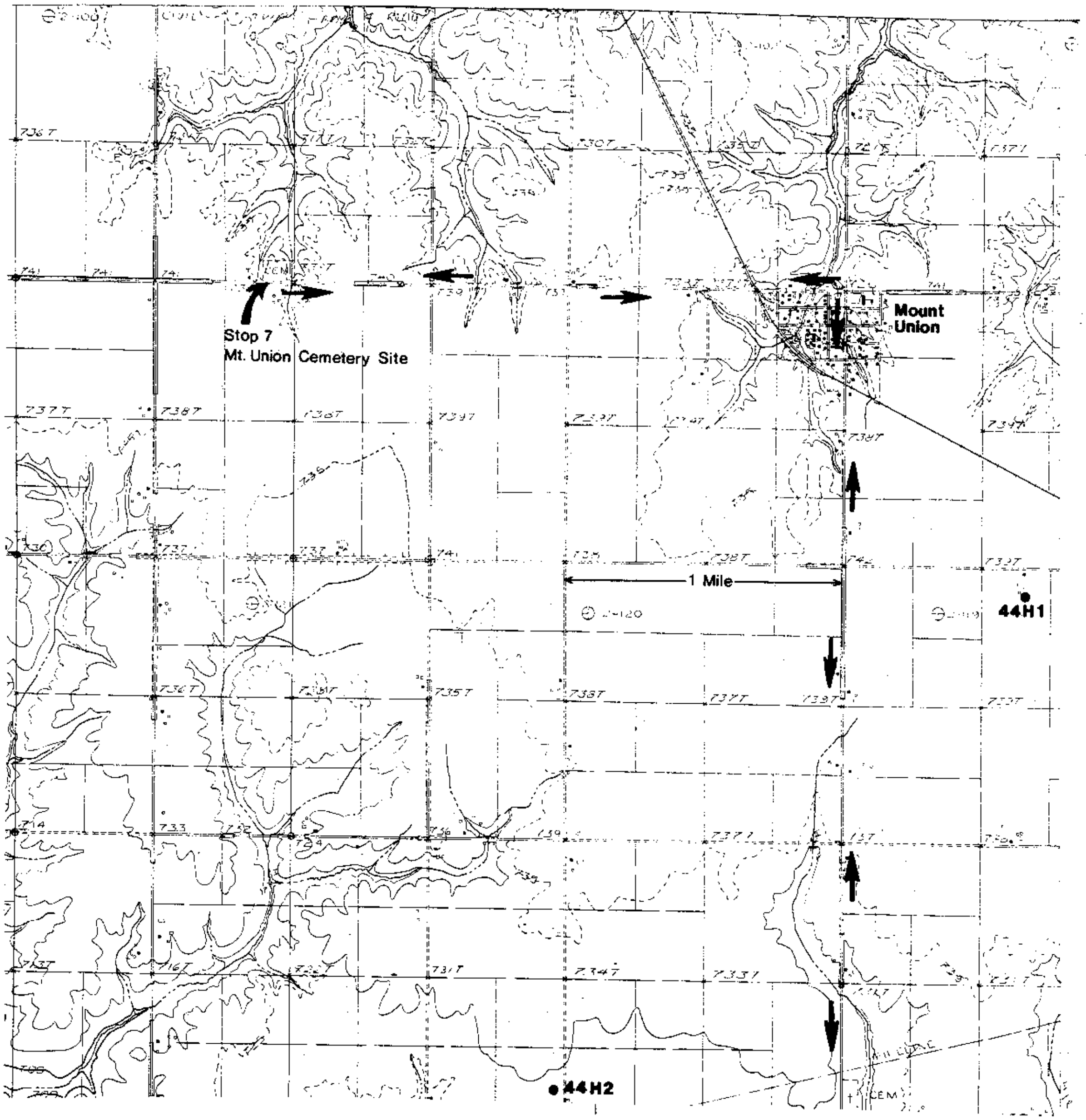


Figure 36. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stop 7.

STOP 7. The Mt. Union Cemetery Core Site.

We have examined the Yarmouth Paleosol and the Sangamon Paleosol. The purpose of this stop is to examine (but it is doubtful if we can comprehend) the Yarmouth-Sangamon Paleosol in one of its most grand expressions.

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 12, figure 37) is an example of one of these thick swale-fill Yarmouth-Sangamon Paleosols. The site is located on the tabular divide which continues to the northwest from near Yarmouth (stop 2). 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

Description 12. 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?	Light olive 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.

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.

Description 12, con't.

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?

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.

Table 17. Summary of mineralogy data - Mount Union Cemetery Core.

			Clay Mineralogy		
Depth (Feet)	Horizon or Zone	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

		Particle Size			Matrix Carbonate			
		Clay	Silt	Sand	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

			Sand-fraction lithologies			
		C/D	TC	TSed.	Q-F	TX.
35.0	MOU	3.0	26	29	60	71

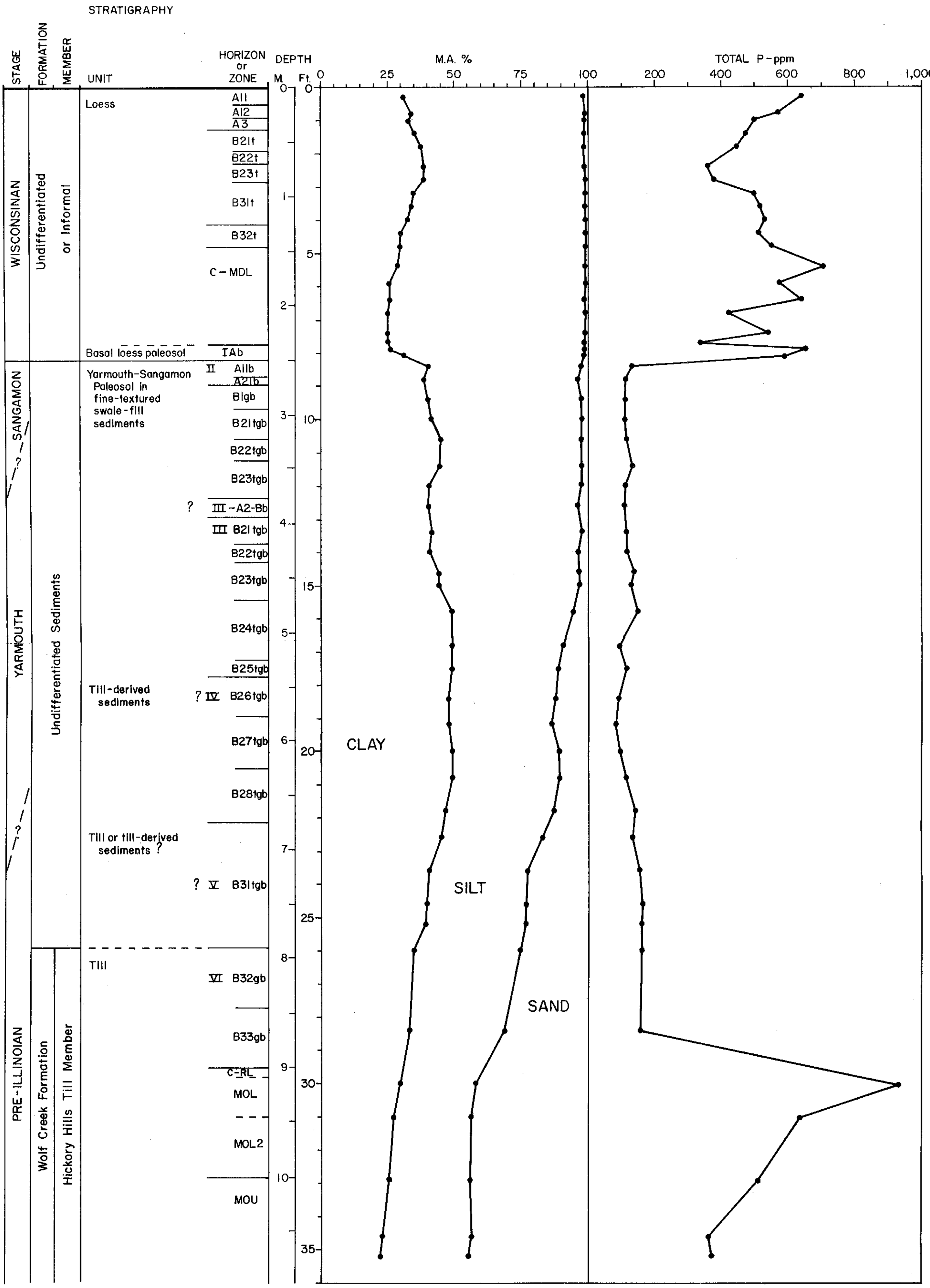


Figure 37. Stratigraphy, particle-size, and phosphorus data for the Mt. Union Cemetery Core Site.

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.

Note the strong structure and clay films throughout. Note also the (?) IIIA2b horizon at about 12.4 feet (Description 12). Ask Fenton about this! Ask Miller to explain the genesis of this solum!

This is the thickest Pleistocene paleosolum known in Iowa at this time. Other sites on this divide do not show this exceptional thickness. Site 44 H-2 (figure 36) shows only 2.7 feet (0.8 m) of the fine-textured sediments over the till-derived sediments, within the Yarmouth-Sangamon Paleosolum (Hallberg, Wollenhaupt, and Wickham, 1980). In such settings in road cuts the paleosolum thickness is on the order of 8.5-10 feet (2.6-3.0 m).

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 Paleosol 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 17; 44 H-1 data, in Hallberg, Wollenhaupt, and Wickham, 1980) 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.

Broad tabular divides, such as the Mediapolis flats on the Illinoian deposits, and in the Mt. Union area, in the area of Pre-Illinoian deposits, are unique and contrast with the more highly dissected landscape present in much of southern Iowa.

Such divides occur in other areas of southern Iowa and have been noted before (Kay and Apfel, 1928). 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. Note the bedrock outcrop at stop 5. Also, on figure 22, the "gravel pits" shown on the U.S.G.S. map are actually rock quarries. It seems likely that the bedrock 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 58 H-4; figure 27). It is somewhat more prevalent along the major streams such as the Mississippi and Skunk Rivers in particular.

We might also note that the loess-derived soils on these broad tabular divides frequently bring some of the highest ag-land sale prices in Iowa. You might have noted the signs about Canaan Township being the richest township in the world, etc. A section of land in this area is worth somewhere around 2 million dollars. As we look at <u>and</u> feel the Yarmouth-Sangamon Paleosol, and look at the total phosphorus data (as an indicator of natural fertility) we might contemplate what Canaan Township would be worth without the Wisconsinan loess. This should also give us an understanding of what 6-8 feet (1.8-2.4 m) of loess is worth from an applied standpoint.

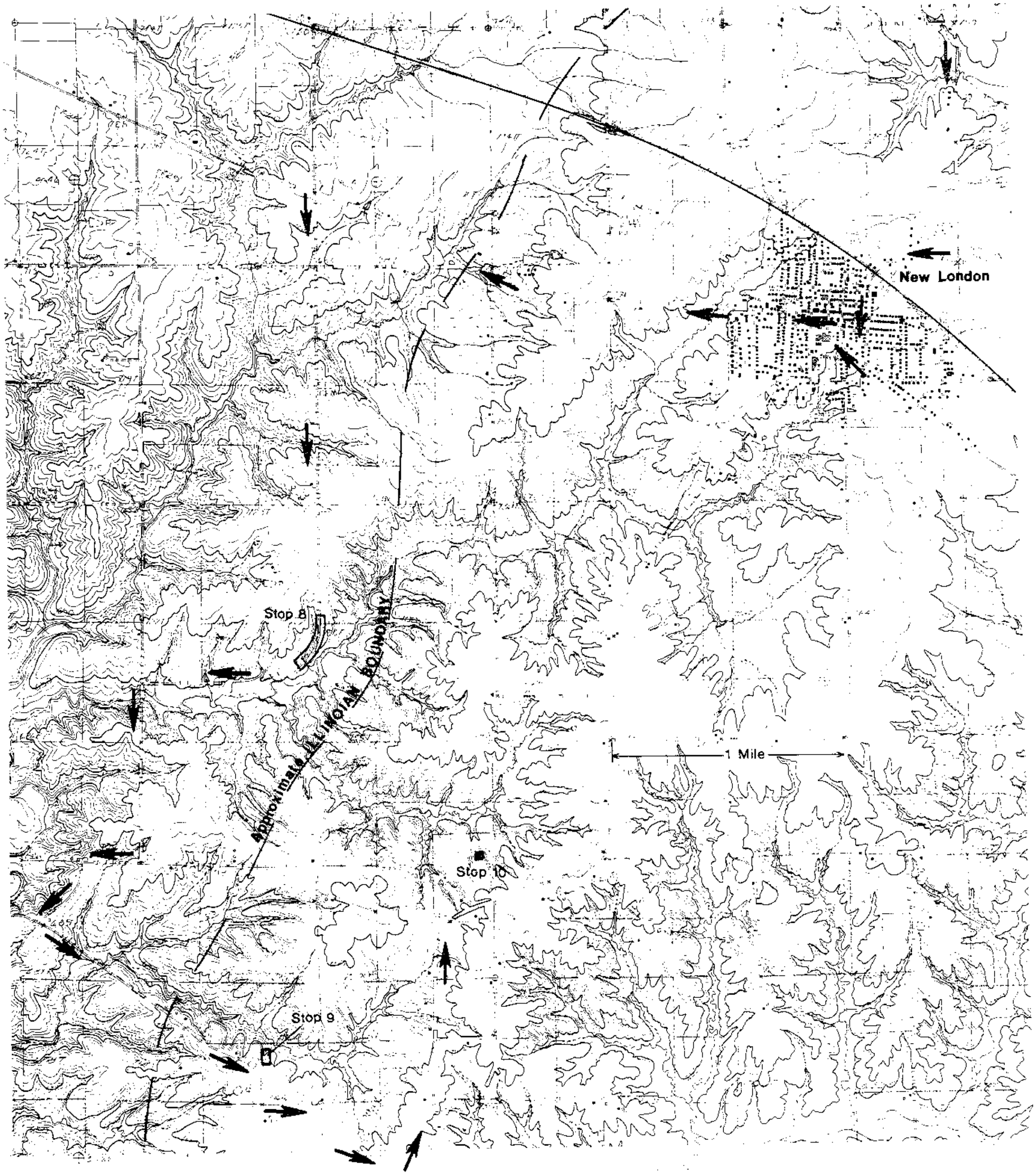


Figure 38. Portion of 7.5 minute, U.S.G.S. topographic quadrangle map (10 foot contour interval) showing location of stops 8, 9, and 10.

STOP 8. Section 44 LC.

An excellent exposure of the Late-Sangamon Paleosol developed on the Hickory Hills Till Member occurs at the 44LC Section in Henry County (figure 39; Description 18). As shown in figure 39 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. The Late-Sangamon Paleosol developed on an erosion surface which is inset below the Yarmouth-Sangamon Surface--hence, younger and thus the name Late-Sangamon (Ruhe, 1967).

Two sections are described, one at the south end and one at the north, where the pedisediment has slightly different relations within the paleosolum. To the north at 44LC-2 strong B-horizon development is evident in the pedisediment as well as the underlying till. This is indicative of the pedologic welding of the two materials into one coherent soil. This is also part of the evidence which indicates that the pedisediment is temporally related to the cutting of the Late-Sangamon erosion surface and to the development of the Late-Sangamon Paleosol.

Table 18. Additional laboratory data for 44 LC Section.

Depth	Clay Mineralogy			Particle Size			Matrix Carbonate			C/D
	EX.	ILL.	K+C	Clay	Silt	Sand	Ca	Do	TC	
		- % -			- % -			- % -		
All Miscellaneous OU-MOJU	61	17	22	18.3	35.3	46.4	2.4	6.5	8.9	0.37
Hickory Hills Till samples.	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

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.

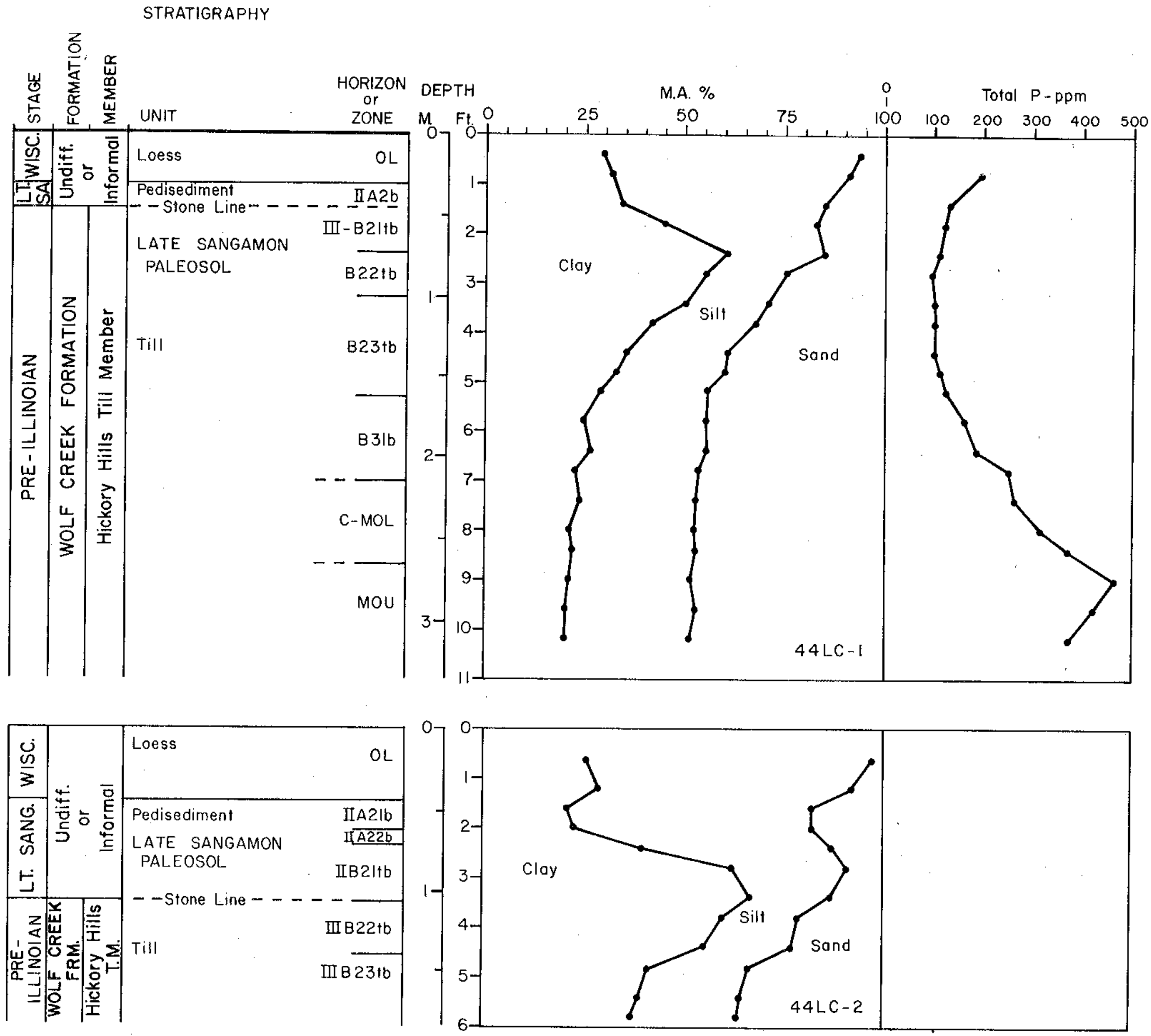


Figure 39. Stratigraphy, particle-size, and total phosphorus data, Section 44LC.

STOP 9. The Baltimore Cut Section (see figure 38).

The Baltimore Cut Section is comprised of a core and an exposure near the Baltimore Riding School in Henry County. The section is near the highly dissected terminus of the Kellerville Till Member (see figure 38). The cut is located on an interfluve, which is a more typical loess-mantled Late-Sangamon pediment, cut in Illinoian deposits.

Thus, we will examine a Late-Sangamon Paleosol in the superglacial facies of the Kellerville Till Member. The outcrop exposes another good example of the superglacial facies for examination and discussion. Unlike at Yarmouth where the deposits appear to be bedded, the superglacial deposits at this section are a contorted melange of various sediments. Figure 40 and Table 19 document a portion of the section. Note the similarities in the paleosols from stops 8 and 9; but also note the distinct contrast in materials.

STOP 10. The Schroder Section.

The purpose of the Schroder Section (figure 39) is to end where we began -- with a view of the Yarmouth Paleosol beneath the early Illinoian Kellerville Till Member.

The section is given in Description 14. The upper portion of the Kellerville, including the Sangamon Paleosol would appear to be the superglacial facies (figure 41). Lower in the section the Kellerville becomes more firm, and uniform texturally (see Table 20).

The Kellerville Till Member overlies the early or pro-Illinoian peat, which in turn overlies a thick gleyed Yarmouth Paleosol.

Preliminary work on the pollen content of the peat indicate that it is dominated by spruce pollen, as at Yarmouth.

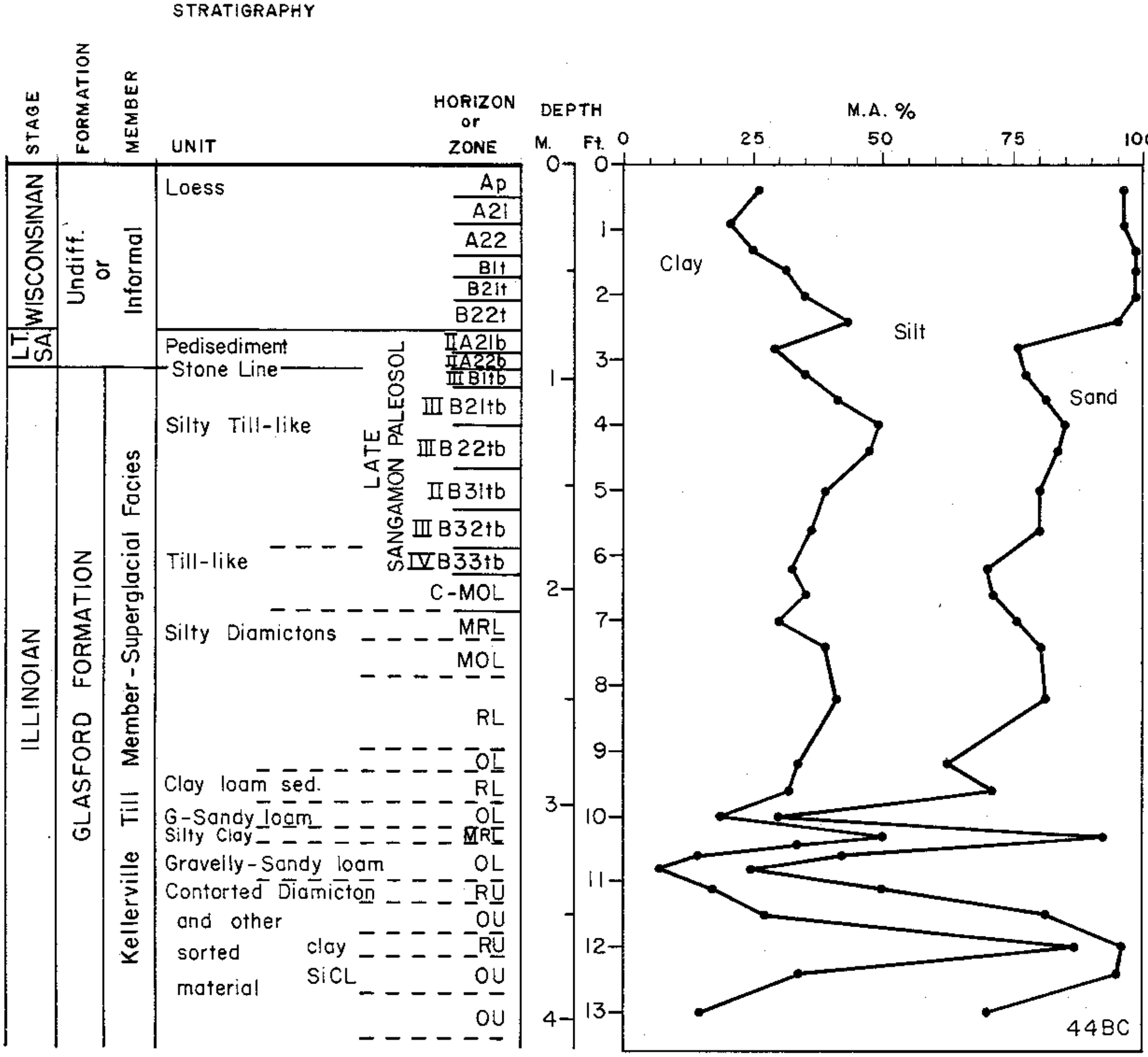


Figure 40. Stratigraphy and particle-size data, Baltimore Cut Section (44-BC). The section is composed of a core (0-7 feet; 0-2.1 m) and a road cut, located in the NW¼, of the NW¼, of the SW¼, of the NW¼, of sec. 9, T. 70N., R. 5W., Henry County; elevation 725 feet.

Table 19. Laboratory data for calcareous grab samples, Baltimore Section (44-BC).

Sample	Clay Mineralogy			Particle-size			Matrix-Carbonates			
Horizon or Zone - Material	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				

Description 14. 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.

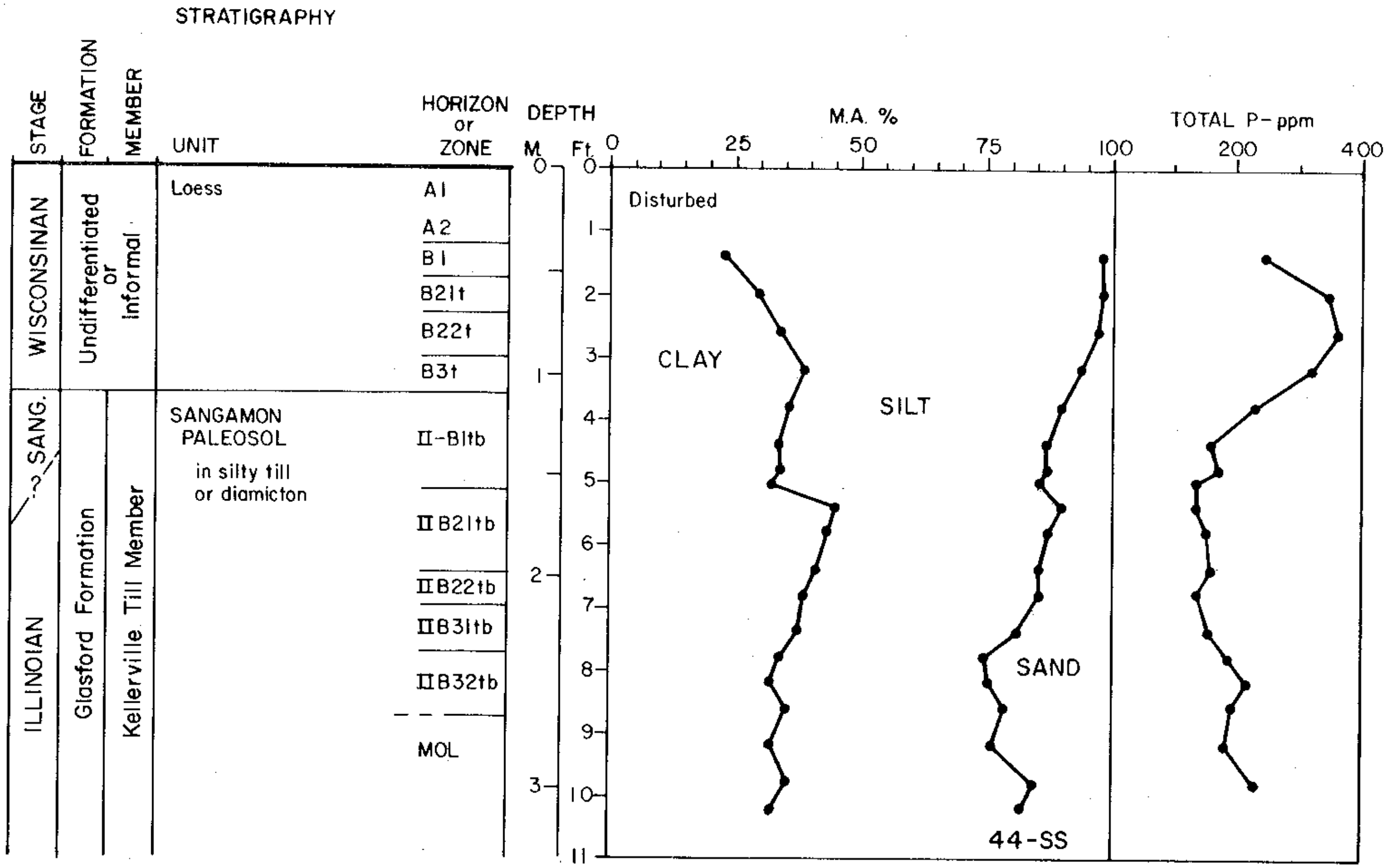


Figure 41. Stratigraphy, particle-size, and phosphorus data for a portion of the Schroder Section (44-SS).

This section would be an ideal reference section for the Yarmouth Paleosol also, because of the section exposed. It is also very near a principle historical section of Kay and Apfel (1929, p. 228) where they describe 11 feet of "Kansan gumbotil" below the Illinoian till. Unfortunately their section is overgrown, and even by the time of our visit the Schroder Section may be under water.

Table 20. 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
All Miscellaneous MRU-MRJU Kellerville Till samples	39	43	18	28.2	46.3	25.5	1.6	8.0	9.6	0.2
	44	34	22	26.6	48.6	24.8	2.6	8.9	11.5	0.2
				24.8	49.9	25.3	2.2	11.3	13.5	0.1
	53	27	20	22.4	53.0	24.6	2.5	12.5	15.0	0.2
	46	31	24	20.2	50.5	29.3	2.5	15.2	17.7	0.1
	37	34	29	32.0	44.4	23.6				

Sand-fraction Lithologies C/D	T.C.	Sh.	T.S.	Q.-F.	T.X.
1.7	41	9	54	39	46

AVAILABLE (Bray 1) AND TOTAL PHOSPHORUS DISTRIBUTIONS IN MODERN SOLA AND PALEOSOLS

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Available (Bray 1) and total phosphorus have been used extensively in Iowa as indicators of pedogenic processes. Several important characteristics make phosphorus an effective tool for pedological and geological investigations. Phosphorus is an essential element for plant growth and is consequently important in organic cycles. Parent materials and organic matter are the sole sources of phosphorus in soils and weathering zones. Phosphorus is considered to be essentially immobile in soils, however, during long spans of time involved in pedogenisis considerable redistribution does occur (Smeck, 1973).

Soil sola typically exhibit a characteristic depth distribution pattern of available phosphorus. Available phosphorus is high near the surface, decreases to a minimum quantity in the lower A or upper B horizon, attains a maximum quantity in the lower B or upper C horizon, and then decreases to a level characteristic of the parent material (Smeck, 1973). Available phosphorus data at Stop 5 (58H-1) illustrates this characteristic depth distribution. A similar available phosphorus distribution can be observed in the Yarmouth Paleosol at Stop 2 (29H-2).

Runge and Riecken (1966) have interpreted the high available phosphorus content in the surface of modern sola to be the result of either P added as fertilizer, or to inorganic P and easily mineralized organic phosphorus compounds from plant residues. Minimum available phosphorus values in the lower A and upper B horizons are attributed primarily to the removal of phosphorus by plant roots and by eluviation. Maximum available phosphorus values in the lower B and upper C horizons are thought to result primarily from weathering of phosphate bearing minerals and illuviation, accompanied by the lack of removal of available phosphorus by plant roots. The subsequent decrease in available phosphorus is related to an increase in pH.

The available phosphorus content in the II A2b and II B1b horizons of the paleosols at Stop 5 are relatively low but still retain the characteristic available phosphorus depth distribution. The very low available phosphorus content of the Sangamon paleosols at Stop 5 may be related to resaturation of the paleosol with calcium carbonate from the overlying loess.

Resaturation of paleosols with secondary calcium carbonate is a common feature in paleosols with pH's of 7.0 and 7.1 have been reported by Fenton (1966) and Miller (1974). The occurrence of secondary carbonates in other paleosols in Iowa has been discussed by Hallberg (1980). Miller (1974) has discussed the relationship of depth and intensity of leaching of carbonates and available phosphorus content in the lower B horizon of soil profiles and weathering zones. Available phosphorus content was found to decrease in the lower portion of the B horizon as pH increased.

Smeck (1973) has summarized the relationship of phosphorus to the weathering processes which occur in soil and weathering zones. Smeck (1973) states that pH of the soil material must be 7.5 or less before phosphorus is released, and at pH values above 7.0 phosphorus is dependent on the solubility of calcium-phosphate. The low available phosphorus content of the Sangamon paleosols may result from fixation of phosphorus as calcium phosphate as a result of calcium carbonate recharge from the overlying materials.

Total phosphorus distribution within soil profiles is similar to that displayed by the available phosphorus distribution. Examination of total phosphorus distribution with depth in the soil sola at Stop 2 (29H-2), Stop 5 (58H-1), Stop 6 (S6H-2) and Stop 7 (S7W7) reveal a similar trend. Total phosphorus is high near the surface and decreases to a minimum quantity in the lower A or upper B horizon. The amount of total phosphorus then increases to a maximum in the C horizon. The factors responsible for the redistribution of available phosphorus are also reflected in the total phosphorus distribution. This characteristic total phosphorus profile distribution has been used by Runge et al. (1974) to delineate paleosols in New Zealand.

The irregular total phosphorus content of the mottled deoxidized and leached loess at Stop 2 (29H-2) and Stop 7 (S7W7) may be related to the variable total phosphorus content of the mottles and/or Fe segregations, and the matrix of the loess. Runge (1963) reported markedly different phosphorus contents for highly mottled subsoils and uniformly gleyed subsoils. These results indicated an appreciable amount of phosphorus was precipitated in the mottles and Fe segregations in an iron phosphate form.

The depth distribution of total phosphorus content in the Sangamon paleosols at Stop 5 (58H-1 and 58H-2), Stop 6 (S6-H2) Stop 8 (44LC2) and Stop 10 (44SS) is similar to that for the modern soil sola. The lower Total P content is probably related to the greater degree of weathering of the materials, although changes in the mineralogy of the parent material may account for some of this difference.

Godfrey and Riecken (1954) and Smeck (1973) reported that total phosphorus content tended to progressively decrease as soils became more weathered. This is evident in the relatively low total phosphorus content of the deeply weathered Yarmouth Sangamon paleosol at Stop 7 (S7W7). The total phosphorus content is low throughout 18 feet of the paleosol probably as a result of weathering and eluviation. The zone of maximum accumulation of total phosphorus in the lower B horizon and C horizon is the result of illuviation from the overlying sediments. The decrease in total phosphorus content below the zone of illuviation probably represents the total phosphorus content of the Pre-Illinoian till.

Runge et al. (1974) suggest that identification of paleosols in a stratigraphic column should be possible by changes in the distribution and form of phosphorus. In addition, the degree of soil development and weathering in each paleosol should be ascertainable by the form and amount of phosphorus.

Examination of the total phosphorus content of the soil developed in Wisconsin loess and the paleosols developed in Illinoian and Pre-Illinoian sediments at Stop 2 (29H-2) reveals a systematic decrease in total phosphorus content from the soil developed in Wisconsin loess through the Sangamon and Yarmouth paleosols. If the weathering of phosphorus during each period of soil formation is similar per unit time, then some indication of the time each paleosol was undergoing soil development should be evident from an examination of their phosphorus content (Runge, et al. 1974). The decrease in total phosphorus content may reflect a greater amount of soil development and weathering of phosphorus in the Yarmouth paleosol, Sangamon paleosol, and the soil developed in Wisconsin loess, respectively. However, some of these differences are also related to differences in the mineralogy and initial phosphorus content of the parent materials.

SOME OBSERVATIONS OF THE LOESS IN THE SOUTHEAST IOWA STUDY AREA

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The loess deposits in Southeastern Iowa constitute the major surficial material on upland positions and represent the dominant Wisconsinan aged deposits in the area. Eolian silts drape the landscape from the summit downward to where paleosols, till, or bedrock outcrops on the sideslope. Because of the majestic loess deposits on the opposite side of the state, the loess in Southeastern Iowa has not received abundant attention, and has for the most part been neglected. As this work is continuing, the intention here is to give only a generalized summary of some of those characteristics. [Recently, work has been initiated to more fully investigate the loess deposits in this area and quantify some of the pertinent characteristics.]

The loess in southern Iowa has traditionally been attributed to the Missouri River floodplain along the western border of Iowa, primarily a result of extending the thinning nature away from the Missouri River into this area. These relations are well known, and need not be repeated here. Handy (1976) estimated the maximum distance of significant loess deposition for the upper Midwest to be about 160 miles. This would seem to rule out any major influence from the Missouri Valley in western Iowa as a source for loess in southeastern Iowa.

Previous studies in this part of the state have led some investigators to consider other source areas for the loess deposits.

A general thinning relationship away from the "Iowan" drift border toward the southeast has been noted. In fact, the "Iowan" area has generally been considered as the significant loess source in eastern Iowa. This is a direct result of the attention given to the "marginal relationship of the loess to the Iowan drift". However, the Iowan drift does not exist and recent work has shown that much circular reasoning was involved in this hypothesis and that the Iowan erosion surface is not a significant source of loess either (Hallberg, et al., 1978). The possibility of multiple source areas has been suggested, with the Skunk and Des Moines River Valleys as options. It does strike us quite peculiar, that across the Mississippi River in Western Illinois the loess attains considerable thickness, and yet this valley has received little attention as a source of loess in Iowa. This is perhaps a result of the "prevailing" wind theory of loess deposition and the problem with state boundaries. After all, the silt didn't know it was Iowa, it walks where it walks, even backwards!

Consider the results of some thickness observations which have been made in the area, heading west away from the Mississippi River floodplain. The thickness measurements were made in Des Moines and Henry Counties. Graphically, these data show the familiar semilogarithmic trends displayed (figure L-1). This trend may be described mathematically by the expression:

$$Y = 149.7 - 38.2 \log X \qquad r = 0.92$$

where

Y = loess thickness (inches)

X = distance (miles)

The occurrence of loess deposits "upwind" from a source has been explained by a variable winds model of deposition (Handy 1976). More recently, the random-walk model (Lutenegger, 1979) predicts that this thickness should decrease more rapidly, and is expressed as log-log function. This does not appear to apply in this case, although it has been very difficult to obtain good observations near the Mississippi Valley. It should be noted that in most instances, one point of "extraordinary thickness" close to the source is enough to change the shape of the curve.

Figure L-1

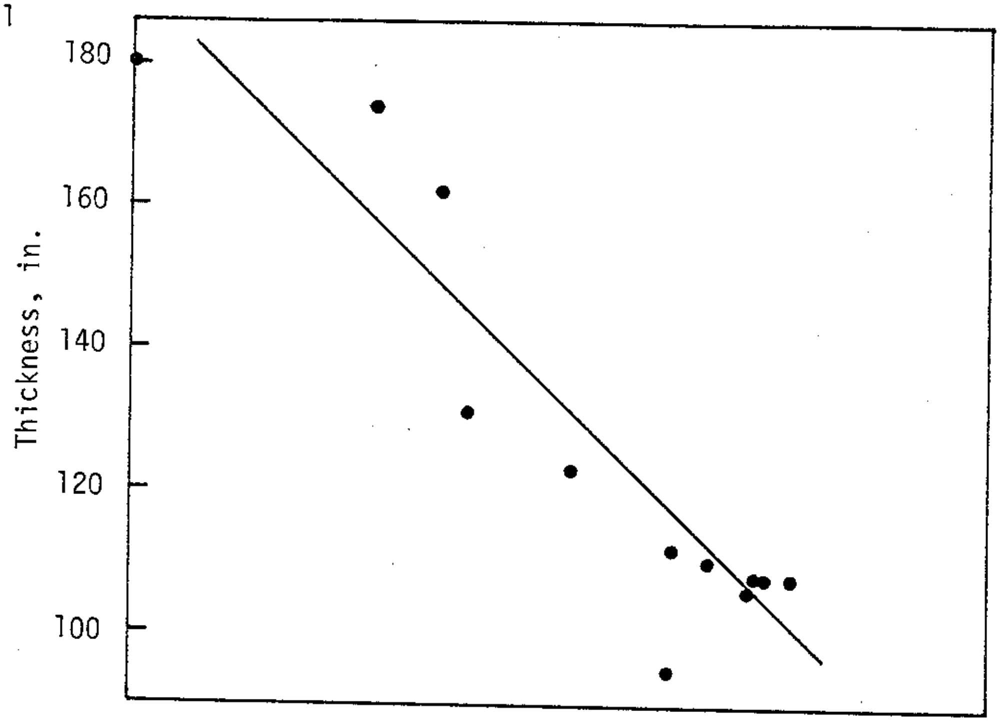
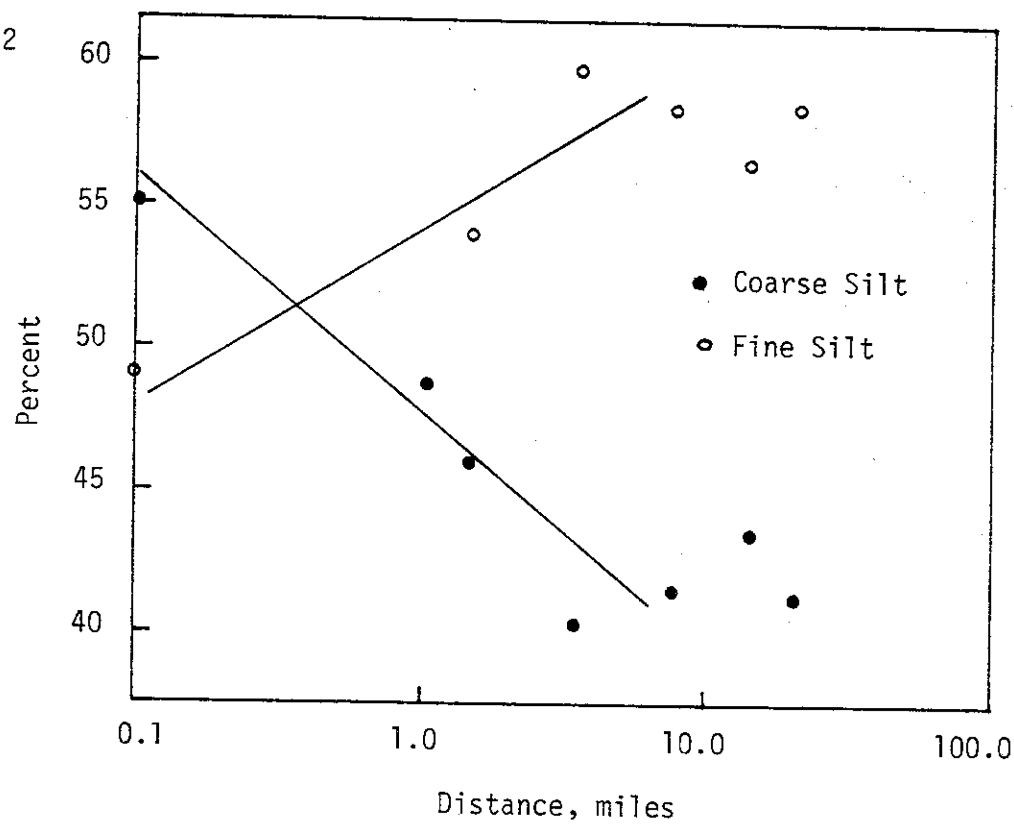


Figure L-2



The scatter of data points on the lower end of the curve is worthy of mention. All but one of the sites investigated were within the boundary of the Illinoian. The subjacent material in all but two of the borings was a till-derived paleosol, the other two sites being underlain by peat. Detailed drilling in this region has shown that the surface expression of the loess does reflect the underlying paleosurface, however numerous fluctuations in microrelief occur, resulting in loess thickness variations of up to 12 inches over a short distance. Even with such variation, the random-walk model predicts that at some distance from the source, a more or less uniform thickness of loess will be deposited. This applies to both "upwind" and "downwind" situations.

We may summarize these thickness observations by saying that in general, there is a distinct relationship between the distance from the Mississippi River and the thickness of Wisconsin loess in Southeast Iowa. Secondary sources, such as the Skunk and Des Moines Rivers, do not significantly influence the regional variation in loess thickness, however they do contribute to local deposits along their course. North of this area, and into east-central Iowa, the Iowa River was a major source of loess (Hallberg, et al., 1978).

Variations in texture of loess accompany variations in loess thickness and usually display a systematic relationship to distance from the source. A decrease in the coarse fraction coupled with an increase in the fine fractions are commonly observed. Where the loess is thin and unweathered material is not readily available in quantity for analysis, the percentages of silt, based on clay-free textural summary, can be used to illustrate this relation. The data shown in figure L-2, although obtained from only a limited number of sites document the changes that occur in the coarse and fine silt fractions.

Note that after a distance of about 5 miles (8.0 Km) these variations are considerably scattered, and assume a relatively constant value. This is similar to the more or less uniform thickness which was shown in figure L-1 at the same distance.

Radiocarbon dates at the base of the loess range from 18,500±520 (I-5848) in Lee County, to 24,900±570 (I-9357) in Des Moines County. These are well within the time frame obtained throughout Iowa for the basal Wisconsin increment of loess, and thus dates the beginning of loess deposition in the area.

Semi-quantitative x-ray analyses for clay mineralogy indicate that the predominant clay mineral is montmorillonite, with lesser amounts of illite and kaolinite and chlorite. Although some variations occur, typical values are about 66%, 25%, and 9% respectively. These results are similar to those obtained by others directly across the river in Illinois. The work on the loess in this area is continuing. Detailed mineralogic data are being collected to assess any change in source material, significant to the Mississippi river diversion.

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APPENDIX: Standard Weathering Zone Terminology, Symbols, and Abbreviations used (after Hallberg, Fenton, and Miller, 1978).

Loess

Standard symbols, terms, and their defined use for loess are:

First Symbol - color reference.

O - oxidized; 60% of matrix has hues of 2.5Y or redder, values and chromas of 3 or higher, and may have segregation of secondary iron compounds into mottles, tubules, or nodules.

D - deoxidized; 60% of matrix has hues of 10YR, 2.5Y, and/or 5Y, values of 5 and 6, and chromas of 1 or 2 with segregation of iron (ferric oxides) into tubules (pipestems) or nodules.

U - unoxidized; matrix has hues of 5Y, 5GY, 5BG, and 5G, values of 4, 5, or 6, and chromas of 1 or less (except 5Y 6/1 is deoxidized), with no segregation of iron into tubules or nodules. May include hues of N or values of 3 or less with the presence of zones with abundant organic matter; these are often described as organic bands.

Second Symbol - leached or unleached state.

U - unleached; primary carbonates present.

L - leached; no carbonates detectable (with dilute HCl).

L2 - leached; primary carbonates absent, secondary carbonates present.

Modifier Symbols - when used precedes first symbol.

M - mottled; refers to zones containing 20-50% contrasting mottles.

Examples: OL - oxidized, yellowish brown or strong brown matrix, and leached.

UU - unoxidized, dark greenish gray matrix and unleached.

MOL - mottled, oxidized - yellowish brown or strong brown matrix with gray mottles, leached.

MDU - mottled, deoxidized - grayish brown matrix with strong brown pipestems and strong brown mottles, unleached.

Till

Standard symbols, terms, and their defined use for till are:

First Symbol - color reference

0 - oxidized; 60% of matrix has hues redder than 2.5Y (ex. - 10YR, 7.5YR); hues of 2.5Y, with values of 5 or higher, but including 2.5Y 4/4; may have segregation of secondary compounds into mottles, tubules, or nodules, etc.

R - reduced; 60% of matrix has hues of 2.5Y, with values of 3 or less, hues of 2.5Y, with value of 4, with chromas of 2 or less; hues of 5Y, N, 5GY, 5G, 5BG, and 5G, values of 4 or higher (usually values in this zone are 5 or higher). Colors in this zone are nearly always mixed as weak mottles, diffuse blends of color, or as discrete bands. Discrete vertical bands of reduced colors may occur for some distance adjacent to joints. These bands may eventually grade into uniform unoxidized material. In this zone there may be considerable segregation of secondary iron compounds (with oxidized colors) into mottles, nodules, or sheets along cleavage planes, of joints.

U - unoxidized; matrix uniform; has hues of 5Y and N, values of 5 or less, 5GY, 5G, 5BG, 5G, with values of 6 or less; with no segregation of iron compounds into mottles, nodules, etc.

Second Symbol - if used

J - jointed, describes the presence of well-defined vertical joints in the till; joints often show oxidized and reduced colors, often have coatings or rinds of secondary iron-oxides; occasionally other secondary minerals such as calcite or gypsum.

Second or Third Symbol - leached or unleached state; same as for loess.

U - unleached.

L - leached.

L2 - leached of primary carbonates, but secondary carbonates present.

Modifier Symbols - when used precede first symbol, as with loess.

M - mottled; zones with 20-50% contrasting mottles; when used with the unoxidized zone designation it infers 20% or less mottles of reduced colors.

Examples: JRU-jointed reduced unleached-mixed olive (5Y4/4 and 5Y4/3) and very dark grayish brown (2.5Y 3/2), with common gray (5Y5/1) and light olive brown (2.5Y 5/4) mottles; prominent vertical joints, with 1 cm strong brown (7.5YR5/8) segregations along the joint; unleached.

JUU - jointed, unoxidized, unleached-uniform dark greenish gray (5GY4/1) matrix, with few thin vertical joints, which have mottled light olive brown (2.5Y 5/6) and olive gray (5Y 5/2) faces, and a 3 cm rind of greenish gray (5GY 5/1); unleached.

MUL - mottled, unoxidized, leached - dark greenish gray (5GY 4/1) matrix with few, small gray (5Y 5/1) mottles; leached.

Other Materials

Other materials, such as alluvium, lacustrine sediments, etc., can also be described by these terms. Dependent upon the texture and density of these materials the terms for loess or till may be more appropriate.