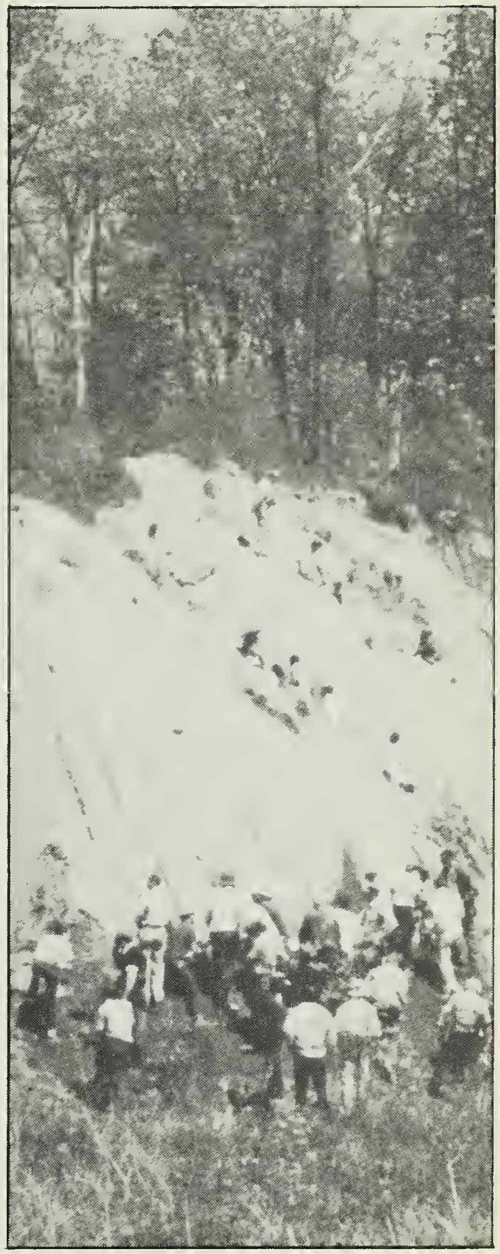
MIDWEST FRIENDS OF THE PLEISTOCENE 26th FIELD CONFERENCE
May 4-6, 1979

Wisconsinan, Sangamonian, and Illinoian stratigraphy in central Illinois



LEADERS:

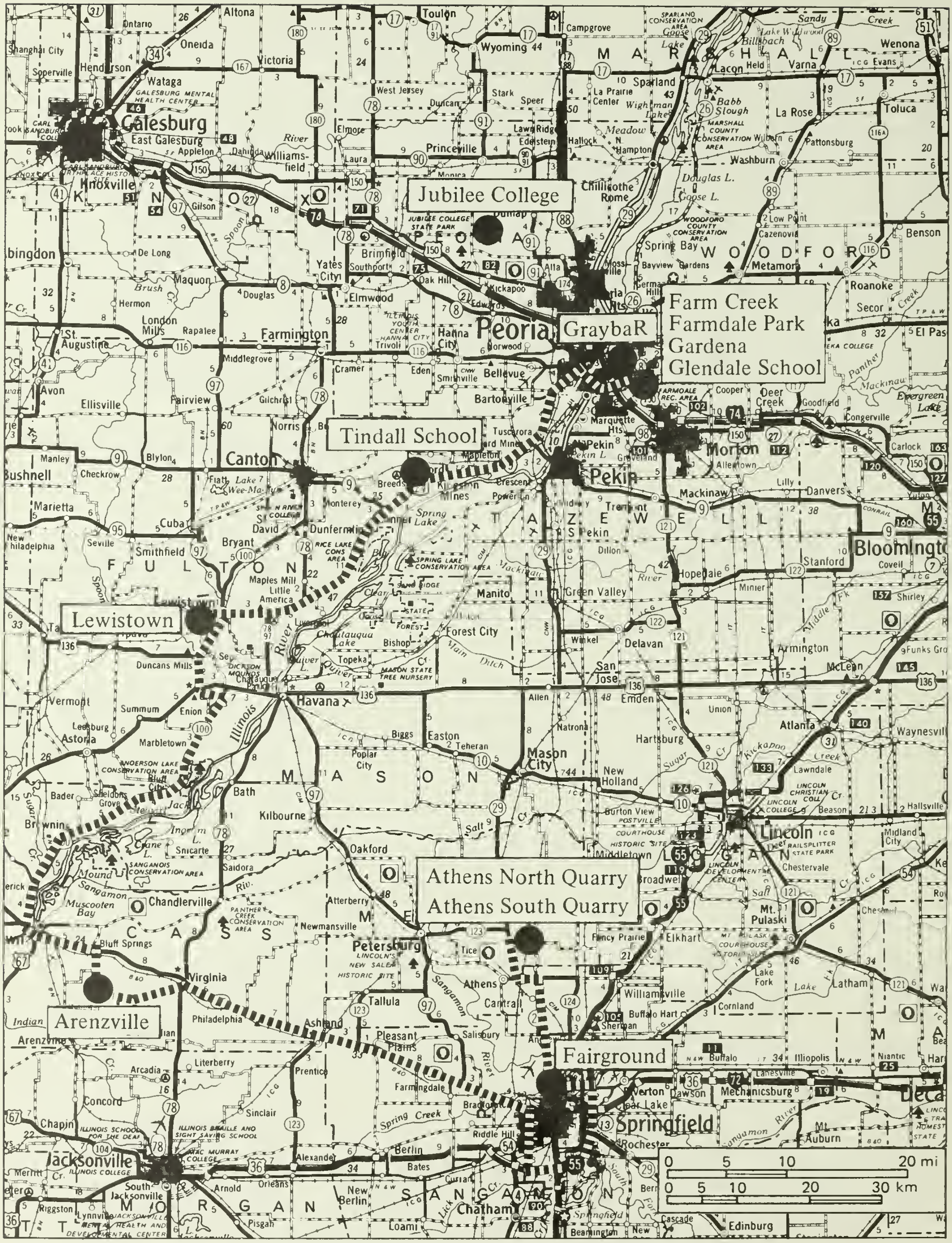
Leon R. Follmer
E. Donald McKay
Jerry A. Lineback
David L. Gross

CONTRIBUTIONS BY:

Jerry A. Lineback
Leon R. Follmer
H. B. Willman
E. Donald McKay
James E. King
Frances B. King
Norton G. Miller

Sponsored by:
Illinois State Geological Survey, Urbana, Illinois, and
Department of Geology, University of Illinois at Urbana-Champaign

ILLINOIS STATE GEOLOGICAL SURVEY
GUIDEBOOK 13



LOCATIONS OF GEOLOGIC SECTIONS
AND FIELD TRIP ROUTE

Wisconsinan, Sangamonian, and Illinoian stratigraphy in central Illinois

contents

Midwest Friends of the Pleistocene Field Conference, 26th, 1979.
Wisconsinan, Sangamonian, and Illinoian stratigraphy in central Illinois : Midwest Friends of the Pleistocene 26th Field Conference, May 4-6, 1979 / contributions by Jerry A. Lineback . . . et al.; sponsored by Illinois State Geological Survey, Urbana, Illinois, and Department of Geology, University of Illinois at Urbana-Champaign. – Urbana : The Survey, 1979.

140p. : ill. ; 28cm. – (Guidebook - Illinois. State Geological Survey ; 13)
Bibliography: p. 135-139.

1. Geology, Stratigraphic–Quaternary–Guide-books. 2. Geology–Illinois–Guide-books. I. Lineback, Jerry A. II. Illinois. State Geological Survey. III. Illinois. University at Urbana-Champaign. Dept. of Geology. IV. Title. V. Series: Illinois. State Geological Survey. Guidebook ; 13.

Dedicated to

Harold Bowen Willman

in recognition of outstanding contributions

to knowledge of Pleistocene geology, and

in appreciation for more than a half century

of service to the geological profession

and for loyalty as a Friend.

Midwest Friends of the Pleistocene
May 5, 1979

ACKNOWLEDGMENTS

A considerable amount of knowledge of the Pleistocene geology of Illinois has been achieved through the work of H. B. Willman, J. C. Frye, H. D. Glass, and many others on the staff of the Illinois State Geological Survey. Although significant milestones of understanding of the Pleistocene have been accomplished in their work, they have encouraged the leaders of this conference to pursue further studies to develop a greater understanding of the glacial history of Illinois.

During the preparation for this conference, the tour leaders received cooperation and assistance from many landowners and organizations. We want to extend our appreciation to James Hildebrand, Superintendent of Farmdale Park, Tazewell County; Dillard Royer; Lewistown City Council; Warren Stock; Charles Dunseth; Loren Hopwood; Daniel Roadruck and Walter Ginn, Western Materials Company, Medusa Aggregates; Jack Brown, Superintendent of Indian Point Quarry, Material Service Corporation; and the Illinois State Museum.

The tour leaders greatly appreciate the support from the Department of Geology, University of Illinois, for cosponsoring the conference and for assistance from the staff and graduate students. Many staff members at the Illinois State Geological Survey assisted in the conference. Clay minerals were analyzed by H. D. Glass. Grain size analyses were made by Rebecca Bianchini and Holly Radis. Radiocarbon age determinations were made by Jack Liu. Inez Kettles assisted in the carbonate mineral analyses. Assisting in conducting the field conference were R. C. Berg, C. S. Hunt, M. M. Killey, J. T. Wickham, S. S. Wickham, P. C. Reed, J. M. Masters, T. M. Johnson, D. E. Lindorff, H. J. H. Harris, P. V. Heinrich, G. M. Fleeger, and W. H. Johnson.

Interpretations were discussed with H. B. Willman, H. D. Glass, J. P. Kempton, J. T. Wickham, and W. H. Johnson, who made many valuable comments. Editing, drafting, and design work was done by Joyce Tikalsky and Nancy Stark. Dorothy Huffman prepared the registration materials and Debra Kaufman typed the manuscript.

INTRODUCTION

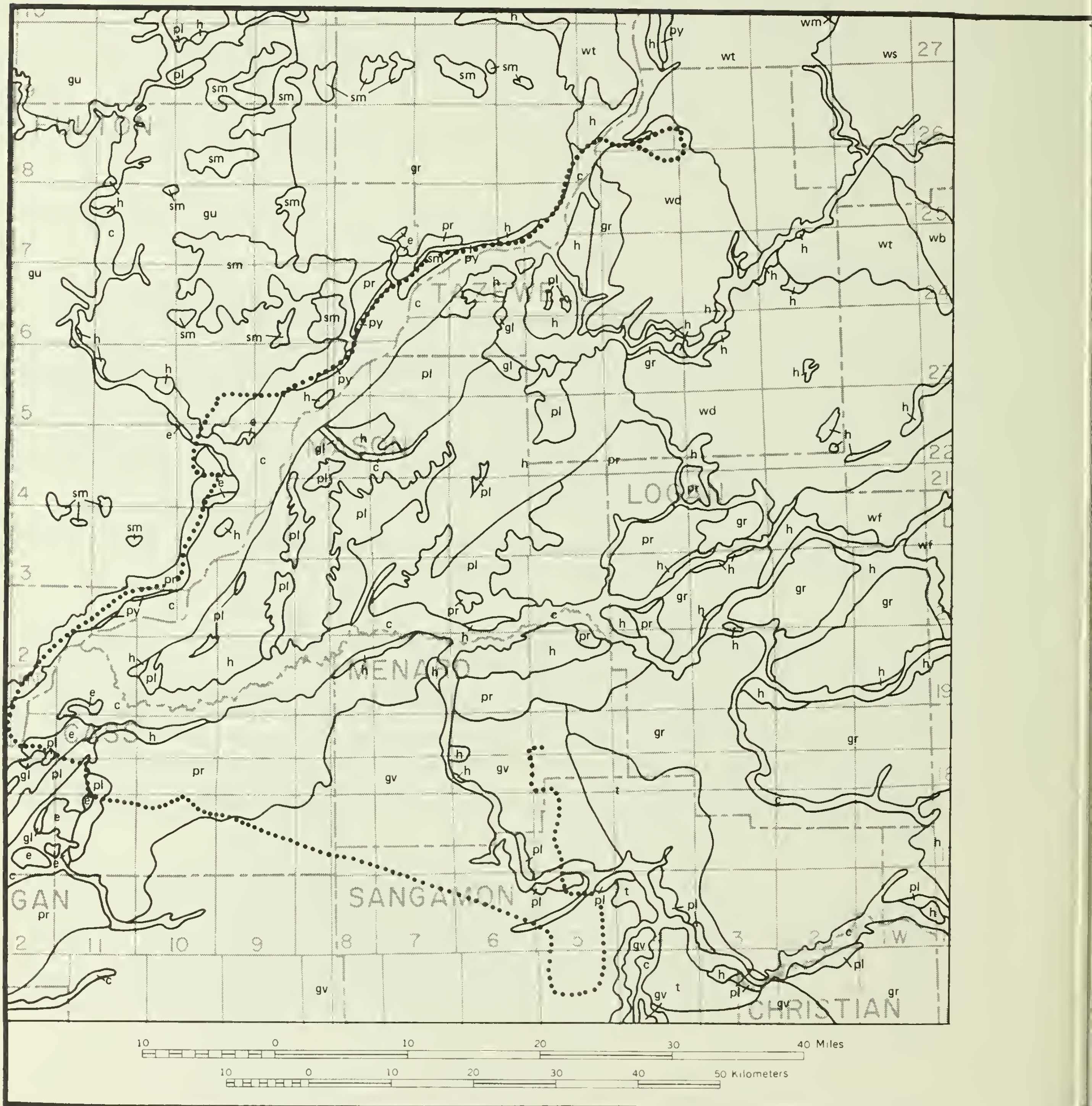
The purpose of this field conference is (1) to reexamine the classic Farm Creek Section, which has been studied by geologists for nearly 90 years and has been used by many workers as a type or reference section for several rock-, time-, and soil-stratigraphic classifications of the Quaternary, (2) to examine details of the development of the Sangamon Soil under varying environmental conditions in its type region, (3) to consider some details of stratigraphic and compositional variations in the Wisconsinan loesses and their relation to Wisconsinan glaciation in Illinois, and (4) to outline some new ideas on the stratigraphy and duration of the Illinoian Stage in Illinois. The papers and interpretations of geologic sections in this guidebook represent a report on the status and development of these continuing investigations.

The Peoria-Springfield, Illinois, region has been trodden by many well-known Quaternary geologists during the last century. Worthen, Leverett, Leighton, MacClintock, Horberg, Willman, and Frye, to name but a few, used sections in the region to develop concepts of Quaternary stratigraphy, yet much remains to be done. Recently developed ideas on basic classification of the Quaternary, on correlation of climatic changes with the marine record, on soil development in the geologic past, and on interpretation of proglacial loess deposits are based on studies in this classical region and will be examined during the field conference.

The papers included in the guidebook contribute to an understanding of the geology of the Peoria-Springfield region. Descriptions, discussions, and analytical data from several major geologic sections in the region, some of which will be visited during the field conference, are also presented. The remainder of the guidebook is intended as a reference to guide the reader in visiting sections that are still available. No road log is provided in the guidebook.

REGIONAL STRATIGRAPHY

Sheets of drift from the Illinoian and Wisconsinan Stages cover the Peoria-Springfield region (fig. 1). Older drift is found in places below the Illinoian. Statewide distribution of Quaternary deposits in Illinois has been mapped recently (Lineback, in press), and statewide stratigraphic nomenclature of the Quaternary (modified from Willman and Frye, 1970) is summarized on the inside back cover.



Time-, rock-, and soil-stratigraphic units used in the Peoria-Springfield region are summarized in figure 2. Nomenclature and time-stratigraphic relationships shown by figure 2 include recent tentative modifications that are discussed in the papers in this volume.

Two major preglacial valleys, the Ancient Mississippi and the Teays-Mahomet, meet in Mason County between Peoria and Springfield. These valleys have been filled by repeated glacial advances during the Quaternary. Drift

WISCONSINAN AND HOLOCENE

sm Surface mines—areas where Quaternary deposits and bedrock are mixed because of surface mining activity.
c Cahokia Alluvium—deposits in floodplains and channels of modern rivers and streams; mostly poorly sorted sand, silt, or clay; in many places overlies well-sorted glacial outwash of the Henry Formation.
py Peyton Colluvium—narrow deposits of largely unsorted debris accumulating on and at the base of steep slopes by creep and slope wash.
pl Parkland Sand—wind-blown sand, well-sorted medium-grained sand in dunes and thick sheets between dunes.
gl Grayslake Peat—peat, muck, and marl; dominantly organic deposits in lake basins on floodplains.

WISCONSINAN

e Equality Formation—largely slack-water lakes in major valleys and tributaries. Occurs mostly as terrace remanents of fine-grained materials.
h Henry Formation—sand and gravel, generally well sorted, glacial outwash in outwash plains, valley trains, terrace remanents of valley trains, and ice-contact deposits.
pr Peoria Loess and Roxana Silt combined—wind-blown silt more than 6 meters (20 ft) thick on uplands; local lenses of fine-grained sand.

Wedron Formation—mainly glacial till with some lenses and beds of sand, gravel, and silt.

ws Snider Till Member—mostly gray silty clay till.
wb, wm Batestown (east) and Malden (north) Till Members—gray silty till; oxidizes to olive brown.
wt, wd, wf Tiskilwa, Delavan, and Fairgrange Till Members—pink, pinkish-gray, gray, brown, and reddish-brown silty to sandy till.

ILLINOIAN

t Teneriffe Silt—mostly silt and clayey silt with beds of sand or clay deposited in proglacial lakes associated with several Illinoian glaciers.

Glasford Formation—mostly glacial till with lenses and beds of sand, silt, and gravel.

gr Radnor Till Member—gray silty till.
gv Vandalia Till Member—gray sandy till.
gu Glasford Formation undifferentiated—several sandy or silty tills in western Illinois underlying the Radnor; mostly the Hulick Till Member.

.••• Field trip route

Figure 1. Quaternary deposits of the Peoria-Springfield region, Illinois. (Simplified from Lineback, in press.)

exceeds 130 m in parts of the valley system and thins to 15 m or less in places on the uplands west of the present Illinois River Valley and south of the Sangamon River.

Various Illinoian glaciers advanced across the entire area. The late Wisconsinan glaciers advanced into the northeastern part of the region, crossing the Illinois River at Peoria. Extensive surficial deposits of glacial outwash and slack-water lake deposits resulting from the late Wisconsinan gla-

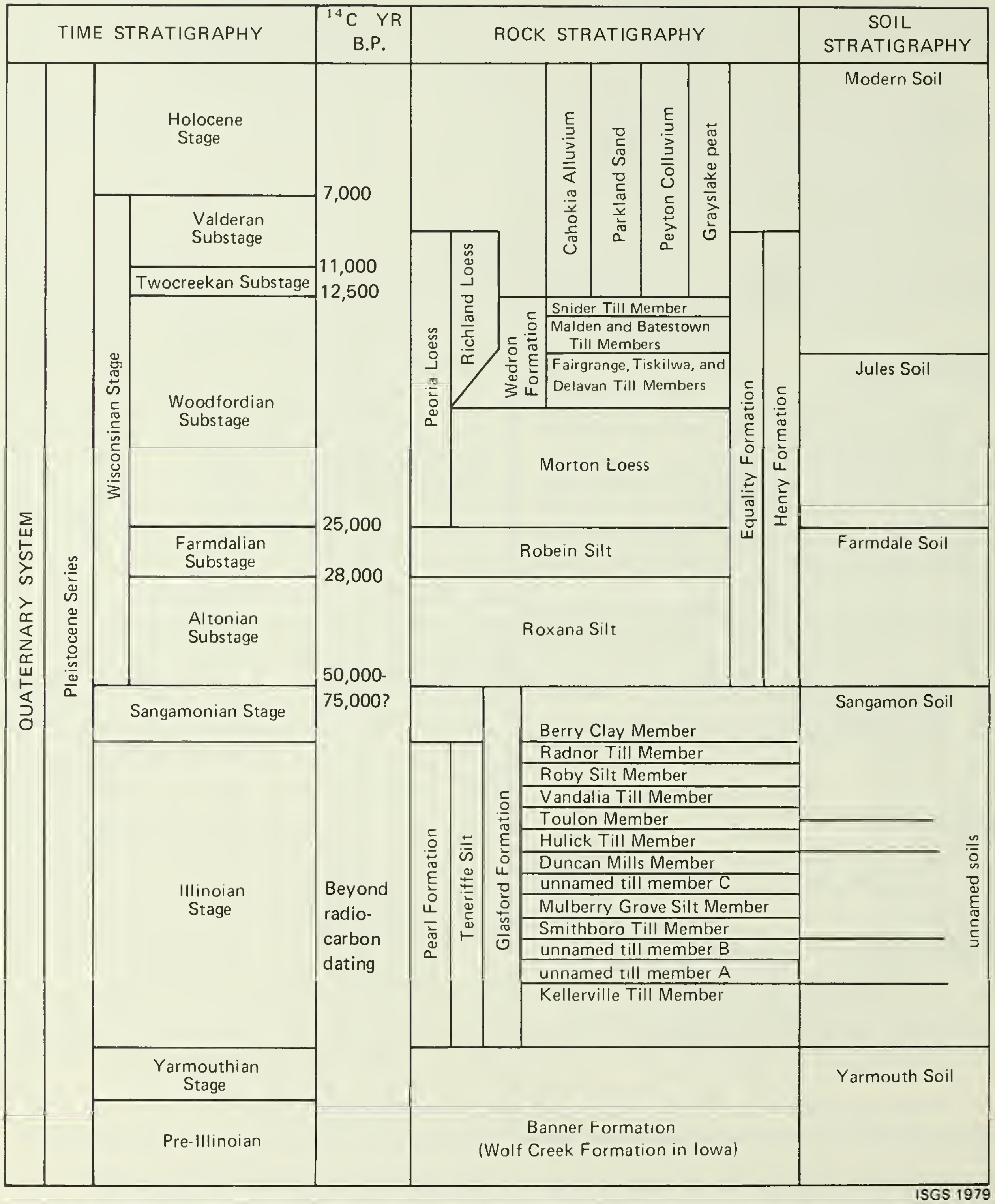


Figure 2. Time-stratigraphic, rock-stratigraphic, and soil-stratigraphic units and absolute dating of the Quaternary deposits in the Peoria-Springfield area. The nomenclature is that used in this guidebook.

ciation are found in the Illinois River and tributary valleys. Uplands were covered by thick deposits of Wisconsinan loess, and extensive areas of sand dunes developed on the valley-train deposits (fig. 1).

Pre-Illinoian drift

Pre-Illinoian drift is present in places below the Illinoian, but little is known of pre-Illinoian drift in the Peoria-Springfield area because of its limited exposure. Some drift previously thought to be pre-Illinoian may be better included in the Illinoian (Lineback, p. 69-78 of this guidebook). Where present, the pre-Illinoian drift is included in the Banner Formation (fig. 2). The Banner probably includes several till sheets of differing lithology and intercalated sand, gravel, silt, and clay deposits. Paleosols may be present within the pre-Illinoian succession, and in many places it is capped by an often truncated, but well-developed, paleosol, the Yarmouth Soil.

Illinoian drift

The youngest known Illinoian glaciation, presumably represented by the Radnor Till Member of the Glasford Formation (fig. 2), advanced only a few kilometers farther than the later Wisconsinan glaciers. The upland beyond the Radnor in the Springfield area is underlain by the older Vandalia Till Member of the Glasford Formation. The Vandalia apparently did not extend west of the Illinois Valley where the Radnor west of Peoria overlies the Hulick Till Member. The Hulick and older Illinoian tills are undifferentiated in figure 1, but a tentative map of their distribution in western Illinois and a description of their composition is given by Lineback (p. 69-78). An extensive late Illinoian proglacial lake existed near Springfield during the Radnor advance (Bergstrom, Piskin, and Follmer, 1976). Deposits of this lake are included in the Teneriffe Silt (fig. 2). Outwash deposits of the Pearl Formation were not mapped.

The Illinoian drift contains several significant unnamed paleosols (Lineback, p. 69-78) and is capped by the Sangamon Soil (fig. 2). The details of the Sangamon Soil are discussed by Follmer (p. 79-91 of this guidebook).

Wisconsinan drift

Tills of the Altonian Substage of the Wisconsinan are known only from northern Illinois; however, meltwater and valley-train deposits from these glaciers extended southward down the Ancient Mississippi Valley, and loess blown from the outwash was deposited on the uplands (Roxana Silt). Regionally, the Roxana, most of which was deposited between about 45,000 and 30,000 years B.P., can be divided into several mineralogical zones and related to Altonian glacial events (McKay, p. 95-108 of this guidebook).

The Robein Silt is commonly organic rich and lies between the Roxana Silt and the Morton or Peoria Loesses in many places. The weakly developed Farmdale Soil formed in the Robein or in the Roxana during the Farmdalian Substage, a minor interstadial in Illinois.

Woodfordian glaciers reached the Peoria area about 19,000 ^{14}C years B.P. Till and intercalated deposits of the Woodfordian Substage are included in the Wedron Formation. The basal Wedron till overlies a proglacial loess, the

Morton Loess, that correlates with the lower part of the Peoria beyond the Wisconsinan glacial limit. An age of 25,000 ^{14}C years B.P. for the base of the Morton Loess indicates that glaciers reentered the Ancient Mississippi drainage basin 6,000 years before they reached the Peoria area. The basal Wedron tills are generally reddish gray, violet gray, reddish brown, brown, or gray, depending on composition and degree of oxidization. The till is generally sandy, relatively high in illite, and dolomitic. Three regional names have been applied to the basal Wedron: the Fairgrange Till Member in east-central Illinois, the Delavan Till Member in the area east and south of Peoria, and the Tiskilwa Till Member east and north of Peoria and in the area west of the Illinois River. In the East Peoria area, the name Delavan has been used at Farm Creek, Farmdale Park, Gardena, and Glendale School. The GraybaR Section is in the area mapped as Tiskilwa (fig. 1), but the till at the base of the Woodfordian succession at that section is indistinguishable from the Delavan at the other sections. The Tiskilwa has been mapped to the front of the Bloomington Morainic System (Willman and Frye, 1970) and may represent an additional increment of the same kind of till on top of the Delavan. In any case, there are few data to allow separation of the Delavan from the Tiskilwa or Fairgrange in the region. East of Peoria, in Woodford and McLean Counties, younger Woodfordian tills are present. The Malden and Batestown Till Members are representatives of a group of gray, silty tills and are in turn overlain and in places overridden by clay-rich till of the Snider Till Member.

With the advance of the Woodfordian glaciers, large volumes of meltwater were channeled into the Illinois River Valley. A large area of outwash (Henry Formation) was deposited in a lowland where the two bedrock valleys join. A complex series of terraces now lie above the present floodplains. Farther downstream, and up tributary valleys, lacustrine deposits were formed in backwater lakes (Equality Formation). Eolian deposition of fine sand took place on these valley-train deposits during the waning stages of glaciation and formed a complex system of sand dunes (Parkland Sand). Finer sediment was blown onto the uplands from the valley-train deposits forming the Peoria and Richland Loesses. Peat and organic-rich sediment was deposited in lakes that formed on the floodplains (Grayslake Peat) as the modern floodplain developed through the deposition of the Cahokia Alluvium. The Peyton Colluvium (fig. 1) is largely unsorted debris that accumulated on and at the base of steep slopes by creep and slope wash.

Quaternary deposits in large areas of western Illinois have been disturbed and mixed with bedrock during surface mining for coal (fig. 1).

LABORATORY DATA AND TECHNIQUES

Many glacial tills, loesses, and other deposits are similar in appearance, and, in certain field situations, definite stratigraphic identification is difficult; however, many of these units have one or more distinctive characteristics in texture or composition that can be determined in the laboratory and can then be used with other data for stratigraphic interpretation (table 1). Laboratory data are also essential in the evaluation of buried soils and in sedimentology. These data are summarized in appendix 1 and in the discussion of the stratigraphic sections.

TABLE 1. Analytical techniques used in the study of Quaternary deposits in the Peoria-Springfield region, Illinois.

Analysis	Technique	Remarks	Analyst(s)
General distribution of grain sizes	Sieve and hydrometer	Sand: 0.062-2.0 mm Silt: 0.004-0.062 mm Clay: <0.004 mm	P. B. DuMontelle, W. A. White, and assistants
Distribution of grain sizes in loess and soil profiles	Sieve and pipette	Sand: 0.062-2.0 mm Coarse silt: 0.031-0.062 mm Medium silt: 0.016-0.031 mm Fine silt: 0.008-0.016 mm Very fine silt: 0.002-0.008 mm Clay: <0.002 mm	P. B. DuMontelle, W. A. White, and assistants
Clay minerals	X-ray diffraction of oriented aggregates	Clay fraction <0.002 mm	H. D. Glass
Carbonate minerals (calcite and dolomite)	Chittick apparatus	After Dreimanis (1962) %<0.074 mm	J. A. Lineback, E. D. McKay, and others
Radiocarbon dating	Benzene liquid scintillation counting		D. D. Coleman
Pollen	HCl, HF, KOH, silicone oil	Relative pollen frequency	J. E. King, Illinois State Museum

DESCRIPTIONS OF SECTIONS

Farm Creek Section

STOP

1

The Farm Creek Section (fig. 3) is a classic Pleistocene exposure that has been studied by geologists for nearly 90 years. The section has been used by many workers as a type or reference section for several different rock-, time-, and soil-stratigraphic units (see McKay, p. 95-108 of this guidebook). It remains well exposed, and recent work has reaffirmed the importance of the exposure to stratigraphic studies.

Pleistocene Stratigraphy of Illinois by Willman and Frye (1970) is the last major work to include a description of the Farm Creek Section. The description of the Farm Creek Exposure, a key part of the work, is reproduced on page 10. In the 1970 classification, Willman and Frye designated Farm Creek as the type section for the Farmdalian Substage, Robein Silt, and Farmdale Soil. Recent stratigraphic studies have suggested that careful reexamination of these units is necessary for a more complete understanding of their stratigraphic importance.

To characterize fully the units exposed at Farm Creek, six vertical profiles were described and sampled (figs. 4, 5, and 6; apps. 1 and 2). Profiles B and E were sampled for pollen analysis (J. King, p. 109-113 of this guidebook), and two radiocarbon dates were run on the Robein Silt from profile B.

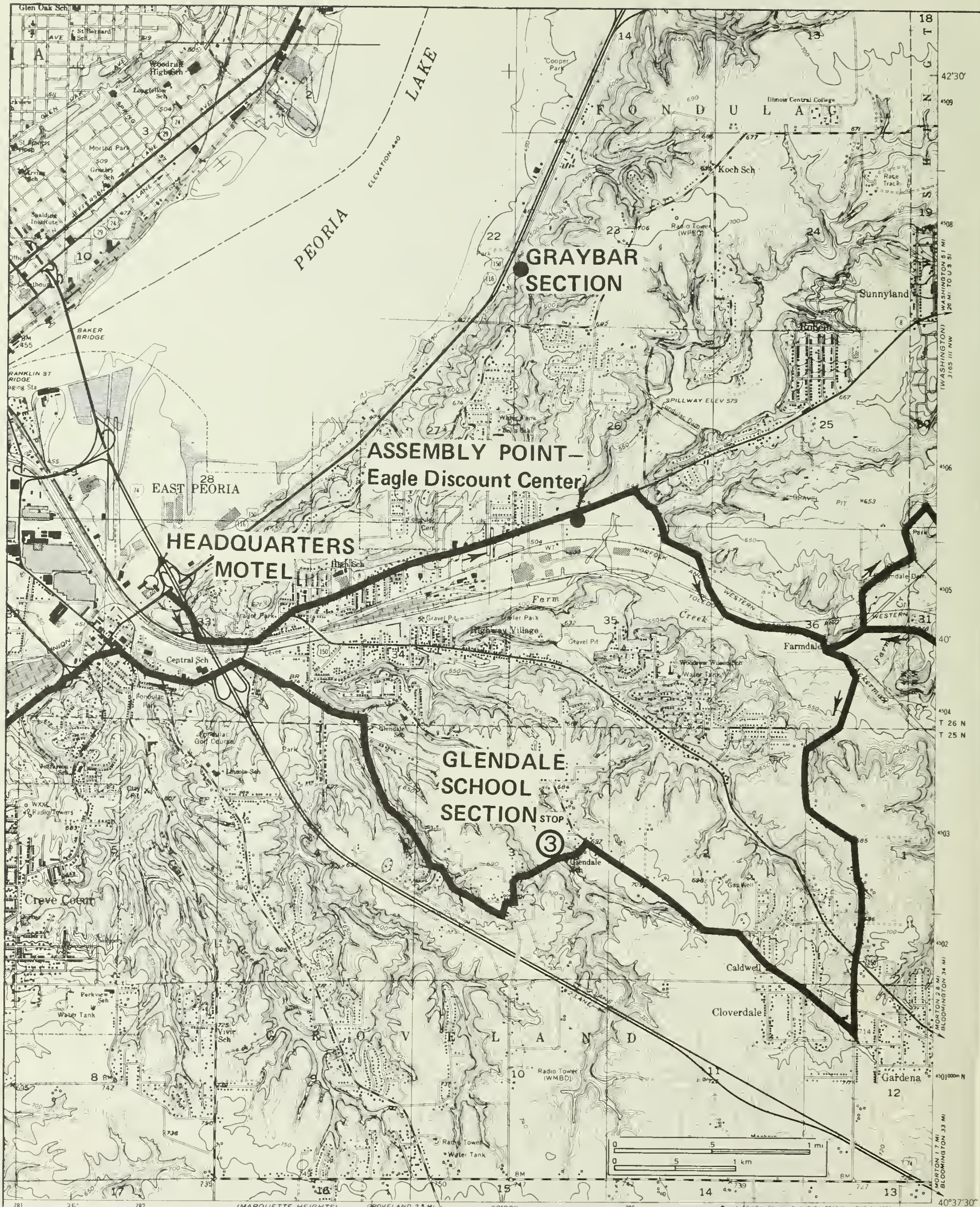
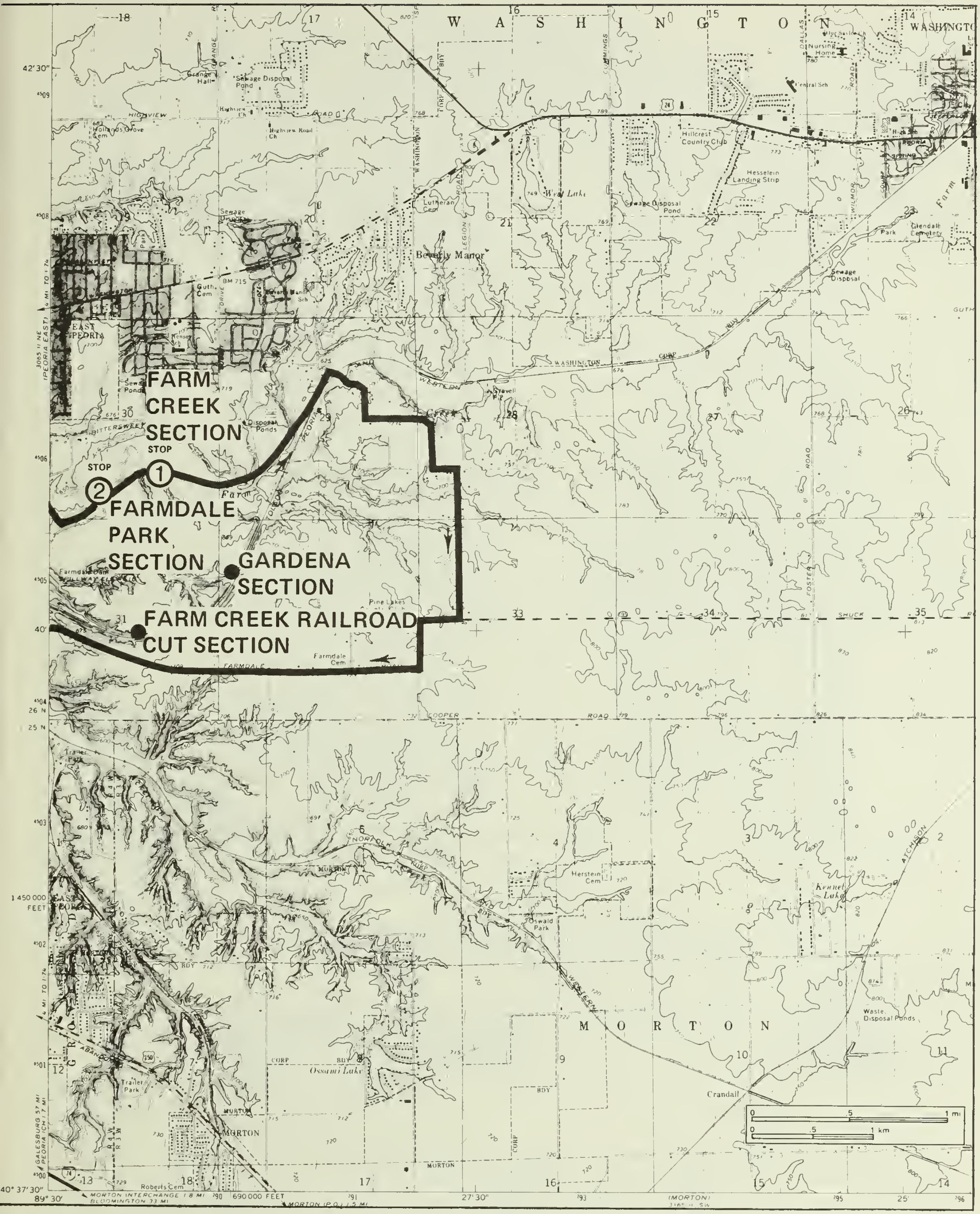


Figure 3. Locations of the Farm Creek, Farmdale, GraybaR, Gardena, Farm Creek Railroad Cut, and Glendale School Sections.


WASHINGTON
FARM CREEK SECTION
STOP
1
STOP
2
FARMDALE PARK SECTION
GARDENA SECTION
FARM CREEK RAILROAD CUT SECTION
EAST PEORIA
MORTON
Crandall
0 .5 1 mi
0 .5 1 km

FARM CREEK SECTION

Described by Leverett, 1899a; Leighton, 1926b, p. 5; 1931. Measured in creek bank exposure in NE SW SE Sec. 30, T. 26 N., R. 3 W., Tazewell County, Illinois, 1959, 1962.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Richland Loess	
11. Loess, gray to tan-brown, leached but locally weakly calcareous in basal part, massive; Modern Soil in top; sharp contact on calcareous till at base	6.0
Wedron Formation	
Delavan Till Member	
Shelbyville Drift	
10. Till, calcareous, gray to blue-gray, compact, massive (P-1487 base)	30.0
Morton Loess	
9. Loess, calcareous, gray to gray-tan, tough, compact, massive; contains dispersed fossil snail shells, generally crushed and fragmented; at a few places a thin zone of organic material, including moss, at upper contact, radiocarbon dated 20,340 ± 750 (W-349); wood from 6 inches below top dated 20,700 ± 650 (W-399) (P-1486 to P-1481 from top downward)	6.0
Farmdalian Substage (type section)	
Robein Silt (type section)	
8. Silt, leached, organic-rich with flakes of charcoal, brown, compact, tough; indistinct bedding or lamination in upper part, grading downward to massive silt; Farmdale Soil (type section) (radiocarbon dates of 22,900 ± 900 (W-68) from upper 1 foot; 25,100 ± 800 (W-69) from 3 to 4 feet below top) (P-1480 to P-1477 from top downward)	4.5
Altonian Substage	
Roxana Silt	
7. Silt, sandy, massive, compact, gray with some streaks and mottles of tan and rusty brown; contains dispersed small pebbles, more abundant in lower part (P-1476 to P-1474 from top downward)	3.5
Illinoian Stage	
Jubileean Substage	
Glasford Formation	
Radnor Till Member	
6. Till, leached, brown with some streaks and splotches of red-brown, tough, clayey; Sangamon Soil; B_2-zone of soil thinner than typical for Sangamon Soil of the region (P-1473 top; P-482B 2.5 feet below top; P-482A 5.5 feet below top)	6.0
5. Till, calcareous, blue-gray, massive, pebbly, compact (P-1472 base)...	8.5
Toulon Member	
4. Sand, medium, calcareous, yellow-brown, loose	0.5
3. Silt, calcareous, laminated, gray, continuous throughout exposure (P-1471)	0.5
2. Sand, fine gravel, and some silt, calcareous, brown	0.5
Monican Substage	
Glasford Formation (continued)	
Hulick Till Member	
1. Till, calcareous, blue-gray, pebbly, bouldery, massive, compact; at top a zone 1 foot thick is reddish brown to purple directly below the overlying sand and gravel but does not show soil characteristics (P-1470 2 feet below top)	25.0
Total	91.0

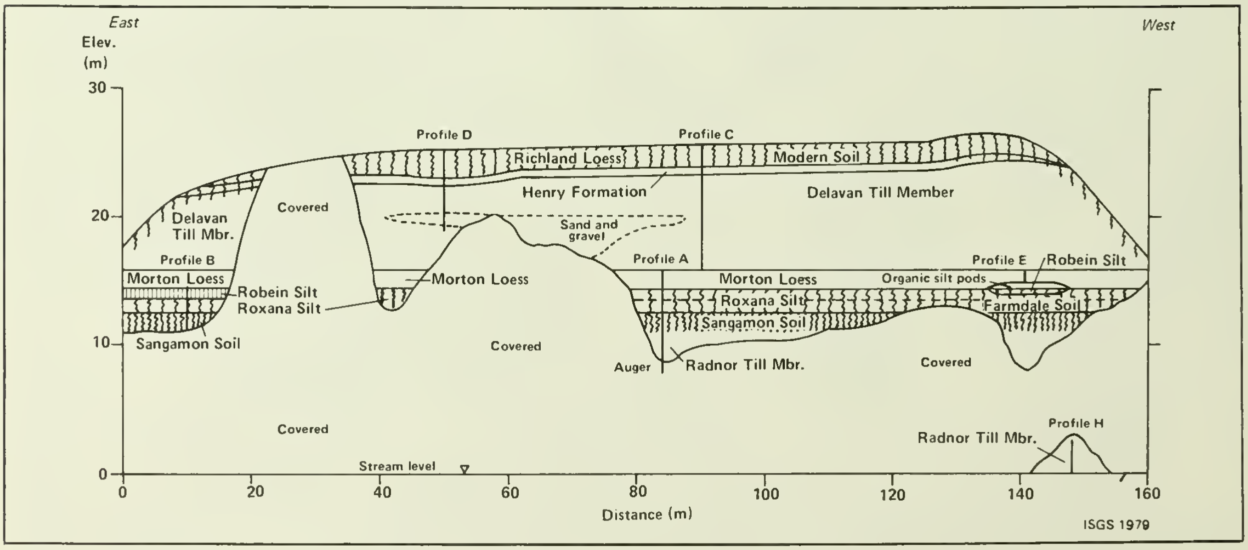


Figure 4. Diagram of the Farm Creek Section. Datum point is stream level.

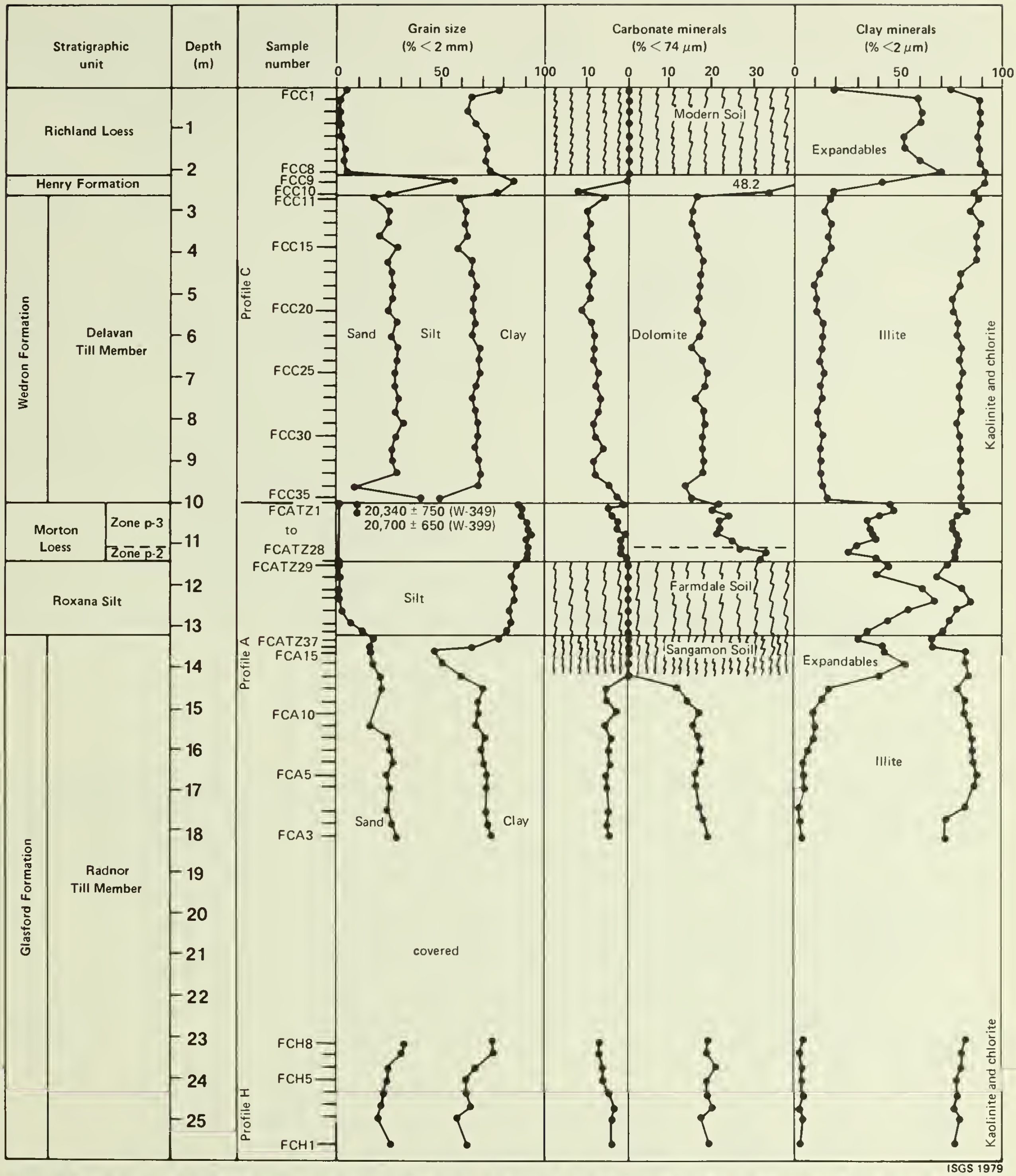


Figure 5. Grain sizes, carbonate-mineral content, and clay mineralogy of profiles A, C, and H of the Farm Creek Section.

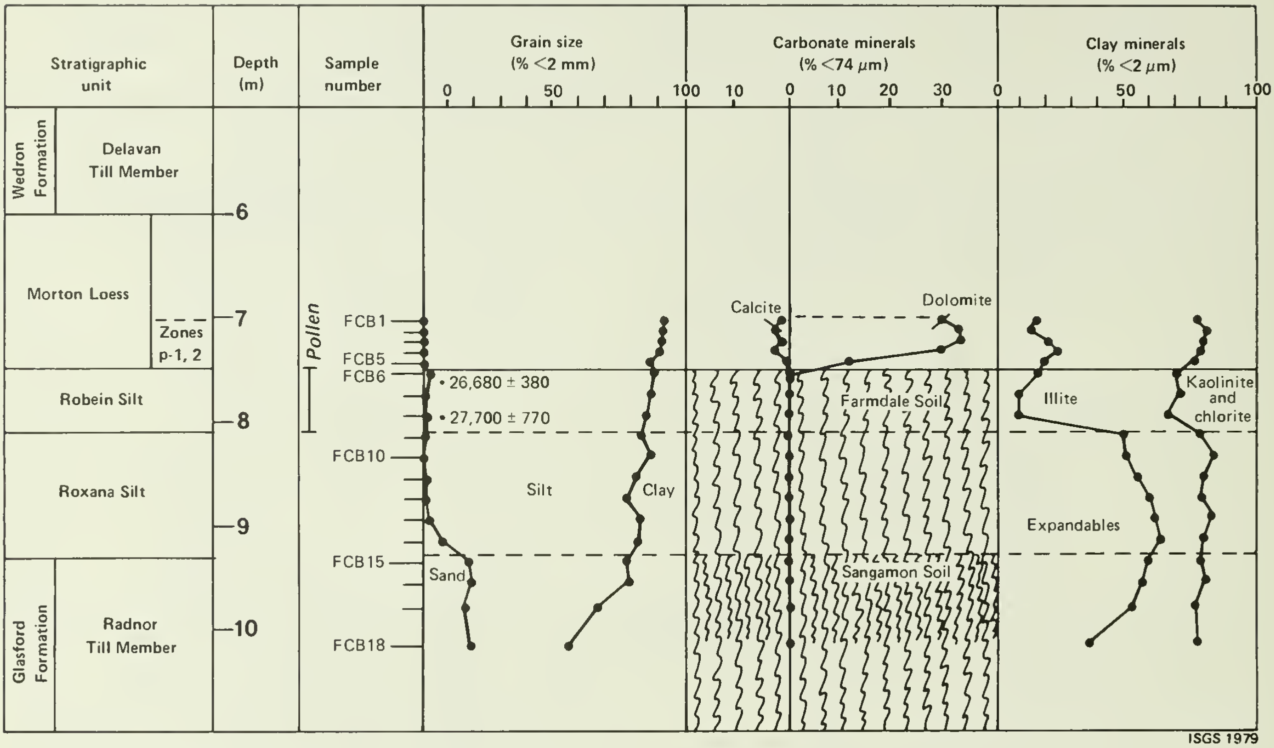


Figure 6. Grain sizes, carbonate-mineral content, and clay mineralogy of profile B of the Farm Creek Section.

Farm Creek Section: Profiles A and C

Section measured near the middle of the classic exposure on the south side of Farm Creek in the NE SW SE Sec. 30, T. 26 N., R. 3 W., Washington 7½-minute Quadrangle, Tazewell County.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Richland Loess — *Modern Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
B and C1	0 to 2.06	FCC1 to FCC8	Loess; leached, weathered, yellowish-brown (10YR 5/4) silty clay loam; moderate subangular blocky; overlain by silty A horizon to east; Typic Hapludalf soil profile......	2.06

Henry Formation

Horizon	Depth (m)	Sample no.		Thickness (m)
Beta and C2	2.30 2.60	FCC9 FCC10	Outwash; dolomitic, gravel, sandy, common cobbles, some rotten; reddish brown (9YR 4/6); upper 20 cm is grayish red (10R 4/2) beta horizon with many thick reddish argillans; somewhat coherent....................	0.60

Horizon	Depth (m)	Sample no.		Thickness (m)
			Wedron Formation *Delavan Till Member*	
C2 and C3	2.70 to 10.00	FCC11 to FCC35	Till; calcareous, loam, common pebbles, few cobbles; upper zone, 2.7 to 4.0 m, reddish brown (5YR 4/4), fine blocky, crumbly (exposure effect); zone 2, 4.0 to 5.0 m, mottled grayish brown (10YR 4/2), coarse blocky; zone 3, 5.0 to 6.0 m, reddish gray (5R 5/2); zone 4, 6.0 to 8.6 m, more gray than above, more gravel at 6.0 to 6.3 m; lower zone, 8.6 to 10.0 m, more brown (10YR 4/2) than above, more sand, fissile (coarse, platy in exposure....................................	7.34
			Morton Loess	
C2	10.05 to 11.40	FCATZ1 to FCATZ28	Loess; dolomitic, brown to olive-brown (10YR-2.5Y 4/3-4.4)(2.5Y 7/2-7/3, dry) silt loam, few 5/6 mottles; traces of brown organic staining, rare fragments of carbonized material; rare small iron-encrusted tubes; few reddish joint stains; few snail shells; rare secondary carbonates; massive, breaks into plates; compact, somewhat friable. Sampled at 5-cm intervals..................	1.4
			Altonian Substage *Roxana Silt* — *Farmdale Soil*	
C/A	11.46 to 13.10	FCATZ29 to FCATZ35	Loess; leached, dark-brown (10YR 3/3)(upper part) and dark grayish-brown (2Y 4/2)(lower part) silt loam, sand increases downward in lower part, few 5/8 mottles; degraded charcoal (manganese replacement) common in places; granular to massive, weak aggregation, largely healed; bleached silt masses in upper part; firm; very gradual lower boundary................................	1.65
			Illinoian Stage *Glasford Formation* *Radnor Till Member* — *Sangamon Soil*	
C/A	13.30	FCATZ36 FCA17	Till; leached, grayish-brown (2Y 4.5/2) loam, low sand, rare pebbles, common 5YR 5/8 stains (exposure effect); massive, no recognizable aggregation; few degraded charcoal-carbonized wood; firm............	0.25

Horizon	Depth (m)	Sample No.		Thickness (m)
B1	13.50	FCATZ37 FCA16	Till; leached, grayish-brown (2Y 4.5/2) clay loam, low sand, rare pebbles, common 5YR 5/8 stains; nearly massive, weak aggregation, healed blocky; few 3/2 argillans outlining peds; bleached ped interiors, firm, somewhat plastic....................	0.20
B2tg	13.60 13.90	FCA15 FCA14	Till; leached; olive-brown (2Y 4/4 upper) and greenish-gray (5GY 5/1 lower) clay, rare pebbles, common 10YR 5/8 (upper) and 5Y 4/4 (lower) mottles; many 5YR 5/8 stains (gley undergoing oxidation due to exposure); moderately fine angular blocky, strong aggregation, partly healed; few pores; many thick 3/1-3/2 and thin 4/1 argillans, some stained red, covering most peds; few slickensides; bleached ped interiors; firm, plastic when wet, hard when dry...........	0.45
B3g	14.20	FCA13	Till; leached; gray (5Y 5/1) clay loam, high clay, low sand, rare pebbles; rare 5/4 mottles, few 5YR 5/8 stains; weak blocky, largely healed; few pores; few thick 3/2 argillans; traces of carbonized roots; firm, plastic; clear lower boundary.............	0.30
C2	14.50 to 16.90 17.50	FCA12 to FCA4 FCA1	Till; calcareous, olive to light olive-brown (5Y-2.5Y 4/3-5/4) loam, common pebbles, few 5/8 mottles; few reddish stains (exposure-enhanced oxidation); few small manganese stains; few 5/8 concretions, few carbonate concretions; weak angular blocky to massive, common conchoidal fractures; few 3/2 argillans and secondary carbonates in upper 50 cm; traces of coal; firm when moist, hard and dense when dry. Base of exposure....................................	3.30
C4	17.80 18.10	FCA2 FCA3	Till; calcareous, dark-gray (5Y 4/1) loam, common pebbles, uniform, no mottles; massive, breaks with conchoidal fracture; dense, hard................................	≥0.50
			Total	18.10

Farm Creek Section: Profile B

Section measured in a fresh slump scarp exposure about 10 m east of the classic exposure in the NE SW SE Sec. 30, T. 26 N., R. 3 W., Washington Quadrangle, Tazewell County. Sampling starts in the Morton Loess about 15 meters above stream level.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Morton Loess

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	7.05 7.15 7.25 7.35 7.45	FCB1 FCB2 FCB3 FCB4 FCB5	Loess; dolomitic, olive-brown to light brownish-gray (10YR-2.5Y 4/4-5/3-6/2) silt loam, variegated (due to exposure), few 5/8 and 6/1 mottles; nearly massive, very weak platy, essentially no aggregation; few pores; few roots and other plant remains; traces of degraded charcoal and carbonized organic remains, intercalated organic remains at base; friable; samples from lower third, total Morton............	1.5

Farmdalian Substage
Robein Silt — *Farmdale Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
O2	7.55 7.75 7.95	FCB6 FCB7 FCB8	Muck; leached, black (N 2/0-10YR 2/1) silty muck; massive, weakly aggregated; grayish appearance and hydrophobic after drying; little fibrous material, much humus; few charcoal or carbonized fragments; few joints filled with dolomitic silt; discontinuous degraded brown (3/3-4/4) zone at top; firm, punky; occasional secondary carbonate and gypsum; B6 and B8 sampled in upper and lower part of black zone, replicate samples (B9K and B3K) taken for dating, (26,680±380 and 27,700±770 ISGS-533 and 535, respectively). Additional samples collected for pollen analysis.............	0.60

Altonian Substage
Roxana Silt

Horizon	Depth (m)	Sample no.		Thickness (m)
C/B	8.15 8.35 8.55 8.75 8.95 9.15	FCB9 FCB10 FCB11 FCB12 FCB13 FCB14	Loess; leached, dark-brown, olive-brown, and dark grayish-brown (10YR-2Y 3/3-4/4-4/2) silt loam, variegated, few 5/8 mottles and stains; few degraded charcoal; massive to granular, weak aggregation; rare channels and pores; few bleached silt masses; traces of roots; occasional gypsum in	

Horizon	Depth (m)	Sample no.		Thickness (m)
			joints; indistinct darker zone near middle; more coarse silt in upper half, more clay in lower half; noticeable sand in lower sample; somewhat friable; gradational boundaries....................................	1.20
Illinoian Stage				
Glasford Formation				
Radnor Till Member			*Sangamon Soil*	
C/A	9.35 9.55	FCB15 FCB16	Till; leached, olive-brown to grayish-brown (1Y 4/3-5/3 moist, 7/3-7/2 dry) loam, rare pebbles, common 10YR-5YR 5/8 mottles, few degraded charcoal particles; massive to granular, slightly platy, healed rounded aggregates; few pores; rare root traces; rare very small argillans; matrix more bleached than above; somewhat firm and brittle; probable A1 and A2 horizons.........................	0.40
B1	9.80	FCB17	Till; leached, light olive-brown (1Y 5/4) clay loam, few pebbles, few 5/8 mottles; few degraded charcoal particles; massive; healed blocky, moderately aggregated; few pores, common 4/3 and 3/2 argillans in pores and outlining peds; bleached ped interiors; firm, somewhat plastic...........	0.25
B2t	10.15	FCB18	Till; leached, olive-brown (1Y 4/4) clay loam to clay, few pebbles, common 5/8 and few 5/2 mottles, few red stains along joints (exposure effect); moderate subangular blocky, largely healed, moderately aggregated; few pores; common thick 5Y 3/2 and 10YR 4/2 argillans; bleached ped interiors; plastic to firm when wet, hard and blocky when dry; base covered with slump....................................	≥0.30
			Total	3.10

Post-Sangamonian stratigraphy

The Richland Loess at Farm Creek is approximately 2 m thick and overlies sand and gravel outwash of the Henry Formation. The Richland contains the profile of the Modern Soil and is leached through its entire thickness. The Illinois River Valley in its present location was the source of the Richland, which thickens to approximately 3 m at the bluff line. The Henry Formation is a high-level outwash on the tops of interfluves along the valley of Farm Creek. The source of the outwash was probably a glacial margin at the Bloomington Morainic System approximately 2 km east of the Farm Creek Section. To the southeast of the section, the Henry Formation becomes an outwash plain 1 to 2 km wide along the Bloomington front. A beta horizon is well developed in the upper part of the highly calcareous outwash in the exposure. The Henry Formation overlies the Delavan Till Member of the Wedron Formation.

The Delavan Till Member is oxidized to a reddish brown in its upper part and is reddish gray to gray in its unoxidized condition. The Delavan in profile C averages 26 percent sand and 35 percent clay. The unoxidized till between FCC 17 and 33 contains an average of 12 percent expandable clay minerals, 67 percent illite, and 21 percent kaolinite plus chlorite. On the basis of carbonate minerals, the Delavan can be divided into two parts: above FCC 23 it averages 9 percent calcite and 20 percent dolomite, and betweeen FCC 24 and 33 the calcite drops to 6 percent and the dolomite averages 21 percent. Samples FCC 34 and 35 at the base are gray, have a variable grain-size composition, and average only 3 percent calcite and 17 percent dolomite. Clay minerals in this zone average 14 percent expandables, 66 percent illite, and 20 percent kaolinite plus chlorite. These compositional differences in the lower part of the Delavan are probably caused by mixing with loess and other units below the Delavan.

Three rock-stratigraphic units—the Morton Loess, the Robein Silt, and the Roxana Silt—are identified in the 3.2-m-thick loess and silt succession between the base of the Delavan Till Member and the top of the Sangamon Soil. If the base of the Wisconsinan Stage in Illinois is placed between 50,000 and 75,000 years B.P., then this succession contains the record of 70 to 80 percent of Wisconsinan time in Illinois.

The type section of the Morton Loess is the Farm Creek Railroad Cut Section located 1.3 km due south of the Farm Creek Section. That section has been overgrown for many years and was last examined in 1958 and 1959 by Frye and Willman (1960).

At the Farm Creek Section the Morton is a 1.5-to-1.75-m thick, dolomitic, gray to brown loess that is overlain on an erosional contact by the Delavan Till Member (fig. 4). Streaks of plant debris and humus in the upper 0.5 m of the Morton accentuate shallow deformation caused by glacial overriding. The till-on-loess contact at the top of the Morton is nearly horizontal and is the most conspicuous boundary in the exposure. The Morton is dolomitic throughout its thickness and contains dolomite zones p-1, p-2, and p-3 (figs. 5 and 6). Radiocarbon dates of 20,340±750 (W-349) and 20,700±650 (W-399) have been reported from the upper part of the Morton at this exposure (Rubin and Alexander, 1958; Frye and Willman, 1960). These dates are from the upper part of zone p-3 and are compatible with the proposed chronology of loess zonation (McKay, p. 95-108 of this guidebook).

The base of the Morton Loess is gradational with the underlying silt unit, either Robein or Roxana Silt. The dolomitic composition and lighter brown or gray color of the Morton serve to distinguish it from these units. Identification of the silt unit beneath the Morton at a given site has proven difficult. Willman and Frye (1970) described 4.5 feet (1.4 m) of Robein Silt and 3.5 feet (1.1 m) of Roxana Silt in the section. The total thickness of combined Robein and Roxana now exposed is only 1.8 m, 0.7 m less than they described.

To characterize and to help distinguish the Robein and Roxana, grain-size analyses with fractionation of the silt-sized fraction were run using the pipette method. Samples from profiles A and B were selected for analysis. Results are given in appendix 2. At profile A, figure 5, and across much of the exposure, the Morton directly overlies a leached, brown, massive silt within which only one depositional unit can be distinguished in the field. In profile B, a 0.6-m-thick, leached, peaty muck occurs just beneath the Morton and overlies the leached brown silt. The Robein Silt has been interpreted as being predominantly the accumulation of sediment derived by water and colluvial action from the older Roxana Silt (Frye and Willman, 1960). Therefore, pipette analyses, including silt fractions, were carried out to test for grain-size discontinuities in the Morton-Robein-Roxana sequence.

The grain-size data show significant differences in composition between the Morton and the underlying unit. In profile A, the Morton is a relatively uniform silt that averages 25 percent coarse silt (62 to 31 μm), 39 percent medium silt (31 to 16 μm), 19 percent fine silt (16 to 8 μm), 9 percent very fine silt (8 to 2 μm), and 8 percent clay. A ratio of coarse to medium (62 to 31 μm/31 to 16 μm) silt is a clay-free index that can be used to evaluate the uniformity of silty materials through weathering profiles. The Morton has an average silt ratio of 0.6. In the silt succession below the Morton in profile A, grain-size data identify only one unit. Within this unit are no discontinuities that can be identified as a contact of Robein Silt with Roxana Silt. The lower three samples (TZ33 to 35) show the effect of mixing of loessial sediments with materials from the underlying Sangamon Soil, a feature typical of the lower Roxana. The entire leached silt section from the base of the Morton to the Sangamon appears loessial in origin and is the Roxana Silt. The upper four samples of the Roxana are above the zone of mixing and have an average grain-size composition of 29 percent coarse silt, 34 percent medium silt, 16 percent fine silt, 8 percent very fine silt, and 13 percent clay. The Roxana contains more coarse silt, less medium silt, less fine silt, and more clay than the Morton and has a silt ratio of 0.9 as compared to the 0.6 of the Morton.

These trends are the same as those between the Peoria Loess and Roxana Silt along the Mississippi Valley in southwestern Illinois. The grain-size differences may in part be pedogenic, but in comparison of dolomitic Peoria Loess to dolomitic Roxana Silt, the same pattern of fine Peoria over coarse Roxana has been found (McKay, 1977). These consistent grain-size differences between loesses probably relate to differences in the grain sizes available to wind erosion from the Altonian and Woodfordian valley trains. Because the grain-size compositions are predictable depositional features, they are useful in identifying contacts between loess units.

In profile B, a 0.5-m-thick silty muck is correlated with the Robein Silt. Its grain-size composition closely resembles that of the Roxana beneath it. The silt ratio averages 1.2. The Morton above contains a coarse zone (samples B2 and B3). The remainder of the Morton has a grain-size composition like that in profile A. The Roxana in profile B above the zone of mixing with the Sangamon has an average grain-size composition that is nearly identical to that in profile A.

It is clear that a 4.5-ft (1.4-m)-thick Robein Silt described by Willman and Frye (1970) is not now exposed at Farm Creek and that the silt unit beneath the Morton Loess is the Roxana Silt. The Robein Silt in this report is restricted to the 0.5-m-thick silty muck exposed in the easternmost part of the Farm Creek Section and sampled in profile B. At Farm Creek, the Robein Silt is merely the O2 horizon of the Farmdale Soil.

The Farmdalian Substage is based on the Robein Silt in the Farm Creek Section. Its boundaries have been placed at 22,000 and 28,000 ^{14}C years B.P. (Frye and Willman, 1960). Two radiocarbon dates from the upper and lower parts of the Robein Silt adjacent to profile B yielded ages of 26,680±380 (ISGS-533) and 27,700±770 (ISGS-535) ^{14}C years B.P., respectively. The two dates fall within the early part of the Farmdalian, and the lower date seems to substantiate the boundary of the 28,000 ^{14}C years B.P.; however, the radiocarbon age of a soil horizon reveals little about the age of the rock unit in which the soil is developed other than that the soil must be younger. The youngest date available in the upper Roxana below the Farmdale Soil profile is 30,980±400 (McKay, p. 95-108 of this guidebook). Thus, the deceleration of loess deposition that marked the end of the Altonian probably occurred between 31,000 and 28,000 ^{14}C years B.P. More study is necessary to define precisely the timing of depositional events in this part of the record.

The age of the base of the Morton Loess from evidence at Farm Creek is uncertain. It has been estimated at 22,000 ^{14}C years B.P. by Frye and Willman (1960), but the upper date on the Robein Silt near the base of the Morton in profile B is nearly 27,000 ^{14}C years B.P. Zone p-2 is present in the Morton and is older than about 23,400 ^{14}C years B.P. in southwestern Illinois (McKay, p. 95-108 of this guidebook).

Gardena Section

The Gardena Section, 1.0 km southeast of the Farm Creek Section, exposes stratigraphic relations in the Morton Loess, Robein Silt, and Roxana Silt that aid in clarification of numerous stratigraphic problems, particularly the age of the base of the Morton and the boundary of the Woodfordian and Farmdalian. The section is described below, and data for samples are plotted in figure 7.

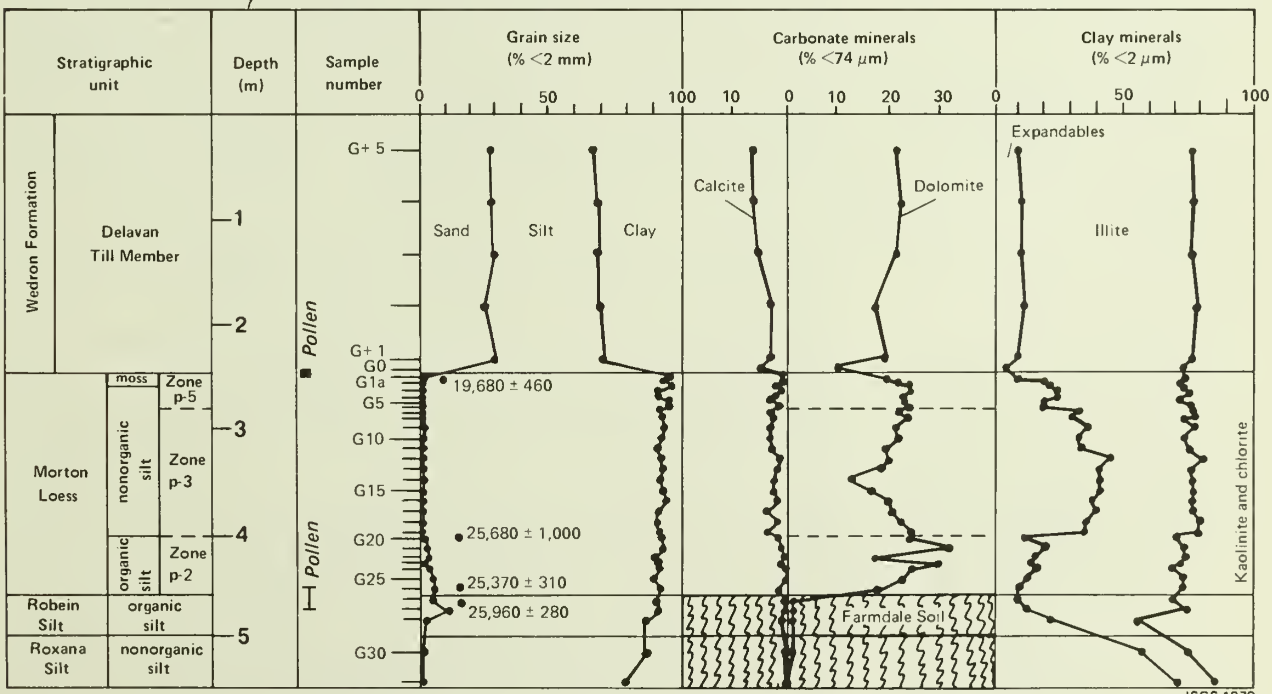


Figure 7. Grain sizes, carbonate-mineral content, and clay mineralogy of the Gardena Section.

Pollen analyses for samples from Gardena are discussed by J. E. King (p. 109-113 of this guidebook). The section is currently well exposed but too remote to be visited on the field trip.

Section measured in stream bank exposure 30 m west (downstream) of Toledo, Peoria, and Western railroad bridge in NW SW NW Sec. 32, T. 26 N., R. 3 W., Washington 7½-minute Quadrangle, Tazewell County, Illinois. Samples taken from outcrop and hand auger.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Delavan Till Member

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	.35 .85 1.35 1.85 2.35	G+5 G+4 G+3 G+2 G+1	Till; calcareous, dark grayish brown (10YR 4/2) in upper part grades to olive gray (5Y 4/2) in lower 0.9 m; uniform loam texture..	2.4
C2	2.45	G0	Lacustrine; calcareous, finely laminated gray (5Y 5/1) silt loam and silty clay.....	0.1
Morton Loess				
O1	2.52	G1a	Moss; dolomitic, very dark-gray (5Y 3/1) organic-rich silt; black (5Y 2.5/1) organic remains are mostly fibrous moss fragments and some small pieces of wood; weak fine platy structure; radiocarbon date of wood and moss, 19,680±460 (ISGS-532)...........	0.03
Ag	2.55 2.60	G1b G2	Loess; dolomitic, dark-gray (5Y 4/1) silt with many very dark gray (5Y 3/1) plant fragments and common secondary carbonates..	0.1
C2g	2.65 to 4.00	G3 to G19	Loess; dolomitic, dark-gray (5Y 4/1) silt; occasional whole snail shell; rare wood fragments; common prominent small masses of secondary carbonates from 2.85 to 3.25 m; weak granular to weak platy throughout; occasional root or root trace with yellowish-brown (10YR 5/6) stain; more common from 3.35 to 4.03........................	1.4
O'	4.05 4.15 4.25 4.30 4.35 4.45 4.55	G20 G21 G22 G23 G24 G25 G26	Loess; dolomitic, dark grayish-brown (10YR 3/2) to very dark brown (10YR 2/2) silty muck and peat; common large flattened twigs; abundant spruce needles; platy to weak granular structure; radiocarbon dates on wood from samples G-20, 25,680±1,000 (ISGS-530) and G-26, 25,370±310 (ISGS-531)......	0.6

Horizon	Depth (m)	Sample no.		Thickness (m)
Farmdalian Substage				
Robein Silt			*Farmdale Soil*	
O	4.65 4.75 4.85	G27 G28 G29	Peat and muck; leached, black (10YR 2/1) silty peat and muck grading downward into dark-brown (10YR 2/2) organic-rich silt; wood from sample G27 radiocarbon dated at 25,960±280 (ISGS-529)......................	0.4
Bg	5.15 5.45	G30 G31	Loess; leached, grayish-brown (2.5Y 4/2 to 10YR 4/2) silt loam; weak granular to massive; abundant pores and channels; indistinctly mottled; few small secondary carbonates.................................	0.5
			Total	5.35

At the Gardena Section, till of the Delavan Member is underlain by a thin lacustrine silt and clay that overlies an in situ moss layer at the top of the Morton Loess. The presence of moss indicates that there has been no erosive truncation of the Morton, and a radiocarbon date of 19,680±460 (ISGS-532) on the moss dates the burial of the Morton by lacustrine sediments just prior to till deposition. At Gardena, the Morton is 2.13 m thick, 0.4 to 0.5 m thicker than at Farm Creek. Probably the same thickness of Morton has been eroded at Farm Creek. Dolomite zone p-5 is present in the upper 0.3 m of the Morton, and its contact with the underlying p-3 is the record of diversion of the Ancient Mississippi River. The increase of dolomite from the middle of p-3 upward may record an increasing proportion of Lake Michigan Lobe outwash prior to diversion. Zone p-2 is present in the lower part of the Morton and contains muck and peat zones that have been dated. Sample G20 at the top of zone p-2 contained only a marginally sufficient amount of wood and yielded a radiocarbon date of 25,680±1,000(ISGS-530). It will be redated. Wood from sample G26 from the lower 10 cm of the Morton yielded a radiocarbon date of 25,370±310 (ISGS-531). Wood from the upper 10 cm of the Robein Silt (sample G27) immediately below the base of the Morton yielded an age of 25,960±280 ^{14}C years B.P. (ISGS-529). These dates are the basis for a conservative estimate that the age of the base of the Morton Loess in the Farm Creek region is 25,000 ^{14}C years B.P., and that the boundary of the Farmdalian and Woodfordian should be placed at 25,000 ^{14}C years B.P.

Time-stratigraphic boundaries established in the rock record do not necessarily coincide with boundaries of climatic events. The age of the contact of the Morton Loess with the Robein Silt in the Farm Creek area is the basis for placement of the boundary between the Woodfordian and Farmdalian time at 25,000 ^{14}C years B.P. The vegetational record of the climate of the region (King, 1979) indicates that the shift from cool spruce-pine interstadial vegetation toward the spruce-dominated stadial, "full-glacial," climate did not begin until after 23,000 ^{14}C years B.P. Thus, the Farmdalian/Woodfordian boundary established in the rock succession does not mark an interstadial-to-stadial transition in the local climate, and the lower part of the Morton Loess, although Woodfordian in age, was deposited while interstadial conditions prevailed in central Illinois.

Initiation of Woodfordian loess deposition along the Ancient Mississippi River in central Illinois does not coincide with changes in local climatic conditions; however, the onset of loess accumulation after the relatively loess-free Farmdalian Substage must record the renewal of glacial activity in the upper reaches of the Ancient Mississippi basin. To initiate loess deposition along much of the Ancient Mississippi, large volumes of meltwater and outwash must have been introduced into the basin about 25,000 ^{14}C years B.P. Thus, while the base of the Morton Loess does not coincide with local climatic trends in central Illinois, it does coincide with geologic events that affected a large region along the Ancient Mississippi Valley and which may, in fact, be related to climatic changes of a larger scale.

Sangamon Soil

Many details of the history of studies on the Sangamon Soil at the Farm Creek Section have been reviewed by Follmer (p. 79-91 of this guidebook). The Roxana Silt here rests on the Sangamon Soil developed in the Radnor Till Member of the Glasford Formation. A zone of mixing causes most characteristics of the boundary between the Roxana Silt and the Sangamon Soil in till to be very gradational. As a result, boundaries are difficult to distinguish; the characteristics of soil horizons in the contact zone are referred to as confounded soil characteristics. These characteristics and soil (weathering) horizons, diagenesis (change after burial), diagnostic soil profile and horizon characteristic, eluviation, aggregation, and soil structures in relation to buried buried soils are described in appendix 3.

To the extent possible, the top of the Sangamon Soil is restricted to coincide with the top of Sangamonian-aged deposits, Illinoian deposits, or older deposits if Sangamonian or Illinoian deposits are missing. At the Farm Creek exposures, the evidence indicates that the material beneath the Roxana Silt is the Radnor Till of Illinoian age. The top of the till is largely blurred because of the Sangamon Soil and mixing with the Roxana by bioturbation and pedoturbation.

The Sangamon Soil is most often buried by Wisconsinan deposits, but occasionally it merges into the Modern Soil on post-Wisconsinan geomorphic surfaces. In the Peoria region, the Wisconsinan deposits are thick enough that the Sangamon is exposed only in deep stream cuts or excavations. At the Farm Creek Section, the Sangamon is about 13 m below the upland surface. As a consequence of burial, the Sangamon (or any buried soil) is removed from the forward forces of soil genesis and experiences some degree of retrogressive development or diagenesis. The weaker the soil profile expression, the more likely the soil horizon characteristics will be lost. In most cases, the retrogressive processes cause soil horizons to return to a state more like the parent material.

The best-preserved soil horizons are O horizons and Bt horizons. The Bt horizons are more useful because they are more widespread and are diagnostic of interglacial paleosols. Clay coatings (argillans) on peds are always preserved to some degree in Bt horizons. Clean silt accumulations (silans) are sometimes present between peds and provide the best evidence for recognizing genuine platy soil structures (aggregations) in the upper solum of buried soils. Compaction and subsequent release of confining pressure sometimes generate platy structures that have clean joint surfaces without silans or other coatings (cutans).

Many kinds of soil features are expressed in the Sangamon Soil at the Farm Creek Sections. The Sangamon is a poorly drained, gleyed podzolic, in situ profile that is being oxidized on the exposure. The Bt horizon is most prominent. It is clayey and dark and has many red stains caused by the flow of iron-bearing ground water that is perched above the Bt and is oxidized as it discharges in the exposure. The iron staining continues into the overlying A horizon along joints and up into the Roxana and Morton in places. Therefore, in this case, the iron staining is not a soil feature, but a geologic feature.

The upper part of the Sangamon B (B1) grades upward into an A (C/A) that is essentially massive in appearance except for joint staining; however, at profile B, internal fabrics show healed or compressed granular to platy aggregates. At profiles A and B, degraded charcoal or carbonized wood is in a C/A horizon that has a slightly "bleached look" (low chroma) compared to adjacent horizons. This zone has some characteristics of an A horizon, but, now in the buried state, it lacks much of the normal characteristics of an A. This horizon is interpreted to be a C/A horizon, that is, C horizon morphology imposed on a buried A horizon. The analytical data do not suggest any change of parent material between the C/A and B1 at either profile A or B. Grain-size and clay-mineral trends in the Sangamon Soil are pedologic features. The sand content is nearly constant, and a strong increase in clay content from the C/A to the B2t (abrupt at profile A—a 34 percent increase—and 22 percent at profile B)is clearly shown. Clay trends of this type are evidence for strongly developed soils. A vermiculitic characteristic of the C/A is evident by the high values of the kaolinite and chlorite at profile A. This characteristic is common in buried A horizons. The morphological and analytical results therefore confirm that a conformable sequence of deposits is present through the critical portions of both Sangamon profiles, so the Sangamon A must be present and must have undergone retrogressive morphologic changes.

Upward into the Roxana, the sand content shows a lithologic (geologic) discontinuity. The decreasing trend to the very low values of sand defines the zone of mixing with the Roxana. Generally, this matches decreasing characteristics of an A horizon up into the Roxana. Together these features distinguish the zone of mixing between the Sangamon Soil and the Roxana at most localities. Old terminology referred to the zone of mixing as a part of the "Late Sangamon loess." In some sections, soil-stratigraphic boundaries have been described in this zone and were defined as the upper boundaries of the Chapin (lower) and Pleasant Grove (upper) Soils (Willman and Frye, 1970).

Pedologic features in the Sangamon Bt horizons at Farm Creek are reasonably well expressed. Most pronounced is the blocky structure (or healed blocky aggregates) that is accentuated by dark (or reddish) clay separations (argillans). The strong degree of aggregation, including the segregation of materials with contrasting colors (mottles, stains, and concretions), is diagnostic of a strongly developed soil profile. This feature is common in the Sangamon Soil and other interglacial paleosols. The clay minerals in the Sangamon B here have been largely altered as shown by the large depletion of illite (from about 75 percent to 30 percent) and by the gain of expandable minerals (from about 5 percent to 50 percent) compared to underlying oxidized calcareous till at profile A. Because of exposure, the colors of the Sangamon profile are changing from gley colors (greenish and bluish gray) to oxidized colors (olive to brown). The degree of alteration and the abruptness of the B horizon suggests that the Sangamon Soil at profile A is an Albaquult (Ultisol). An alternate classification of Albaqualf (Alfisol) must be considered because of the lack of chemical, temperature, and other data required for classification.

No morphologic or laboratory data indicate any discontinuity with the underlying calcareous till. In most places the lower boundary of the soil appears to be gradual, although a B3 commonly overlies a C2 in most places. The absence of a Cl horizon may indicate a rapidly developing soil or a hydrogeologic control.

Illinoian Till

The till in which the Sangamon Soil developed at Farm Creek is Illinoian and is correlated to the Radnor Till Member of the Glasford Formation (Willman and Frye, 1970). The Radnor Till is largely covered with slump except for the upper part near the center of the section and a portion (profile H) at creek level near the old railroad structure at the west end. About 5 m of section could not be sampled.

The oxidized C2 under the Sangamon is exposed. It averages 24 percent sand and 29 percent clay (4 μm). The carbonates average 5 percent calcite and 17 percent dolomite. Clay minerals show a trend in this zone. The lower part averages about 80 percent illite and slowly decreases upward to the Sangamon B3t, where it drops to about 45 percent. Values of expandables and kaolinite and chlorite gradually increase up through the C2. The unaltered, unoxidized C4 horizon (augered samples A2 and A3) contains about 2 percent expandables, 69 percent illite, and 29 percent kaolinite and chlorite. Upon oxidation of the C4, primary chlorites are altered, which causes the value for kaolinite and chlorite to drop. At this section the value drops to about 15 percent, which causes the relative illite value to increase from 69 percent to about 80 percent. The grain size and carbonate content of the C2 and C4 are the same. Considering all the parameters, this till closely resembles the Radnor at the Farmdale Park and GraybaR Sections.

The till exposed at profile H just above stream level was correlated to the Hulick Till Member of the Glasford Formation by Willman and Frye (1970). Recent work by Lineback has shown that this lower till is more like the Radnor. In comparison of the C4 horizon of profile A to samples H1 to H6, all parameters are essentially the same except for the higher clay content (38 percent) in H1 to H6. Samples H7 and H8 are similar in clay content and other parameters but have a higher sand content (32 percent). These variations are not yet understood, and the till is correlated to the Radnor until more information is available.

The Radnor overlies the Vandalia Till Member at the Farmdale Park Section (Stop 2) about 1 km west of the Farm Creek Section. The contact of the Radnor with the Vandalia lies 12 m below the top of the Morton Loess at Farmdale Park. At the GraybaR Section, this contact is about 17 m below the top of the Morton. The Farm Creek Section, which has only 15.7 m exposed below the Morton, may not extend to the level of the Vandalia.

STOP 2 Farmdale Park Section

The Farmdale Park Section is in a cut bank just west of the ford across Farm Creek about 0.5 km southwest of the Farm Creek Section, near the center of the SE SW Sec. 30, T. 26 N., R. 3 W., Tazewell County, Illinois, Washington 7½-

minute Quadrangle (fig. 3). Tills of the Glasford Formation are better exposed in the Farmdale Park Section than at the Farm Creek Section. Profile A of the Farmdale Park Section was measured in the eastern part of the cut, near the road. Farmdale Park B Section was measured at the bottom of the western end of the cut to sample the only gray till in the section.

Farmdale Park Section: Profile A

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Wedron Formation
Delavan Till Member

Depth (m)	Sample no.		Thickness (m)
		Till; top not exposed, loam, blocky, calcareous, gray (5Y 4/2)................................	≥2.0
		Morton Loess	
		Silt; gray, mottled with brown, calcareous.........	~1.65
		Farmdalian Substage *Robein Silt* — *Farmdale Soil*	
		Silt; pinkish, noncalcareous.....................	0.2
		Silt, black, organic-rich, A horizon of Farmdale Soil..	0.2
		Altonian Substage *Roxana Silt*	
		Silt; C1 horizon of Farmdale Soil, contains part of A1 horizon of Sangamon Soil at base...........	1.6
		Illinoian Stage *Glasford Formation* *Radnor Till Member* — *Sangamon Soil*	
		Till; weathered, clayey, noncalcareous, oxidized, reddish-brown mottled, blocky, A2, B, and C1 horizons of Sangamon Soil...........................	1.35
7.0	FPA1	Till, loam; calcareous, oxidized, mottled, brown (10YR 5/4).................................	0.2
7.3 7.6	FPA2 FPA3	Till, loam; mottled, 10YR 4/3, oxidized, friable, calcareous..................................	0.5
7.9 8.2	FPA4 FPA5	Till, loam; friable, 10 YR 5/4, iron stains along joints, calcareous............................	0.6

Depth (m)	Sample no.		Thickness (m)
8.5 8.8 9.1 9.4 9.7 10.0 10.3 10.6 10.9 11.2	FPA6 FPA7 FPA8 FPA9 FPA10 FPA11 FPA12 FPA13 FPA14 FPA15	Till, loam to silty loam; 10YR 5/4, more compact than above, calcareous, a few irregular thin beds of sand or silt....................................	3.0
11.5 11.8	FPA16 FPA17	Till, clay loam to loam; 10YR 6/4, reddish layers (5YR 6/4 and 2.5Y 6/4); calcareous, secondary calcite cement in places............................	0.7
12.1 12.4 12.7 13.0 13.3 13.6	FPA18 FPA19 FPA20 FPA21 FPA22 FPA23	Till, loam; 10YR 5/4, iron stains on joints, a little sandier than above, thin silt beds.........	1.65
		Sand; gravelly, lenticular, oxidized.............	0.1
	Vandalia Till Member		
13.9 14.2 14.5 14.8 15.1	FPA24 FPA25 FPA26 FPA27 FPA28	Till; dense, sandy loam; 2.5Y 5/4, hard, calcareous, secondary carbonate cement in places........	1.45
		Sand; covered, 4.8 m above stream................	0.1

Farmdale Park Section: Profile B

This section was measured across the contact between the Radnor and Vandalia Till Members near the base of the cut at its west end, 15 m west of profile A.

Pleistocene Series
Illinoian Stage
Glasford Formation
Radnor Till Member

13.0 13.3	FPB1 FPB2	Till, loam; brown, oxidized, 10YR 5/4, calcareous.	≥0.5
13.6	FPB3	Till, loam; gray, 5Y 4/1, calcareous.............	0.2

Depth (m)	Sample no.		Thickness (m)
	Vandalia Till Member		
13.9	FPB4	Till, sandy loam; brown, 2.5Y 5/4, mottled with	
15.8	FPB5	10YR 5/8, oxidized, iron stains along joints.......	≥2.1

Two tills of the Glasford Formation are exposed in this section (figs. 8 and 9; app. 1). They are oxidized, and, as a result, the illite contents are increased because of the degradation of the chlorite minerals (see discussion of the GraybaR Section for more detail). The single unoxidized sample of the Radnor Till Member (FPB3) has 5 percent expandables, 71 percent illite, and 24 percent kaolinite and chlorite, essentially identical in clay mineralogy to the unoxidized Illinoian tills at the Farm Creek and GraybaR Sections. The Radnor Till is sandier (29 percent) in its lower part (FPA18 to 23) and in this characteristic also resembles the Radnor in the GraybaR Section. The Radnor averages 17 percent dolomite and 22 percent total carbonate in the Farmdale Park Section.

The Vandalia Till Member is identified at Farmdale Park by its being sandier and higher in carbonate than the Radnor. This change takes place between samples FPA23 and 24 and between FPB3 and 4. The Vandalia averages 38 percent sand and only 19 percent clay, very similar to the Vandalia at GraybaR. It averages 6 percent calcite and 23 percent dolomite, for a total carbonate content of 29 percent. Clay-mineral compositions of the two oxidized tills are identical.

Secondary carbonates were noted in the Radnor in several places and also in the Vandalia. The Vandalia Till Member is oxidized below the contact with gray unoxidized Radnor Till. The Vandalia Till was also oxidized below unoxidized Radnor at the GraybaR Section. Perhaps this indicates a period of oxidization and weak surface weathering between the two tills or the presence of a truncated soil profile. It is also possible that the Vandalia Till is more rapidly oxidized by ground-water flow because it is more permeable.

The Sangamon Soil in profile A is typical of a moderately well-drained, in situ soil in till. Well-drained Sangamon Soil profiles are rarely found in till, and, when they are, they are usually truncated; however, at this section, the Sangamon Soil profile appears to be complete with all of its horizons. A conformable relationship exists with the overlying Roxana Silt, which means there is a gradation from the Sangamon A horizon up into the Roxana. This boundary is difficult to pinpoint because of the lack of an erosion surface and because of the physical similarity of the materials.

The Sangamon profile is probably a paleo-Ultisol here. The A1 horizon is gradational into the Roxana and can be included in the Roxana. The A2 horizon is a well-expressed light-colored horizon that tongues down into the B. The B horizon is a reddish-brown clay to clay loam with strong blocky structure, well-developed argillans, common iron-manganese concretions and stains, and mottling in the lower part. The Sangamon Soil has not been studied in detail at the Farmdale Park Section, but in other sections significant mineral alterations and depletion of weatherable components have been found in in situ profiles (Brophy, 1959; Willman, Glass, and Frye, 1966; and Johnson et al., 1972).

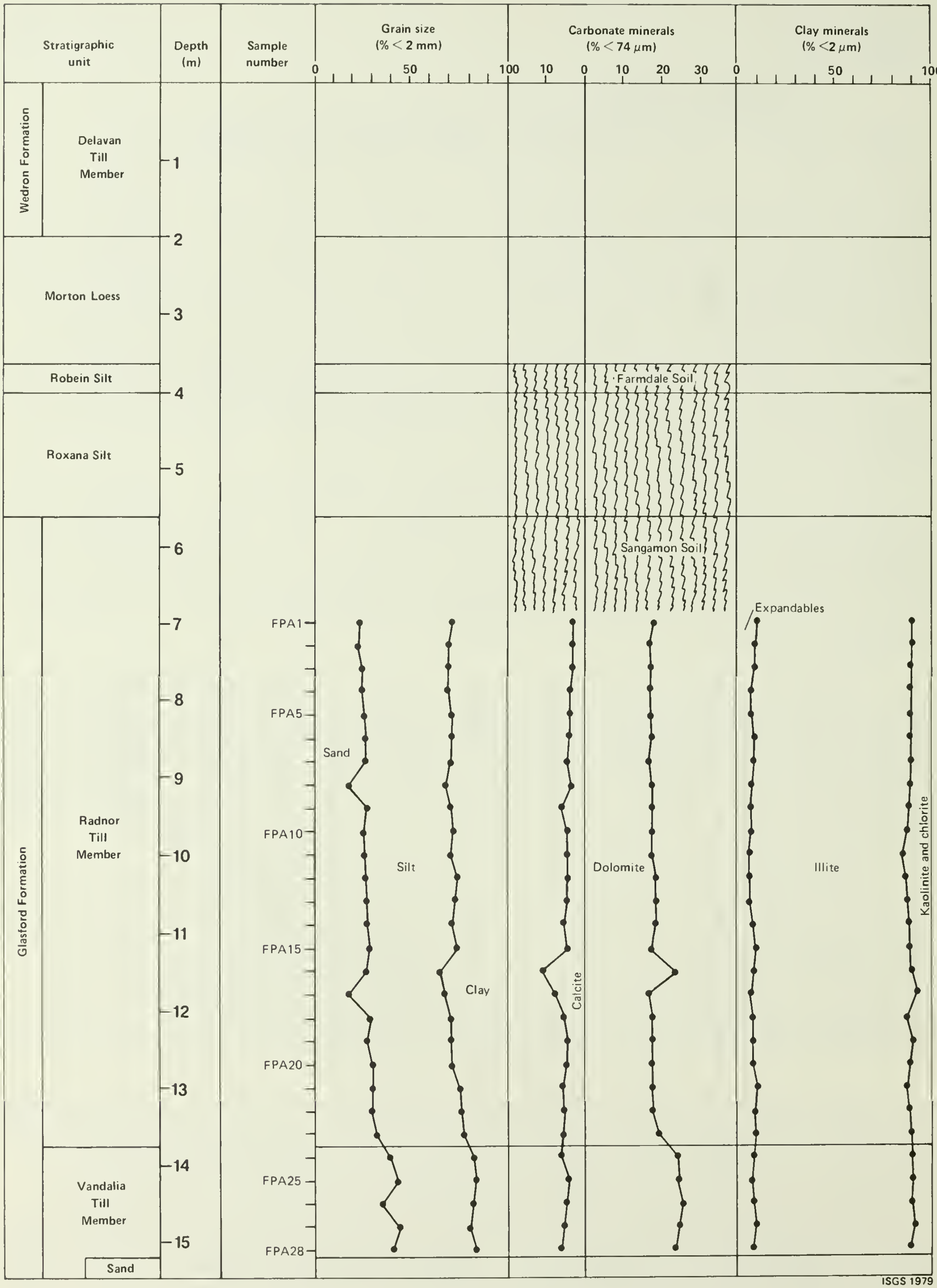


Figure 8. Grain sizes, carbonate-mineral content, and clay mineralogy of profile A of the Farmdale Park Section.

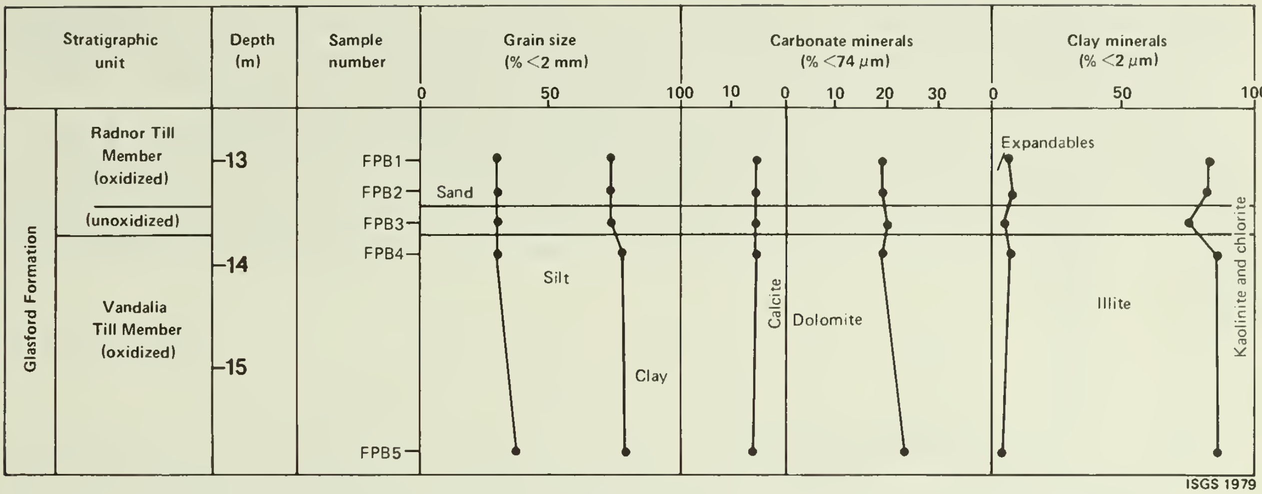


Figure 9. Grain sizes, carbonate-mineral content, and clay mineralogy of the Farmdale Park Section.

Glendale School Section

STOP 3

The Glendale School Section is in the north valley wall of a minor tributary to Farm Creek in the SE SW NE Sec. 3, T. 25 N., R. 4 W., Tazewell County, Illinois, Peoria East 7½-minute Quadrangle (fig. 3). The section is noted for a layer of cemented outwash, 7 to 8 m thick, in the Glasford Formation. Two tills lie between the outwash and the Sangamon Soil. The section has not been sampled in detail.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Wedron Formation
Delavan Till Member

Depth (m)	Sample no.		Thickness (m)
3.0	GS5	Till, loam; brown, calcareous, top covered........	≥4.0
		Morton Loess	
4.5	GS7	Loess, gray.......................................	1.0
		Altonian Substage	
		Roxana Silt — *Farmdale Soil*	
5.6	GS6	Loess, brown, C1 horizon of Farmdale Soil.........	1.0
		Illinoian Stage	
		Glasford Formation	
		Radnor Till Member — *Sangamon Soil*	
		Till; weathered, oxidized, leached, clayey, brown, B and C1 horizons of Sangamon Soil................	1.5

Depth (m)	Sample no.		Thickness (m)
		Till, silty loam; brown, oxidized, calcareous....	2.5
10.4	GS1	Till, silty loam; gray, calcareous..............	1.0
11.6 12.8	GS2 GS3	Till, sandy loam; brown, oxidized, calcareous....	2.2
13.8	GS4	Till, silty loam; gray, calcareous..............	0.8
15.0	GS8	Gravel, some sand; cemented, hard, bedded, base not exposed....................................	≥8.0

Both samples GS1 and GS4 of gray unoxidized till are similar in grain size, carbonates, and clay minerals to the Radnor Till Member at GraybaR, Farmdale Park, and Farm Creek (fig. 10, app. 1). The oxidized part of the lower till is somewhat sandier (34 percent), but the clay content is higher than in the Vandalia Till Member at the other sections. There is a zone of oxidization between the Radnor and Vandalia at the GraybaR and Farmdale Park Sections. It is possible that the zone of oxidization at Glendale School correlates with that zone in the other sections, but the lower till here has the characteristics of the Radnor Till and is here correlated with the Radnor. There are indications of zones of oxidization between beds of the Radnor at the GraybaR Section, and the oxidization at Glendale School Section may correlate with one of those.

The degradation of chlorite caused by oxidization can result from brief surface exposure during an intraglacial event. In a mineralogic sense it probably is a part of an incipient paleosol. On the other hand, oxidization

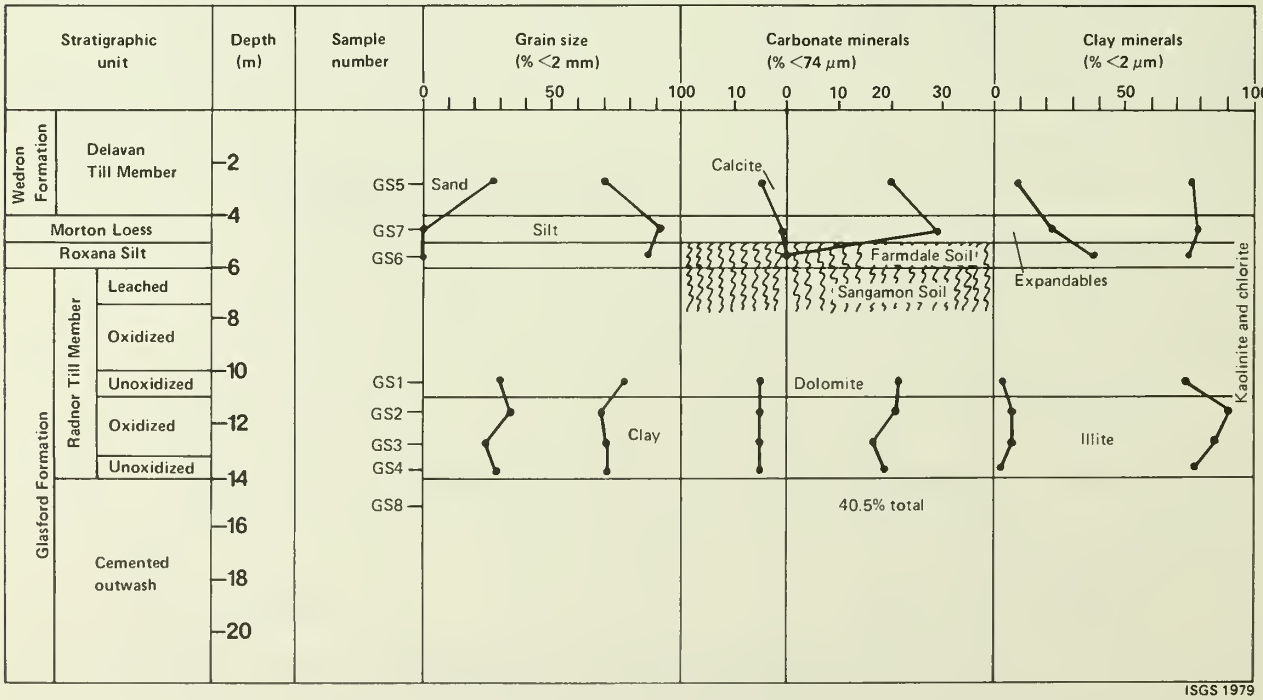


Figure 10. Grain sizes, carbonate-mineral content, and clay mineralogy of the Glendale School Section.

between glacial drifts can represent the position of a truncated, eroded interglacial paleosol where all but the base of the oxidized zone has been removed. Without other evidence of weathering or erosion, or correlation to a place where leaching and weathering are observed, determining the significance of such oxidization is not always possible. Oxidization can also be caused by oxygen-bearing ground water moving through porous zones in the drift. No paleosol involving leaching or intense weathering has yet been identified within the Radnor or between the Radnor and Vandalia Tills (Lineback, 1979).

GraybaR Section

The GraybaR Section is in a high barrow pit cut into the east bluff of the Illinois River behind the GraybaR warehouse in the SW NW SW Sec. 23, T. 26 N., R. 4 W., Tazewell County, Illinois, Peoria East 7½-minute Quadrangle (fig. 3). The section was sampled and described in 1978.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Wedron Formation
Delavan Till Member

Depth (m)	Sample no.		Thickness (m)
2.6	GB1	Till, loam; 10YR 5/4, top covered................	≥3.0
		Morton Loess	
4.0	GB1A	Silt; oxidized brown, 10YR 5/5....................	1.6
		Altonian Substage	
		Roxana Silt — *Farmdale Soil*	
5.0	GB1B	Silt loam; 7.5YR 4/4, leached, C1 zone of Farmdale Soil..	0.27
		Silt loam; 10YR 5/4...............................	0.25
		Silt loam; 10YR 4/3...............................	0.24
		Silt loam; 7.5YR 5/4..............................	0.29
		Silt loam; 10YR 4/4...............................	0.55
		Illinoian Stage	
		Glasford Formation	
		Radnor Till Member — *Sangamon Soil*	
		Till; weathered, leached, blocky, clay skins, silty clay loam, 10YR 4/5, mostly covered, B and C1 zones of Sangamon Soil...........................	1.0

Depth (m)	Sample no.		Thickness (m)
8.2	GB2	Till, loam; calcareous, 10YR 5/4, oxidized brown...	3.0
8.7	GB3		
9.2	GB4		
9.7	GB5		
10.2	GB6		
10.7	GB7	Till, silty loam; gray, 10YR 4/2 to 10YR 4/1......	1.0
11.2	GB8		
11.7	GB9	Till, silty loam; oxidized by ground-water seepage along sand layer below, 10YR 5/4..................	0.7
12.5	GB10	Sand, sand and silt, silt, in thin beds; calcareous, oxidized, till-like layers, silty loam 2.5Y 6/4..	0.8
12.8	GB11	Till, silty loam; calcareous, gray 5Y 5/1, 4/1, 4/2; layers of reddish-brown till, 5YR 5/3........	1.75
13.2	GB12		
13.7	GB13		
14.2	GB14		
14.7	GB15	Till, sandy loam; brown, 10YR 5/4, oxidized, calcareous...	0.75
15.1	GB16		
15.7	GB17	Sand, coarse, gravel layers, bedded, till layers, thin, oxidized, 10YR 5/4, covered................	1.0
16.3	GB18	Till, sandy loam; gray, 10YR 4/2, becoming 2.5YR 4/2 and 10YR 4/2 downward, compact...............	2.9
16.8	GB19		
17.2	GB20		
17.7	GB21		
18.2	GB22		
18.7	GB23		
19.2	GB24	Silt; gray, distorted, 10YR 5/3..................	0.15
		Till and gravel, thin layers intermixed..........	0.13
19.7	GB25	Till, sandy loam; gray, 10YR 5/2, less sandy at base, base 10YR 4/2................................	0.82
20.2	GB26		
20.7	GB27	Till; gray, 10YR 4/2, loam till, more clayey than above, fewer pebbles............................	0.7
	Vandalia Till Member		
21.2	GB28	Till, oxidized, 10YR 5/3, sandy loam.............	0.5
		Sand and till interbedded........................	0.5
		Sand; medium, well sorted, oxidized brown, some silt, some till-like material in thin beds, partly covered..	1.9

Depth (m)	Sample no.		Thickness (m)
24.7 25.2 25.7	GB29 GB30 GB31	Till, sandy loam; friable, 2.5Y 6/4 to 6/2........	2.0
		Sand; coarse, pea gravel at base, oxidized brown..	1.1
27.2 27.7 28.0	GB32 GB33 GB34	Till; oxidized, sandy, soft, friable, calcareous, brown, 10YR 5/4, becoming gray, 2.5Y 5/2 in lower part..	1.2
28.2	GB35	Clay; gray, blocky, silty, till?.................	0.2
29.2 30.2 31.2 31.4	GB36 GB37 GB38 GB39	Silt; sand and gravel in thin beds, oxidized brown, gray silt at base; samples are of silt layers..	3.3
		Covered and mixed by benching, section moved 50 m north on exposure and begins at the base of this unit..	3.4
35.0 35.5 36.0 36.5 37.0 37.5 38.0 38.5 39.0 39.5	GB40 GB41 GB42 GB43 GB44 GB45 GB46 GB47 GB48 GB49	Till, sandy loam; friable, 10YR 4/2, becoming 10YR 5/2 in middle and 10YR 4/2 in lower part, more compact than overlying unit; pebbly, coal pebbles, base not reached................................	4.5
		Total	$\geq$40.5

Weathering effects can produce significant alterations in clay-mineral compositions which must be assessed before correlations on the basis of clay-mineral composition can be attempted. A decrease in illite and increase in chlorite downward between samples GB6 and GB7 are notable (fig. 11; app. 1). GB6 and higher samples were oxidized during the development of the Sangamon Soil. GB7 is the gray, unoxidized parent material. The upward increase in illite is due to a loss of chlorite, which causes a relative increase in the calculated illite content. The mineral discontinuity produced by oxidization of sample GB6 should not be interpreted as a boundary between two till units. Similar oxidization effects can be noted adjacent to sand layers where ground water has oxidized the materials (for example, GB9, GB10, GB15, GB16, and GB17). Sand and tills between GB28 and GB32 are also oxidized and the chlorite degraded. Because oxidization in this case takes place through a body of till, it may represent a profile of oxidization or a truncated paleosol. Because of the lack of other indicators of weathering and the presence of considerable outwash material in the section, the significance of this oxidization cannot be determined, even though, in this case, it occurs between two compositionally different till units.

All of the till in the GraybaR Section is high in illite and dolomite. An abundance of these minerals is characteristic of the tills of the Lake Mich-

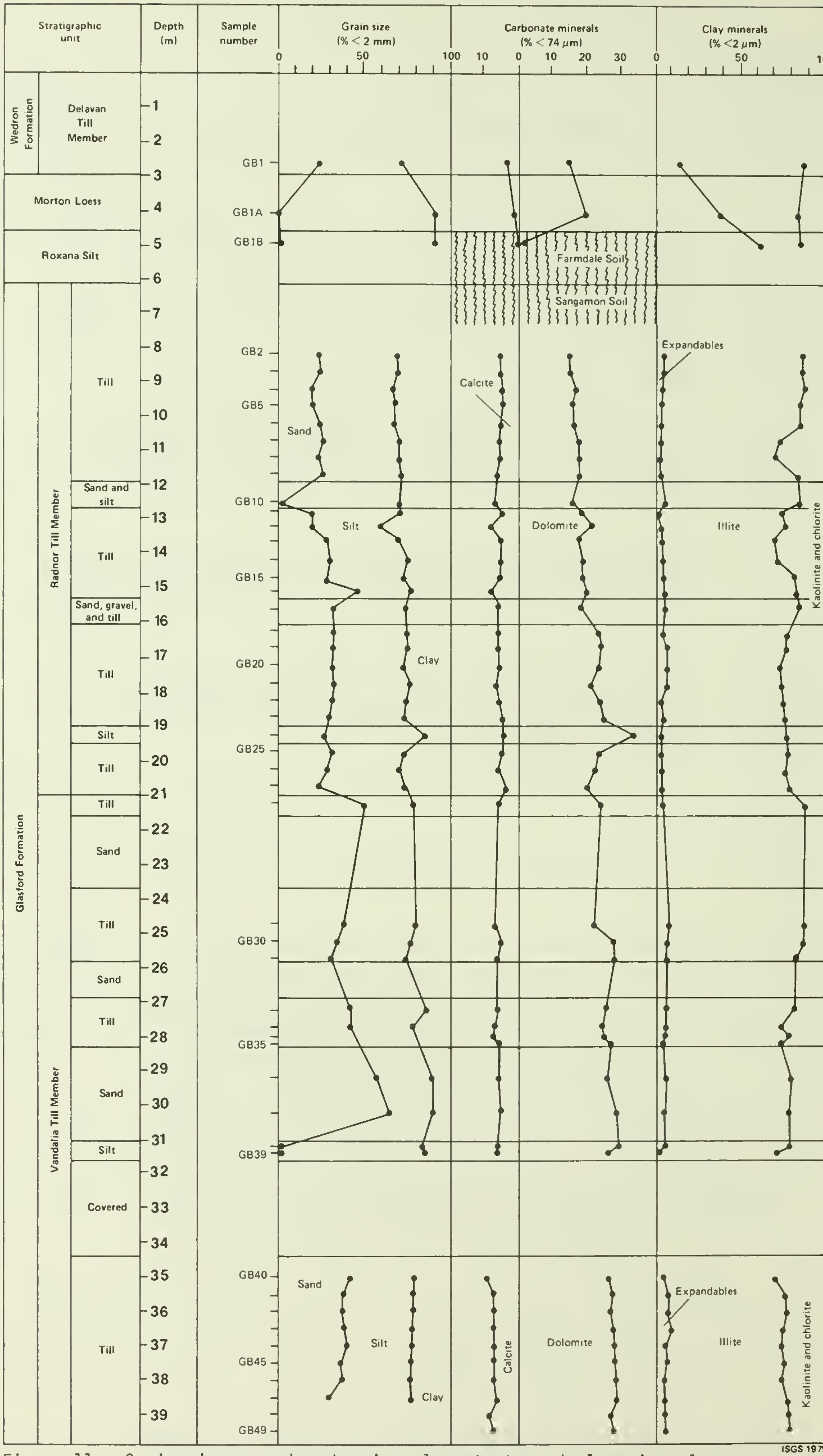


Figure 11. Grain sizes, carbonate-mineral content, and clay mineralogy of the GraybaR Section.

igan Lobe. From observations of oxidization effects on clay minerals in this exposure, it is likely that the tills had about the same composition when they were deposited, namely, about 6 percent expandables, 70 percent illite, and 24 percent kaolinite plus chlorite. The uppermost till appears similar to the Radnor Till Member in the Farm Creek, Farmdale Park, Glendale School, Tindall School, and Jubilee College Sections. Three subunits can be recognized in the Radnor at GraybaR on the basis of grain size and carbonates. From GB2 to GB9 the till averages 24 percent sand and 17 percent dolomite. Between GB11 and GB17 the till is sandier, averaging 29 percent sand, and is more dolomitic, averaging 19 percent dolomite. Between GB18 and GB27, the tills average 30 percent sand and 23 percent dolomite. These three compositional units are believed to represent compositional subunits of the Radnor Till Member.

The most significant downward change in till composition in the GraybaR Section is the increase in sand content to 40 percent between samples GB27 and GB28. The till from GB28 to GB35 is a sandy, friable unit that also is higher in dolomite (25 percent) than the overlying Radnor. The till from GB40 to GB49 is harder and firmer than GB28 to GB35 and is even higher in dolomite (28 percent) and in total carbonate (35 percent), but is slightly less sandy (38 percent). The average clay content of tills below GB28 is less than 22 percent, compared with 27 percent to 30 percent in the Radnor.

The lower two tills in this section resemble tills once included in the Jacksonville Drift, as identified in Morgan and Sangamon Counties to the south of the GraybaR Section (H. D. Glass, personal communication, 1979). Sandy tills in central Illinois that are similar in composition and stratigraphic position to those below GB28 were included in the Vandalia Till Member by Jacobs and Lineback (1969). Therefore, the till below GB28 in the GraybaR Section is tentatively correlated with the Vandalia Till of central Illinois.

Tills resembling the Hulick Till Member or unnamed till member C which underlie the Radnor in Fulton and Peoria Counties were not recognized in this section. The Vandalia Till of the GraybaR Section may not have extended west of the Illinois River Valley.

Tindall School Section (Landowner did not grant permission to visit this section.) STOP 4

The Tindall School Section is in an inactive borrow pit in the bluff of the Illinois Valley in the SW SW NE Sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois, Glasford 7½-minute Quadrangle (fig. 12).

The Tindall School Section was examined several times between 1957 and 1969,and a description was published by Willman and Frye (1970). They designated this section as the type section for the Glasford Formation, which encompasses the tills and intercalated deposits of the Illinoian Stage and the Banner Formation, which they defined as encompassing tills and intercalated deposits of a glaciation that they assumed to be of Kansan (pre-Illinoian) age. Their description is reproduced on page 37.

Willman and Frye identified three Illinoian tills in the Tindall Schoool Section. This section was also designated a paratype section for the Illinoian Stage (Willman and Frye, 1970, p. 120). The section is largely overgrown, but the paleosol they correlated with the Yarmouth Soil and the tills above and below that soil can still be seen in several gullies on the lower slopes of the hill.

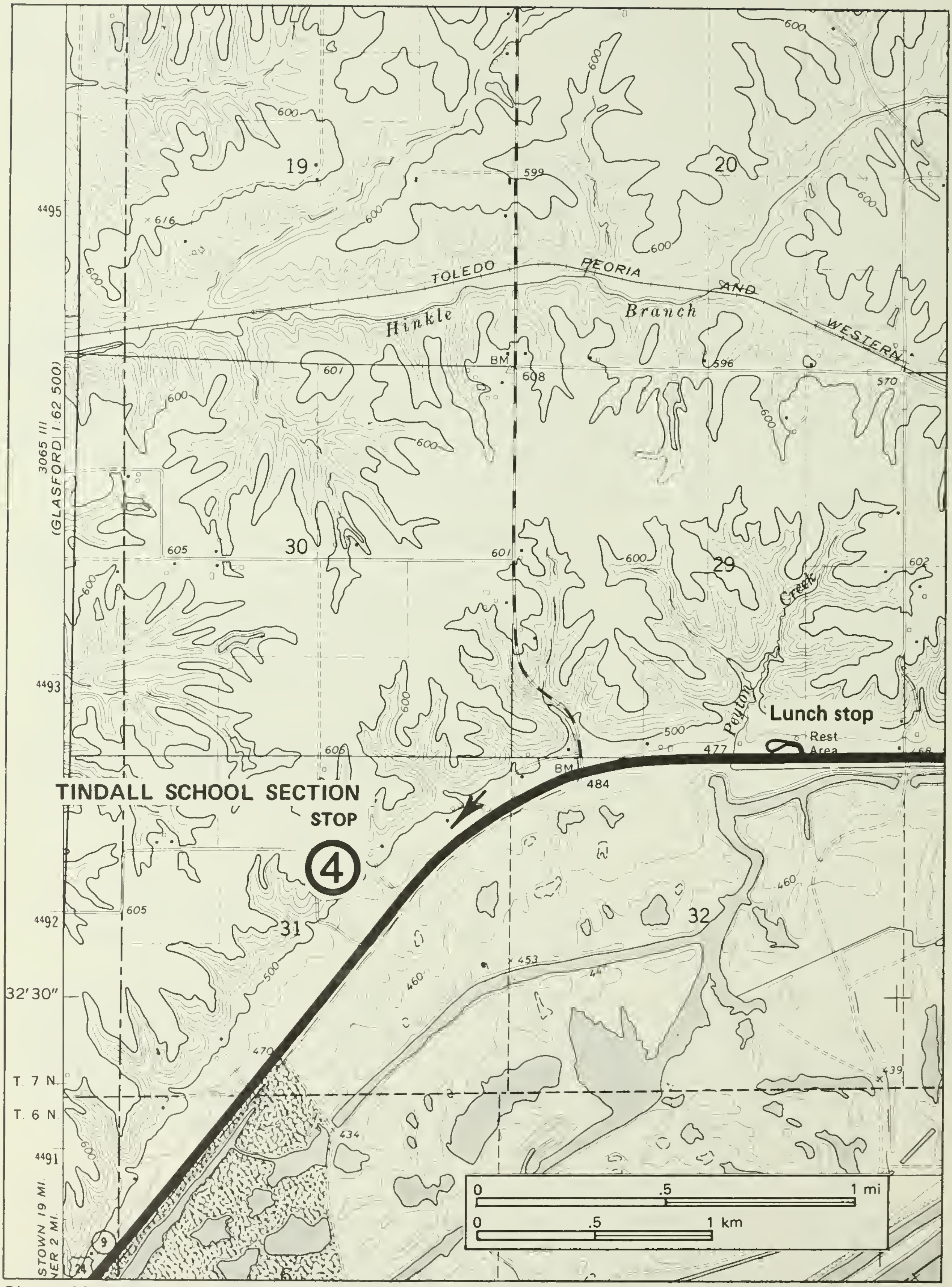


Figure 12. Location of the Tindall School Section.

TINDALL SCHOOL SECTION

Measured in borrow pit in SW SW NE Sec. 31, T. 7 N., R. 6 E., Peoria County, Illinois, 1957, 1958, 1962, 1969.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess (type section)	
15. Loess, leached in top 5 feet, tan to gray streaked; rusty brown root tubules and color banding; Modern Soil in top; calcareous in lower part, tan-gray, massive	12.0
Farmdalian Substage and Altonian Substage	
Robein Silt and Roxana Silt	
14. Silt, leached in upper and lower parts, dark gray to black humic streaks, contorted by cryoturbations, light gray between humic streaks in upper part, rusty tan in lower part; contains iron concretions and tubules of limonite; cryoturbations prevent a sharp differentiation of Robein and Roxana Silts; Farmdale Soil in upper part	4.5
Altonian Substage	
Roxana Silt	
Markham Silt Member	
13. Silt and sand; dark gray to tan-gray, leached, massive; Chapin Soil	1.0
Illinoian Stage (paratype)	
Jubileean Substage	
Glasford Formation (type section)	
Radnor Till Member	
12. Till; Sangamon Soil; gleyed in-situ profile, leached, dark gray to tan-gray, massive	4.0
11. Till with network or "box work" of rusty brown iron-cemented and leached streaks and plates; blocks within iron-cemented streaks are gray calcareous till; Sangamon Soil ferretto zone (P-126)	2.0
10. Till, calcareous, gray, tan, well jointed, gradational at top (P-6720)	3.0
Toulon Member	
9. Silt, with some sand, calcareous, tan to gray streaked with red; thin zones cemented with $CaCO_3$; zone pinches out southward and is replaced by a zone of oriented cobbles and boulders that suggest truncation by the overriding glacier	2.0
Monican Substage	
Glasford Formation (continued)	
Hulick Till Member	
8. Till, calcareous, oxidized, gray to light brown, compact, pebbly (P-6718, P-6719)	3.0
7. Sand and gravel in discontinuous lenses; lenses aligned at this stratigraphic position and generally flattened on top; locally cemented with $CaCO_3$; brown (may be the Duncan Mills Member)	3.0
Liman Substage	
Glasford Formation (continued)	
Kellerville Till Member	
6. Till, calcareous, blue-gray, massive but well jointed throughout with oxidized rinds on joints; pebbly (P-125 lower part)	18.0
Kansan Stage	
Banner Formation (type section)	
5. Till, leached, dark brown mottled with rusty brown and gray, clayey; truncated Yarmouth Soil; A-zone and upper part of B-zone removed by erosion; blocks of B-zone material occur locally as boulders in lower part of overlying till; secondary carbonate nodules present locally; upper contact sharp (P-124)	4.5
4. Till, calcareous, massive, gray, compact, pebbly, cobbly, locally mottled with brown in upper part, jointed throughout; blocks or boulders of sand and silt with contorted bedding occur locally in middle part (P-123A upper; P-123 middle)	18.0
3. Sand, fine to medium, calcareous, brown with gray streaks; grades downward to gray silt, calcareous, massive; contains some streaks of brown limonite cementation and some fossil snail shells (P-122 top; P-121; P-121A)	4.0
2. Till, calcareous, compact, blue-gray at base, tan to light brown upward; contains streaks of coal fragments and a few thin streaks of gravel (P-119 base; P-119A lower; P-120 2 feet below top)	5.0
Harkness Silt Member	
1. Silt, calcareous, thinly bedded; alternating bands of ash gray and tan-brown; contains fossil snail shells throughout (P-1367X upper; P-1366X middle); to bottom of temporary drainage ditch	5.0
Total	89.0

Analytical data from this section are not as extensive as for other sections (fig. 13, app. 1). Nevertheless, several observations on correlations can be made on the basis of the available data. The Radnor Till Member in this section is similar to the surficial high-illite till in the rest of Peoria County that has been called Radnor, and to the upper tills in the Farm Creek, Farmdale Park, and GraybaR Sections.

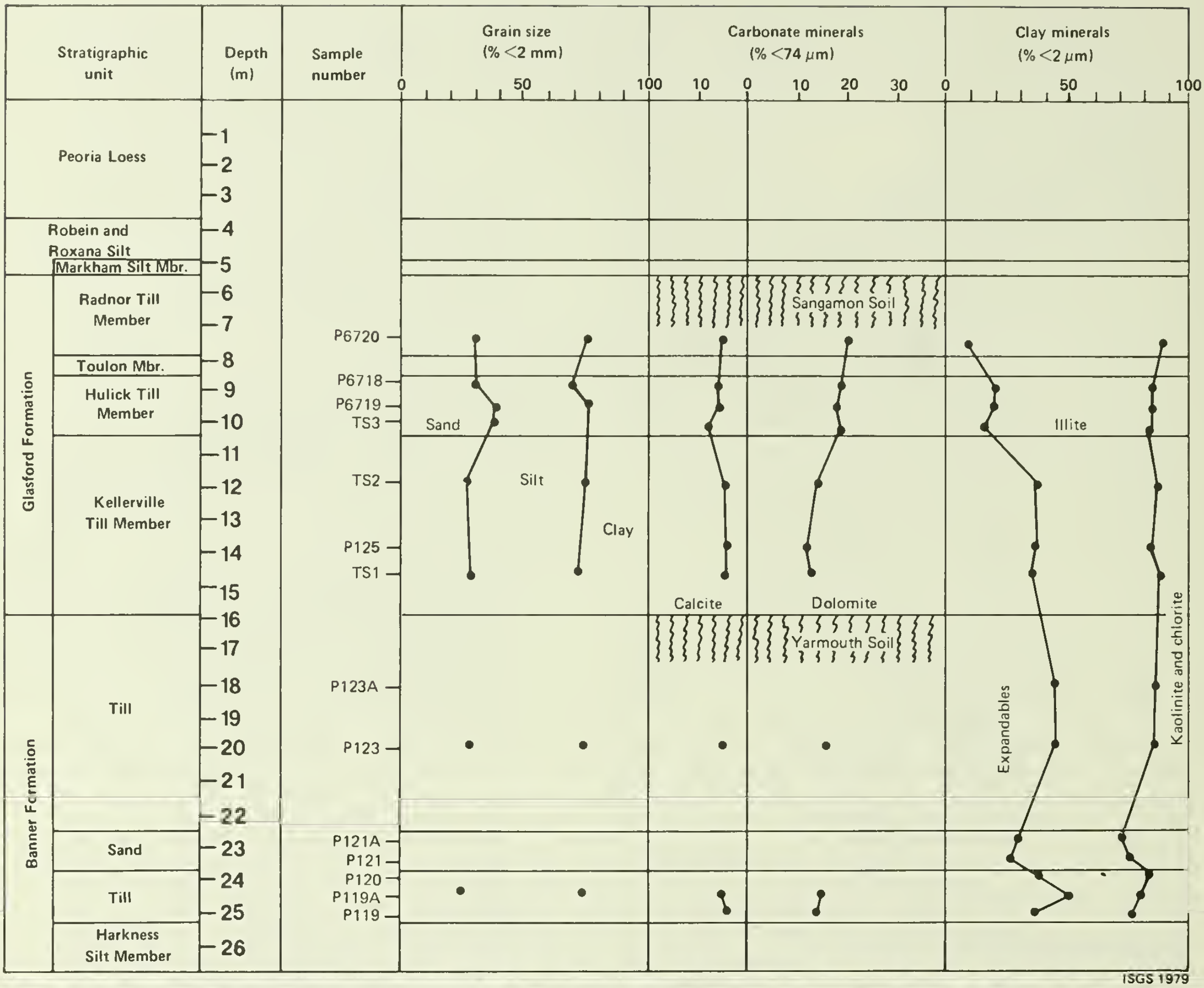


Figure 13. Grain sizes, carbonate-mineral content, and clay mineralogy of the Tindall School Section. Nomenclature is that of Willman and Frye (1970) section.

The till described by Willman and Frye as the Hulick Till Member in the Tindall School Section has a higher content of expandables (20 percent) and is more dolomitic than the type Hulick Till Member at the Lewistown Section, the Hipple School Section, and the Jubilee College Section. The till at Tindall School is similar to the unnamed till member C (Lineback, p. 69-78 of this guidebook) in Fulton County and is here tentatively correlated with that till. Therefore, in the present interpretation, the Hulick is absent at the Tindall School Section.

The tills above and below Willman and Frye's Yarmouth Soil at Tindall School are similar. Both are dolomitic, relatively low carbonate, silty tills with approximately equal amounts (40 percent) of expandable and illite clay minerals. Both of these tills are similar to other Lake Michigan Lobe tills in being dolomitic. Regionally, two named till members have this composition—the Smithboro and the Kellerville. The Smithboro Till Member is found in many sections in central and western Illinois beneath both the Vandalia Till Member and unnamed till member C. Thus the till called Kellerville in the Tindall School Section may be better correlated to the Smithboro Till Member.

The lower paleosol at Tindall School was correlated with the Yarmouth Soil at a time when the Quaternary depositional model dictated that the first major paleosol below the Sangamon should be the Yarmouth; however, as indicated by Lineback (p. 69-78 of this guidebook), there is a strong probability of multiple paleosols within the Illinoian Stage. The till of the Banner Formation at Tindall School resembles the type Kellerville of Adams County and the Kellerville in Hancock County. Thus it is possible that all tills at Tindall School are of Illinoian age. Additional work in the region must be undertaken, however, before redefinition of the Glasford and Banner Formations at this section can be attempted.

Lewistown Section

STOP 5

The Lewistown Section is a short distance (~50 m) north of the road intersection at the western edge of Lewistown, Illinois, opposite the highway barn in SW SE SE, Sec. 21, T. 5 N., R. 3 E., Fulton County, Lewistown 7½-minute Quadrangle (fig. 14).

The northern part of the Lewistown Section was described by Willman and Frye (1970) and is the type section for the Hulick Till Member. Their description is reproduced below.

LEWISTOWN SECTION

Measured in roadcuts in SW SE SE Sec. 21,
T. 5 N., R. 3 E., Fulton County, Illinois, 1969.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage and Illinoian Stage	
6. Partly covered; Peoria Loess on Roxana Silt on Sangamon Soil developed in Teneriffe Silt	8.0
Illinoian Stage	
Jubileean Substage	
Teneriffe Silt	
5. Silt, vesicular, calcareous, platy to bedded, light tan to medium gray; contains abundant $CaCO_3$ concretions (P-6698 lower)	3.0
Pearl Formation	
4. Sand, gravelly in upper part, tan, calcareous (P-6697 upper)	4.0
Monican Substage	
Glasford Formation	
Hulick Till Member (type section)	
3. Till, calcareous, sandy, pebbly, loose, massive to platy, gray-tan; basal contact, though sharp, is contorted, suggesting glacial overriding (P-6696, P-6639)	3.0
Duncan Mills Member	
2. Silt and clay with some fine sand, calcareous, irregularly bedded and locally distorted, gray, dark gray with red-brown clay zones at top and bottom (P-6693 base; P-6694 lower; P-6695 top; P-6638)	6.0
Liman Substage	
Glasford Formation (continued)	
Kellerville Till Member	
1. Till, calcareous, silty, tan to gray-tan to yellow-tan, compact, blocky; lower part pebbly and contains large amounts of locally derived shale and siltstone (P-6690 lower; P-6691 middle; P-6692 upper; P-6636, P-6637)	9.5
Total	33.5

The section is now much overgrown. The following is our description from parts of the section that were excavated in 1978.

Pleistocene Series
Illinoian Stage
Pearl Formation

Depth (m)	Sample no.		Thickness (m)
		Sand; fine to medium grained, noncalcareous, bedded, oxidized brown 7.5YR 4/2, top covered; C1 horizon of Sangamon Soil......................	≥0.8

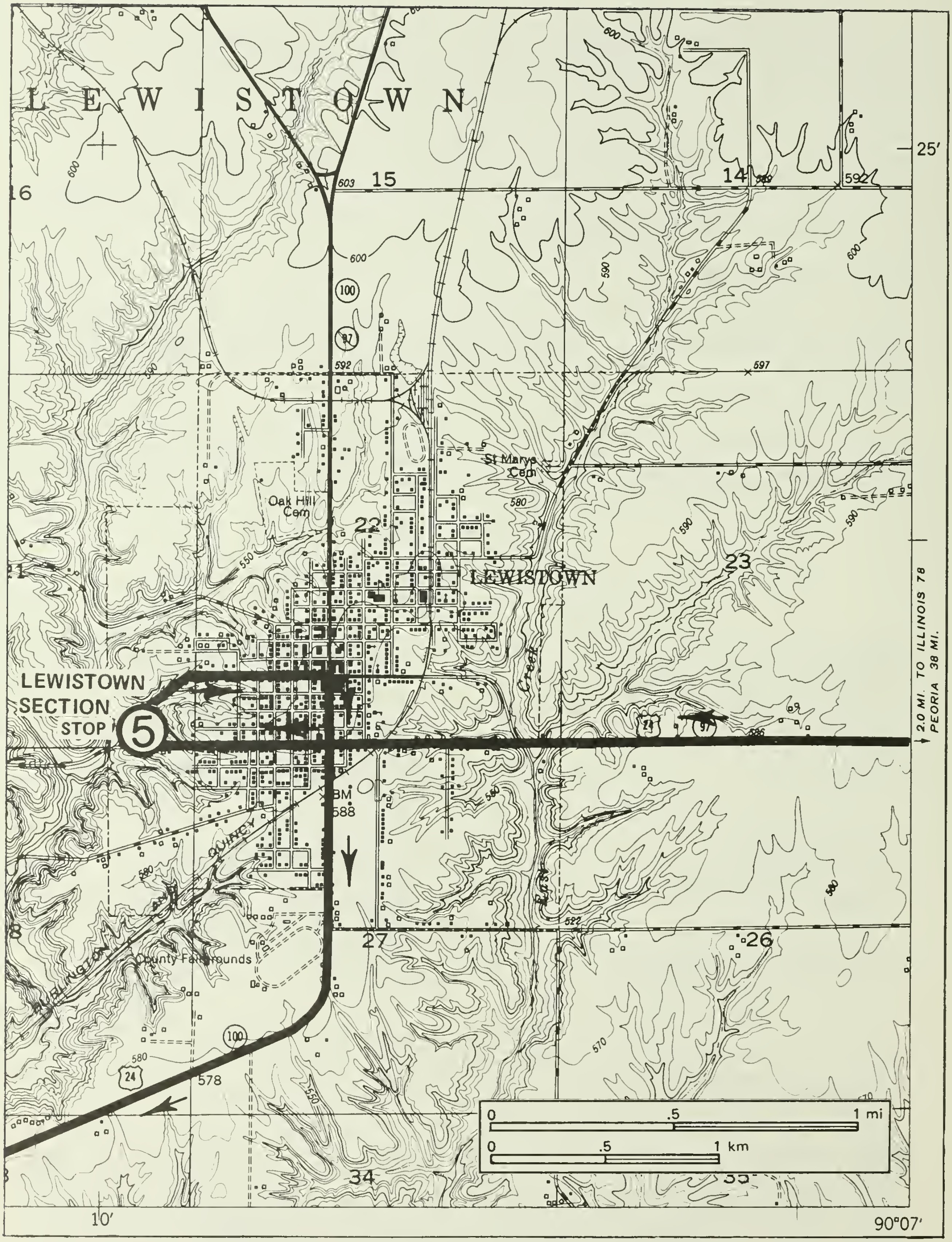


Figure 14. Location of the Lewistown Section.

Depth (m)	Sample no.		Thickness (m)
		Glasford Formation	
		Hulick Till Member (type section)	
0.9 1.2 1.5 1.8	LB10 LB9 LB8 LB7	Till, sandy loam; top 10 cm noncalcareous (C1 horizon of Sangamon Soil), rest calcareous; noncompact, massive to platy, oxidized, 10YR 5/4 at top, 10YR 5/3 at base..........................	1.2
		Duncan Mills Member — *Unnamed soil*	
2.1 2.4 2.7 3.0	LB6 LB5 LB4 LB3	Clay; silty, some fine sand, noncalcareous; faint bedding, microblocky, a few pebbles; gray 10YR 6/1 with brown, 10YR 5/4 mottles, becoming gray 5Y 5/1 downward, mixed with blebs of overlying calcareous till at top; accretion gley, Bg horizon of an unnamed soil..	1.2
		Unnamed till member C	
3.3 3.6 4.1 ~4.5	LB2 LB1 LB11 LA5	Till, loam; top 40 cm weathered, yellowish-brown (10YR 5/8) B3-C1 horizons of unnamed soil; rest is grayish brown (10 YR 6/3); calcareous, firm, blocky, pebbles of coal, sandstone, and shale common; base covered..	≥3.0

The upper part of Willman and Frye's section was a composite of the southern part of the exposure. The Hulick Till Member appears similar in the two descriptions. The Hulick, here at the type section, averages 30 percent sand, 38 percent silt, and 32 percent clay (fig. 15, app. 1). The top 10 cm of the Hulick is oxidized and leached because the profile of the Sangamon Soil extended through the Pearl and the upper part of the Hulick. The calcareous part of the Hulick averages 5 percent calcite and 10 percent dolomite. The Hulick at Lewistown is lower in dolomite content than the other till unit exposed and is in general less dolomitic than most other Illinoian tills. The top three samples of the Hulick average 26 percent kaolinite and chlorite, and 65 percent illite among the clay minerals. Illitic Illinoian tills with a high content of kaolinite and chlorite are often referred to as "shale types" because it is thought that additional kaolinite is derived from erosion of Pennsylvanian bedrock. The Hulick here, and in other places, contains fewer obvious Pennsylvanian pebbles than unnamed till member C. The lower sample (LB7) of the Hulick has a clay-mineral composition similar to the underlying weathered clay. Close examination shows a zone of mixing and incorporation of the underlying material at the base of the till.

In Fulton and adjacent counties, the Hulick can be distinguished from the underlying unnamed unit C by its composition, which is slightly higher in illite and less dolomitic (Lineback, table 1, p. 74 of this guidebook). The Hulick at Lewistown appears to correlate with the Hulick as selected by Willman and Frye (1970) in the Hipple School, Fairview, and Jubilee College Sections, and possible that in the Enion Section. It can also be distinguished in the area of Table Grove, along the boundary between Fulton and McDonough Counties.

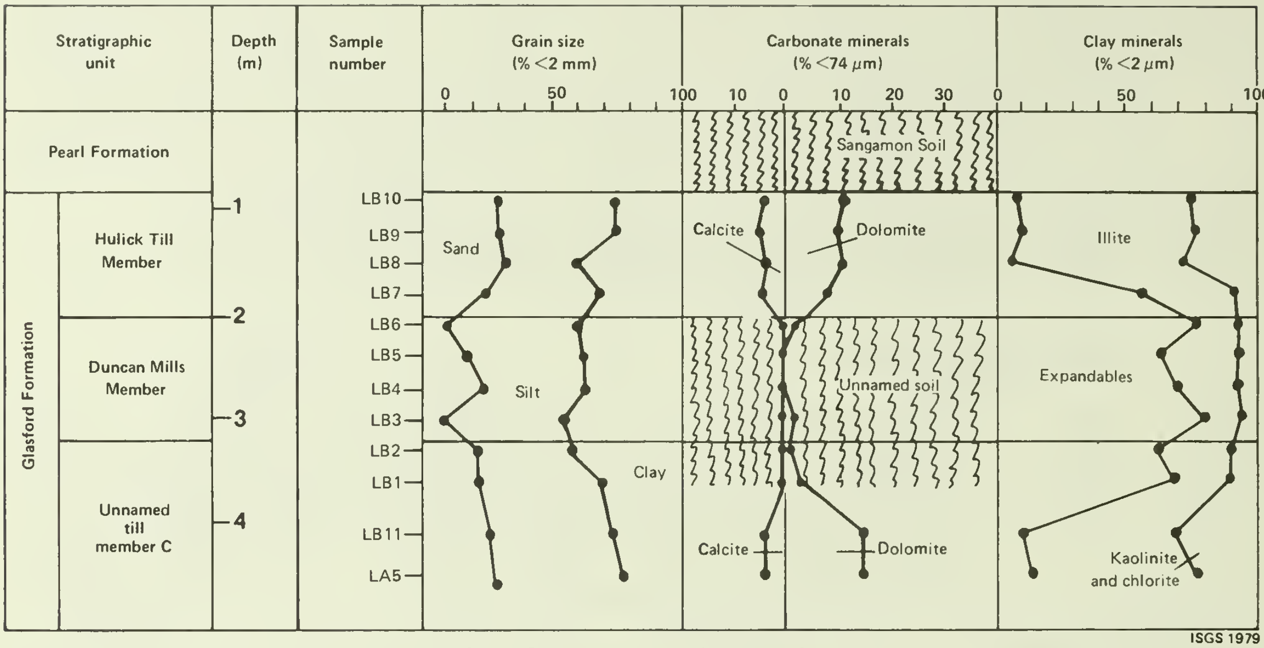


Figure 15. Grain sizes, carbonate-mineral content, and clay mineralogy of the Lewistown Section.

The Duncan Mills Member at Lewistown was correlated with the Duncan Mills type section at the Enion Section (Willman and Frye, 1970). At the type section, the Duncan Mills has been described as being deeply weathered and containing a truncated paleosol that Willman and Frye correlated with the Pike Soil. Whether the soils at Enion and Lewistown are equivalent to the Pike Soil is as yet unknown, and the paleosol at Lewistown is unnamed here.

The Duncan Mills Member at Lewistown is mostly noncalcareous (fig. 15, app. 1),as noted in Willman and Frye's field notes. The samples from the Duncan Mills were noncalcareous (Willman and Frye, 1970, p. 177), but their description above erroneously reports the unit as calcareous. Expandable clay minerals in the Duncan Mills have been relatively increased and chlorite lost because of weathering. The unit has a fine angular blocky structure typical of fine-grained accretionary deposits and is probably an accretion gley formed during a period of warm-climate soil development. The till below the Duncan Mills Member is leached, clay-enriched, and has expandable clay minerals increased to the depth of 30 cm, which was not noted by Willman and Frye. The accretion-gley deposit in the Lewistown Section is truncated by the overlying Hulick Till, as indicated by some intermixing of till and gley at the contact and the absence of an A horizon on the soil. The composition and thickness of the gleyed zone (1.2 m preserved) and the intensity of weathering of the underlying till indicate that the paleosol formed under interglacial conditions.

The lower till at Lewistown was called the Kellerville Till Member by Willman and Frye (1970), but the current interpretation is that it is mineralogically and texturally unlike the Kellerville and in fact overlies a till that in turn overlies the Kellerville of western Illinois (Lineback, p. 69-78 of this guidebook). The lower till at Lewistown correlates best with unnamed till member C (Lineback, in this guidebook). It averages 28 percent sand, 48 percent silt, and 34 percent clay (fig. 15; app. 1). Unit C contains more dolomite (15 percent) than the Hulick and less illite (61 percent). Kaolinite and chlorite average 27 percent in the unweathered till, indicating that this is also a "shale type" of till. In contrast to unnamed member C and the Hulick, the Kellerville Till Member in the region averages 40 percent each for both expandables and illite.

Fragments of Pennsylvanian sandstone, coal, and shale are common in unnamed till member C. This till is believed to correlate with the till previously called Kellerville in the Enion Section, with the Illinoian tills in the Rushville Sections, the Hulick Till at Tindall School, and various other illitic shale types of tills called either Hulick or Kellerville at points in Fulton and adjacent counties. Unnamed till member C consistently contains less illite and more dolomite than the Hulick (Lineback, table 1, p. 74 of this guidebook).

Willman and Frye (1970) indicated that the two tills at the Lewistown Section are Illinoian in age. The Hulick Till and the unnamed till can be traced westward into McDonough County, where they overlie older tills in the Illinoian sequence which extend into Iowa. Thus, these two tills fit into the succession of drifts named as the Illinoian Stage by Leverett (1899) and considered to be Illinoian by subsequent workers. At Lewistown, the two tills are separated by a truncated remnant of a paleosol that is believed to have formed during one of the interglacial intervals indicated in paleoclimatic interpretations from marine cores. If this is so, and if the correlations are correct, the Illinoian Stage as defined and used in Illinois for 80 years encompasses more than one glacial-interglacial transition.

Arenzville Section

STOP 6

The Arenzville Section is a borrow exposure 1 km east of the eastern bluff of the valley of the Illinois River in Cass County (fig. 16). The section exposes thick Wisconsinan loess, 7 m of Peoria Loess, and 5 m of Roxana Silt (fig. 17). An auger boring at the base of the section was drilled to sample an additional 1 m of Roxana and a 3-m-thick section of the underlying till in which a Sangamon Soil has developed in the upper part. Samples through the entire section were taken at 20-cm intervals and analyzed for carbonate and clay-mineral composition (fig. 18).

The section is measured in a vertical borrow exposure 15 m east of road in NW NW SW Sec. 10, T. 17 N., R. 11 W., Arenzville 15-minute Quadrangle, Cass County, Illinois. Measurements begin at 1.2 m below ground surface next to Black Cherry Tree.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	1.2 to 6.8	AZ1 to AZ29	Loess; dolomitic, light olive-brown to yellowish-brown (2.5Y-10YR 5/4) silt loam, rare 4/2 or 5/6 mottles; few small pores and channels in upper 3.4 m, apparent collapsed channels and essentially no pores in lower 2.2 m; brown humus stains in upper 5.2 m; nearly massive, fracture surfaces	

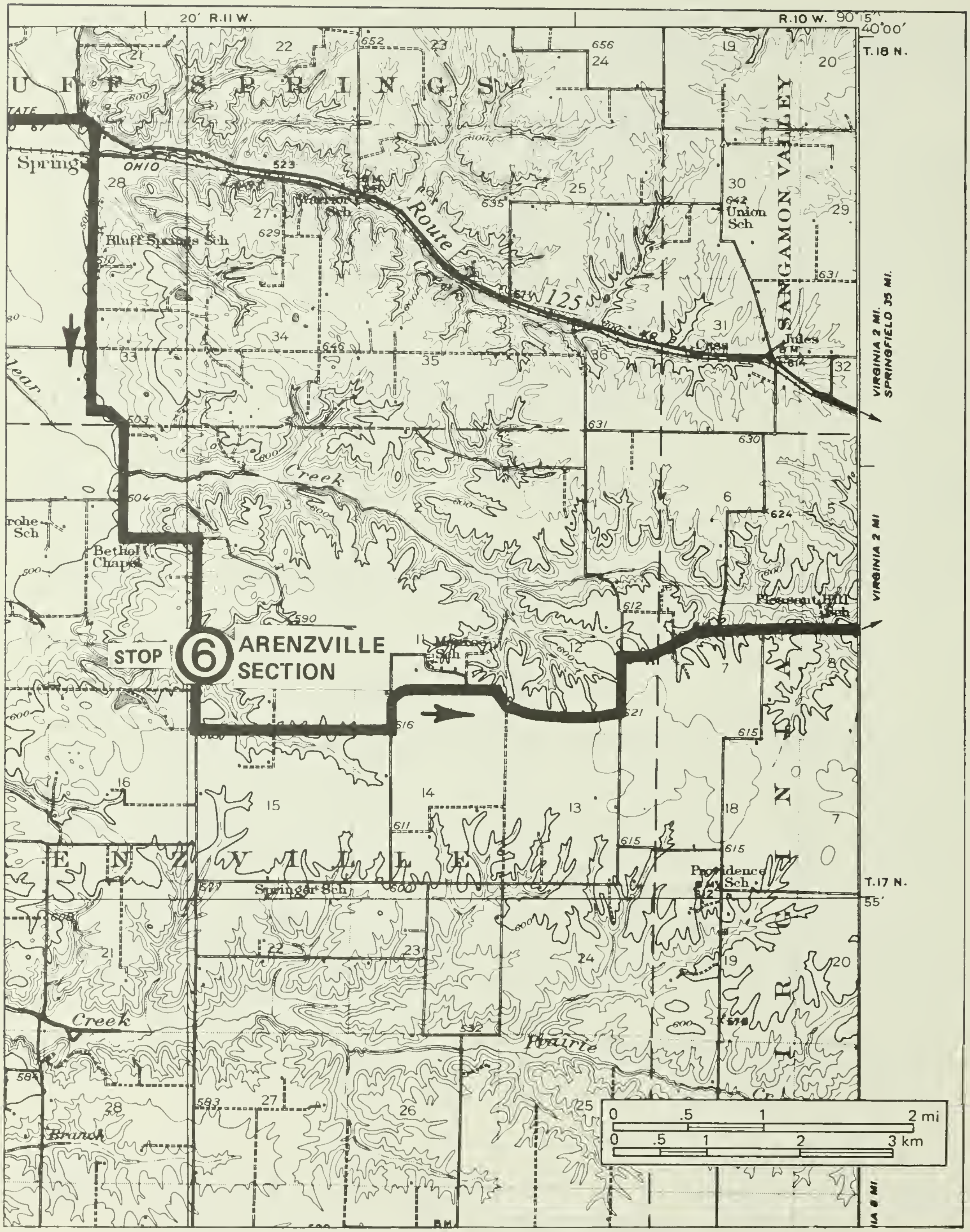


Figure 16. Location of the Arenzville Section.

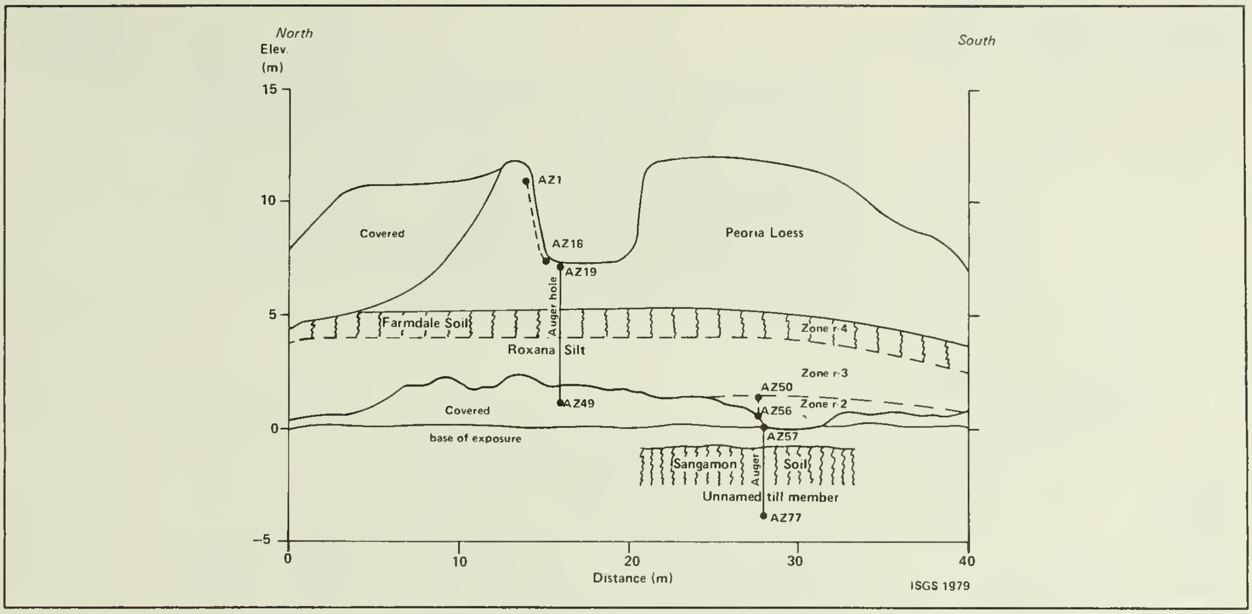


Figure 17. Diagram of the Arenzville Section. Datum point is the base of the exposure.

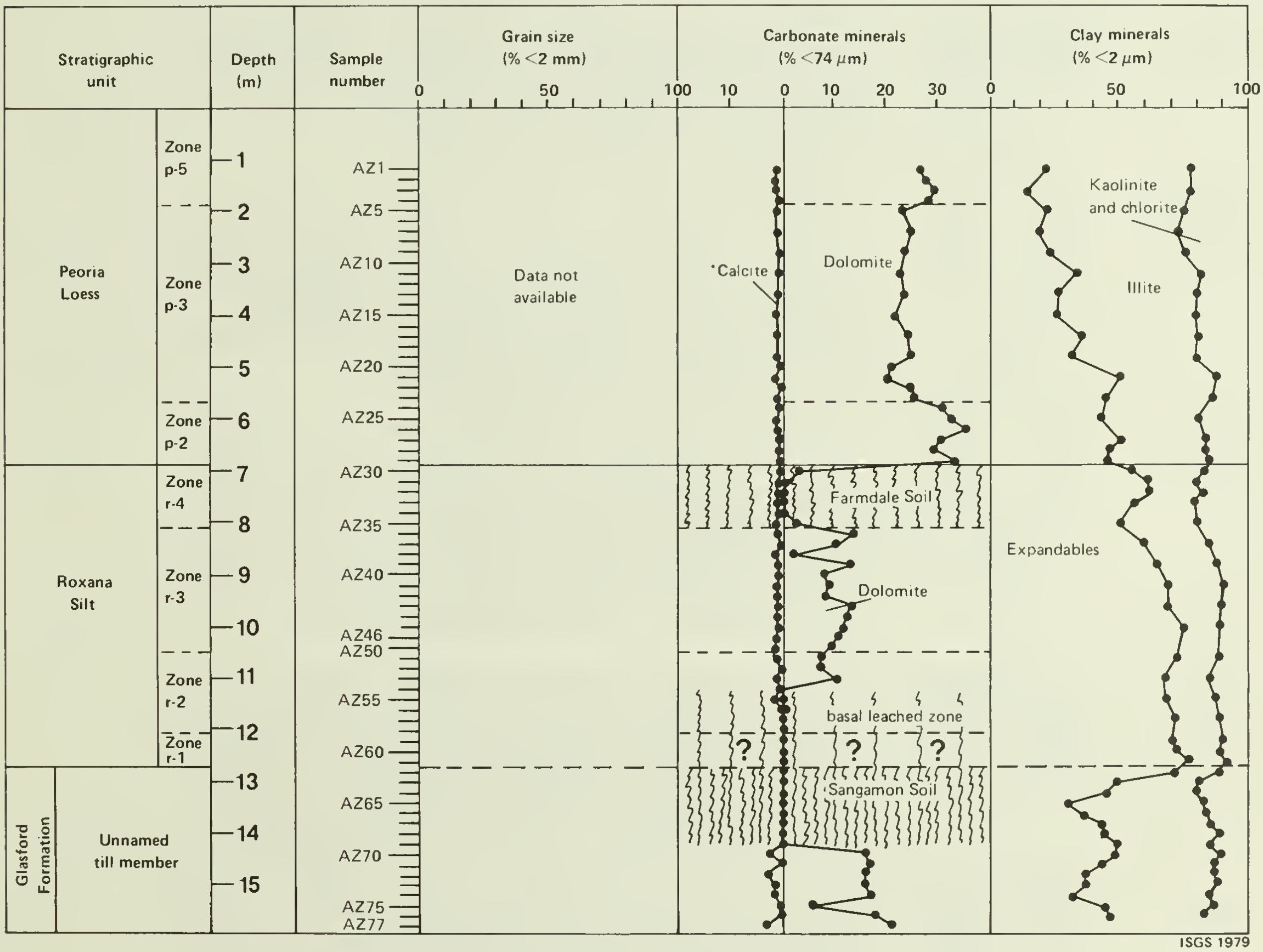


Figure 18. Grain sizes, carbonate-mineral content, and clay mineralogy of the Arenzville Section.

Horizon	Depth (m)	Sample no.		Thickness (m)
			rough with small rounded forms, very weakly aggregated, lower 2 m more massive; occasional root or root trace; occasional secondary carbonate in channels; few snail shells; friable; no visible zonation. Outcrop samples, AZ1 to AZ18, and hand auger samples, AZ19 to AZ29, taken at 20-cm intervals..................................	6.9
Altonian Substage Roxana Silt			*Farmdale Soil*	
C/A (r-4; informal color designation, McKay, p. 95-108 of this guidebook)	7.0 7.2 7.4	AZ30 AZ31 AZ32	Loess; leached pinkish-brown (9YR 4/3) silt loam with few light-colored diffuse mottles; few small iron-manganese-organic masses (degraded charcoal); few pores and channels; nearly massive, weak aggregation, rough rounded forms on fracture surfaces; firm, hard when dry; gradational boundaries.	0.6
C1 (r-4)	7.6 7.8 8.0	AZ33 AZ34 AZ35	Loess; leached pinkish-brown and dark-brown (9YR 4/3-3/3) silt loam; no pores; massive, very weak aggregation; firm, hard; few root channel carbonate concretions at 7.8 m (possible Ab)..............	0.6
C21 (r-3)	8.2 to 10.2	AZ36 to AZ46	Loess; dolomitic brown, slightly olive (10YR-1Y 4/3-4/4) silt loam; rare dark mottles; no pores; massive, very weak aggregation; firm, hard, traces of secondary carbonates; traces of degraded charcoal at 9.4 m; gradational boundaries.............	2.2
C22 (r-2)	10.4 to 11.0	AZ47 to AZ53	Loess; dolomitic, pinkish-brown to dark yellowish-brown (9YR-10YR 4/4) silt loam; no mottles; few pores; massive, very weak aggregation; firm, hard; traces of secondary carbonates; traces of degraded charcoal at top; base of auger boring at sample 49, shifted to outcrop samples at 50.......	0.8
C1' (r-2)	11.2 to 12.6	AZ54 to AZ59	Loess; leached, pinkish-brown (9YR 4/4) silt loam; no mottles; more pores than above; firm, hard; massive, weak aggregation becoming stronger with depth. Sand grains apparent in lower 0.4 m. Base of exposure at AZ56, augered beyond AZ56......	1.2
C/A (r-1)	12.4 12.6	AZ60 AZ61	Loess; leached, dark yellowish-brown (10YR 4/4) silt loam; few pores; massive to weak granular, stronger aggregation than above; few secondary carbonates, few sand grains; gradational boundaries....................	0.4

Horizon	Depth (m)	Sample no.		Thickness (m)
Illinoian Stage				
Glasford Formation				
Unnamed till member			*Sangamon Soil*	
C/A1	12.8	AZ62	Till; sandy, few pebbles; leached, dark yellowish-brown (10YR 3.5/4) silt loam; porous; massive to weak granular; weak aggregation; firm, hard; traces of degraded charcoal; few secondary carbonates..	0.2
A2	13.0	AZ63	Till; leached, pinkish, dark yellowish-brown (9YR 4/5) loam with rare dark reddish-brown stains; few pebbles; porous; massive to weak granules, weak aggregation, firm, hard..........................	0.2
B1	13.2	AZ64	Till; similar to above except for lighter color (9YR 5/4), very weak blocky structure, few thin argillans and few stains; gradational boundaries....................	0.2
B2t	13.4 13.6	AZ65 AZ66	Till; leached, pinkish-brown (7.5YR 5/4) clay loam with many 10YR 5/5 and few 2/1 mottles, few 5/8 concretions; common 4/6 argillans; few silans; porous, weak blocky to granular, strongly aggregated; somewhat friable, hard when dry; many pebbles....................................	0.4
B3t	13.8 14.0	AZ67 AZ68	Till; leached, mixed brownish-yellow and olive-yellow (10YR-2.5Y 6/6) clay loam with few 5/8 and 2/1 mottles and stains; many thick (5YR 4/4 and 3/2) argillans; weak coarse blocky, strongly aggregated; firm (compacted); few pebbles..................	0.4
C1	14.2	AZ69	Till; leached, brownish-yellow (1Y 6/6) loam with few 6/1 and 6/8 mottles, few 2/1 stains; common 5YR 4/4 argillans; weak blocky, weakly aggregated; firm; few pebbles....................................	0.2
C21	14.4 to 15.2	AZ70 to AZ74	Till; calcareous, yellowish-brown (10YR 5/6-5/4) loam with few 6/8 mottles, few 2/1 stains; few argillans, masses of secondary carbonates in upper part; massive to coarse angular blocky; few pebbles...............	1.0
C22	15.4 15.6	AZ75 AZ76	Silt; weakly calcareous, light olive-brown (2.5Y 5/4) silty clay loam with common 5/8 mottles, few 2/1 stains; rare argillans; mostly secondary carbonates in upper part, (B?), massive to weak, fine angular blocky.	0.4

Horizon	Depth (m)	Sample no.		Thickness (m)
C23	15.8	AZ77	Sand and gravel; calcareous, grayish-brown (2.5Y 5/3) gravelly sandy loam with few 6/8 mottles; massive...........................	0.2
			Total	15.8

The Peoria Loess in the upper part of this exposure contains dolomite zones p-2, p-3, and p-5, which correlate with zones identified in the Morton Loess at Farm Creek and Gardena and with zones in the Peoria south along the Illinois and Mississippi Valleys. The upper part of the Peoria has been removed by erosion at this site. It is likely that at least 2 m of zone p-5 has been removed. Zone p-1, the basal transition zone, is absent or not sampled, and zone p-2 rests directly on the Roxana Silt.

The Farmdale Soil is developed in the upper 1.2 m of the Roxana and has a very weakly expressed profile. The Farmdale C/A horizon is a 0.6-m-thick leached zone containing a few small iron-manganese or organic masses, probably degraded charcoal, and a few pores and channels. The C1 horizon of the Farmdale is a 0.6-m-thick layer of massive leached loess.

The Roxana Silt has four color zones that are generally recognizable only in thick sections and correspond to zones r-1 through r-4 (McKay, p. 95-108 of this guidebook). Zone r-4, the upper pinkish brown zone, corresponds to the Farmdale Soil profile and probably reflects a pedogenic reddening of the upper Roxana.

Zone r-3, the middle brown zone, is a 2.2-m-thick massive loess that has an average dolomite content of about 10 percent. It is the thickest and most dolomitic Roxana zone, but it contains only half as much dolomite as the least dolomitic Peoria. The carbonate compositions of the Peoria and the Roxana in the Arenzville Section are typical of thick loess exposures along the Illinois Valley, and the compositional trends in the two loesses are very useful aids in distinguishing the units.

Zone r-3 overlies zone r-2 on a gradational contact. The upper part of the 2.0-m-thick zone r-2 contains an average of about 8 percent dolomite. The lower 1.2 m of the zone is leached. The color change from r-2 to r-3 represents a minor lithologic and mineralogic boundary within the Roxana, a change in carbonate, clay-mineral, and grain-size composition. Thus, the color boundary probably reflects a change in the composition of the Altonian valley train.

Zone r-1, a yellowish-brown leached loess, is 0.4 m thick and contains properties of both a C horizon and a very weakly expressed A horizon. It is the stratigraphic equivalent of the Markham Silt and McDonough Loess Members, but neither of these units, nor the Chapin nor Pleasant Grove Soils, are differentiated at Arenzville. Instead, r-1 and the leached part of r-2 are informally referred to as the basal leached zone. The upward decrease of soil characteristics through the basal leached zone is the result of decreasing soil formation as increments of loess were being added.

The Sangamon Soil at this stop is typical of the near-red, well-drained, in situ type of profile developed on loam till. The upper solum has hues of

7.5YR to 10YR and becomes more yellow in the lower solum. Sangamon profiles developed on till in central Illinois are rarely more red than this one. A sand and gravel bed is present below the till, which helps explain the good drainage of the Sangamon here.

The soil horizon at the top of the Sangamon is confounded with A and C horizon characteristics (see app. 3 for further explanation). This horizon, the C1/A, is slightly darker and has a noticeable pebble content, which is the basis for picking the top of the till; however, the clay-mineral composition shows that this horizon is more like the overlying horizon than the underlying A2. Because of the lack of any truncation evidence and the conformable relationship with the A2, the C/A1 is considered the uppermost horizon of the Sangamon.

Under the A2 is an argillic horizon about 1 m thick. Total solum thickness is about 1.6 m. Many argillans are present from the B1 through the C1; maximum expression is in the B3t. This profile could be an Ultisol or an Alfisol. The clay mineral results are erratic through the B, which suggests there is some interference caused by the high amount of oxidized material in the B. In this case, the illite appears to increase where expandable minerals are affected by iron or other components.

The calcareous till in the C21 horizon is considerably altered compared to C4 horizons at other locations. The till here may be either the Vandalia Till Member or unnamed till member C. Under the till is a possible B horizon in a silty material, but it may be an inclusion in the till. Below the silty zone is a sand and gravel bed that could not be penetrated with a hand auger.

Fairground Section STOP 7

The Fairground Section, shown in figure 19, was selected for a typical example of in situ Sangamon Soil that is commonly exposed in the central Illinois area. The thickness of the solum is about 2.25 m, and the color profile is within the range of an intermediate drainage class. All of the soil horizons are preserved. The solum has a conformable relationship with the overlying Roxana Silt, which is about 1 m thick. The Roxana also has a conformable relationship with the overlying Peoria Loess, but the boundary is more distinct because the lower part of the Peoria is calcareous.

The Sangamon Soil is developed in the Vandalia Till Member of the Glasford Formation, which is about 5 to 6 m thick at this section. The till extends to the base of the section and rests on Pennsylvanian Shale. The upper part of the section has been disturbed and truncated so that actual depth measurements could not be made. The Peoria Loess on level areas in Springfield is about 3 m thick and thins to about 1 to 2 m on shoulders of valley slopes. Based on soil horizons found at the top of the section in the Modern Soil, about 1 m of Peoria has been removed. Measurements of the section begin at the upper street level.

The section is measured near the middle of the west side of a borrow area (parking lot) west of the Illinois State Fairground in the NE SW SW Sec. 15, T. 16 N., R. 5 W., Springfield West 7½-minute Quadrangle, Sangamon County, Illinois.

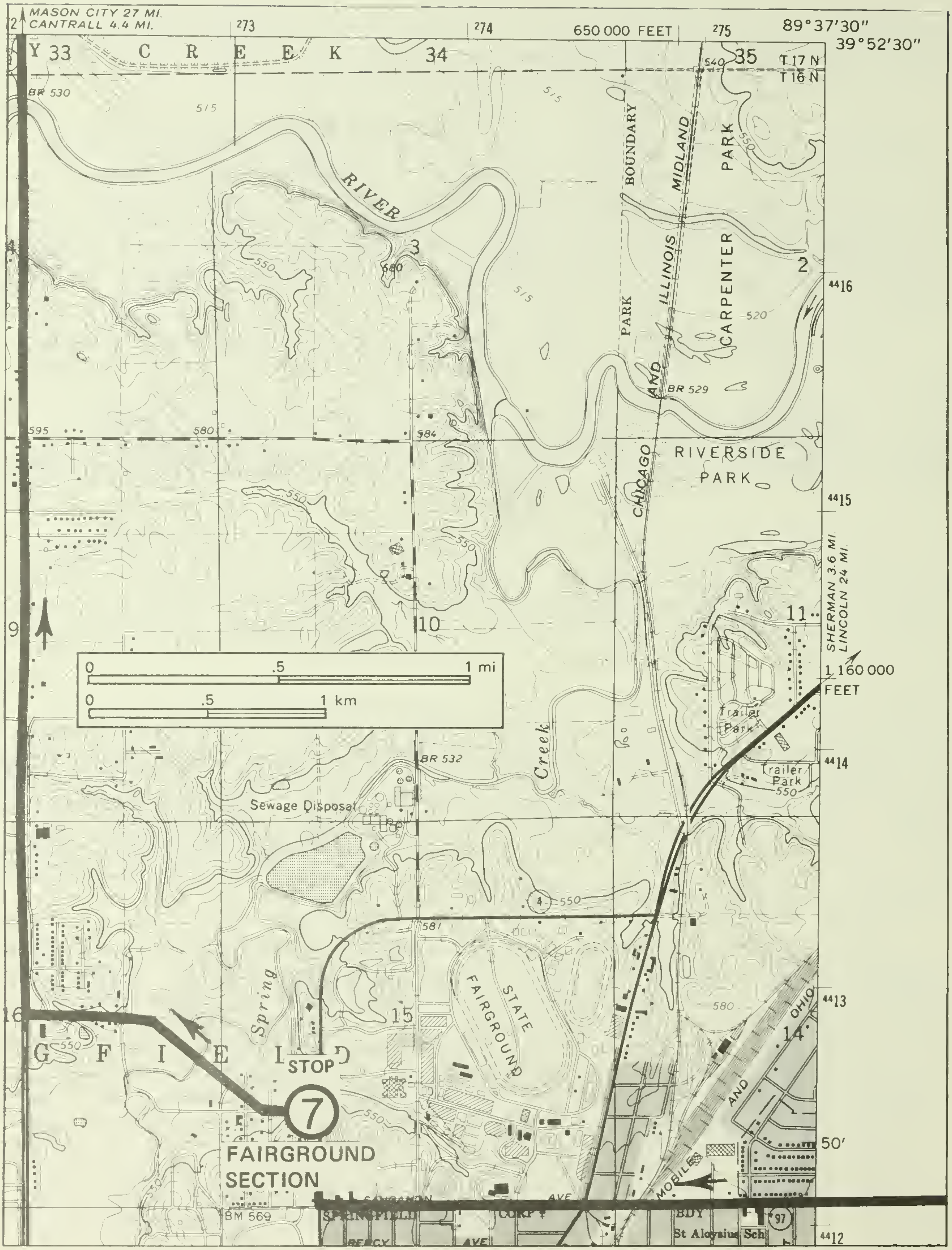


Figure 19. Location of the Fairground Section.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess — *Modern Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
B3 C1 C2	0.10 0.20 0.35	FG32 FG31 FG30	Loess; leached, yellowish-brown (10YR 5/5) silt loam grading downward to dolomitic, light brownish-gray (10YR 6/2) silt loam; few 4/4 stains and thin argillans in B3, common 5/4-5/8 mottles in C2; few small iron-manganese concretions; weak blocky grading downward to nearly massive, weak aggregation in B3 becoming more uniform in C2; few pores; friable....................................	0.40

Altonian Substage
Roxana Silt — *Farmdale Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
C/A and C/B	0.50 to 1.40	FG29 to FG23	Loess; leached, yellowish-brown to dark yellowish-brown (9YR 5/4-4/4) silt loam, some sand in lower part; rare 5/8 mottles; few small secondary carbonates in channels; weakly platy and granular, weakly aggregated, healed, platyness enhanced on exposure; few pores; traces of argillans in lower part; somewhat blotchy due to clean silt segregation; few roots; friable to firm, somewhat brittle; very gradual lower boundary..................................	1.05

Illinoian Stage
Glasford Formation
Vandalia Till Member — *Sangamon Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
C/A	1.55	FG22	Silt(?); leached, yellowish-brown (10YR 5/4) silt loam; low sand, few 4/4 mottles and stains; few small manganese (2/1) concretions; traces of secondary carbonates in pores; more granular than above, moderate aggregation, healed, breaks into rough angular blocks; few argillans in channels, somewhat blotchy; firm; very gradual boundaries................................	0.20
B1	1.70 1.85	FG21 FG20	Silt(?); leached, yellowish-brown (10YR 5/4) silt loam, low sand, high clay, few 5/6 and 2/1 stains; rare secondary carbonates; somewhat porous, more blocky than above, moderate aggregation, healed, some peds outlined by thin 3/3-4/4 argillans; firm...	0.25

Horizon	Depth (m)	Sample no.		Thickness (m)
B2t	2.00 2.30 2.60	FG19 FG18 FG17	Till; leached, brown to grayish-brown (10YR-2Y 5/3) silty clay, rare pebbles, low sand, common 5/6 mottles, few manganese concretions and stains; moderately blocky, strong aggregation, largely healed; common pores; many thin and common thick 4/3 and 3/2 argillans; bleached ped interiors; traces of secondary carbonates; plastic and massive when wet, hard and structured when dry....................................	0.85
B3t	2.90 3.20 3.50 3.65	FG16 FG15 FG14 FG13	Till; leached, mixed colors of grayish-brown and light olive-brown (2Y 5/3-5/6-6/2) clay loam, common pebbles, many 5/4 to 6/8 mottles, few 2/1 stains; weak coarse blocky, weak aggregation, healed; common pores; few 3/2 argillans; bleached ped interiors; traces of secondary carbonates; firm..	0.95
C2 and C3	3.80 to 7.10	FG12 to FG1	Till; calcareous, light olive-brown (2Y 5/5, upper) and gray (5Y 6/1, lower) loam, high sand, many pebbles, few 6/8 mottles, few 7.5YR 4/4 joint stains, few 2/1 stains in upper part; common large carbonate concretions, some rounded, some cemented angular masses; lower 1 m oxidizes to 2.5Y 6/3 upon exposure; nearly massive; upper part friable; lower part dense, hard, and breaks into blocks with conchoidal fractures; planar fractures common; common lenses of silt and sand; base of exposure on Pennsylvanian Shale.....................	3.40
			Total	7.10

Samples were collected on 15- or 30-cm intervals (fig. 20; apps. 1 and 2). The Peoria Loess is typical in its characteristics. The leached portion is yellowish brown compared to the lighter brownish gray of the C2 horizon, which contains 11.9 percent dolomite. The lower boundary of the Peoria is reasonably clear to distinguish by an increase in clay and expandable clay minerals and the disappearance of dolomite in Roxana Silt.

The 1-m thickness of Roxana is relatively uniform in appearance. A relatively high content of medium and coarse silt (51-54 percent), and a low content of sand indicate that the Roxana is loess. The Farmdale Soil is developed in the Roxana and is very weakly expressed. This interpretation is based on the fact that the Roxana is leached and possesses subtle soil characteristics. These characteristics are confounded A-B-C horizon features (app. 3). In this section the soil structures are small and strongly healed, and appear to be upper solum features that have undergone retrogressive development.

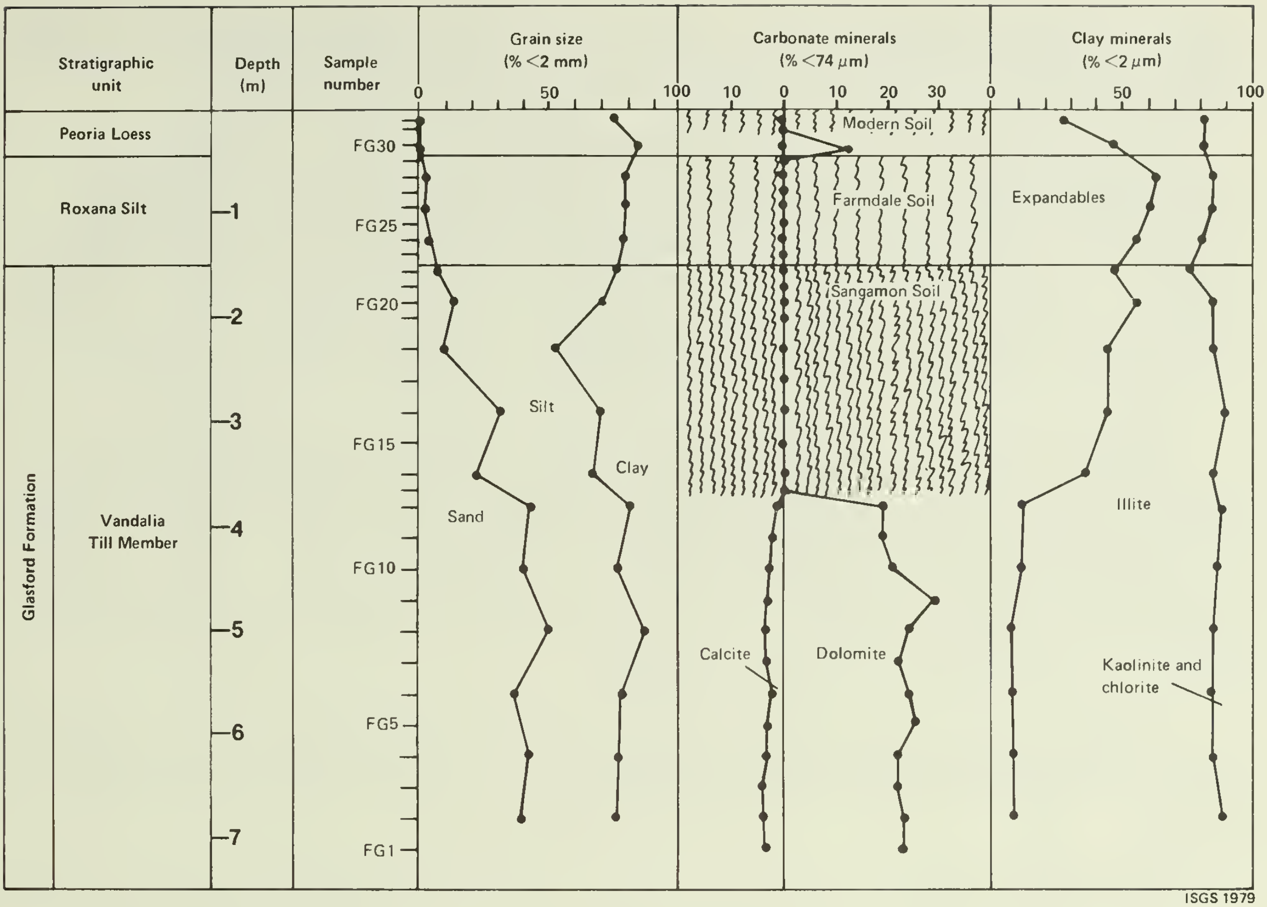


Figure 20. Grain sizes, carbonate-mineral content, and clay mineralogy of the Fairground Section.

The lower portion of the Roxana is gradational into the Sangamon C/A horizon, indicating that the Sangamon is not eroded. The contact zone is a gradational zone of mixing, but a boundary can be deduced from the morphological and analytical data. The Roxana has a slightly reddish hue, and the Sangamon C/A is slightly lighter in color and more firm. The sand content rises downward through the contact, but the clay mineral contents are reasonably contrasting. Expandable clay content is about 60 percent in the Roxana and drops to about 47 percent across the contact. The Sangamon C/A has the highest amount of vermiculite of all the samples of the section. A vermiculitic characteristic is common in buried A horizons.

Very few pebbles are present in the upper horizons of the Sangamon Soil. The total silt content of the C/A is about 70 percent. This suggests that the upper horizons are not till-derived, but that pedogenic mixing of till with an overlying silt can explain the high silt content. The overlying silt may be early Roxana or even be a pre-Roxana nontill deposit, but there is as yet no way of classifying it with certainty. Because there is pedologic continuity from the C/A downward, the top of the C/A was used in part to determine the top of the till as a formal stratigraphic unit.

The Sangamon B horizon is about 2 m thick. Sand content increases with depth to about 40 percent. A large but normal clay increase occurs between the C/A and the B2t (at sample FG18). The increase amounts to about 100 percent over an interval of 75 cm. The clay-mineral composition is dominated by

40 to 56 percent expandables that formed by alteration of the illite. A comparison of illite contents of the solum and C horizon shows a 25 to 45 percent loss, a depletion of about 60 percent in the B1.

The base of the B is marked by the presence of dolomite and common carbonate concretions. The calcareous till contains an average of 23 percent dolomite and 7 percent calcite; the grain-size distribution averages 42 percent sand and 21 percent clay; the clay-mineral contents average 10 percent expandables, 75 percent illite, and 15 percent kaolinite and chlorite. Weathering has affected the C horizons to the extent that geologic chlorite minerals have been altered to expandable minerals. In general, the till here is much like the Vandalia Till at GraybaR, Farmdale Park, and Athens North Quarry.

The drainage class of the Sangamon profile may be considered moderately well drained based on the mottle-free 10YR 5/4 color of the B1; however, the B2t has a paler, more olive color, which suggests that the drainage class was orginally lower and has undergone improved drainage over time. This site may have been more remote from valley slopes, and, as time passed, slope evolution brought better surface drainage to the site. Then, after each event of loess deposition, the developing soil on a new geomorphic surface experienced better drainage as the slope evolution continued.

Although insufficient data is available, the Sangamon Soil here may be an Ultisol based on the relatively high degree of illite alteration and solum thickness. The Modern Soil in the vicinity of the stop is a lesser developed Alfisol.

Athens South Quarry Section

STOP 8

The Athens South Quarry Section is a limestone quarry exposure at the north end of the east highwall that cuts through a northward-sloping ridge (fig. 21). This well-drained upland site is within the area where Worthen (1873) described the buried soil that was later named the Sangamon by Leverett (1898a). The South Quarry exposure of the Sangamon Soil is being considered for a type section for the well-drained member of a type Sangamon Soil catena. A proposed type poorly drained member will be seen at the next stop about 1 km north.

The South Quarry Section exposes 4.0 m of Peoria loess, 0.95 m of Roxana Silt, 1.2 m of Sangamon Soil in till, and 3.15 m of calcareous Vandalia Till overlying a Pennsylvanian siltstone. Measurement, sampling, and description were started at a depth of 3.2 m in the Peoria Loess. Grain size, carbonate-mineral, and clay-mineral analyses were performed (fig. 22 and apps. 1 and 2).

The section is measured from a highwall of a limestone quarry operated by Medusa Aggregates in the NE NE NE, Sec. 19. T. 18 N., R. 5 W., Mason City Southwest 7½-minute Quadrangle, Menard County, Illinois.

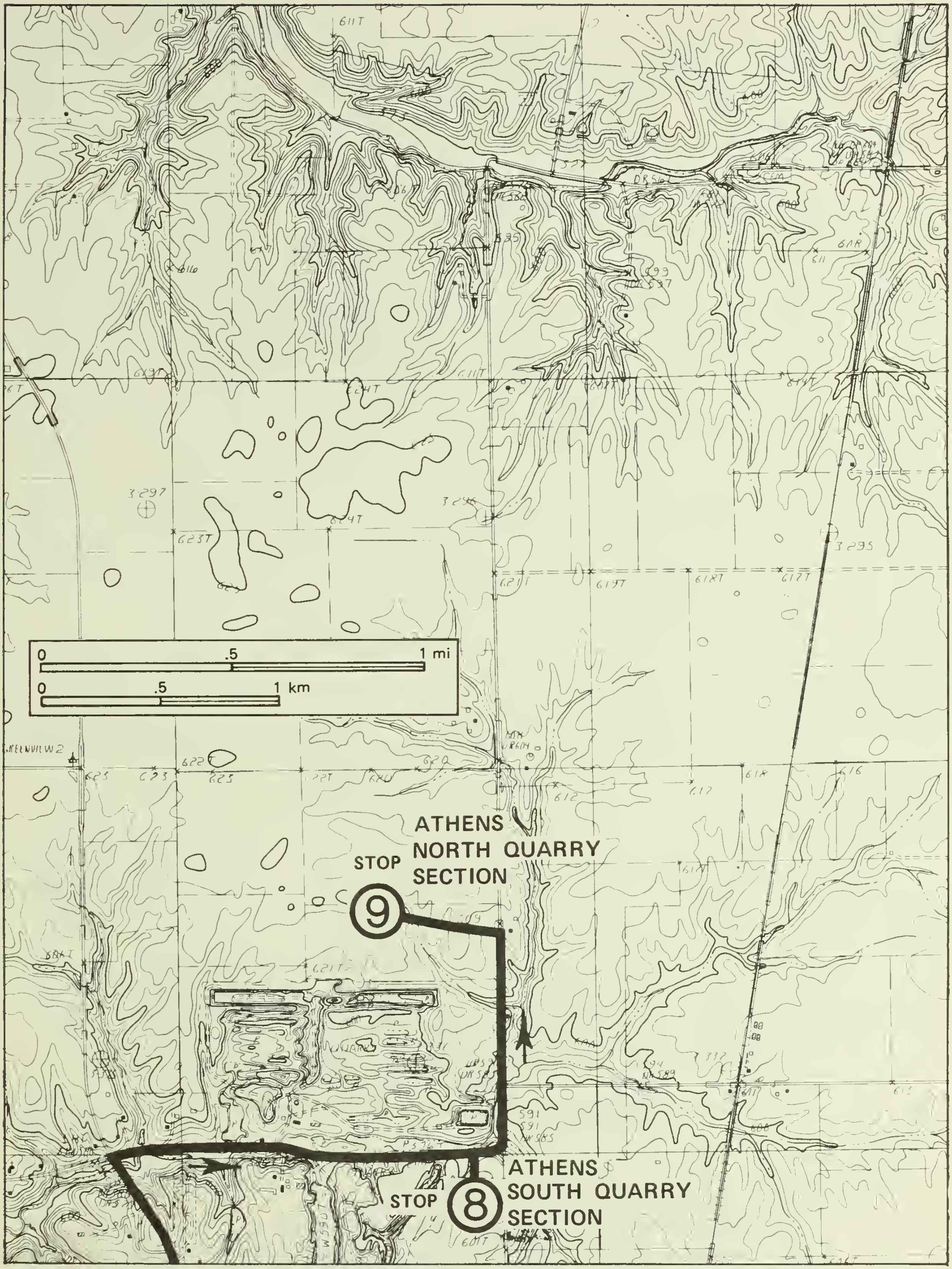


Figure 21. Locations of the Athens North Quarry and South Quarry Sections.

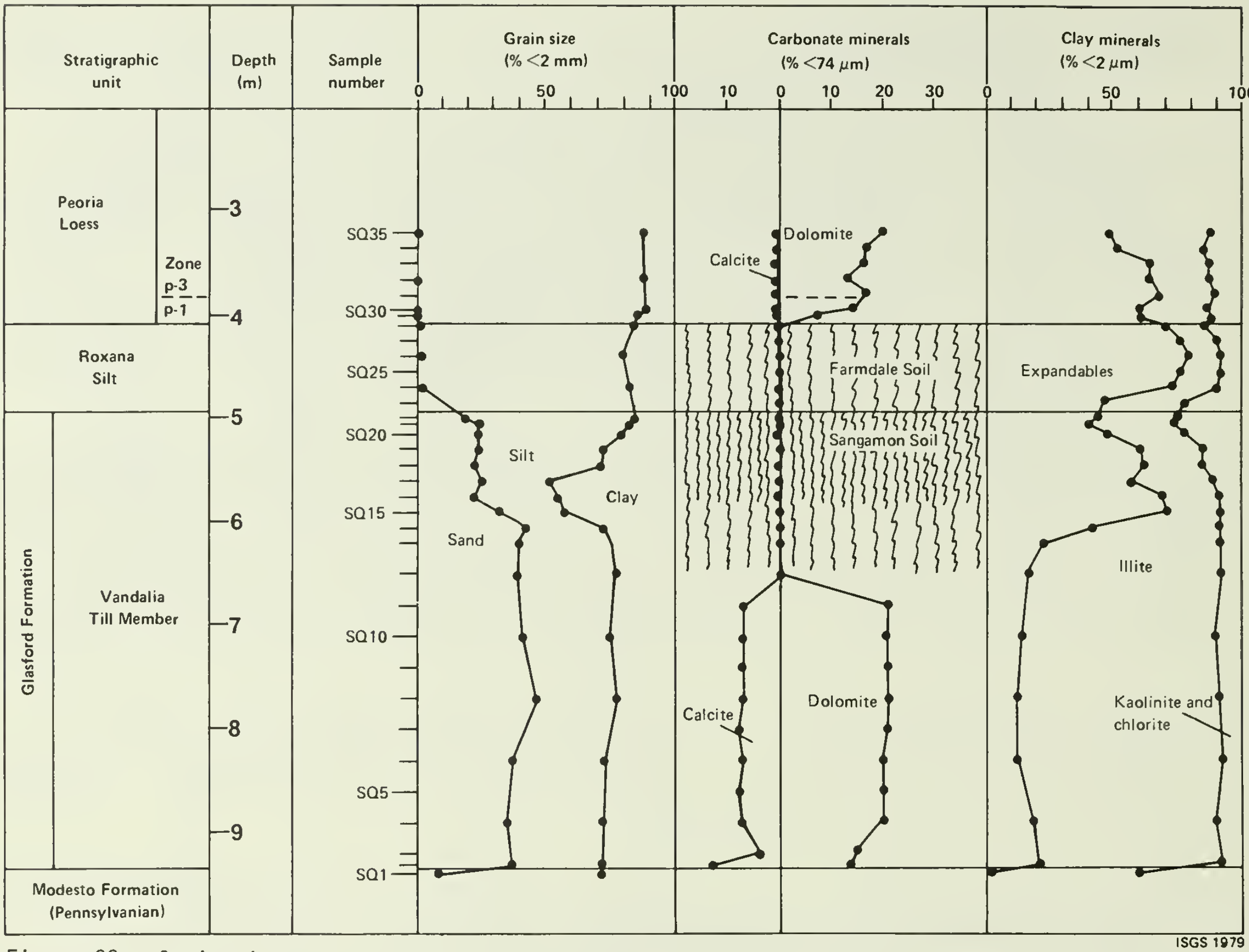


Figure 22. Grain sizes, carbonate-mineral content, and clay mineralogy of the Athens South Quarry Section.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	3.20 to 4.00	SQ35 to SQ29	Loess; dolomitic, light olive-brown (2.5Y 5/4-5/3) silt loam, common 10YR 5/8 mottles, few 4/4 stains, rare small manganese concretions; exposure generated platy structure, very weakly aggregated; few small channels and pores; friable; gradational lower boundary. Sampled at 15-cm intervals.......	4.0

Altonian Substage
Roxana Silt — *Farmdale Soil*

Horizon	Depth (m)	Sample no.		Thickness (m)
A	4.10 4.25 4.40	SQ28 SQ27 SQ26	Loess; leached, dark-brown (8YR 3/3) silt loam, rare 5/8 mottles; weak platy and granular aggregates; traces of very small argillans, faint silans; traces of charred roots; few pores; friable to firm..................	0.45

Horizon	Depth (m)	Sample no.		Thickness (m)
B B B/A	4.55 4.70 4.85	SQ25 SQ24 SQ23	Loess; leached, pinkish-brown (8YR 4/3-4/4) silt loam, few small 5/6 mottles and 2/1 stains; weak platy to granular, increasing aggregation downward becoming more platy; few small pores; traces of argillans in channels; few silans or bleached masses of silt and more sand in lower part; friable; clear lower boundary......................	0.50
Illinoian Stage *Glasford Formation* *Vandalia Till Member*			*Sangamon Soil*	
A2	5.00 5.05	SQ22 SQ21	Till; leached, brown (10YR 5/3)(10YR 7/2 dry) loam, few pebbles; rare small carbonized, manganized wood fragments; weak platy, moderate aggregation, porous, brittle, firm..................................	0.15
A/B	5.15 5.30	SQ20 SQ19	Till; leached, brown to dark yellowish-brown (10YR 5/3-4/4) loam, few pebbles; coarse platy; to fine blocky, moderate aggregation; common channels and pores, common thin 4/2-3/2 argillans; common bleached masses between peds; firm to friable; gradual, irregular boundaries.................	0.25
B1	5.45	SQ18	Till; leached, yellowish-brown (10YR 5/4) loam, few pebbles, mottle free; moderate subangular blocky, porous; common 3/2 argillans in channels and on ped surfaces; bleached ped interiors; few fecal pellets; firm....................................	0.15
B21t	5.60 5.75	SQ17 SQ16	Till; leached, "reddish" brown (9YR 5/5-4/3) clay, few pebbles, few 5/8 mottles and stains; strong fine to medium angular blocky; porous; many 5YR 3/2-2/2 argillans; bleached ped interiors; firm..............	0.30
B22t	5.90	SQ15	Till; leached, brown (10YR 5/3) clay, few pebbles, common 5/8 mottles; strong subangular blocky; porous; common, few thick 2/2 and 4/2 argillans; bleached ped interiors; traces of secondary carbonates; firm; abrupt lower boundary.....................	0.20
C1	6.05	SQ14	Till; leached, olive (2Y 5/4) loam, few pebbles; common 5/8 and few 6/2 mottles and stains; weakly blocky, weak aggregation; common pores; common 4/2-3/2 argillans; few large carbonate concretions; somewhat friable....................................	0.15

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	6.20 to 8.60	SQ13 to SQ5	Till; calcareous, olive (2.5Y 5/5) loam, few pebbles, few 5/8 mottles, few 6/1 mottles and few large carbonate concretions in upper part, few 5YR 4/4 stains in lower part; nearly massive, dense, hard, breaks into angular blocks..........................	2.55
C3	8.90 9.20 9.30	SQ4 SQ3 SQ2	Till; calcareous, olive (2.5Y 4/3) loam, few pebbles, rare 5/8 mottles; massive, breaks into angular blocks with conchoidal surfaces; dense, hard; slightly browner and more clay in lower 15 cm; abrupt lower boundary..	0.60
Pennsylvanian System				
Modesto Formation				
R	9.40	SQ1	Siltstone; noncalcareous olive (5Y 5/3), weakly bedded; soft and plastic when wet; hard when dry; micaceous; about 6 m above quarry operations....................	≥0.10
			Total	9.40

The lower part of the Peoria contains the common carbonate transition zone (p-1), which appears to be grading upward into an intermediate carbonate zone (p-3). The high carbonate zone (p-2) appears to be missing, because the dolomite value at the lower maximum is only 17 percent. The p-2 zone at other localities ranges from 25 to 35 percent dolomite. Because of a lack of data through the upper part of the Peoria, a more accurate appraisal of the carbonate zones is not possible. Morphological features of the Peoria are typical for the area. Depth of leaching in the Modern Soil (Mollisols) is about 1 m. The clay minerals in the lower Peoria show an upward decreasing content of expandables that may relate to the clay mineral zones I and II.

At various locations in the South Quarry Section, the top of the Roxana shows a darkened (7.5YR to 10YR 3/3) A horizon of the Farmdale Soil. Clay content increases slightly and the color becomes lighter going down into the B. On first inspection, the Farmdale solum appears to be a normal, weakly expressed soil developed in the Roxana; however, study reveals that the horizons are confounded with A-B-C characteristics (app. 3). Near the middle of the Roxana, A horizon characteristics increase toward the base, paralleling the trend in the sand content. Clay-mineral data also indicate that the lower part of the Roxana belongs pedogenically to the top of the Sangamon Soil. Samples 20 through 23 have a relatively low expandable and high illite content. Also, these samples have a high vermiculite content, which causes the calculated kaolinite and chlorite values to reach a maximum in this zone. These features are associated with A horizons.

Selecting the base of the Roxana at this section is somewhat arbitrary, as it is at other sections where a conformable sequence of Roxana overlies the Sangamon. It is clear that pedologic processes continued to operate as the Roxana was deposited. In other words, the Sangamon Soil transgresses into Wisconsinan time. The notable amount of pebbles present at the 5 m depth in a zone that has a strong A2 horizon expression was used to establish the top of the Sangamon Soil in till. The original Sangamon A1 could have been eroded, but, based on our model of Sangamon Soil genesis, the original A1 probably transformed into an A2 before the later increments of loess buried and removed it from the soil-forming environment. Pedogenic mixing of the Roxana into the Sangamon Soil is evident from the ratio of coarse to medium silt which shows a loessial influence down to sample 19 of the A/B horizon (app. 2).

Solum thickness of the Sangamon Soil in the measured section is 1.2 m. The B including the C1 is 0.8 m thick. Although the Sangamon is well drained, it is only slightly redder than 10YR. The argillic horizon may be somewhat unusual in that an abrupt change in clay content occurs at the upper and lower boundaries of the B2t. The change across both boundaries is about 20 percent in absolute amounts. The relative increase from the B1 to the B2 is about 100 percent and attains a texture of clay.

The sharpness of some of the Sangamon Soil horizon boundaries suggests that before burial by the Roxana, all the horizons were developing downard at a fairly rapid rate. Erosion was probably removing material from the surface, but the horizonation processes appear to have kept pace. The upper B (the A/B) is degraded, and the maximum clay accumulation zone (B2t) appears to have been moving downward as a pulse. This implies that the maximum rate of clay removal occurred just above the upper boundary of the B2t, and the maximum rate of deposition occurred near the base.

The high clay content in the B2t appears to cause a suppression in the sand content, but in the lower part of the horizon, the gravel content increases significantly. Also, discontinuities appear in the silt fraction data (app. 2), which suggest some changes of parent material; although the effect of these factors on the genesis of the Sangamon is not clear, they may have contributed to distinctness of the B2t.

The clay minerals also show the abruptness of the base of the B2t; the relative increase of expandable minerals from the C2 to the B2t is about 50 percent. This change comes at the expense of illite, which correspondingly decreases about 50 percent. Mineral weathering of this nature suggests that the Sangamon Soil at this section is an Ultisol.

The calcareous Vandalia Till (C2, oxidized, and C3, partly oxidized) averages about 39 percent sand and about 27 percent clay (4 μm). It contains about 29 percent carbonate minerals, averaging 8 percent calcite and 21 percent dolomite. Large rounded carbonate concretions are fairly common in the upper part. The illite content ranges from 70 percent to 78 percent. The primary chlorite minerals have been altered through the entire calcareous zone. Although weathered to some degree, the calcareous Vandalia here is hard and dense, a common characteristic for the Vandalia. The till parameters here are common for the Vandalia in other sections in central Illinois.

Athens North Quarry Section

STOP 9

The Athens North Quarry Section (fig. 21) is at the east end of the north high-wall of an active limestone quarry. A poorly drained composite of organic-rich material and gley zones are exposed. The sequence here matches very closely the generalized description published by Worthen in 1873 which became the basis for recognizing the organic-rich zone as the Sangamon Soil. Details are discussed by Follmer (1978). The exposure described and sampled in the summer of 1978 will not be available for the field trip. Grain sizes, carbonate minerals, and clay mineralogy for the section are presented in figure 23 and tabulated data are given in appendixes 1 and 2. Results of pollen analysis are presented by J. King (p. 109-113 of this guidebook).

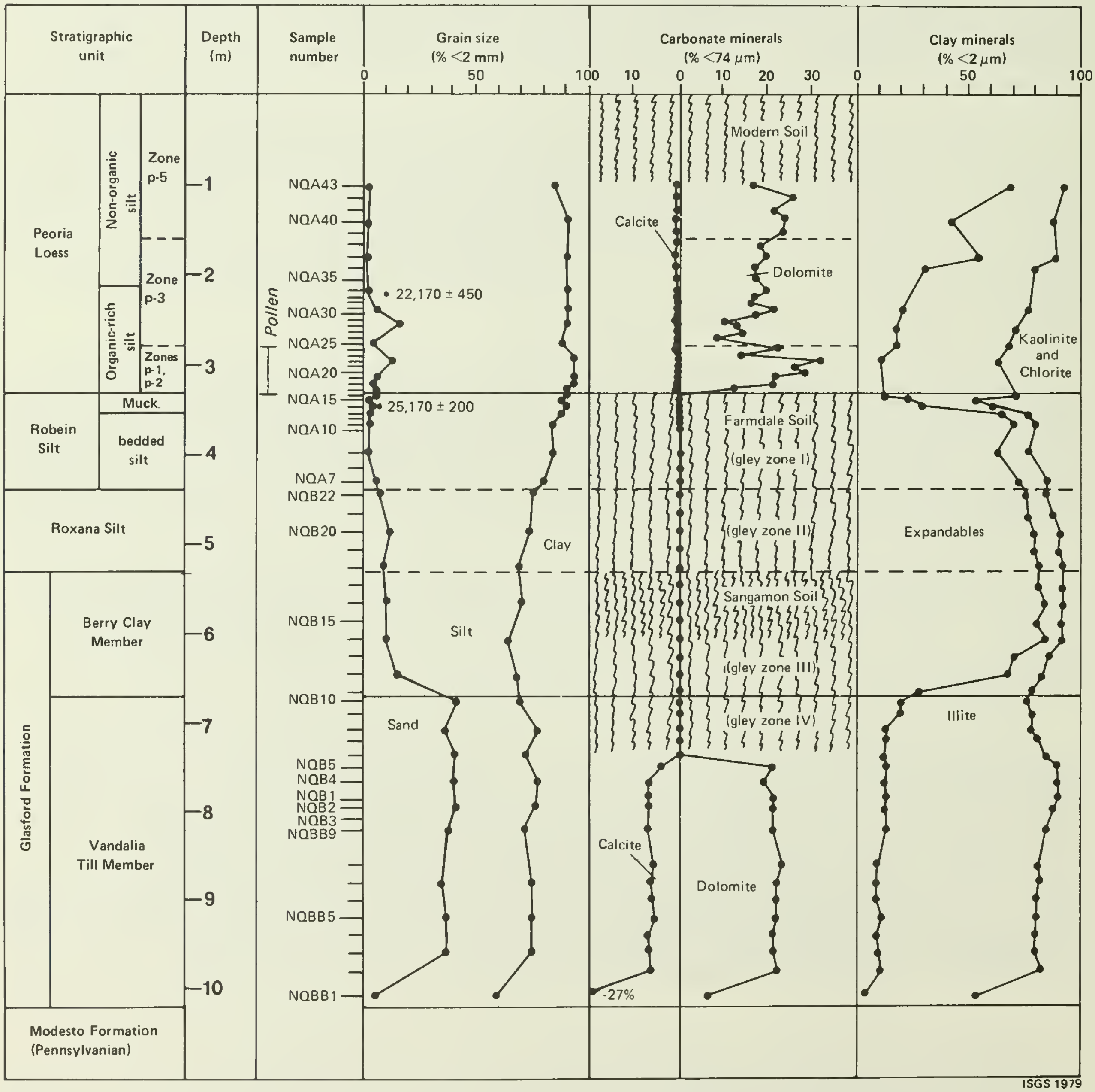


Figure 23. Grain sizes, carbonate-mineral content, and clay mineralogy of profiles A, B, and BB of the Athens North Quarry Section.

The section was measured at the east end of operating Material Services limestone quarry, August 1978, in the SW SE NE Sec. 18, T. 18 N., R. 5 W., Mason City Southwest 7½-minute Quadrangle, Menard County. Upper meter of section disturbed.

Pleistocene Series
Wisconsinan Stage
Woodfordian Substage
Peoria Loess

Horizon	Depth (m)	Sample no.		Thickness (m)
C2	1.02 to 2.05	NQA43 to NQA35	Loess; dolomitic, light olive-gray (5Y 6/2) silt loam, common 10YR 6/8 mottles, common dark stains and small iron concretions; massive to weak platy, very weak aggregation; porous, common small channels with thin dark argillans; friable. Upper 1.0 m not sampled. Sampled at approximately 13-cm intervals..............................	2.1
O' and A'	2.18 to 3.28	NQA34 to NQA17	Silt, organic rich; dolomitic, very dark grayish brown to black (10YR 3/2 and 2/1) color-stratified muck and silt loam, few to common 5/6 mottles, few pipestem concretions in upper part; few continuous small channels; weak platy "bedded" structure with ragged vertical fracture faces and felted horizontal surfaces; well-preserved spruce needles and charred-carbonized wood fragments in upper part, zones of highly decomposed organic material between zones of moderately well preserved woody fragments, generally more decomposed downward; abundant wood remains in lower 5 cm; sampled at 13 cm intervals. (Sampled wood at 2.25 m for dating, 22,170±450, ISGS-534)...	1.2

Farmdalian Substage
Robein Silt

Farmdale Soil

Horizon	Depth (m)	Sample no.		Thickness (m)
O2	3.37 3.40 3.47	NQA16 NQA15 NQA14	Muck; leached, black (10YR 2/1) mucky silt, rare 5/4 mottles in upper part; massive to very weak platy; firm when moist, hard and punky when dry. (Sampled wood and muck at 3.35 m for dating, 25,170±200, ISGS-536)...	0.2
A	3.53 3.60	NQA13 NQA12	Silt; leached, black (10YR 2/1) silt loam; massive, very weak aggregation, fracture surface rough with small rounded forms; somewhat friable..............................	0.1

Horizon	Depth (m)	Sample no.		Thickness (m)
Bg Gley zone I	3.66 3.73 3.98 4.14 4.30	NQA11 NQA10 NQA9 NQA8 NQA7	Silt; leached, very dark gray to dark gray (5Y 3/1-4/1) silt loam, more sand at base; nearly massive, healed platy (bedding?); rare pores and small channels; few very thin argillans; few thin bleached silt lenses; traces of organic matter; somewhat friable, hard when dry; occasional krotovina filled with 2/1 or 3/1 silt; common large-scale involutions (differential compaction or cryoturbation?); very gradational boundaries............................	0.7
Altonian Substage *Roxana Silt*				
Bg/A Gley zone II	4.46 to 5.27 4.45 to 5.25	NQA6 to NQA1 NQB22 to NQB18	Silt; leached, gray (5Y 5/1) heavy silt loam, rare 5/6-6/8 mottles; B horizon superimposed on A horizon, structures largely healed, breaks into blocks with rounded forms (welded aggregates) on fracture surfaces, distinct platyness and traces of degraded charcoal in B21; few small channels, porous in places; few thin argillans in pores; rare silans separating platy forms; friable to plastic; occasional krotovina filled with Robein material; very gradational boundaries.........................	1.0
Sangamonian Stage *Glasford Formation* *Berry Clay Member*			*Sangamon Soil*	
Bg Gley zone III	5.45 5.65 5.85 6.05 6.25 6.45 6.65	NQB17 NQB16 NQB15 NQB14 NQB13 NQB12 NQB11	Clayey silt; leached, dark gray to gray (5Y 4/1-5/1) in upper part to dark greenish gray (5GY 4/1) in lower part, silty clay loam, some sand, few pebbles; few 7.5YR 6/6 mottles, few 2/1 stains and small concretions; rare degraded charcoal in upper sample; nearly massive when wet, weak blocky with irregular aggregate forms when dry; few thin to large dark argillans; few silans; few pores more firm than above; plastic when wet, hard when dry; few krotovina, clear lower boundary.............	1.4

Horizon	Depth (m)	Sample no.		Thickness (m)
Illinoian Stage				
Glasford Formation (continued)				
Vandalia Till Member				
Bg Gley zone IV	6.75 6.90	NQB10 NQB9	Till; leached, dark greenish-gray (5GY 4/1) loam, common pebbles, many 5Y 6/6 mottles; few stains and small concretions; nearly massive when wet, healed weak blocky with moderate aggregate expression when dry; few 5Y 4/1 argillans; firm to plastic; occasional krotovina..........................	0.3
B3	7.05 7.20 7.35	NQB8 NQB7 NQB6	Till; leached, olive (5Y 5/4) loam, common pebbles, common 5G 6/1 and 10YR 6/8 mottles, few manganese concretions; weakly blocky with few argillans on healed ped surfaces, few pores; firm..........................	0.4
C2	7.50 7.65 7.85 7.95 8.05	NQB5 NQB4 NQB1 NQB2 NQB3	Till; dolomitic, light olive-brown (2.5Y 5/4) loam, common pebbles, gravel-rich zone at base, common 10YR 5/8 and rare 5G 6/1 mottles; weak coarse platelike blocks; rare small argillans; somewhat friable; gradual boundaries. (NQB1 to NQB3 from auger boring.)..................................	0.7
C4	8.20 to 10.10	NQBB9 to NQBB1	Till; dolomitic, olive-gray (5Y 4/2) loam, common pebbles, more olive (5/3) with common 5/8 mottles at top and base; middle part uniform with coarse blocky to platy fracture pattern, internally massive, commonly break with smooth to hackly conchoidal surfaces; firm, brittle, and dense; lower 20 cm contains common secondary carbonate and more clay, rests upon glacially polished Pennsylvanian limestone; 20-cm sample interval above BB1......................	2.1
			Total	10.2

The Peoria Loess at North Quarry is dolomitic and 3.3 m thick. It contains dolomite zones p-1, p-2, p-3, and p-5. The clay-mineral composition of the Peoria increases in expandable clay minerals and decreases in kaolinite and chlorite upward from the base.

The lower 1.2 m of the Peoria Loess, zones p-1, p-2, and the lower half of p-3, contain well-preserved spruce wood, needles, and other plant debris. Wood and muck at the base of the Peoria and at the top of the O2 horizon of the Farmdale Soil yielded a radiocarbon date of 25,170±200 ^{14}C years B.P. (ISGS-536). This date supports the interpretation that the age of the base of the Peoria Loess is about 25,000 ^{14}C years B.P. The upper part of the organic zone (sample NQA33) yielded a date of 22,170±450 ^{14}C years B.P. (ISGS-534). This date is from just below the middle of zone p-3, which has been estimated to range from about 20,500 to about 24,000 ^{14}C years B.P. (McKay, p. 95-108 of this guidebook).

The O2 horizon of the Farmdale Soil is more compact than the overlying organic-rich zone and stands out in the exposure as a more resistant bed. As organic-rich as this horizon appears, it only contains 6.3 to 7.3 percent organic carbon. It is leached of carbonates and contains about 85 to 90 percent silt. The vermiculite content in this horizon, which is higher than any of the A and O horizons seen on this trip, is the principal cause of the high values in the kaolinite and chlorite calculations (inseparable at 7 angstroms but resolvable at 14 angstroms). This also causes large reductions in the values for expandable clay. An A horizon occurs below the O2, and from that point downward, the clay-mineral trends change very little until the till is encountered. This indicates a similarity of the materials, or of the soil-forming environment, or both. The environmental conditions may be the more important of the two.

The parent material of the Farmdale Soil here is interpreted to be the Robein Silt. The upper part is organic-rich silt and the lower part is an involuted gleyed silt loam (gley zone I). This gley appears to have a wavy bedding and a few soft-sediment penetration structures. The clay content gradually increases downward and sand becomes noticeable in the lower part. The lower boundary is placed where the color becomes lighter and the apparent bedding stops. All other features are very gradational across the boundary into gley zone II.

Passing down into gley zone II, the small soil features change somewhat and become more granular or have a welded granular aggregation within a weak blocky or platy structure. (See app. 3 for explanation of these features.) Mottling becomes apparent and the clay and sand content continues to increase downward. Gley zone II is interpreted to be the Roxana Silt simply because no pedologic, stratigraphic, or geomorphic evidence was found to suggest that it is missing at this section. A reasonable alternative is to include the overlying material, up to the base of the Peoria, into the Roxana Silt. Even if an accretionary character can be demonstrated with certainty, the "Robein" material was clearly derived from the Roxana.

An equally difficult problem exists in distinguishing the lower boundary with gley zone III. It is also very gradational, but structural and aggregation characteristics help distinguish the two zones. Blocky aggregates with argillans and internal granularity help distinguish zone III. Pebbles become apparent and texture becomes a silty clay loam in zone III. Traces of charcoal are present in the upper sample of this zone, which indicates that that position was a surface. Therefore, gley zone III is interpreted to be the Berry Clay (accretion-gley) and the upper part of the Sangamon Soil. The principal argument for Berry Clay is based on the conformable relationships it has with the Vandalia Till below and the Roxana-derived material above. For practical purposes, the top of the Sangamon Soil is arbitrarily placed at the top of the Berry Clay. An alternative for consideration is to place the top of the Sangamon at the top of the Farmdale Soil, as did Leverett in 1898; however, Leverett did not realize that a glacial deposit (Roxana) separated the weathered till (Sangamon) from the Farmdale organic horizon.

A third alternative for gley zone III comes from the silt fraction data (app. 2). The medium silt content is about 10 percent higher than in the underlying till. This suggests that a loessial component is in zone III; however, the admixture of some Roxana Silt in the Sangamon Soil is common in all profiles that have been examined.

The lower boundary of gley zone III with gley zone IV is clear in comparison to the other zone boundaries. Pebbles are more common, the sand content is higher, and the zone takes on the appearance of gleyed till. The boundary is dark greenish gray with many "orange" mottles. The blocky aggregates are more distinctive, but in a fresh exposure the zone is usually wet, plastic, and appears massive, as in zone III. In places a coarse layer is found at the top of the till. The sand content of zone IV (about 40 percent) is the same as the till under the gley. Also, the clay mineralogy shows a genetic relationship to the underlying till. The gleying has caused some increase in the values of the expandables and kaolinite and chlorite, and a decrease in the values for illite. Therefore, gley zone IV is interpreted to be the upper part of the Vandalia Till.

The olive-colored B3 beneath the gley zone IV is a normal pedologic feature in gleyed soil profiles. The solum thickness of the Sangamon as defined in this study is 2.1 m, and the B3 is in sharp contact with a calcareous C2 horizon in the Vandalia. Average carbonate content of the C2 is slightly lower (27.4 percent) than the C4 (28.5 percent). Grain size is essentially the same for both horizons, averaging 38 percent sand and 27 percent clay (20 percent $<2\ \mu m$). The C4 is an unaltered zone compared to the oxidized C2. Unaltered chlorite is present in the C4, but is largely destroyed in the C2. This causes the warp shown in figure 23. The value for kaolinite and chlorite is about 20 percent in the C4. When oxidation alters the chlorite, the value for kaolinite and chlorite drops to about 10 percent, and the difference is largely made up by the apparent increase in illite from about 71 percent to 77 percent. This difference in illite content points to the value of recognizing subdivision of the C horizons so that the degree of weathering can be taken into account when till correlations are made.

The plans for continuing study of the Sangamon Soil involve establishing a type Sangamon Soil catena or transect. Future excavation at the North Quarry locality may expose other types of Sangamon profiles that are needed to fill out a catena. Drilling is being considered east of the quarry exposures in the hope that a well-drained Sangamon can be found within a reasonable distance from the gleyed profiles. At least four types that range from accretion gley, in situ gley, an intermediate member, to a well-drained member need to be studied in detail; we hope that the work at the North and South Quarry Sections will begin to fill this need.

Jubilee College Section

The Jubilee College Section is in a road cut on the east side of the road just north of the intersection in the SW SW SW Sec. 7, T. 10 N., R. 7 E., Peoria County, Illinois, Oak Hill 7½-minute Quadrangle (fig. 24). The section is now completely overgrown. It was used as the type section for the Radnor Till Member and for the Jubileean and Monican Substages of the Illinoian by Willman and Frye (1970). Their description is reproduced on page 67.

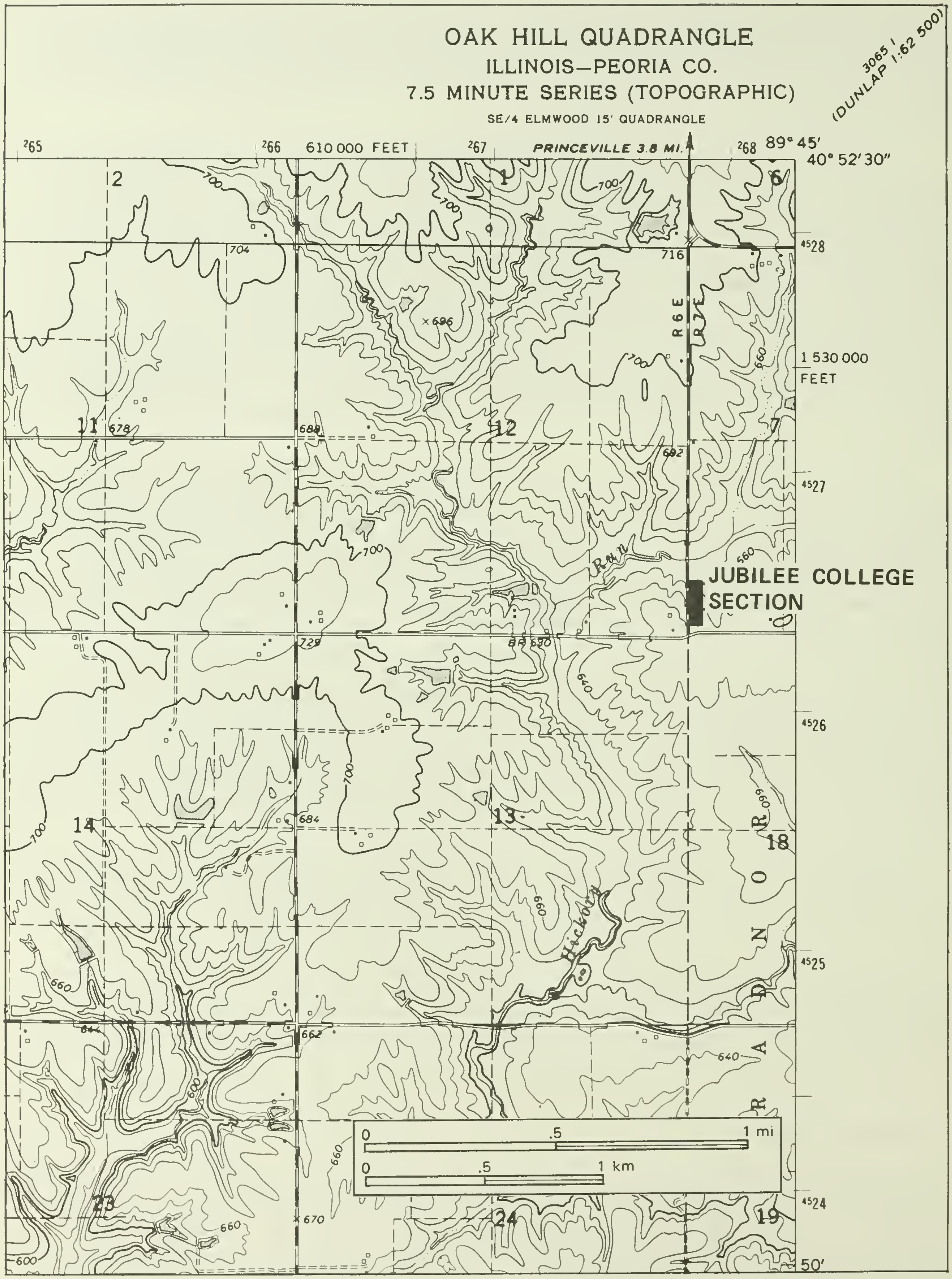


Figure 24. Location of the Jubilee College Section.

JUBILEE COLLEGE SECTION

Measured in roadcuts and auger boring in SW SW SW Sec. 7, T. 10 N., R. 7 E., Peoria County, Illinois, 1964, 1965, 1969.

	Thickness (ft)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, massive; upper half leached; tan - brown grading downward through a mottled zone to gray in lower part; Modern Soil in upper half with caliche nodules at the base of the leached loess; lower half calcareous (Sample P-1932 6 inches above base; P-1933 1.5 feet above; P-1934 2.5 feet above; P-1935 3.5 feet above; P-1936 4.5 feet above; P-1937 6.5 feet above)	10.0
8. Loess, massive, weakly calcareous in upper part, gray streaked with rusty brown; contains small Mn-Fe pellets (P-1931)	1.0
Altonian Substage	
Roxana Silt	
Meadow Loess Member	
7. Loess, massive, leached, tan to light brown with a purple-tan zone at top; truncated Farmdale Soil; contains some small Mn-Fe pellets (P-1927 1 foot above base; P-1928 2 feet above; P-1929 3 feet above; P-1930 4 feet above)	4.0
Markham Silt Member	
6. Silt, with some fine sand and clay, massive, leached, gray-brown; Chapin Soil; contains some Mn-Fe pellets (P-1926)	0.5
Illinoian Stage	
Jubileean Substage (type section)	
Glasford Formation	
Radnor Till Member (type section)	
5. Till; Sangamon Soil; B-zone 2 feet thick, clayey, microblocky to indistinct columnar structure, mahogany-brown, micromottled with black Mn-Fe pellets, clay skins; some concentration of pebbles at base of B-zone suggests an incipient "stone-line"; CL-zone below B-zone is massive, gray-tan to light brown and contains sparse caliche nodules (P-1925 from B-zone)	4.0
4. Till, massive, calcareous, blue-gray, cobbly, bouldery, well jointed with oxidized rinds along joints (P-6829 6 inches above base; P-1922 1 foot above; P-6830 2 feet above; P-6831 4 feet above; P-1923, P-6832 8 feet above; P-1924, P-6833, P-6834 12 feet above)	18.0
Toulon Member	
3. Silt with some sand, massive, calcareous, gray to light tan; some jointing; locally cemented at top; pinches out toward north (P-6827 base; P-1921 middle; P-6828 top)	3.0
Monican Substage (type section)	
Toulon Member (continued)	
2. Sand, silt, sandy silt, pebbly sandy clayey silt; occupies a channel cut in till below and pinches out to north; irregularly bedded; locally leached and strongly oxidized in upper part, but elsewhere calcareous, tan, gray-tan, and rusty brown (P-1919, P-1920, P-6826 top; P-6825, P-1918 4.5 feet below top; P-1917 7 feet below top)..........	8.0
Hulick Till Member	
1. Till, massive, calcareous, gray; contains cobbles and boulders, and some joints (P-6817 base in auger boring; P-6818 1 foot up; P-6819 2 feet up; P-6820 3 feet up; P-6821 4 feet up; P-1872, P-1916A, P-6822 6 feet up; P-6823 8 feet up; P-6824 10 feet up; P-1916B 11 feet up)..	14.0
Total	62.5

The Jubilee College Section lies 27 km northwest of the GraybaR Section on the uplands west of the Illinois River. The unoxidized samples of the Radnor Till Member are very similar in clay mineralogy to the Radnor at the GraybaR, Farmdale Park, Farm Creek, and Glendale School Sections (fig. 25, app. 1). Grain size is that of a silty loam (22 percent sand and 27 percent clay) similar also to the Radnor east of the Illinois. The carbonates are similar, except that the dolomite content is slightly less, particularly in the upper part at Jubilee College. The differences are small, however. Texture, mineralogy, and stratigraphic position all indicate that the type Radnor correlates with the Radnor Till Member identified at Tindall School and the sections in the East Peoria area.

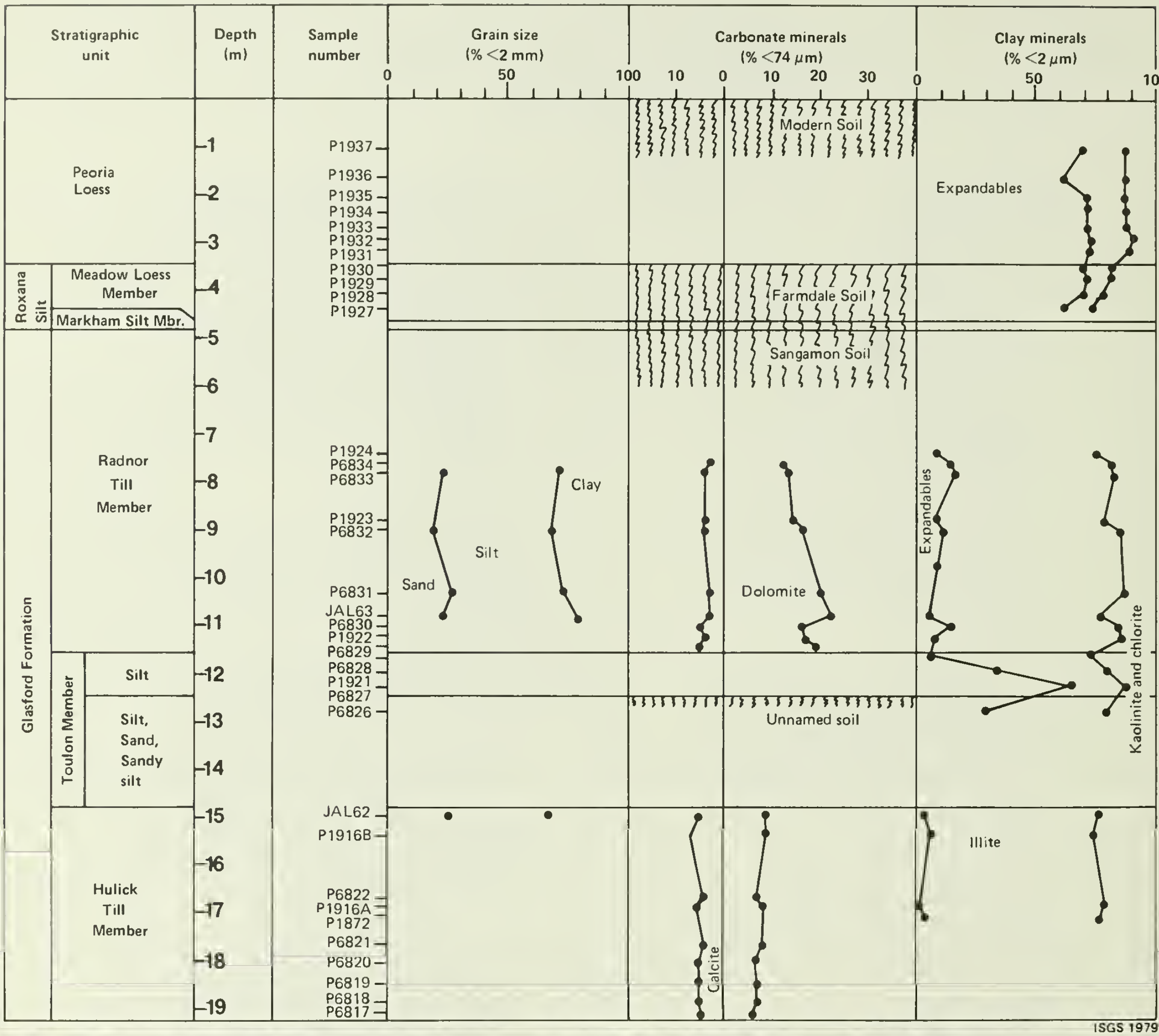


Figure 25. Grain sizes, carbonate-mineral content, and clay mineralogy of the Jubilee College Section.

The Toulon Member separates the Radnor from the Hulick Till Member at Jubilee College. The Toulon here is probably polygenetic. The lower part consists of sand, silt, and mixtures of sand and silt that occupy a channel cut into the Hulick. The top of the lower part of the Toulon Member was used to mark the Monican/Jubileean Substage boundary since it is strongly oxidized and locally leached (Willman and Frye, 1970). On this basis, they indicated minor paleosol at this position (fig. 25). A few miles west, on the boundary between the Knox and Peoria Counties, a series of borings along I-74 also show a truncated paleosol between the Radnor and the Hulick Till Members. The lower part of the upper Toulon at Jubilee College is high in expandables and is a silt, probably loessal in origin. The upper part has a clay mineralogy similar to the Radnor, showing the influence of the approaching glacier that deposited the Radnor.

The Hulick Till at Jubilee College, as at Lewistown and Hipple School in Fulton County, is characterized by a low dolomite content. The dolomite averages 9 percent, just less than twice the 5 percent calcite. The dolomite content of the Radnor is four times the calcite content.

THE STATUS OF THE ILLINOIAN GLACIAL STAGE

Jerry A. Lineback
Illinois State Geological Survey, Urbana, IL 61801

INTRODUCTION

Nearly 100 years ago, Leverett and other pioneer Quaternary geologists divided "the Great Ice Age" into several glacial stages separated by interglacial stages. The concept of fluctuations between warm and cold climates during the Quaternary has become traditional in geologic thought. Climatic variations were first interpreted in the continental record because the glacial deposits contained buried soil horizons marked by deep weathering and deposits thought to have formed during warm, nonglacial periods.

Variations between warm and cold Quaternary climates were noted in fossils taken from North Atlantic cores by Cushman and Henbest (1940). The addition of oxygen isotope determinations to the record of fossil species distribution (Emiliani, 1955) provided a method to judge changes in water temperature during glacial events. The discovery and dating of recorded magnetic reversals allowed the relative dating of the Quaternary paleoclimatic events. Additional dating information has come from determinations of sea level and studies of reefs. The number of cold-warm variations during the Quaternary is still uncertain, but evidence presented by various authors (e.g., Cline and Hays, 1976) indicates 8 or 9 oscillations between cold and warm climates since the Brunhes/Matuyama reversal (700,000 to 800,000 years B.P.) and perhaps 20 to 25 in the last 2 to 3 million years.

Only four or five such cycles have traditionally been interpreted from North American and European continental glacial records for the entire Quaternary; however, a number of recent workers have questioned that tradition. Fink and Kukla (1977) have studied the loess record in Central Europe and determined that paleosols and other indicators show at least 17 interglacials after the Olduvai paleomagnetic event. Kukla (1977) demonstrated that the classical European glacial terminology was inadequate and recommended its abandonment. Boellstorff (1978) demonstrated that the classical North American stage terms, *Kansan and Nebraskan*, had been applied to overlapping sequences of glacial deposits ranging from 700,000 to 2.2 million years in age and are essentially useless because more than two glacial-interglacial events took place in this interval of time.

Lineback and Wickham (1977, 1978) suggested that several glacial-interglacial events may be represented by glacial deposits between 500,000 and 127,000 years B.P. that have traditionally been assigned to the Illinoian Stage in Illinois and Iowa.

LEVERETT'S ILLINOIAN

Leverett first divided the Illinoian from older drift in southeastern Iowa in

1894 (Leverett, 1899). He observed erratic boulders that he believed had been moved from the Georgian Bay area across Illinois at a time later than the glaciation of the rest of southeastern Iowa. He thought the western limits of this eastern source lobe were indicated by a marginal ridge. Leverett traced this marginal position from Wisconsin, through eastern Iowa and western Illinois, to southern Illinois, and eastward into Indiana.

Leverett (1898c) named the paleosol below the Illinoian the *Yarmouth Soil*. He believed that the Illinoian Stage reached to the limits of the Illinois Glacial Lobe and considered the lobe border a single line occupied by the Illinoian Stage ice lobe. The concept of the Illinoian Stage has changed very little since it was named by Leverett in his 1899 monograph. Many workers in Illinois, including MacClintock (1926, 1929, 1933), Leighton (1959), Leighton and Brophy (1961), Horberg (1956), Johnson (1964), and Willman and Frye (1970) have accepted Leverett's concepts. The main change in concept over the years was the differentiation of the Illinoian drift into three parts that later were defined as substages of the Illinoian Stage (Frye, Willman, and Glass, 1964; Willman and Frye, 1970).

Rock-stratigraphic concepts applied to the Quaternary by Willman and Frye in the 1960s were formalized in 1970 (figs. 1 and 2) by naming several till members of the Glasford Formation of Illinoian Age. These, added to previously named till members, began to make rock stratigraphy the basis for possible subdivisions of the Illinoian Stage. A separate time-stratigraphic terminology was developed for each substage.

Willman and Frye showed a minor paleosol between the Monican and Jubileean and a significant paleosol, the Pike Soil, between the Liman and Monican Substages (fig. 2). They also showed a minor soil within the Duncan Mills Member in the Monican Substage.

CURRENT STATUS

Studies now in progress have shown that tills assigned to each Illinoian substage are widespread in Illinois and that they can be further subdivided into several units that are separated in places by paleosols, some of which represent interglacial or major interstadial weathering. At least three additional major rock-stratigraphic units can be recognized within the Illinoian of western Illinois and there may be more. Our work is still in progress and the results and interpretations presented in this paper must be considered preliminary and subject to change as new data are developed.

TILL STRATIGRAPHY

Several widespread till units can be identified at the surface in the area adjacent to the Illinois River and between the Illinois and Mississippi Rivers. Additional units are known only from the subsurface. The surface drift in this area has previously been mapped as Illinoian (Willman and Frye, 1970; Lineback, in press). In western Illinois, the oldest known Illinoian till, the Kellerville Till Member (Willman and Frye, 1970) extends the farthest west of the Illinoian tills, across the Mississippi, and into Iowa. Leverett based the Illinoian Stage on the Kellerville Till in Iowa, which overlies the Yarmouth Soil. Most younger Illinoian tills lie imbricated, and the youngest till extends only a short distance beyond the Illinois River (fig. 3). Thus, several different Illinoian till units lie at the surface over the area; other units lie between these till sheets and have been completely overridden by younger advances.

The Kellerville Till and other Illinoian units so far identified above it differ in texture and mineralogy. The Illinoian tills overlie pre-Illinoian tills that are believed to have entered Illinois from the northwest. These older tills have been called western Kansan (Banner Formation) in Illinois (Willman and Frye, 1970) and are now classified as the Wolf Creek Formation in Iowa (Hallberg and others, 1978). The Illinoian tills appear to contain more illite in the clay minerals than do the western source pre-Illinoian tills. The Illinoian tills contain two to four times as much dolomite as calcite, whereas the western source tills range from having more calcite than dolomite to less than twice as much dolomite. These mineralogical differences serve to separate the western and eastern source tills in western Illinois. Till fabrics, orientations of glacial landforms, and mineralogy indicate that all Illinoian tills moved in a southerly and westerly direction in western Illinois and that they probably have an eastern source (Lake Michigan Lobe).

It was previously thought that Illinoian tills west of the Illinois River varied in composition from east to west as a result of westward movement of the glaciers (Frye, Willman, and Glass, 1964). The higher content of expand-

Time-stratigraphic units		Rock-stratigraphic units			
			West	South	North
Illinoian Stage	Jubileean Substage	Glasford Formation	Radnor Till Member	Radnor Till Member	Sterling Till Member
	Monican Substage		Hulick Till Member	Vandalia Till Member	Winslow Till Member Ogle Till Member
	Liman Substage		Kellerville Till Member	Smithboro Till Member	Kellerville Till Member

Figure 1. Classification of the tills of the Illinoian Stage by Willman and Frye (1970).

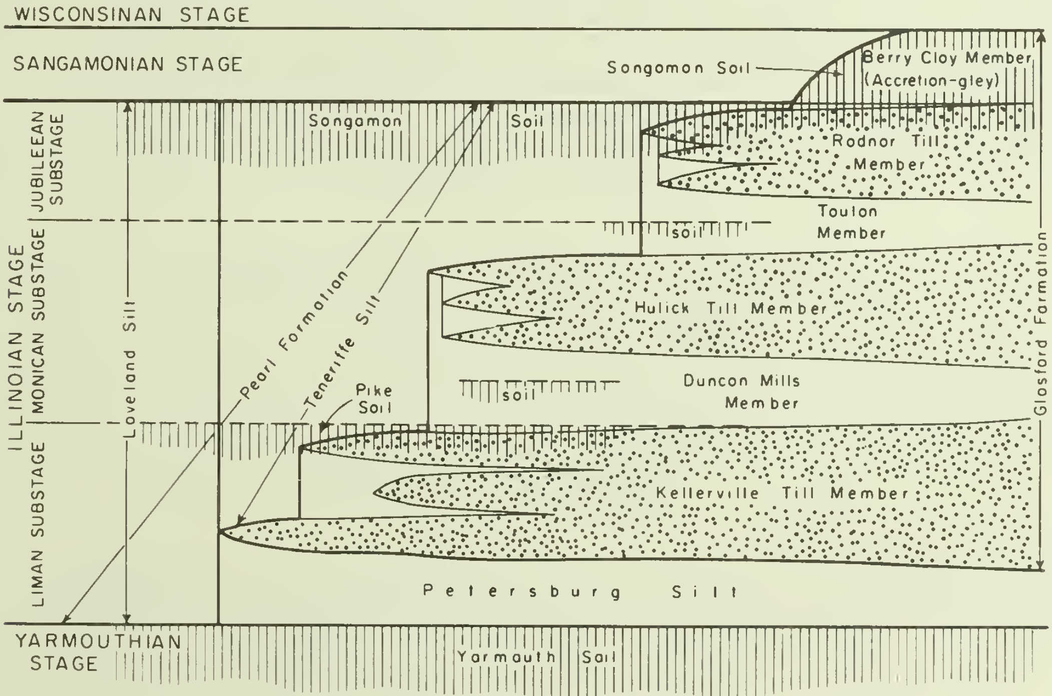


Figure 2. Classification of the Illinoian and the position of intra-Illinoian paleosols. (From Willman and Frye, 1970.)

able clay minerals in tills at the western edge of the Illinoian was assumed to have resulted from the incorporation of weathered material of the Yarmouth Soil and of underlying high-expandable western Kansan drift; however, recent, denser sampling shows that while Illinoian tills studied typically have a mixed zone at their base, they generally maintain their essential mineralogical identity to their western extremity. Additionally, tills of different compositions, previously thought to grade laterally into one another, have been found superposed in borings and outcrops and in some places are separated by oxidized zones or truncated paleosols.

All Illinoian till units are currently considered to be members of the Glasford Formation (fig. 3) (Willman and Frye, 1970). Time-stratigraphic differentiation is being delayed until the rock-stratigraphic units are more firmly established.

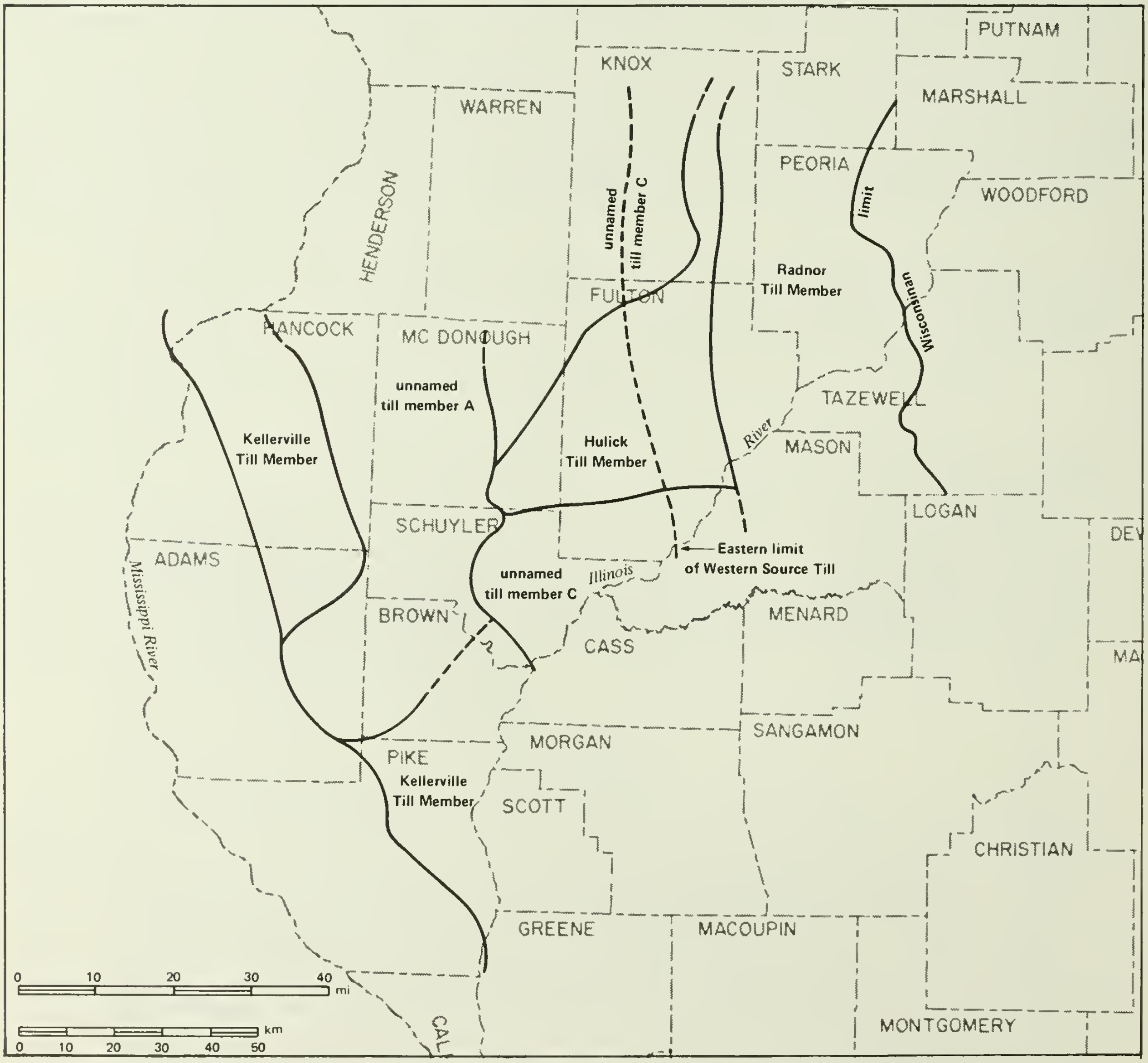


Figure 3. Preliminary surface distribution of tills of the Illinoian Stage in western Illinois.

Kellerville Till Member and unnamed till member A*

The Kellerville Till Member of the Glasford Formation forms the outer boundary of the Illinoian deposits in parts of western Illinois and in eastern Iowa (fig. 3). It was defined as the lowermost Illinoian till unit and is bounded at the base by the Petersburg Silt, or, in its absence, by the top of the Yarmouth Soil (Willman and Frye, 1970). The unit extends northward from Jersey County to Carroll County, a distance of approximately 340 km.

In defining the till member, Willman and Frye (1970) and Frye, Willman, and Glass (1964) recognized that clay-mineral compositions varied within the Kellerville. Based mainly on a study of surface exposures, they interpreted the changes as progressive westward dilution of an illitic eastern source till as the Illinoian glacier overrode the montmorillonite-rich western source pre-Illinoian tills.

A major problem in interpretation of these mineralogic changes is that the Kellerville Till, and other till units also, have been described in isolated exposures that occur in different landscape positions. Before mineralogic variations can be evaluated, the relationships of regional physical stratigraphy and exposure on the landscape must be understood in order to find all stratigraphic units. Drilling on stable land surfaces is required to establish firmly the complete stratigraphic sequence from which mineralogic variations within units from isolated exposures can be evaluated. Data from Kellerville Till in stable landscape positions or stratigraphically bounded sections are as yet insufficient to establish regional changes of composition.

Despite these difficulties, two till units have tentatively been distinguished within the till called Kellerville (fig. 4). As an example, texture and clay-mineral and carbonate content break sharply between two tills at a depth of 9.6 m in a boring from an interfluve in northeastern Hancock County. The upper till (called *unnamed till member A* in this report) is sandy and has a relatively high portion of expandable clay minerals (table 1). The lower till (which we continue to call *Kellerville*) is interlaminated with stratified silts, is silty, and has approximately equal proportions of expandable clay minerals and illite. Thin light and dark bands alternate throughout the lower till and are especially prominent at the base of the unit. Below the lower (Kellerville) till is a thick sequence of sand overlying a woody layer at 27.4 m.

Unnamed till member A appears to be less extensive than the Kellerville and has been identified with certainty only in Hancock, McDonough, and Adams Counties (fig. 3). Member A contains 60 to 70 percent expandable clay minerals but usually contains more illite and relatively more dolomite than pre-Illinoian western source tills (table 1). The higher illite content (20 to 30 percent), higher dolomite content, and till fabrics indicate that this till was brought into western Illinois from the northeast rather than from the northwest.

The lower till in Hancock County probably correlates with the till that forms the terminus of the Kellerville Till in Iowa (Hallberg, personal communication, 1978). This lower till is probably the same unit as the type Kellerville in southeastern Adams County. The Kellerville is generally silty and

---

*Discussion of these units from work by J. T. Wickham.

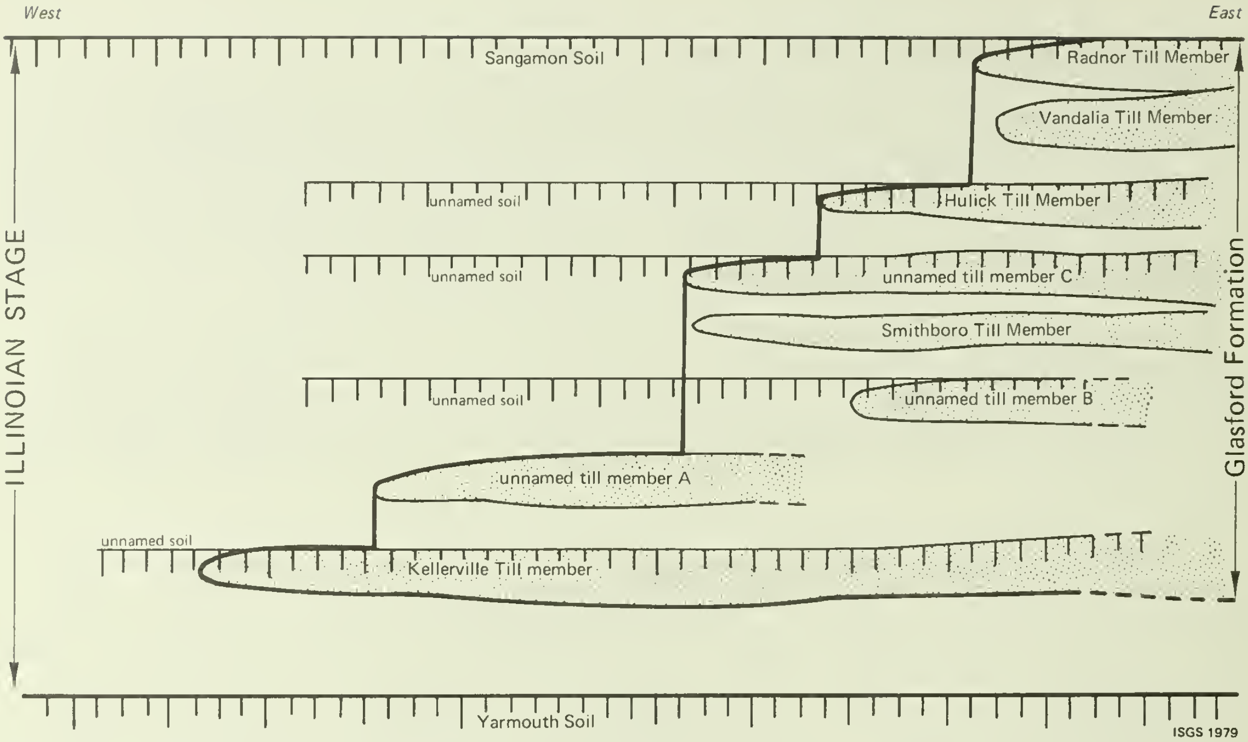


Figure 4. Suggested position of some rock- and soil-stratigraphic units of the Illinoian Stage in the region between the Illinois and Mississippi Valleys.

TABLE 1. Textural and mineralogical parameters of tills in western Illinois, values in percent.

	Textures				Clay mineralogy				Chittick carbonate		
Till members	Sand	Silt	Clay	*N*	Expand-ables	Illite	Chlorite & kaolinite	*N*	Calcite	Dolomite	*N*
Radnor											
Mean	25	49	26	8	7	73	20	17	5	19	8
s.d.	*4*	–	*3*		–	*5*	–		*1*	*2*	
Vandalia											
Mean	39	40	21	2	6	74	20	2	6	25	3
s.d.	–	–	–		–	–	–		–	–	
Hulick											
Mean	26	45	29	17	10	65	25	27	5	12	16
s.d.	*8*	–	*4*		–	*4*	–		*1*	*3*	
C											
Mean	35	39	26	21	20	55	25	45	5	15	17
s.d.	*7*	–	*6*		–	*5*	–		*1*	*3*	
Smithboro											
Mean	25	46	29	17	41	39	20	26	3	10	16
s.d.	*6*	–	*2*		–	*6*	–		*1*	*2*	
B											
Mean	17	56	27	5	53	29	18	11	3	10	4
s.d.	*7*	–	*2*		–	*5*	–		*2*	*1*	
A[a]		(Sandy)		-	(60-70)	(20-30)	–	-	(3)	(10)	-
Kellerville[a]		(Silty)		-	(40)	(40)	(20)	-	(3-5)	(10-15)	-
Western pre-Illinoian											
Mean	28	37	35	10	70	14	16	13	3	4	5
s.d.	*6*	–	*4*		–	*4*	–		*1*	*1*	

[a]Insufficient data to provide meaningful averages.
N = Number of data localities, some of which represent multiple sampling.
s.d. = Standard deviation (percent).

may be interlaminated with silt in its marginal zone. It generally contains about 40 percent expandable clay minerals and an equal percentage of illite (table 1). While low in total carbonate, the unit is dolomitic.

Drumlins and glacial fluting are prominent on these two tills in western Illinois. The drumlins, which apparently occur on both till units, range widely in their orientations, indicating that the directions of glacial flow were highly variable. Locally, sharp changes in flow directions may have affected till composition. Regionally, it appears that the early Illinoian ice in Warren and northern McDonough Counties was generally moving west-southwest, and, near its margin in Adams and Hancock Counties, the ice flowed more southerly.

Unnamed till member B

Unnamed till member B lies below the Smithboro Till Member (fig. 4) in eastern Schuyler and Fulton Counties. It is characterized by having more expandable clay minerals than illite, but not as high an expandable content as unnamed till member A (table 1); however, both tills lie below the Smithboro Till, and units A and B may occupy the same stratigraphic position or may be the same till. The higher illite content of the more eastern exposures may result from incorporation of older illite-rich tills or bedrock by the glacier that deposited till member A. In western Fulton County, however, unnamed member C or the Smithboro have thus far been found overlying only high-expandable till presumed to correlate with unnamed till member A or bedrock. Thus, units A and B are tentatively shown as separate entities.

Smithboro Till Member

The Smithboro Till Member was named by Jacobs and Lineback (1969) from exposures in Fayette and Bond Counties. This till underlies the illite-rich younger Illinoian tills. It has previously been correlated with the Kellerville Till Member because both tills are mineralogically and texturally similar; however, in Fulton County, a Kellerville-like till overlies unnamed till member A and, because of its position below the high illite tills, is believed to best correlate with the Smithboro Till east of the Illinois River (fig. 3). The Smithboro may be at the surface in isolated small areas, but is generally overlain by either unnamed till member C or the Hulick Till Member. The Smithboro is silty, contains about 40 percent each of expandable and illite clay minerals and, while low in total carbonate, is dolomitic (table 1).

Unnamed till member C

The younger Illinoian tills are illitic and dolomitic. The oldest of these is a widespread sandy till that contains abundant shale, sandstone, and coal, derived from erosion of Pennsylvanian bedrock. This unit has previously been labeled Kellerville and Hulick in various exposures in western Illinois and is probably included in the Vandalia Till Member east of the Illinois River. It is here distinguished as an unnamed till member C (fig. 3). This till averages about 20 percent expandables and 55 percent illite (table 1). Unit C and the Hulick above contain more kaolinite derived from the Pennsylvanian bedrock than other tills in the section. Till member C and the Hulick are difficult to distinguish where they are not separated by a paleosol, but member C is generally lower in illite, sandier, and more dolomitic. Member C is slightly more extensive than the Hulick over western Illinois (fig. 4).

Hulick Till Member

The Hulick Till Member was named by Willman and Frye (1970) from the Lewistown Section in Fulton County, where it is the surface till over most of the county (fig. 4). The Hulick contains sandstone, coal, and shale, but these components are less obvious than they are in unnamed member C. The Hulick is more illitic (65 percent) and contains relatively less dolomite than the tills above and below (table 1). The Hulick is generally more silty than member C, being texturally like the Radnor Till Member. The Hulick, like member C, may have been included in the Vandalia Till Member if it extends into central Illinois.

Radnor and Vandalia Till Members

The GraybaR Section, east of the Illinois River, shows part of the section of late-Illinoian tills that are found preserved in the preglacial Mississippi-Mahomet valley system. These tills are illitic (70 percent) and carbonate rich (25 to 35 percent). No representatives of the Hulick or member C were found in this section. Rather, the lower sandy tills in the GraybaR Section seem to resemble the tills of the Jacksonville drift that are now included in the Vandalia Till Member in Menard and Sangamon Counties (Athens North Quarry, Athens South Quarry, and Fairground Sections) and other areas south of the major bedrock valley system. A till resembling unnamed till member C is found below the Vandalia in places in central Illinois but has previously been included in the Vandalia there.

The uppermost Illinoian till in the Farm Creek, GraybaR, Farmdale Park, and Glendale School Sections is similar to a till that was named the Radnor Till Member in Peoria County (Willman and Frye, 1970) and that also extends into Fulton County. The Radnor is silty, high in illite, and very dolomitic (table 1). It overlies the Hulick or unnamed member C in several sections in Peoria and Fulton Counties.

SIGNIFICANCE OF PALEOSOLS

Consideration of modern stratigraphic evidence led Morrison (1978, p. 94) to several conclusions regarding Quaternary paleosols that are summarized and condensed below. Examination of the same data and evidence from Illinois has led me to concur with these generalizations:

1. In higher latitudes, periods of relatively rapid soil-profile development alternated with times of much slower rates of soil-profile development during the Quaternary.

2. Strongly developed paleosols formed during interglacials that were both as warm as, or warmer than, the Holocene and times of increased precipitation. Moderately strong to weak paleosols formed during interstadials. Negligible profile development took place during glacials, that is, degree of profile development (where preserved for observation) is directly proportional to the degree of warmth and length of the warm interval.

3. The interglacial soil-forming episodes were much shorter than intervening glacial-interstadial parts of the glacial cycles. Likewise, the interstadial events were much shorter than glacial intervals during which formation of soils was severely limited.

4. The deep-sea record proves that the interglacials and first-order interstadials were nearly synchronous on a global basis.

5. Paleosols that are not composite and thus represent individual interglacials or first-order interstadials are among the best chronostratigraphic units in the Quaternary succession.

In Illinois, which underwent repeated glacial advances during the Quaternary, paleosols developed on drift sheets obviously formed primarily during interglacials and major (first-order) interstadials. These soils are characterized by a profile of mineral alteration that is most intensive at the top and grades downward into unweathered material (in situ profiles). Other major paleosols are composed of heavily weathered material that has been subject to transportation into poorly drained environments (accretion gleys). The materials in these major interstadial or interglacial soils exhibit loss of carbonates, intensive clay-mineral alteration (generally, loss of chlorite and illite, and increases in expandables), and textural changes (generally, clay enrichment) related to pedogenesis.

Paleosols overridden by subsequent glacial advances are not commonly preserved in Illinois because of erosion before or during the glacial advance. Where present, they are often truncated. Therefore, it is difficult to determine whether the preserved remnant represents part of a major interstadial paleosol or a truncated interglacial soil. In practice, the profiles that have developed a B zone with major clay-mineral alteration and leaching or have developed an accretion gley are considered to indicate a paleosol that formed during a major warm interval. Cold-climate (minor or second-order interstadial) soils are characterized by oxidization (if they are well drained) or by organic accumulation (if they are poorly drained). Minor cold-climate paleosols may also be indicated by thin zones of leaching and minor clay-mineral alteration such as degradation of chlorites. Clay enrichment and other pedogenetic changes are minor in the cold-climate paleosols.

Examples of paleosols of major interstadial or interglacial rank observed on this field trip include the Sangamon Soil at various sections, the so-called Yarmouth Soil at Tindall School, and the unnamed accretion-gley soil at Lewistown. Cold-climate paleosols include the Farmdale Soil seen at Farm Creek and other places. It is not known whether paleosols marked only by zones of oxidization, such as those on the Vandalia Till Member at the GraybaR and Farmdale Park Sections, represent warm or cold conditions, but if the profile is not truncated, it represents a brief event.

Previous workers, using the four-glaciation model of Quaternary events, have traditionally called the first observed major paleosol below the Sangamon Soil the Yarmouth Soil. The marine record and the European loess record indicate several brief (∿10,000-year) interglacials and major interstadials in the time period probably represented by the Illinoian Stage in western Illinois. Several paleosols may be present between the Yarmouth Soil of eastern Iowa that lies below the Kellerville Till Member and the Sangamon Soil on youngest Illinoian drift. Most of these paleosols, where previously identified, have been correlated with the Yarmouth; therefore, many miscorrelations of glacial drift in Illinois have developed. Some deposits indicated to be "Kansan" (Banner Formation) or "Nebraskan" (Enion Formation) in older literature may actually fall within the Illinoian Stage as defined by Leverett. The Sangamon Soil has also developed on drifts of increasing age westward across western Illinois. It merges with each buried paleosol as the drift sheet between pinches out until the whole Sangamon Soil complex, including all inherited paleosols, merges with the Yarmouth Soil in Iowa.

Since tills of all glacial advances are not present at a single place in western Illinois, complete sections showing all drifts and paleosols have not, and probably will not, be found. The sequence must be inferred from the superposition of drifts in sections commonly containing only two or three of the drifts or paleosols involved. Recent detailed sampling has shown that tills in western Illinois can generally be traced widely with confidence on the bases of physical appearance, texture, mineralogy, and stratigraphic position (fig. 4). Paleosols of sufficient development to warrant designation as interglacial or major interstadial (warm-event) soils have been tentatively identified on the pre-Illinoian Wolf Creek Formation in Iowa, and, within the Glasford Formation, on the Kellerville Till Member, on unnamed till member A, on unnamed till member B, on unnamed till member C, and on the Hulick Till Member.

THE ILLINOIAN SUPERSTAGE

The Illinoian may indeed be a superstage (Lineback and Wickham, 1978). The Illinoian Stage contains several till units of differing physical and mineralogical properties. Each can be traced and correlated over distances exceeding 100 km in western Illinois. Paleosols have been identified in places on some of these tills. Each of these paleosols is marked by leaching and clay-mineral alteration and appears to indicate a period of warm climate marking an interglacial or major interstadial. Therefore, the Illinoian as defined by Leverett is now believed to include several of the pre-Wisconsinan glacial-interglacial fluctuations seen in the marine record. If we assume that the youngest part of the Radnor is the youngest Illinoian, its top is therefore about 127,000 years old (end of isotopic stage 6) based on the marine record.

Volcanic ashes lie within the sequence of western source pre-Illinoian tills in central Iowa and have been dated at 600,000 and 700,000 years B.P. (Boellstorff, 1978). Very preliminary paleomagnetic information indicates that the Illinoian tills are all of normal polarity. Therefore, the Kellerville Till Member may be about 400,000 to 500,000 years old. The marine record indicates perhaps 6 to 7 glacial-interglacial fluctuations between 500,000 and 127,000 years B.P. Many of these appear to be represented by glacial deposits in western Illinois.

A HISTORICAL REVIEW OF THE SANGAMON SOIL

Leon R. Follmer
Illinois State Geological Survey, Urbana, IL 61801

A considerable amount of study on glacial stratigraphy in Illinois has been directly or indirectly related to the Sangamon Soil. In a general sense, the Sangamon became known as a zone of weathering on glacial deposits about the same time as the drift upon which the Sangamon Soil developed was recognized as the Illinoian till sheet (Leverett, 1898a). Leverett and others recognized the need for a term to identify the interruption in the glacial record between the Illinoian and Iowan (Wisconsinan) Stages of glaciation. The utility of the term Sangamon carried it into the literature outside Illinois. The "Sangamon weathered zone" forms the basis for naming the Sangamon Soil and the Sangamonian Stage. Because of the widespread use of the term to name both a soil and an interglacial stage, this historical review will be restricted to the past studies of the Sangamon Soil in its type area, central Illinois.

CONCEPTS OF BURIED SOILS IN ILLINOIS BEFORE 1898

The Sangamon Soil was the first buried soil in Illinois to be consistently recognized in its correct stratigraphic position. It was first recognized as a soil by Worthen in 1873 in the fifth volume of his report to the Illinois General Assembly on the geology and paleontology of Illinois. Worthen had not recognized the existence of a buried soil until his fourth volume (Worthen, 1870), when he reported a soil zone or "bed resembling the surface soil was observed below the Drift" in a coal mine shaft in Adams County in western Illinois. Worthen thought the soil was "Post Tertiary" or predrift in age, but it is now known to be within the Quaternary deposits. At the time, a soil was simply known as a bed of "black mould or muck" or a "forest bed."

In 1873, Worthen came to the conclusion in his Sangamon County report that there were two buried soils in the Quaternary deposits, one below the "boulder clay" and the other above the "boulder clay" and beneath the loess. The Soil above the "boulder clay" was later named the Sangamon Soil by Leverett (1898a). In the Sangamon County report, Worthen (1873) presented a generalized sequence of "beds" described by a well driller as occurring in the northwestern part of Sangamon County and the adjoining portion of Menard County:

No. 1	Soil	1 to 2½ feet
No. 2	Yellow clay	3 feet
No. 3	Whitish gray jointed clay with shells	5 to 8 feet
No. 4	Black muck with fragments of wood	3 to 8 feet
No. 5	Bluish colored boulder clay	8 to 10 feet
No. 6	Gray hard pan, very hard	2 feet
No. 7	Soft blue clay without boulders	20 to 40 feet

The present interpretation of these beds is based on the recent work of Bergstrom, Piskin, and Follmer (1976):

No. 1 A horizon of Modern Soil in Peoria Loess
No. 2 B horizon of Modern Soil in Peoria Loess
No. 3 C horizon in calcareous Peoria Loess
No. 4 Organic horizon of the Farmdale Soil, developed in the Robein and Roxana Silts
No. 5 Bg (gley) horizon of Sangamon Soil in accretion gley and/or Illinoian till
No. 6 Unaltered calcareous Illinoian till
No. 7 Unknown Illinoian lacustrine deposit or Yarmouthian accretion gley

EARLY CONCEPTS OF THE SANGAMON SOIL

Between 1873 and 1898, resolution of many complexities of the Quaternary progressed considerably. The idea of multiple glaciations separated by interglaciations and characterized by episodes of nonglacial erosion and weathering of the surficial materials had been largely accepted. The U.S. Geological Survey furthered the progress with a program directed toward the study of the glacial formations of the Midwest. Their greatest contribution to the Quaternary studies in Illinois came from Frank Leverett.

During his work in the Midwest, Leverett discovered that a soil occurred above and another occurred below a formation of glacial deposits that he named the *Illinoian till sheet* (Leverett, *in* Chamberlin, 1896). In 1897 Leverett gave these soils formal status by naming them the *Sangamon soil* and the *Yarmouth soil*, respectively (Leverett, 1898a and 1898c). By 1898 the concept of the Sangamon Soil was reasonably well understood, as indicated in Leverett's paper introducing the Sangamon as "the weathering zone between the [Wisconsinan] loess and the Illinoian till sheet . . . found from central Ohio westward to southeastern Iowa, i.e., to the limits of the Illinoian till sheet" (1898a, p. 75). The first use of the term *Sangamon soil* by Leverett in 1898 restricted it to the black soil, muck, or peat that contains remains of coniferous wood occurring at the base of the loess. The purpose of naming the Sangamon was to formalize a term so that an interval of geologic time could be named, "the Sangamon interglacial stage," to separate the "Illinoian and Iowan stages" of glaciation. The Iowan was later included in the Wisconsinan and eventually dropped as a time term (Ruhe, 1969).

Recognition of a soil naturally precedes the recognition of particular soil characteristics. The relation of the black muck or peat beds to the underlying "blue clay" or leached horizons was not fully understood in 1898. The terms *soil* and *subsoil* were often used to suggest that they were two beds and not genetically related, as in a soil profile. Whether Leverett meant to include the subsoil as a part of the soil is not clear. The apparent dual usage of soil came from recognition of a weathered zone on the Illinoian deposits whether the "black soil" was present or not (Leverett, 1898a, p. 77). He probably intended this to mean that a catena relationship existed, and the weathered zone therefore had to be included as a part of the soil-time unit.

The relation of a leached horizon to the soil was also used in a dual sense. Leverett (1898a) commonly referred to a zone of leaching and weathering beneath the "Sangamon soil," but also implied that this zone is the Sangamon Soil where the "black soil" is absent. The uncertainty of the relationship between the Sangamon Soil and some of its features carried into Monograph 38 (Leverett, 1899). In the opening remarks of his chapter entitled "The Sangamon Soil and Weathered Zone," he stated that the "Sangamon interglacial stage" is "a period marked by leaching and oxidation of the Illinoian drift, of peat and soil accumulation, and of erosion." The leaching process is not necessarily related to soil formation from this statement, but he goes on to say that "the leaching therefore took place prior to the loess deposition in connection with the development of the soil." A two-member catena, "the black soil" and "the slightly reddened till surface," was confirmed in this chapter (p. 126) with his statement, "These two phases seem to be mutually exclusive."

To draw any specific conclusions from Leverett on the Sangamon Soil is difficult. The primary significance of recognition of the soil is its effect on resolution of glacial stratigraphy in the Midwest. Leverett had a correct understanding of glacial stratigraphy but a rudimentary understanding of soil stratigraphy. He lacked a technical vocabulary to express soil concepts, as did most scientists of his time, and he was inconsistent in recognizing the Sangamon Soil. A subordinate problem was equating different soil horizons. He correlated the A or O horizon of the wet member of his catena to the B horizon of the oxidized, well-drained member. In the present context, these two members are at opposite ends of a catena that contains several intermediate members. Therefore, the main deficiency of Leverett's conclusions was that he generally did not recognize as soils the poorly drained and somewhat poorly drained mineral soil profiles, which he referred to as "gumbo." The discovery of a relationship of the organic horizon to the oxidized portion of the Illinoian deposits in surrounding areas led to their correlation as a stratigraphic feature, "The Sangamon."

Perhaps Leverett's most astute observation was that the type of organic matter in the "black soil," particularly the coniferous wood, is not characteristic of conditions during an interglacial climax, but of "the close of that stage when glacial conditions were being inaugurated." Probably all of the woody deposits that Leverett observed below the loess in central Illinois are post-Sangamonian by present definition, but were interpreted to be the Sangamon Soil by Leverett.

EVOLUTION OF THE GENERAL CONCEPTS OF THE SANGAMON SOIL

The evolution of concepts of the Sangamon Soil after 1899 paralleled evolving concepts of the Yarmouth Soil and, to a great degree, the Modern Soil. Much of the progress made in Iowa from the studies on the Yarmouth Soil was applied to the Sangamon Soil in Iowa and Illinois (Leighton and MacClintock, 1962). The term *soil* was used by geologists and pedologists prior to 1923 in a restricted sense to mean an organic-enriched layer or ground-surface "accumulation." The term *subsoil* had no particular meaning other than that it was the next underlying layer. Weathering was normally related to oxidation and leaching processes. The effects of reduction or gleying in a poorly drained environment were not recognized or were poorly understood.

The poorly drained, gleyed deposits on the Kansan and Illinoian deposits received much attention in the years between 1898 and 1920 (Leighton and MacClintock, 1962). The gleyed deposits referred to as "gumbo" by Leverett and earlier workers were thought to be of sedimentary origin. Kay (1916) proposed the name *gumbotil* to replace the term *gumbo* in the "superdrift" position because *gumbo* was a common term that had a variety of meanings. He claimed that gumbotil was chiefly the result of chemical weathering and defined it to be "a gray to dark-colored, thoroughly leached, non-laminated, deoxidized clay, very sticky and breaking with a starch-like fracture when wet, very hard and tenacious when dry, and which is, chiefly, the result of weathering of drift." Kay also added that "the name is intended to suggest the nature of the material and its origin."

Four years later, Kay and Pearce (1920) published a paper entitled "The Origin of Gumbotil." Their insight into the chemical soil-forming factors was a major contribution toward understanding soil genesis and the origin of gumbotil. Their theory contains several flaws, however, especially the assumption that an oxidizing environment was required to promote leaching and other processes in the formation of gumbotil.

Kay and Pearce explained in detail the horizonation that is typical in exposures containing gumbotil. The organic-rich layer at the top of the sequence was referred to as "soil" but was greatly de-emphasized. Gumbotil occurred below the "soil" or was frequently placed at the top of the sequence if the "soil" was not recognized. They described the oxidized and leached zone, which lies beneath the gumbotil, that in turn overlies the oxidized and unleached zone. At the base of complete sections is the unweathered till, which they referred to as the unoxidized and unleached zone.

Gumbotil, as viewed by Kay and Pearce, was strongly weathered till, but they did not discount that "wind action, freezing and thawing, burrowing of animals, slope wash and other factors may have contributed to the formation of gumbotil" (p. 125).

In 1923, C. F. Marbut of the U.S. Department of Agriculture presented a series of lectures at the University of Illinois which had a great impact on the understanding of soil genesis, including buried soils. He introduced to the United States the Russian school of concepts of soil genesis, morphology, and classification. The fundamentals of modern pedology were established during the 1920s largely because of Marbut and his 1927 translation into English of a book by Glinka. The concept of a soil profile was introduced and was defined as a sequence of three horizons—A, B, and C. The A is the organic-enriched surface layer informally called "topsoil." The B is the genetic layer under the A and quite naturally assumed the informal designation, "the subsoil." The C horizon is the "parent material" from which the A and B horizon developed, but only if one geologic material can be demonstrated in the profile.

Norton and Smith (1928), soil scientists from the University of Illinois, were the first to relate soil horizons clearly to the weathering zones of Kay. The definitions of the soil horizons had not yet been resolved, so they used two described profiles from south-central Illinois to explain their proposal for standardizing the soil horizon concepts. Without recognizing it as such, they were the first to make soil-stratigraphic correlations between a well-drained, oxidized Sangamon Soil and a poorly drained, gleyed Sangamon Soil; however, their examples were thin loess-over-till profiles, and they did not recognize the buried Sangamon Soil beneath the loess. They were under the impression that the profiles had developed in drift. Five major horizons were designated:

A The topsoil, the horizon of biotic accumulation and eluviation
B The subsoil, the horizon of illuviation and disintegration

C The horizon of oxidation, disintegration, and leaching
D The horizon of oxidation and slight decomposition; calcareous
E The calcareous, unaltered parent material

Two years later Leighton and MacClintock (1930) published their classic paper on the "Weathered Zones of the Drift-Sheets of Illinois." They acknowledged the "active collaboration" with Smith and Norton but did not reference their work. Leighton and MacClintock reached a very important point in the understanding of the Sangamon Soil. They recognized a type of catena: the gumbotil profile in poorly drained areas, the siltil profile in well-drained areas, and the mesotil profile in intermediate areas. They did not call them *types of Sangamon Soil*, but *weathering profiles on Illinoian drift*. They used the term *Sangamon* only in a time-stratigraphic sense.

In 1931, the stratigraphic position of the Sangamon Soil was adjusted when Leighton (1931) reinterpreted the loesslike silt described at the "Farm Creek exposure" (Leighton, 1926) to be the "Late Sangamon loess." This exposure was considered by Leighton to be a "type Pleistocene section," and, in effect, became the reference section for the Sangamon Soil. The inference that can be drawn from Leighton (1931) is that the Sangamon Soil transgresses from interglacial to glacial conditions and consists of two parts: (1) Illinoian gumbotil in the lower part and (2) a youthful soil profile formed in the Late Sangamon loess which may have developed during the "Iowan," the first glacial stage of the "Wisconsin." After 1931, no significant modification of the two-part concept of the Sangamon Soil was made for about twenty years. Then Leighton eliminated the "upper Sangamon" by changing the name of the "Late Sangamon loess" to the Farmdale loess (Wascher, Humbert, and Cady, 1948) and placing it into the "Wisconsin" stage (Leighton and Willman, 1950). During the 1940s, Leighton and others came to realize that the Farmdale loess was a deposit related to glacial conditions. But the Sangamon peat described by Leverett (1899) at the "Farm Creek exposure" overlies the Farmdale loess. Therefore, by placing the peat and Farmdale loess into the Wisconsinan, the peat bed containing the boreal remains (coniferous wood) was deleted from the Sangamon Soil as conceived by Leverett.

The Sangamon Soil at the "type Pleistocene section" during the 1950s was restricted to the nonorganic portion of the "profile of weathering." This led to a false conclusion that was commonly drawn after field examination of similar exposures—that the Sangamon Soil did not have (or appear to have) an A horizon. Recognition of a buried A horizon at this time required identifiable organic remains; otherwise, the A horizon, if present, was misidentified as gumbotil or a deposit overlying the gumbotil. Criteria for establishing the presence or absence of a buried A horizon have not been resolved in the literature on buried soils. The recognition problem is due to postburial alteration, which causes a loss of soil characteristics, referred to as *pedometamorphism* (Gerasimov, 1971) or *diagenesis* (Valentine and Dalrymple, 1976).

The geo-pedologic solution to the apparent absence of the A horizon in many buried soils and the cause of the time-transgressive nature of the Sangamon Soil in central Illinois was first proposed by Thorp, Johnson, and Reed (1951), who reasoned that "the first Wisconsin loess seemed to have collected very slowly on the old Sangamon soil in Nebraska and Kansas . . . soil formation kept pace with deposition" and produced an "over-thickened A horizon." They also suggested that this loess may correlate with the Farmdale loess in Illinois. This concept explains the development of an organic-rich horizon upward as loess is being deposited and why some layers of gumbotil (the gleyed zone) appear to be too thick (Simonson, 1954). The most significant proposition Simonson (1954) offered is, "If deposition of the loess were slow and continuous, the B horizon (of a gumbotil profile) could 'grow' upward, first into the former A horizon and later into the loess."

The latest and most controversial change in the concept of the Sangamon Soil occurred in 1960 when Frye and others published the paper, "Accretion-gley and the Gumbotil Dilemma." They criticized the dualism of the empirical and genetic definition of gumbotil and suggested that gumbotil be restricted to the truly in situ, gleyed soil. They reviewed the term *gley*, a product of reduction in a wet environment, and defined "accretion gley," a product of "slowly accumulating deposits of surficial clay" in a wet soil environment. In their criticism of gumbotil they contended that five genetic processes can meet the empirical definition of gumbotil: (1) glaciofluvial deposition before soil formation, (2) slope-wash accretion during soil formation, (3) eolian accretion during soil formation, (4) combination of accretion and in situ gleying during soil formation, and (5) in situ gleying during soil formation.

The concept of gleyed Sangamon Soil profiles was discussed much earlier by Thorp, Johnson, and Reed (1951), but was rejected by Leighton and MacClintock (1962) and other gumbotil advocates because it contradicted their claim that oxidizing conditions are required for gumbotil formation.

Shortly after publishing their paper on the gumbotil dilemma, Frye and others (1960) presented the first broad analysis of the physical features of the Sangamon Soil in Illinois, but they did not describe any soil profiles. The significant conclusions drawn by Frye and others (1960) are: (1) the degree of mineral decomposition in accretion-gley profiles is less than in the in situ profiles and much less than ascribed to the gumbotil, and (2) the term *gumbotil* is not a good scientific term and "should be used only in a general sense to refer to those plastic and sticky surficial clays resting on till." Leighton and MacClintock (1962) disputed much of the work of Frye and others but acknowledged that some deposits are accretion gleys, and, by quoting Trowbridge, stated "gumbotil as originally defined can be distinguished readily enough from other clays."

Frye and Willman (1963) countered by commenting on what they considered to be archetypical gumbotil sections that "At every reported exposure that we have recently examined the 'gumbotil' is accretion-gley." The dilemma can be explained by considering a conceptual catena. Given a nearly level ground surface with an occasional rise and isolated depressions, an in situ, poorly drained gleyed soil can exist on the level ground between the accretion gley in the depression and the better-drained, in situ soil on the rise. In fact, this sequence is typical on a large part of the flat Illinoian till plain. In a soil-geomorphic sense, disregarding the chemical and mineralogic requirements, the in situ, gleyed profile could be called *gumbotil*; however, Willman and others (1966) did not approve of differentiating a poorly drained, in situ soil from the better drained, in situ soils because they did not consider it practical.

Frye and Willman succeeded in replacing the concept of gumbotil with the concept of accretion gley in Illinois, but this exchange has to a degree created a new dilemma. Accreted material in a soil environment is generally distinguishable from in situ material in the field, but the distinction is often difficult. As a result, accretion gley and in situ gley, both gleyed materials, are commonly confused. In the field, probably all gleyed soils would be called accretion gley because of the over-emphasis on accretion gley.

The current concept of the Sangamon Soil in Illinois was described by Willman and Frye (1970) from two paratype sections and several other typical occurrences of the Sangamon Soil. The folowing features of the Sangamon Soil can be derived from their description:

1. It underlies Wisconsinan-aged deposits and has developed in Sangamonian, Illinoian, or older deposits.

2. It is composed of two genetic types:

    a. Accretion gley—A gray to blue-gray massive clay, with some pebbles and sand, formed by accretion under poor drainage and gleying conditions; may have sharp contact with the till below, gradational upper boundary.

    b. In situ—A red-brown to sometimes dark-gray profile developed in place under moderately good drainage to sometimes poor drainage on till or other glacial deposits; has a distinctive clayey B2 zone, typically has manganese-iron pellets and staining; gradational lower boundary, sharp upper boundary.

3. It is leached of carbonates to about 6 to 10 feet; depth of leaching slightly diminishes northward in the state; leached below the till contact in some accretion-gley profiles.

4. It is strongly developed:

    a. In situ profiles are more strongly developed in the south than in the north.

    b. Accretion-gley profiles are similar throughout Illinois.

5. It is not restricted to the Sangamonian time interval:

    a. Soil formation started in some localities during the Illinoian Stage.

    b. Early Wisconsinan sediments, to some extent, were incorporated into the gleyed profiles.

Because the Sangamon Soil is time-transgressive, its recognition in a sequence of deposits does not necessarily establish that the beginning of Wisconsinan time is marked by the top of the soil. The Wisconsinan time boundary commonly lies within the A horizon of the Sangamon Soil and has been determined in Illinois by detailed analyses of grain sizes (Follmer, 1970, summarized in Johnson and others, 1972) or by mineralogical analysis (Frye and others, 1974). The beginning of Wisconsinan time has been estimated by Frye and others to be about 75,000 years ago. Studies in Iowa (Ruhe, 1976) and in Indiana (Kapp and Gooding, 1964) suggest that the Wisconsinan begins at a younger age.

The fundamental question that arises concerns the basis for assigning the Wisconsinan-Sangamonian boundary in the continental record. Should the beginning of the Wisconsinan be based on the first Wisconsinan sediments on the Sangamon Soil in its type area (Frye and others, 1974) or on the introduction of, or some measure of, boreal remains into the Sangamon Soil profile? Kapp and Gooding (1964) included the upper boreal pollen zones in the Sangamon Soil because of the observed field relation of the soil with overlying sediments and because of radiocarbon-dead material (>41,000 ^{14}C years B.P.) obtained from the top of the soil identified as the Sangamon Soil.

Finite age determinations are needed in the type area of the Sangamon Soil where a complete section of early Wisconsinan sediments can be documented to overlie the soil. Identification of the type of organic remains in the soil and at the base of the Wisconsinan sediments is needed to answer the fundamental question on the age. A possibility exists that the "first sediment" criteria will be compatible with the "first boreal remains" criteria.

REFERENCE SECTIONS OF THE SANGAMON SOIL

Many profiles of the Sangamon Soil have been described in Illinois since Leverett named the soil in 1898. Most of the descriptions are skeletal and describe only the general appearances. The recognition of a "soil" was sufficient for the purposes of much of the work in the early days because glacial stratigraphy was the major objective, and little attention was given to the actual characteristics of the soil.

A general evaluation of all known published descriptions of the Sangamon Soil in central Illinois has been summarized by Follmer (1978). Only 7 of the 88 described sections (fig. 1) included detailed description of the Sangamon Soil. At 17 other sections, only the major horizons were noted. The general appearances of the profile were described at 52 sites; at the remaining 12 sites the Sangamon Soil was noted as occurring in the described section, but was not described. The type area of the Sangamon Soil had not been designated until the area shown in figure 1 was designated as the type area by Follmer (1978). Also shown in figure 1 are the locations of all samples collected in the Sangamon Soil or immediately overlying a horizon of a described Sangamon Soil for which radiocarbon dates were determined.

Figure 1. Location of reference sections, Sangamon soil descriptions, and samples for which radiocarbon dates have been determined for central Illinois.

Four sections (Farm Creek, Effingham, Chapin, and Rochester) can be considered reference sections for the Sangamon Soil and have received the most attention in the literature. They display four common types of Sangamon Soil and contain the common variations in the loess that overlies the Sangamon in Illinois; however, they are geographically separated. The Farm Creek was, in effect, a reference section for the Sangamon peat of Leverett (1899), a "type Pleistocene section" to Leighton (1926), the type section of the Farmdale loess of Leighton (Wascher, Humbert, and Cady, 1948), and is currently the type section for the Farmdalian Substage and the Robein Silt (Willman and Frye, 1970). The Effingham Section was, in effect, the type gumbotil section for Leighton and MacClintock (1930), a Sangamon Soil reference section for Simonson (1954) and Brophy (1959), and a reference section for the accretion gley (Berry Clay) for Willman, Glass, and Frye (1966) and Willman and Frye (1970). The Chapin and Rochester Sections have been proposed as paratype sections for the Sangamon Soil and the Sangamonian Stage by Willman and Frye (1970).

Farm Creek Section (Stop 1)

The exposures along Farm Creek were first discussed by Leverett (1899). In one exposure he described 10 feet of Iowan loess resting on a deeply leached and weathered zone at the top of the Illinoian till. In another exposure, the railroad cut, he found a peat within a silt sequence in the Iowan position. He called the peat *Sangamon* and questioned whether the loesslike silt under the peat should be called *Iowan*. Leverett offered a two-phase origin of the Sangamon Soil: the first phase was the weathering of the Illinoian till, and the second was the formation of the peat. This explains the apparent dualism in his expression "The Sangamon soil and weathered zone."

The Farm Creek exposures were studied again by Leighton (1926) and Willman and Frye (1970). The correlation of their sections with the Farm Creek exposures described by Leverett are shown in figure 2. The thickness of the units shown in figure 2 are adjusted by ±1 foot to maximize similarity. The railroad-cut section at Farm Creek is about a half mile away, but is included because it has stratigraphic features that can be easily correlated with the features described by Leighton and by Willman and Frye. The major stratigraphic elements, except for Leverett's Farm Creek Section, are in good agreement; however, the names and interpretations of time have been changed.

Leighton (1926) described the upper 1 to 1½ feet of the "Sangamon" as "old soil, dark with flakes of carbon, some . . . wood . . ., loessial in texture, noncalcareous." The next zone below, 7 to 8 feet thick, he described as a "loess-like silt," leached to about 5½ feet at the east side of the exposure where the silt has brown and yellow colors, but leached only to about 6 inches below the "old soil" at the west side. The 6 inches are described as "greenish loess" and overlie a bluish-gray calcareous zone, presumably 4 to 5 feet thick, which contains "scattered small pebbles in lower 3 feet." He described 4 feet of gumbotil under the silt as "brown with reddish specks on east side, brownish to brick red at top with bluish spots on west side." He also noted that it is "tenacious, [has a] hackly fracture, [and contains] siliceous pebbles, mostly under 3/4-inch, . . . and grades downwards into very calcareous till."

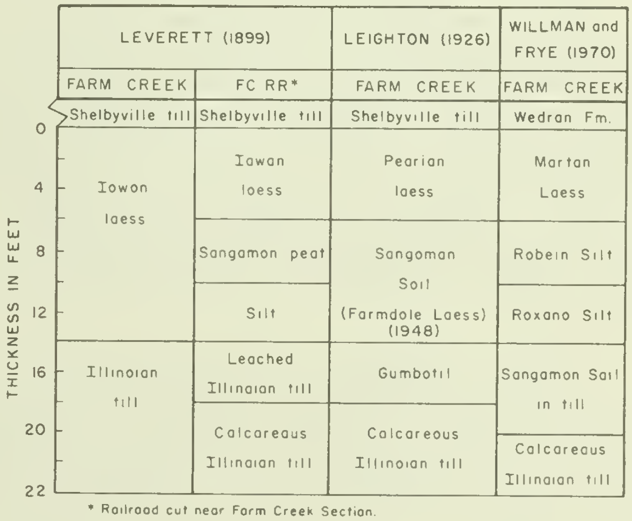


Figure 2. Development of stratigraphic classifications of the Farm Creek Section.

The interpretations of the Farm Creek Section, drawn by Leighton (1926) were largely in agreement with Leverett. Important interpretations made by Leighton were (1) the silt under the "Sangamon peat" is loess, (2) the original color of this loess was probably a "brown to grayish yellow color" and was altered to the "bluish-gray," and (3) the section displayed a catena, or local conditions in which "the subsurface drainage of an oxidizing character" existed within a short distance to a "nearly stagnant drainage of either unoxidizing or deoxidizing character." Leighton apparently lost sight of this catena concept in his 1930 paper and virtually denied the existence of the process of "deoxidation" in 1962.

Willman and Frye (1970) used current concepts of the Sangamon Soil and rock-stratigraphy to reinterpret the Farm Creek Section. The Sangamon peat of Leverett, known for many years as the Farmdale Silt, was renamed *Robein Silt* (Willman and Frye, 1970) because of confusion caused by the multiple use of the name *Farmdale*; it had been used as a name for a rock, a soil, and a time. The radiocarbon ages of two wood samples (22,900 and 25,100 ^{14}C years B.P.) taken from the Robein Silt at the Farm Creek Section before 1978 are listed by Follmer (1978) along with all other radiocarbon determinations on organic materials historically associated with the Sangamon Soil. Most of the dates are remarkably similar, ranging from about 20,000 to 30,000 ^{14}C years B.P. A few determinations are greater than 30,000 ^{14}C years B.P. and were interpreted to be from the Robein Silt, Illinoian, or older deposits.

The description of the Sangamon Soil at the Farm Creek Section by Willman and Frye (1970) is skeletal. Essentially, only the general appearances are described, although they recognized the B2 horizon as being "thinner than typical." They described the soil as "till, leached, brown with some streaks and splotches of red-brown, tough, clayey" and overlain by 3.5 feet of Roxana Silt and 4.5 feet of Robein Silt.

Effingham Section

The Effingham Section was first described by Leighton and MacClintock (1930). They called the Sangamon Soil a "weathered zone on the Illinoian drift-sheet" and never used the term *Sangamon Soil*. The Effingham Section was used by them to characterize the gumbotil profile that occurs on the broad, flat, poorly drained areas in the Illinoian drift region of southern and western Illinois.

The description by Leighton and MacClintock of the Sangamon Soil at Effingham is partially detailed. The major horizons are described by color, texture, consistency, and a few other features that appear to be related to soil structure. Subdivisions are described, but appear to be related more to material boundaries than to soil-horizon boundaries. Their example "profile" is overlain by 2 feet, 10 inches, of "soil and loess." Horizon 1 is the "Fossil soil," meaning ancient or buried soil. Horizon 2 is the gumbotil. Horizon 3 is the leached, oxidized, and little-altered till. Horizon 4 is the calcareous, oxidized till, and horizon 5 is the unweathered, unaltered, blue-gray till.

Figure 3 compares the horizons of the Sangamon Soil profile described by Leighton and MacClintock to the zones (horizons) described by Simonson (1954), Brophy (1959) and Willman and others (1966) at the Effingham Section. The original designations of the authors are retained. The measurements at this section were intended to be at the same location, but were probably separated by a distance less than 100 feet. Lateral variations can explain the difference in thickness, but not the interpretation of each horizon or zone. The Effingham Section was the first place where the gumbotil was directly equated to accretion gley (Willman and others, 1966), although the equivalency was pointed out earlier by Frye and others (1960) and Frye and Willman (1963).

Simonson (1954) interpreted the Sangamon Soil at Effingham to be a planosol and described the soil using soil-horizon designations; however, no quantifying expressions were used, nor was any pedological structure interpreted. Brophy (1959) redescribed the Effingham Section by weathering-zone designations. Brophy established that depletion of hornblende, illite, and chlorite in zones I and II was significant and only slight in zones III and IV. His results on the degree of weathering were in agreement with the work in Iowa by Ruhe (1956), and he concluded that the weathering-ratio method is a promising technique for "evaluating profile maturity, especially in buried profiles where standard pedological tests of maturity may not work." His reference to "standard pedological tests" means the assessment of the degree of development of soil structure and may include the degree of soil horizon differentiation. The stronger the expression of soil structure or the greater the contrast between the A and B horizons, the more mature the soil is interpreted to be. But, as Brophy noted, this test often fails in some buried soils, particularly in buried poorly drained soils.

Willman and others (1966) recognized that local slope wash, which may include some loess, was a component present at the Effingham Section, but they expanded the interpreted accretionary zone to include all the gleyed deposits, which they called accretion gley. Interpretations made by Leighton and MacClintock, Simonson, and Brophy on the Effingham Section are in general agreement and contrast with the interpretations made by Willman, Glass, and Frye. The differences arise from the genetic interpretations of the origin of gumbotil and accretion gley.

Chapin Section

The Chapin Section was first described in 1965 for the purpose of demonstrating a complete sequence of the overlying Roxana Silt to the INQUA field conference (Frye and Willman, 1965a). The Sangamon Soil at this section is a well-drained, in situ soil developed in Illinoian till. Willman and Frye (1970) selected the Chapin Section as a paratype section of the Sangamon Soil to represent the in situ profile developed in Illinoian till. Willman and Frye considered the Sangamon to be better developed here than in some localities because younger Illinoian deposits are missing, making the interval of soil formation longer. The Sangamon is overlain by the Markham Silt, the oldest member of the Roxana Silt. The profile is leached to 6½ feet and has a distinctive red-brown, clayey B2 horizon with iron-manganese concretions and stains.

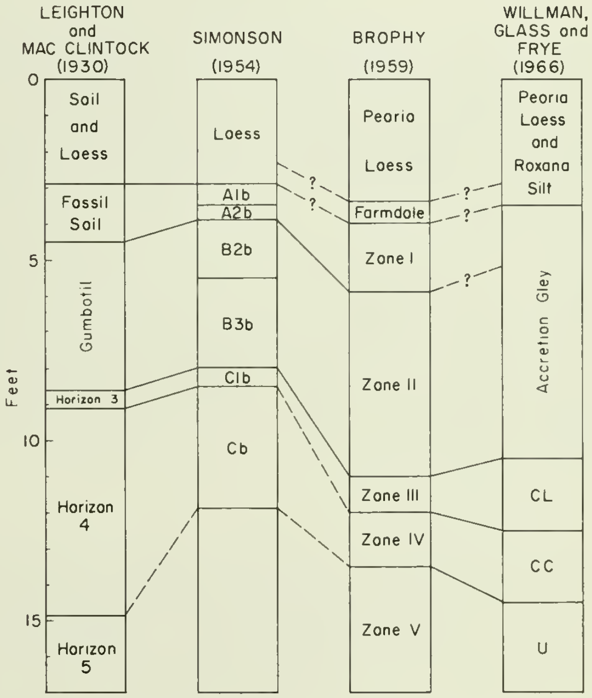


Figure 3. Development of stratigraphic classifications of the Effingham Section.

Rochester Section

The Rochester Section was first described in a general way by Frye, Willman, and Glass (1960). The Rochester Section at that time was considered a typical exposure of the Sangamonian accretion gley. The Rochester Section was discussed again by Frye and Willman (1963 and 1965b). In 1979 the Rochester Section was chosen to be a paratype section of the Sangamon Soil and to serve as a representative section of the accretion-gley profile. The accretion gley was named Berry Clay at this section. Their Sangamon Soil description is skeletal. General features of color, texture, and structure are noted, and only two zones are recognized. The upper zone appears to be due to postburial alteration and is interpreted to be evidence of Farmdale Soil formation. They stated that the Roxana has been truncated, and Peoria Loess directly overlies the accretion gley.

Willman and Frye (1970) also considered the Rochester Section to be a paratype section of the Sangamonian Stage; however, they stated that "the interval of soil formation exceeded the time span of the Sangamonian Stage." This statement can be interpreted in two ways: in the context of their statement, soil formation began before the end of the Illinoian at the Rochester Section, but they also stated that "early Wisconsinan sediments" were incorporated into the "gleyed material" of the Sangamon Soil after the end of Sangamonian time. The fact that the Roxana has been truncated at the section indicates that an erosional surface overlies the accretion gley and suggests that some of the gley has also been removed by erosion. Therefore, it is not clear from their discussion whether the Rochester Section contains a complete sequence of Sangamonian (Berry Clay) deposits or whether the Sangamon Soil profile is complete; however, the top of the Sangamon Soil at Rochester has been arbitrarily defined as the Sangamonian-Wisconsinan boundary even though the Sangamon Soil there may be incomplete.

A similar problem of interpreting the Sangamonian and the Sangamon Soil exists at the Chapin Section. The A and B1 horizons of the Sangamon Soil were not differentiated and were described as having a combined thickness of 6 inches. This means that the A horizon is probably missing because a "normal" Sangamon Soil in this position is a podzolic type of soil (Ultisol)(Ruhe, 1974) and should have an A horizon 8 to 12 inches thick and a B1 horizon 10 to 18 inches thick. Therefore, an important part of the Sangamon profile appears to be missing or has been misidentified. The uncertainty of the probable erosional surfaces at the Rochester and Chapin Sections greatly diminishes the possibility of deriving a more precise definition of the Sangamonian interval and the beginning of the Wisconsinan Stage at those sections. New reference sections should be established that describe the common types of Sangamon Soil profiles and record the complete sediment record free from erosional surfaces.

CONCLUSIONS

The major concepts of the origin and stratigraphic position of the Sangamon Soil in Illinois have evolved into a reasonably clear picture in the 80 years since the introduction of the Sangamon Soil by Leverett (1898a). Some of the details remain to be resolved, however. The details pertaining to the Sangamon Soil and its age have become increasingly important as more precise correlations to other areas, particularly the oceanic record, are being attempted.

The need for more precise information has always been recognized. Leighton initially went to the Farm Creek Section in 1926 because he thought a "detailed examination" was needed. Even after the great amount of work Leighton accomplished himself, he described the need for a comprehensive study of the weathering profiles (1962) and made recommendations that the "Farm Creek Section should be opened up" and studied again (1965). In the most recent work, Willman and Frye (1970) thought that paratype sections of two types of Sangamon Soil profiles were needed because none had existed before.

For a general summary of the present status of the Sangamon Soil in its type area, the following conclusions can be drawn:

1. It has generally been consistently recognized in stratigraphic sections.

2. It has been successfully used as a general marker bed to separate the Wisconsinan and Illinoian deposits.

3. The mineralogy of the profile has been satisfactorily characterized by major horizons.

4. The uniformity of parent material has not been specifically tested at the reference sections, except for the work by Brophy (1959).

5. The soil morphology has not been studied in sufficient detail.

6. A catena or toposequence has not been studied or adequately described. A type transect should be established.

7. The contributions of early Wisconsinan loess and Illinoian lacustrine deposits in gleyed profiles have not been fully assessed.

8. The age of the Sangamon Soil has not been precisely defined.

9. The paratype sections of the Sangamon Soil do not appear to contain complete profiles on which the Sangamonian Stage should be defined.

COMMENTS ON THE SANGAMON SOIL

H. B. Willman
Illinois State Geological Survey, Urbana, IL 61801

Perhaps a brief restatement of the gumbotil or accretion-gley problem and a few comments on the classification of the Sangamon Soil will clarify some questions that are particularly pertinent for central Illinois. These remarks are intended to supplement the much more detailed discussion in this guidebook by Leon R. Follmer.

After intensive study of the buried soils of Iowa, George F. Kay (1916) applied the name *gumbotil* to the very clayey, dark soil, commonly called *gumbo*, that occurred on the Illinoian, Kansan, and Nebraskan tills in Iowa. Kay believed that the gumbotil mantled the upland surfaces of those drifts, except where it was truncated by erosion or where its original characteristics had been modified by extraction of the colloids during a later interval of weathering that followed uplift and dissection of the till plain. Kay believed that gumbotil was the product of decomposition of the underlying till in situ, whereas many had previously considered it to be a deposit on the till. This is amply clear in his papers with J. N. Pearce (1920), Earl Apfel (1929), and Jack B. Graham (1943). In all his writings, only once did Kay mention slope wash as one of several local factors in the origin of gumbotil.

In Illinois, M. M. Leighton, a student and later a colleague of Kay, followed Kay's interpretation of the gumbotil, but recognized its more local occurrence and the presence of other types of soils based on the degree of subsurface drainage. The classification in 1930 by Leighton (with Paul MacClintock) of soil types as gumbotil, mesotil, and silttil demonstrated his interpretation of the gumbotil as an in situ soil.

It is apparent that neither Kay nor Leighton recognized any soils as sedimentary deposits on the till and that they both selected exposures of the thickest and most clayey soils to serve as typical examples of gumbotil.

After independent studies convinced them that the materials cited as typical gumbotil by Kay and Leighton were in fact sedimentary accumulations in the poorly drained, swampy depressions on the till plain, Frye, Shaffer, Willman, and Ekblaw (1960) and Frye, Willman and Glass (1960) proposed the term *accretion-gley* for these deposits. The deposits were not till, and the term *gumbotil* was not appropriate. They, of course, were not the first to question the in situ origin of gumbotil.

Most of Kay's original sections were no longer available, but numerous exposures of accretion gley, as well as in situ profiles, were found near some of his sections, and he undoubtedly included many poorly drained in situ soils in his gumbotil. As one eminent Iowa geologist, who may not wish to be quoted, said, "Gumbotil includes everything, including the kitchen sink." In Illinois, all exposures that were still available and described as gumbotil by Leighton and MacClintock are believed to be accretion gleys.

The lateral gradation of the accretion gleys to in situ profiles is sometimes suggested, because they are essentially contemporaneous, but so far as matching zones occurs, this is an impossibility. The first accumulation of slope-wash material in the depression ends the possibility of any of the overlying material being an in situ soil on the till. It does not prevent weathering of the underlying till from continuing, although the clay barrier serves to slow down the process and results in a generally much thinner zone of leaching of carbonates than is found in adjacent in situ profiles. The clay in the accretion gleys is largely washed from the bordering surfaces and therefore is equivalent to the A or B zones in the bordering in situ soils, which vary from poorly drained to well drained.

Some lateral variations occur in the accretion gleys, particularly on the sloping margins. Grading of accretion gleys to other sediments, such as peat and lacustrine deposits, occurs but appears to be uncommon. Peat deposits probably were much more abundant in association with the accretion gleys, but they disappeared rapidly when the depressions were drained.

The problem of look-alikes between accretion gleys and in situ soils occasionally arises. Generally there is little difficulty in recognizing the accretion gleys by various field criteria, which can be supplemented by mineralogical data, as described elsewhere. An accretion gley overlying a very clayey till that contains few pebbles could be a problem, although I have not encountered it. Identifying the underlying material as till can be more of a problem.

Without much question, thin accretion deposits that accumulated in shallow sags in the surface are completely incorporated and not recognizable in the upper part of the B zone of soils with normal in situ profiles. The same applies to thin deposits of wind-blown material and even gravel, which also lose identity in the tops of the soil profiles.

The accretion gleys are not as abundant as is commonly inferred from correlations with gumbotil, as identified by Kay and Leighton. The accretion deposits certainly would not dominate a landscape, although they probably contributed to the exceptional flatness of the Illinoian till plain. Examination of several miles of coal strip-mine faces in western Illinois revealed only a few examples of sags filled with accretion deposits on the Illinoian till plain.

As the present conference deals with the type region for the Sangamon Soil and the Sangamonian Stage, a few remarks about the problem of stratigraphic classification may be appropriate.

The only Sangamonian sediments in the type region are the accretion gleys, and therefore the Sangamonian Stage is based on the Sangamon Soil, particularly the Berry Clay Member of the Glasford Formation. By intent and definition, the Sangamonian is the interglacial stage between the Illinoian and Wisconsinan glacial stages, and established procedures require that it be bounded by time planes based on type sections.

Characteristically, the boundaries of glacial and glacio-fluvial deposits and soils do not conform closely to time planes, and the time planes, therefore, are accurately fixed only in their type sections. It is customary, however, to project the time planes on rock- and soil-stratigraphic boundaries that differentiate the practical time-stratigraphic units needed for organization and correlation in stratigraphy. In many cases their boundaries may not be far from the actual time planes.

In other cases this practice can be very misleading, and the Sangamonian Stage, based on the Sangamon Soil, is a good example. The Sangamon Soil in Sangamon County began to form not long after the middle of Illinoian glaciation and in some regions it extended into the early part of Wisconsinan glaciation. Therefore, both boundaries of the Sangamonian Stage, as based on intent or definition, fall at some undetermined position within the accretion gley. Nevertheless, it is difficult to find any locality where more accurate, or more useful time planes can be established.

Although the soils, particularly the Sangamon Soil, are among the most useful units for regional correlation, their boundaries do not make good time planes for establishing conventional time-stratigraphic units. The use of type sections has obvious merit, but the overriding factor in evaluating a unit should be its definition. The possibilities for modification of boundaries are almost unlimited, and most Pleistocene type sections are here today and gone tomorrow. It is perhaps better to consider the glacials and interglacials as events, unhindered by the requirements of fixed time planes based on type sections.

Despite the problem of establishing boundaries between the Illinoian, Sangamonian, and Wisconsinan type sections, the Sangamon Soil and the Sangamonian Stage exist, and very little could be accomplished by changing their names and type sections.

WISCONSINAN LOESS STRATIGRAPHY OF ILLINOIS

E. Donald McKay
Illinois State Geological Survey, Urbana, IL 61801

Loess deposits in midcontinental North America are genetically related to continental glaciation, and because of their particular mode of origin and occurrence in the Midwest, they contain one of the most complete records of geologic events during the Wisconsinan. The mineralogic and, to some degree, textural compositions of loess deposits are determined by the composition of the valley-train sediments and ultimately the composition of the outwash source. The responsiveness of loessial and valley-train compositions to glacial action in the upper parts of the drainage basin provides a basis for relating glacial and loessial records. Over a short term, loess accumulates intermittently, probably responding to seasonal fluctuations in flood frequency, sediment availability, vegetation, and wind direction and velocity. From the perspective of geologic time, Wisconsinan loess in Illinois accumulated nearly continuously during at least two intervals, each longer than 10,000 years. The thick loesses of near-valley areas give stratigraphic separation to units or zones that merge in areas of thin loess. Loess accumulating on stable landscapes buries and preserves older surfaces and sediments. Nondepositional intervals or long periods of marked reduction in accumulation rate can be recorded as weathered zones when buried by renewed sedimentation. Variations in sedimentation rates related to distance from the source allow study of the balance between deposition and soil formation during the period of accumulation.

HISTORY OF THE STRATIGRAPHIC CLASSIFICATION OF WISCONSINAN LOESSES

The stratigraphic significance of loess deposits in the depositional record of the Quaternary of the Midcontinent was recognized in the late nineteenth century. Since that time, the evolution of stratigraphic classification of the time and rocks of the Quaternary, and especially the Wisconsinan, in Illinois has in many respects paralleled the development of concepts of loess genesis. To trace the history of interpretation and classification of loesses in Illinois is to follow the development of stratigraphic concepts and classifications widely used to identify and subdivide the rocks and time of the Wisconsinan.

Leverett (1898b) applied the term *Iowan Loess* to fossiliferous loess that he correlated with the Iowan stage of glaciation and that is found beneath Wisconsin till and beyond its margin. He cited the occurrence of a weathered zone in the upper part of the Iowan loess in several exposures in northern Tazewell County east of Peoria, Illinois, as evidence for a time interval between the Iowan and early Wisconsin glaciations. He named the interval the *Peorian interglacial stage,* and the weathered zone, which he miscorrelated with extensive muck and peat deposits in northern Illinois, he named the *Peorian soil.*

In 1899, photographs and brief descriptions by Leverett of two exposures along Farm Creek in Tazewell County were published. His descriptions and interpretations of these exposures are depicted in figure 1. In a railroad cut approximately a half mile east of stop 1, Leverett (1899, pl. XI) identified Bloomington gravel (6 feet thick) at the top, Shelbyville till (8 feet thick), Iowan loess (6 feet thick), Sangamon peat (3 to 5 feet thick), and silt below peat (2 to 5 feet thick). He noted that below the silt an Illinoian till is leached and weathered at the top and calcareous 4 feet below the top. In the nearby Farm Creek stream cut (stop 1 of this trip), Leverett described a similar succession of materials with thicker Iowan loess (10 feet) and without the peat or underlying silt of the railroad exposure. Although Leverett did refer to the lower silt as loesslike (Leverett, 1899, p. 32) and believed it was deposited during the Sangamon interglacial, he correlated most other loesses, e.g., Iowan loess, with glacial intervals. Leverett probably favored the eolian theory of loess genesis, but he clearly considered possible the subaqueous deposition of some loesses (Leverett, 1899, p. 33).

Leighton (1926) published a detailed description of the Farm Creek stream exposure (stop 1) with several significant changes of interpretation. To Leighton, loess was eolian in origin (1926, p. 121). Citing Alden and Leighton's (1917) conclusion that "the great body of loess associated with the Iowan drift was deposited almost immediately following the recession of the Iowan ice sheet," Leighton (1926) interpreted Leverett's Iowan loess as an interglacial deposit and changed its name to *Peorian loess*. Leighton identified a 2-inch humus streak 10 inches below the top of the Peorian loess in the Farm Creek exposure as the Peorian soil and suggested that loess above the humus was deposited during the approach of Shelbyville ice. Beneath the Peorian loess and above Illinoian gumbotil, Leighton described a 1 to 1½ foot Old soil over 7 to 8 feet of "loesslike silt," units Leverett had not recognized in this exposure. The silt he interpreted as weathered loess deposited during the latter part of the Sangamon interglacial and correlative with Leverett's (1899) silt in the railroad cut. The Old soil, a noncalcareous loessial silt containing carbon and wood fragments, was correlated with Leverett's Sangamon peat. Leighton believed there were three periods of weathering beneath the Shelbyville till: (1) weathering of the Illinoian till prior to deposition of the loesslike silt, (2) weathering of the loesslike silt and peat accumulation prior to deposition of the Peorian loess, and (3) Peorian soil formation.

After an extensive but unsuccessful search for the Peorian soil at the top of loess beneath Wisconsin till and within the loess beyond the Wisconsin till margin, Leighton in 1931 rejected the Peorian as an interglacial interval, but retained the term *Peorian* as the name of the loess. Because no interglacial was recognized between the Iowan and Wisconsin stages, he made the Iowan the earliest substage of the Wisconsin. A key section in his interpretations was the Farm Creek exposure (fig. 1). Leighton summarized his interpretation of the history recorded at Farm Creek, stating, "the Sangamon stage was long, much longer than the Recent. A mature profile of weathering was developed, an episode of loess deposition followed, and weathering of this loess ensued. The black soil may represent the accumulation of humus during the Iowan glacial stage when cold or subarctic temperatures prevailed. Then followed the accumulation of the Peorian loess under arboreal conditions, which continued until ice of the early Wisconsin substage claimed the area."

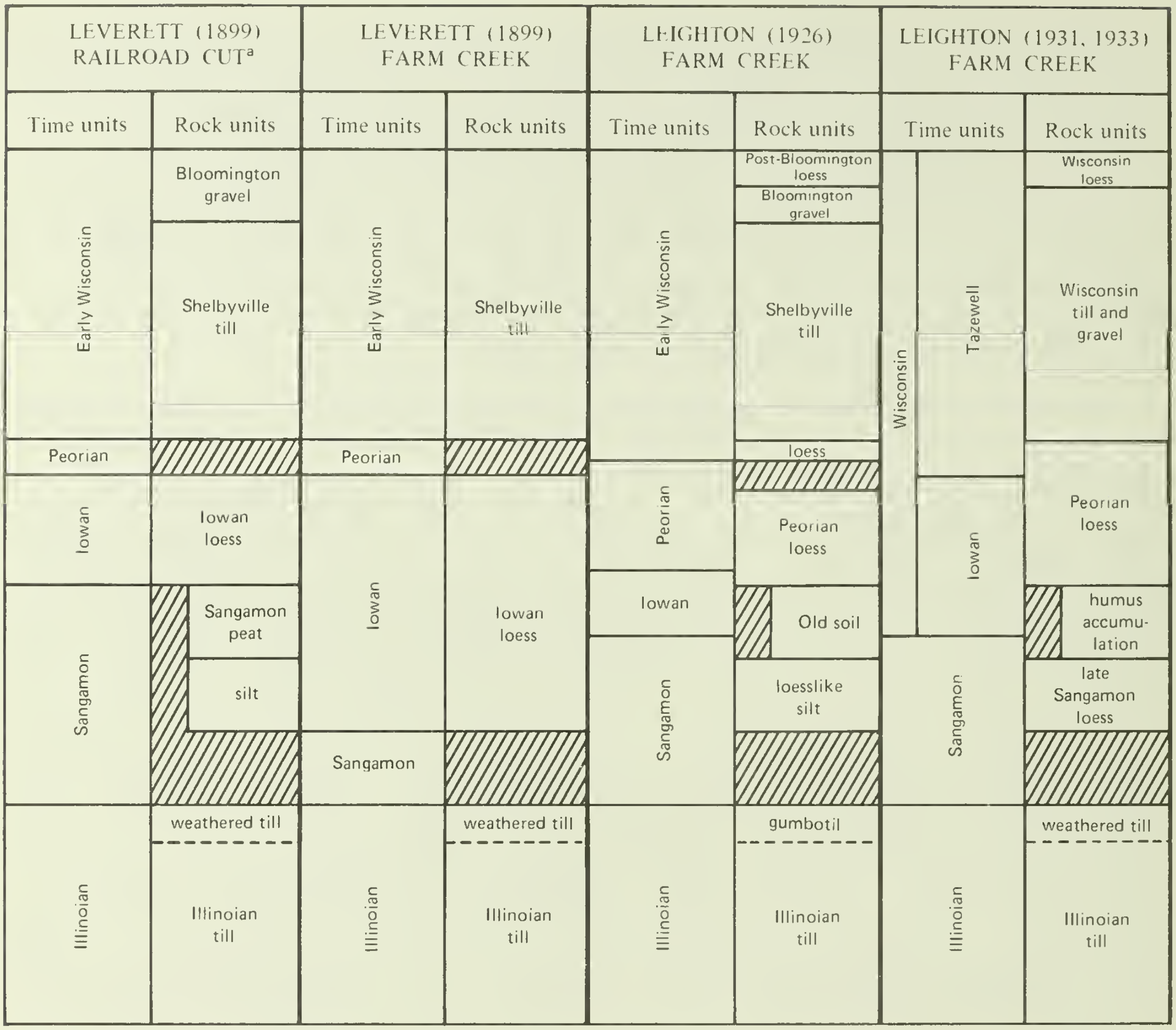
In 1933, Leighton proposed the terms *Iowan*, *Tazewell*, *Cary*, and *Mankato* as substages of the Wisconsin stage (fig. 1). Kay and Leighton (1933) established the convention of using Iowan loess for loess beneath Wisconsin till and Peorian loess for that beyond the till margin.

Smith (1942) demonstrated the genetic relationships of thinning and textural fining of the late Sangamon and Peorian loesses to the Illinois and Mississippi River Valleys. During the middle 1940s, Leighton became convinced (1) that the late Sangamon loess was deposited during a glacial interval and (2) that the peat and humus soil at the top of the late Sangamon loess exhibited insufficient profile development to be considered interglacial in origin. For these reasons he proposed the name *Farmdale loess* (in Wascher, Humbert, and Cady, 1948) as a replacement for late Sangamon loess, removing the implied tie to the Sangamon interglacial stage. He considered the Farmdale loess "pro-Wisconsin" in age and included the Farmdale substage in the Wisconsin as its oldest subdivision (Leighton and Willman, 1950).

In 1960, a revision of the Wisconsin classification of the Lake Michigan Lobe was proposed by Frye and Willman. Major revision had become necessary because of new data, largely radiocarbon dates, that were inconsistent with earlier classification schemes. Probably the most important contribution of the revision to Quaternary stratigraphy was the application of the concept of multiple independent systems of classification (Willman, Swann, and Frye, 1958). The use of multiple systems required elimination of much of the nomenclatural overlap of time- and rock-stratigraphic units and dictated the renaming of several such units. The result was a rather substantial revision containing many new names. With few exceptions, the 1960 modifications remain in use today.

Adjectival endings were added to the names of the Wisconsin and Sangamon stages, changing them to *Wisconsinan* and *Sangamonian* (fig. 1). Because radiocarbon dates (Ruhe, Rubin, and Scholtes, 1957; Ruhe and Scholtes, 1959) indicated that type Iowan till of Iowa was in fact part of a much older drift (now called *Kansan*), the Iowan substage was dropped. The Tazewell, Cary, and Mankato substages were also eliminated. The newly defined substages of the Wisconsinan were the Altonian (28,000 to 50,000 or 70,000 ^{14}C years B.P.), Farmdalian (22,000 to 28,000 ^{14}C years B.P.), Woodfordian (12,500 to 22,000 ^{14}C years B.P.), Twocreekan (11,000 to 12,500 ^{14}C years B.P.), and Valderan (5,000 to 11,000 ^{14}C years B.P.).

Prior to 1960, two silt units, the Iowan and Farmdale loesses of Leighton and Willman (1950), had been recognized between the base of the Shelbyville till and the top of the weathered zone in Illinoian till in central Illinois. These units were the basis for two time units, the Iowan and Farmdale glacial substages; however, no formal time unit had been assigned for the period recorded as a weathering profile in the Farmdale loess. In 1960, Frye and Willman recognized a third rock unit. They divided the Farmdale loess into the Roxana silt (lower) and the Farmdale silt (upper). They also changed the name of Iowan loess to *Morton loess* (fig. 1). The Roxana was named from exposures in southwestern Illinois, was the basis for the Altonian Substage, and was interpreted as predominantly loess that accumulated during the glacial advances of the Altonian. The age of the base of the Roxana, the boundary between Wisconsinan and Sangamonian time, was estimated at between 50,000 and 70,000 ^{14}C years B.P. Dates available from the Roxana in 1960 ranged from 35,200$\pm$1,000 (W-729) to 37,000$\pm$1,500 (W-869). The overlying Farmdale silt was regarded as largely a slope-wash deposit "derived by water transport and colluvial action from the older Roxana loess," (Frye and Willman, 1960, p. 6). The Farmdalian Substage, based on the Farmdale silt exposed in the Farm Creek area, was considered an interval of glacial withdrawal characterized by slow sediment accumulation, stability of alluvial surfaces, and moderate weathering. Frye and Willman used radiocarbon dates ranging from 26,150$\pm$700 (W-406) to 22,900$\pm$



[a] Railroad cut about a half mile east of classic Farm Creek Section.
[b] No section in Farm Creek area specifically described.
[c] Railroad cut about three-quarters mile south of classic section.
[d] Used only outside the area of Wisconsinan drift.
[e] Absent at this locality.

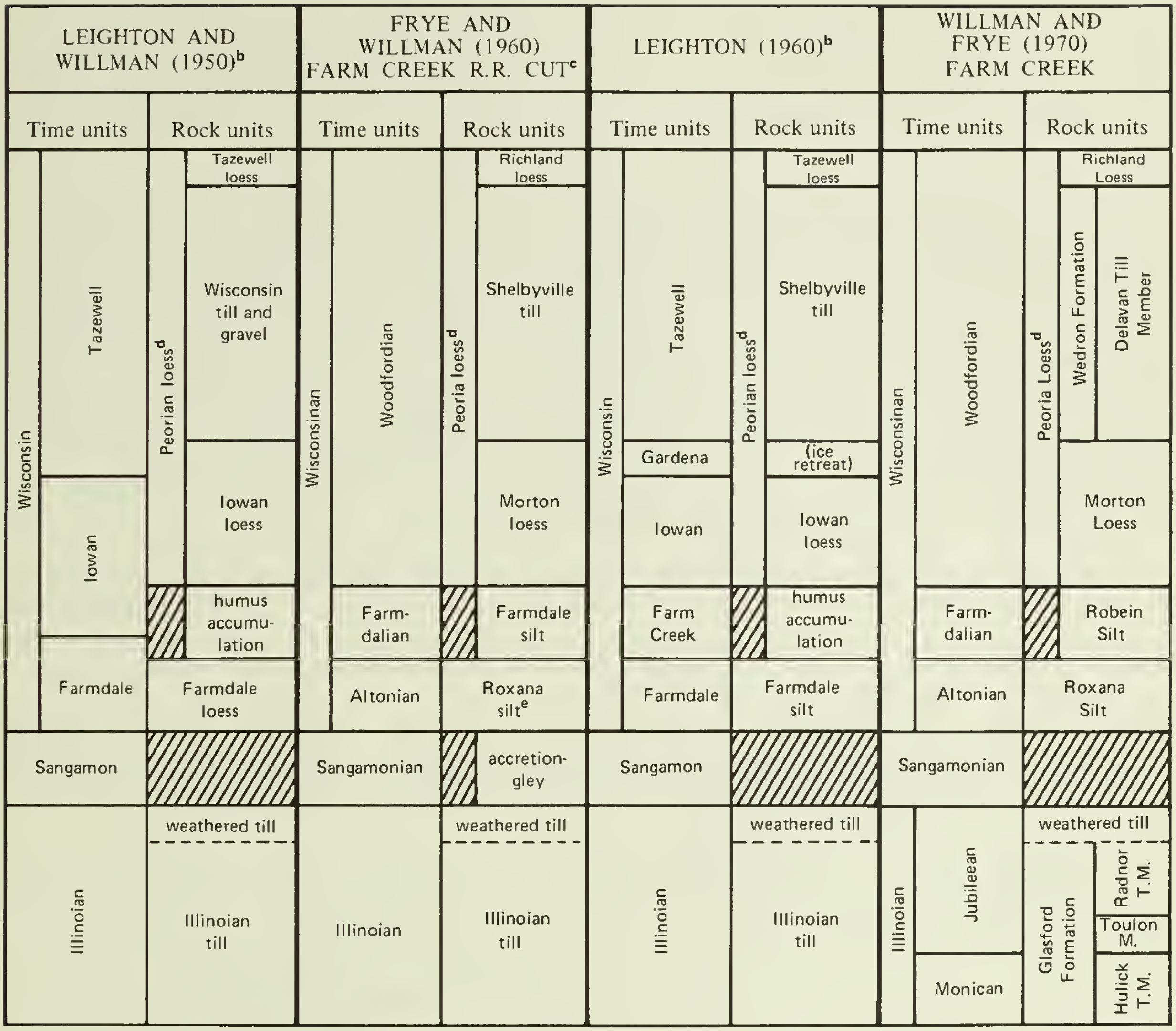
Weathering interval

Figure 1. Principal developments of the stratigraphic classification of Quaternary deposits exposed in the Farm Creek area of central Illinois.

900 (W-68) from organic sediments correlated with the Farmdale silt to establish a range of radiocarbon years of 28,000 to 22,000 for the Farmdalian Substage. The youngest Farmdalian date (W-68) cited was collected by Guy Smith in the early 1950s from an exposure along Farm Creek about a half mile east of the classic exposure (stop 1).

The contact of the Morton loess on the Farmdale silt is the basis for the time boundary between the Woodfordian and Farmdalian Substages. The Woodfordian includes the succession of deposits upward from that contact to the base of the Two Creeks forest bed and spans the Iowan, Tazewell, and Cary substages of Leighton and Willman (1950). Woodfordian and Valderan loess beyond the limit of Shelbyville till and loess that lies above the Shelbyville till were referred to by Frye and Willman (1960) as the *Peoria* and *Richland loesses*, respectively.

Leighton (1960) responded to Frye and Willman (1960) with his own revised classification in which he gave names to five "intraglacial" substages within



ISGS 1979

the Wisconsinan and reasserted the validity of the Farmdale, Iowan, Tazewell, Cary, and Mankato substages. From the deposits in central Illinois, Leighton (1960) recognized evidence for the Farm Creek intraglacial (24,000 to 28,000) between his Farmdale and Iowan glacials, and the Gardena intraglacial (19,500 to 21,000) between the Iowan and Tazewell (fig. 1). The Farm Creek intraglacial corresponds closely with Frye and Willman's Farmdalian Substage; however, the Gardena interval was not recognized in their classification. In stratigraphic position, the Gardena corresponds to the contact of the Shelbyville drift on the Morton loess and to the Peorian interglacial of Leverett (1898b, 1899) which Leighton had considered earlier but rejected in 1931.

Willman and Frye (1970) continued the revision of the stratigraphic classification begun in 1960. They formalized the ranking of most of their previously described rock-stratigraphic units and formally named several soil-stratigraphic units. Of the Wisconsinan loesses, they classified the Roxana Silt, Peoria Loess, Morton Loess, and Richland Loess as formations (fig. 2). The

Farmdale silt was renamed *Robein Silt* and given formation rank. Color zones recognized in thick sections of Roxana Silt (Frye and Willman, 1960) with the informal designations Ia (base), Ib, II, III, and IV (Frye and Willman, 1963), were grouped into three members: the Markham Silt (zone Ia), McDonough Loess (zone Ib), and Meadow Loess (zones II, III, and IV).

The Markham Silt Member was regarded as a colluvium of loessial material and products of slope wash that accumulated on and mixed with the underlying Sangamon Soil and occurred entirely within the solum of the Chapin Soil (Willman and Frye, 1970; Frye et al., 1974a). The McDonough Loess Member above the Markham was considered a loess derived from an early Altonian valley train and terminated at the top by the top of the Pleasant Grove Soil (Willman and Frye, 1970). The Meadow Loess Member is terminated upward by the Robein Silt, Morton Loess, or Peoria Loess. In thick sections it is a massive dolomitic loess that is commonly 80 to 90 percent of the total Roxana thickness. Three distinct color zones discernible in the Meadow are the lower pink (zone II), middle gray or tan (zone III), and the upper pink (zone IV).

The Farm Creek Exposure was designated the type section of the Farmdale Soil and of the Robein Silt in which the soil is developed. In the absence of the Robein, the Farmdale Soil is developed in Roxana Silt or older deposits and overlain by the Peoria Loess, Morton Loess, or Wedron Formation (Willman and Frye, 1970).

Within the Peoria Loess, a very weakly developed soil, the Jules Soil, has been recognized (Willman and Frye, 1970) and dated at between 15,500 and 16,500 ^{14}C years B.P. (Frye et al., 1974b).

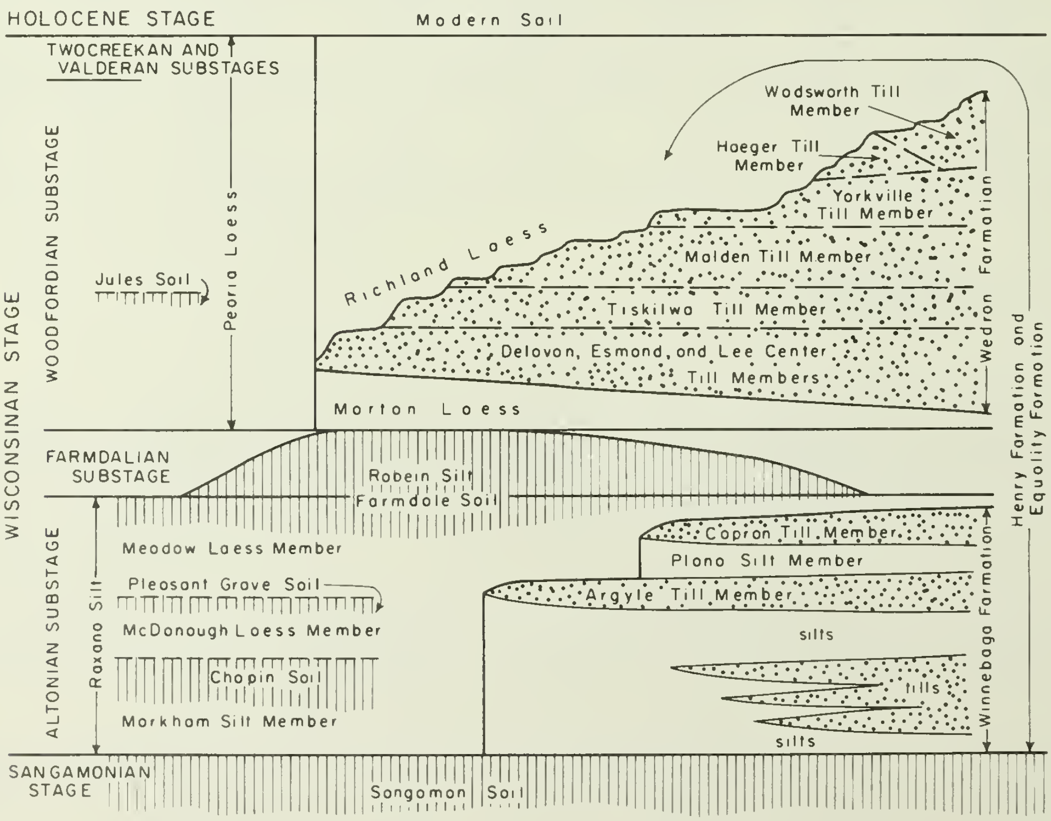


Figure 2. Diagrammatic cross section showing the relations of formations and members of Wisconsinan age in northern and western Illinois. (From Willman and Frye, 1970.)

CURRENT STATUS OF LOESS STUDIES

Roxana Silt

Thick loessial Roxana Silt along the Ancient Mississippi Valley is convincing for the presence of a major Altonian valley train in that drainage basin (fig. 3); however, the relationship of the loessial record in the Roxana to the Altonian glacial record is poorly understood. Available radiocarbon dates from the Roxana (table 1) range from 30,980±400 (ISGS-400) to 40,200±1500 (ISGS-393), but the base of the Roxana has not been dated, and its age can be determined only by estimation. It is certainly older than 40,000 years, but estimates of about 75,000 (Willman and Frye, 1970) may be excessive. Reddish-brown glacial tills in a range of time of 30,000 to 40,000 years have been found in northern Illinois (Frye et al., 1969), but they occur in an area where the bordering Roxana Silt is very thin. Thus, their stratigraphic relations to the loess are difficult to determine. Until much additional stratigraphic work is done and more radiocarbon dates from the complex glacial record become available, the relation of the Altonian loessial and glacial records will remain uncertain.

Zones in the Roxana Silt, I to IV in previous studies, are here referred to as zones r-1 (base) to r-4 to avoid confusion with zone designations in the Peoria Loess (table 2). The zones in the Roxana are distinguished in the field principally by color. In the laboratory, the unique mineral identities of the zones are determined by analyses of carbonate and clay minerals.

Zone r-1, the lower tan or gray zone, contains the record of deposition of the first Wisconsinan sediments on the Sangamonian landscape of Illinois. The zone is thin and pedologically complex, but its interpretation is critical to reconstruction of geologic history. Within the zone, Willman and Frye (1970) and Frye et al. (1974a) have recognized two depositional units, Markham Silt and McDonough Loess, and two soil-forming intervals represented by the Chapin and Pleasant Grove Soils. In a recent study of zones in the Roxana Silt in its type area in southwestern Illinois (McKay, 1977), no evidence was found for significant periods of cessation of loess deposition and soil formation in the lower part of the Roxana. Rather, the lower Roxana on tabular upland divides is texturally and mineralogically gradational from the weathered upper part of the Sangamon Soil to the unweathered dolomitic loess of zone r-2. The upward change toward typical loess compositions was interpreted as resulting from an upward decrease in the degree of mixing of the loess with the upper horizons of the Sangamon. The upward change in composition is accompanied by a gradational decrease in the expression of soil characteristics from the strong expression of the Sangamon to the very weak expression of zone r-2. This gradational sequence represents the accumulation of the initial increments of Roxana Silt on the surface of the Sangamon Soil and shows that the loess events that produced these materials were not interrupted by any substantial cessations or soil-forming intervals. Future studies must reconcile the conflicting interpretations of the basal Roxana. It seems possible that the Markham Silt Member and the Chapin Soil may occur on parts of the Sangamonian landscape that were subjected to local colluviation during the early Altonian. Only detailed studies of the variation in the characteristics of the Roxana Silt across the Sangamonian landscape will resolve these uncertainties.

Zones r-2, r-3, and r-4 may represent depositional colors, although the colors of r-2 and r-4 have certainly been somewhat altered by pedogenesis.

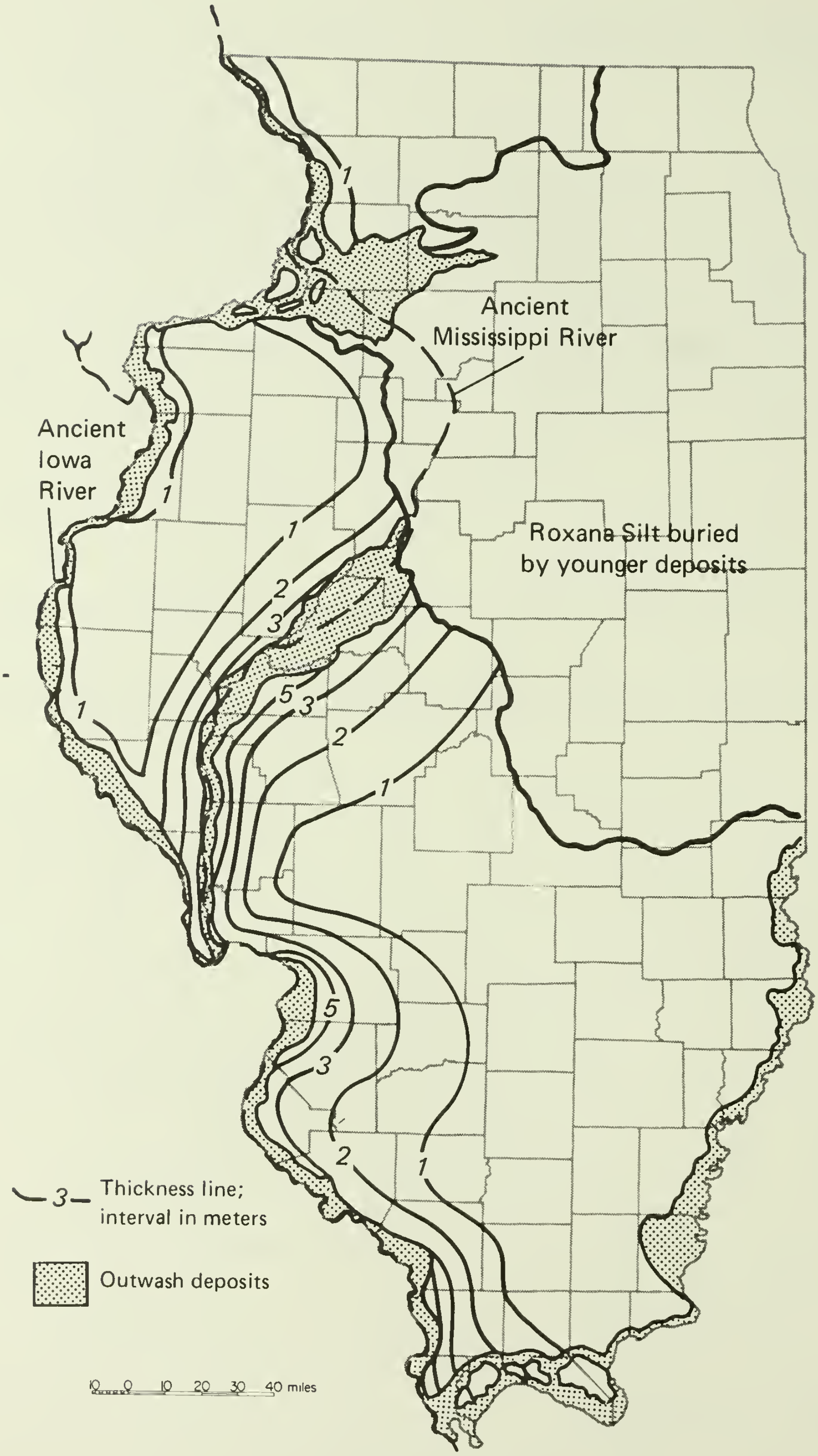


Figure 3. Thickness of the Roxana Silt in Illinois.

TABLE 1. Determinations of radiocarbon age on the Roxana Silt in Illinois.

^{14}C date		Zone	Material	Reference
30,980±400	ISGS-400	upper (r-3)	shells	McKay, 1977
35,200±100	W-729	II (r-2)	shells	Rubin and Alexander, 1960
35,750±760	ISGS-157	I (r-1)?	shells	Coleman, 1974
37,000±1,500	W-869	lower III (r-3)	shells	Rubin and Alexander, 1960
>33,000	ISGS-25	?	peat	Kim, 1970
36,100±550	ISGS-392	r-3/r-2 contact	humus	McKay, 1977
40,200±1,500	ISGS-393	r-3/r-2 contact	wood	McKay, 1977

TABLE 2. Color zones in the Roxana Silt.

	Frye and Willman, 1960	Frye and Willman, 1963	Willman and Frye, 1970	This study
Upper pink	IV	IV	Meadow Loess Member	r-4
Middle tan or gray	III	III		r-3
Lower pink	II	II		r-2
Lower tan or gray	I	Ib	McDonough Loess Member	r-1
		Ia	Markham Silt Member	

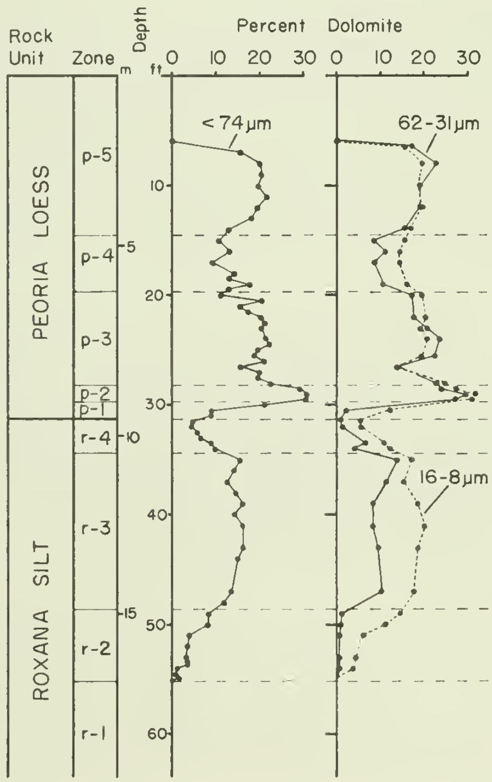


Figure 4. Carbonate-mineral content of fractions of Peoria Loess and Roxana Silt samples from core G39 in Madison County, southwestern Illinois. (From McKay, 1977.)

Zone r-4 contains the Farmdale Soil and is generally leached of carbonate minerals. Zone r-3 in thick sections is consistently dolomitic, averaging about 15 percent dolomite (fig. 4). Zone r-2 is frequently leached or partially leached, and, where dolomitic, contains less than 10 percent dolomite. Zone r-3 is somewhat more dolomitic and illitic than r-2 or r-4, and McKay (1977) suggested that it was derived from Lake Michigan Lobe outwash and that r-2 and r-4 were derived from an outwash source further north in the Ancient Mississippi River basin.

The Farmdale Soil is the most significant soil within the Wisconsinan loess succession of Illinois above the soil of zone r-1 of the lower part of the Roxana. Yet, in areas of thick loess where the depositional records of the Roxana Silt and overlying Peoria or Morton Loesses are most complete and where the soil-forming interval is restricted to the Farmdalian Substage, the Farmdale Soil is very weakly developed. It lacks a textural or structural B horizon and often consists of a thin, weakly expressed A horizon over a C horizon that is usually leached or partially leached of carbonates to a depth of 1 meter (3 ft) or less. Clearly, soils like these, which developed in the thick loess area roughly during the Farmdalian pause in loess accumulation, indicate that the period was very brief and that the peak intensity of pedogenesis during that period was at a very low level. Evidence from sites along the Mississippi Valley in southwestern Illinois where the Roxana is only partially leached in its upper part suggests that loess accumulation in near-source areas slowed substantially, but never entirely ceased during the Farmdalian (McKay, 1977).

Peoria Loess

The general aspects of stratigraphic correlations between the loessial and glacial records of the Woodfordian in Illinois are more certain than those of the Altonian. The relative completeness of the Woodfordian depositional record and the availability of a large number of radiocarbon dates have facilitated correlations; however, recent studies of the Woodfordian loesses have progressed beyond the general aspects of correlation, producing a level of knowledge of loess stratigraphy that exceeds current knowledge of the details of the glacial record. Woodfordian loesses are mineralogically zoned. Up to six zones have been identified in the Peoria Loess in studies using clay minerals (Frye, Glass, and Willman, 1962, 1968; Glass, Frye, and Willman, 1964, 1968; Kleiss, 1973; Kleiss and Fehrenbacher, 1973), magnetic susceptibility (Jones and Beavers, 1964), and carbonate minerals (McKay, 1977).

The clay mineral zonation studies recognize zone I (low illite) at the base, zone II (intermediate illite), zone III (high illite), and zone IV (low illite) in the Peoria Loess along the Illinois River. Zone I has been interpreted as loess derived from the Ancient Mississippi River Valley prior to its blockage and diversion by ice advancing from the Lake Michigan Lobe. With diversion of the Mississippi westward from its course through central Illinois to its present course about 20,000 ^{14}C years B.P., a low illite outwash source in the upper Mississippi basin northwest of Illinois was cut off from the present Illinois Valley. The major outwash source for the Illinois Valley was then the more illitic Lake Michigan Lobe, and the higher illite of zone II has been interpreted as reflecting the moderately illitic tills of the lower part of the Wedron Formation. The boundary between zones I and II was first recognized in the Morton Loess and interpreted as the record of diversion (Glass, Frye, and Willman, 1964). At the boundary between zone II and the more illitic zone III, the Jules Soil has been recognized (Willman and Frye, 1970; Frye et al., 1974b). The Jules Soil has been interpreted as a weathered zone developed in the top of zone II during a period of slowed loess accumulation that coincided with a major retreat of glacial ice in the Lake Michigan Lobe. Following the retreat, readvance of glaciers depositing the highly illitic tills of the upper part of the Wedron Formation yielded highly illitic outwash, the source for zone III. The composition of the uppermost zone of the Peoria, zone IV, is high in expandable clay minerals and low in illite. Zone IV had its principal source in the postdiversion Mississippi Valley (Frye, Glass, and Willman, 1968); however, Kleiss (1973) suggested that a portion of zone IV may have derived from the Illinois Valley.

TABLE 3. Comparison of zone designations for clay mineral and dolomite zonations of the Peoria Loess.

Clay mineral zones		Dolomite zones
IV	(low illite)	p-6 (low dolomite)
III	(high illite)	p-5 (high dolomite)
		p-4 (low dolomite)
II	(intermediate illite)	p-3 (intermediate dolomite)
		p-2 (high dolomite)
I	(low illite)	p-1 (low dolomite)

A fivefold dolomite zonation of the Peoria Loess identified from thick loess sections along the Mississippi River in southwestern Illinois (fig. 4) records compositional changes in valley-train sediments during much of the Woodfordian. From the base upward, the zones are p-1 (low dolomite), p-2 (high dolomite), p-3 (intermediate dolomite), p-4 (low dolomite), and p-5 (high dolomite). A sixth zone, p-6 (low dolomite), is the uppermost zone along the Mississippi Valley in western Illinois, north of its confluence with the Illinois Valley. Table 3 shows a correlation of dolomite zones and their clay mineral zone equivalents.

Zone p-1 is a transitional zone that is gradational in composition between the underlying unit, usually Roxana Silt, and the overlying highly dolomitic zone p-2. It is probably equivalent to zone I of the clay mineral zonations. Zones p-2 and p-3 have distinctive dolomite contents, but they have similar clay mineral compositions, and both have been included in zone II of previous studies. In southwestern Illinois, zone p-4 is a low-illite, low-dolomite, and high-expandable clay-mineral zone. It does not occur in the Illinois Valley and has no direct equivalent in the clay-mineral zonation, although it has been incorrectly correlated with the Jules Soil in some previous studies. Zone p-4 was probably derived from outwash transported down the Missouri or postdiversion Mississippi Valleys. Along the Illinois Valley, zone p-5, zone III equivalent, directly overlies zone p-3. Radiocarbon dates show the lower portion of p-5 in the Illinois Valley to be time-equivalent to zone p-4 along the Mississippi to the south. The mineralogic discontinuity at the zone p-3/p-5 contact in the Illinois Valley is the most probable position in the sequence to relate to the diversion of the Ancient Mississippi River; however, clay-mineral studies have placed the diversion at the I/II (p-1/p-2) contact. Zone p-6, not identified in the field trip area, is probably the direct equivalent of clay-mineral zone IV.

At several sites in Illinois, some of which will be examined on this trip, the lower portion of the Peoria or Morton Loesses contains organic zones consisting of plant fragments (dominantly well-preserved wood, twigs, and needles) in a dolomitic loessial matrix. Determinations of radiocarbon age on wood from these organic zones provide information for development of a relatively accurate chronology of Woodfordian loess deposition in Illinois. Using paired radiocarbon dates to calculate the average sedimentation rate at a site, McKay (1977) assumed uniformity of rate through time and estimated the ages of the base of the Peoria and of dolomite zones within the Peoria at two southwestern Illinois sites (fig. 5). Despite the intrinsic inadequacy of the constant-rate assumption, the remarkable similarity of estimates from the two sites suggests there is some validity to the approach. Not only are these estimates consistent among the southwestern Illinois sites, but they are substantiated by five additional radiocarbon dates for this trip from the North Quarry Section (stop 9) in Menard County and the Gardena Section 0.6 miles (1 km) southeast of the Farm Creek Section in Tazewell County.

Estimates of age for the Peoria Loess and its zones made after new dates became available differ markedly from estimates made in most previous studies (fig. 6). This is true primarily because of the paucity of dates available to previous workers. As more radiocarbon dates become available, the estimates of ages of specific features will undoubtedly be further refined.

The age of the base of the Peoria Loess and Morton Loess in near-source regions along the Ancient Mississippi Valley in central and southwestern Illinois is about 25,000 ^{14}C years B.P. It may exceed 25,000 B.P. in central Illinois and transgress to less than 25,000 down-valley (fig. 7). There is no question that the apparent age of the base of these loesses will transgress to younger dates at greater distances from the source valleys (Ruhe, 1969); however, the age of the base of the loess unit adjacent to the source is the most meaningful age for reconstruction of regional geologic events.

The first accumulation of Peoria Loess or Morton Loess at near-source sites along the Ancient Mississippi Valley marks the renewal of loess deposition following the lull of the Farmdalian. This in turn suggests an increased influx of meltwater and outwash from glacial margins advancing into the upper reaches of the Ancient Mississippi basin. Evidence that can be used to identify the source of this early outwash is somewhat ambiguous; however, it is likely that the first increments of Peoria Loess along that valley were derived from a highly dolomitic valley train originating at the margin of the Lake Michigan Lobe in northeastern Illinois and not from sources northwest of Illinois. The principal evidence for a Lake Michigan Lobe source is the occurrence of the highly dolomitic zone p-2 along the Ancient Mississippi Valley only south of Bureau County. Northward from that point the lower part of the Peoria has a p-3 mineralogy. The simplest explanation for the distribution of p-2 is that it was derived from an early, highly dolomitic valley train originating in northeastern Illinois. There are no radiocarbon dates at present from beneath the Woodfordian tills in extreme northeastern Illinois that eliminate the possibility that glacial ice was present there as early as 25,000 B.P. One date of 23,000+2,100-1,950 (J-2783) in Northwestern Cook County has been used to suggest that ice had advanced approximately 40 kilometers west of the present lake border by 23,000 B.P. (Kempton and Gross, 1971).

Kleiss (1973) and Wascher et al. (1971) have estimated the age of the base of the Poeria Loess to be about 25,000 years and agreed with estimates made for this study. Most other studies have estimated this age at about 22,000 ^{14}C years B.P., however. On the basis of a 22,000 B.P. estimate of the age of the Morton Loess contact on the Robein Silt in the Farm Creek area, Frye and Will-

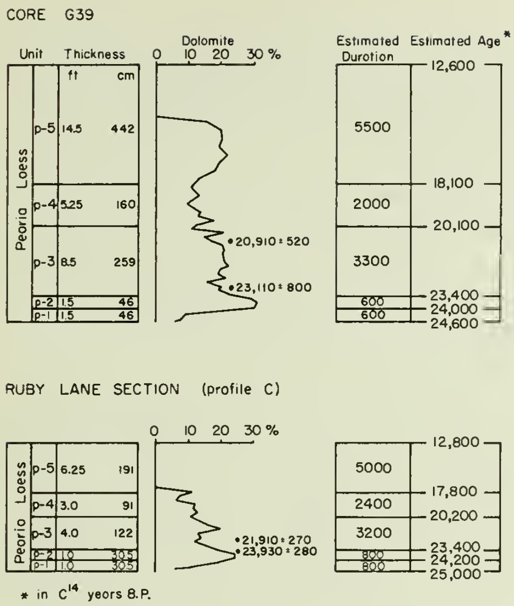


Figure 5. Estimated ages and durations of zones of Peoria Loess in the Ruby Lane Section and core G39. (From McKay, 1977.)

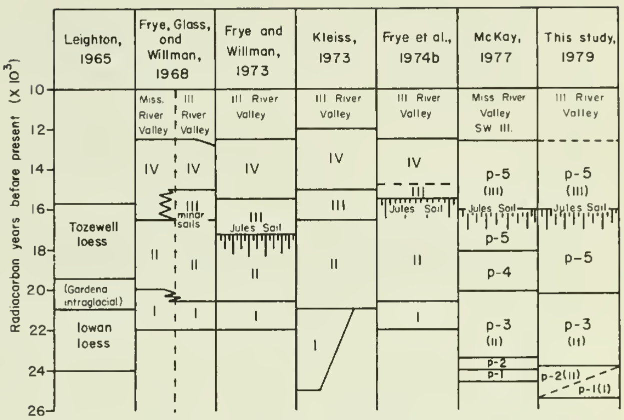


Figure 6. Comparison of estimates of radiocarbon age for mineral zones and soils in the Peoria Loess. (Modified from McKay, 1977.)

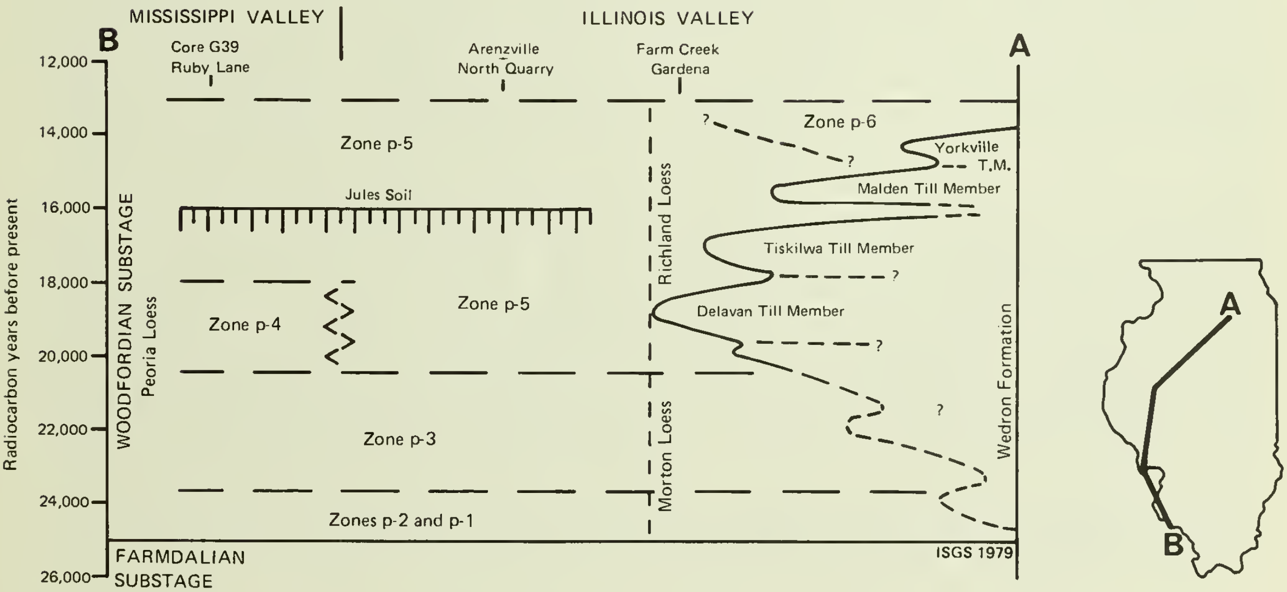


Figure 7. Dolomite zonation in Woodfordian loesses along the Illinois and Mississippi Valleys in central and southwestern Illinois.

man (1960) placed the boundary of Woodfordian and Farmdalian time at 22,000 B.P. If a time-stratigraphic boundary is to be determined, as the stratigraphic practice of the American Commission of Stratigraphic Nomenclature (1961) and Illinois State Geological Survey (Willman, Swann, and Frye, 1958; Willman and Frye, 1970) dictate, on the age of a rock contact at the type locality, then the age of the boundary should be revised when new data become available. The current best approximation of the age of the base of the Morton Loess in the Farm Creek Section is 25,000 ^{14}C years B.P. This means that the time span of the Farmdalian Substage in the type section is from approximately 28,000 B.P. to approximately 25,000 ^{14}C years B.P., and that the time span of the Woodfordian is from approximately 25,000 to 12,500 ^{14}C years B.P.

Diversion of the Ancient Mississippi River is recorded in the mineral zonation of Woodfordian loesses, and the new chronology allows for a better interpretation of that record. Radiocarbon dates from the Morton Loess and from the base of the overlying tills place the diversion between about 20,000 ^{14}C years B.P. and about 21,000 ^{14}C years B.P. (Glass, Frye, and Willman, 1964; Frye, Glass, and Willman, 1968). These studies identified in the Morton a low-illite zone overlain by a higher-illite zone, the contact of zones I and II, as the record of the diversion. The new chronology indicates that the diversion occurred about 20,500 B.P. and is recorded by the contact of p-3 and p-5 in the Illinois Valley and the contact of p-3 and p-4 in the Mississippi Valley in southwestern Illinois (figs. 6 and 7). Radiocarbon dates also indicate that the contact of zones I and II in the Morton Loess identified by several previous studies is probably the contact those same studies identifed as the boundary of zones II and III in the Peoria Loess.

The term *Jules Soil* has been applied to dark bands in two different mineral zones in the Peoria Loess. At the type section, the Jules Section in Cass County, the soil zone occurs within a high-dolomite, high-illite zone correlated with zone p-5 (zone III). Further south, in the Bunkum South Section in St. Clair County, a series of dark bands within a low-dolomite, high-expandable clay-mineral zone (zone p-4) have been correlated with the type Jules (Frye et al., 1974b). Zone p-4 ranges in age from about 18,000 ^{14}C years B.P. to 20,000 ^{14}C years B.P. and is clearly older than the type Jules, which is estimated to have formed during an interval from approximately 15,500 to 16,500 ^{14}C years B.P. (Frye et al., 1974b). A prominent dark band occurring within zone p-5 along the Mississippi Valley in St. Clair County has been dated at 16,020±260 (ISGS-421) and is probably correlative to the type Jules Soil (McKay, 1977). The Jules Soil has been interpreted as the record of a retreat of the Lake Michigan Lobe after the deposition of the Tiskilwa Till Member and prior to deposition of the Malden Till Member of the Wedron Formation. Although no direct means of correlation is available and no zone boundary in the loess at the Jules position can be correlated with the compositional change between the moderately illitic Tiskilwa and the slightly higher illite of the Malden and later tills, a 16,000 ^{14}C years B.P. age for the till contact is consistent with available dates on the Wedron Formation. The Woodfordian loesses of Illinois contain numerous dark bands in addition to the Jules Soil. Formalization of any of these as soil-stratigraphic units is not possible at present because of the uncertainties of correlation.

POLLEN ANALYSIS OF SOME FARMDALIAN AND WOODFORDIAN DEPOSITS, CENTRAL ILLINOIS

James E. King
Illinois State Museum, Springfield, IL 62706

Many of the classical descriptions of late Quaternary glacial history are based on deposits located in central Illinois. A number of these key localities are type sections that have been intensively studied; however, most of them have not been investigated palynologically, and, as a result, the vegetational interpretations that are available have been based on limited plant macrofossil data. The presence of dark organic-rich units with visible plant macrofossils in the sedimentary exposures at Athens North Quarry in Menard County and at Farm Creek and the Gardena Section in Tazewell County, Illinois, prompted us to sample them for pollen analysis. The section at Athens North Quarry is the proposed location of a Sangamon Soil catena study. The pollen sections in Tazewell County are from the Farmdalian type locality at Farm Creek and from nearby correlative deposits at Gardena. The Gardena locality also includes deposits of Woodfordian age. The complete geological description of these sections and their significance is presented elsewhere in this guidebook.

ATHENS NORTH QUARRY

The Athens North Quarry section was collected from an exposed wall of the Material Services Indian Point Quarry, 5 km north of Athens, Illinois. The pollen samples were collected from a cleaned face at the east end, north wall, of the main quarry pit from the sediments located stratigraphically within the Peoria Loess. At the east end of this pit, the upper horizon of the Farmdale Soil is a compact muck that grades upward into a 50-cm-thick, dark peatlike silty deposit in the lower part of the Peoria Loess (see fig. 23, p. 60 of this guidebook). Abundant wood fragments, plant macrofossils, and small logs are present at the base of the Peoria. Most of these macrofossils are of *Picea* (spruce) and *Larix* (larch); see F. King (p. 114-115 of this guidebook) for a description of these plant fossils.

Pollen in the Athens North Quarry section was preserved only in a 50-cm section above the Farmdale Soil in the lower part of the organic-rich Peoria Loess (fig. 23, p. 60). Spruce wood, along with the Peoria Loess/Robein Silt contact, at the base of the pollen profile was radiocarbon dated at 25,170 ± 200 B.P. Wood from near the top of the organic-rich silt and 80 cm above the uppermost pollen sample is dated at 22,170 ± 450 B.P. The dark organic-rich silt with the preserved pollen therefore dates between about 23,000 and 25,000 B.P.

The pollen in this section (fig. 1) is dominated by *Pinus* (pine) and *Picea* (spruce); together these two types comprise about 70 percent of the total pollen. (NOTE: In these pollen diagrams, the pollen of aquatic and marsh plants is excluded from the basic pollen sum, or N, so that the percentages are based only on upland flora.) Other taxa commonly present throughout the section include *Quercus* (oak), *Gramineae* (grass), and *Tubuli-*

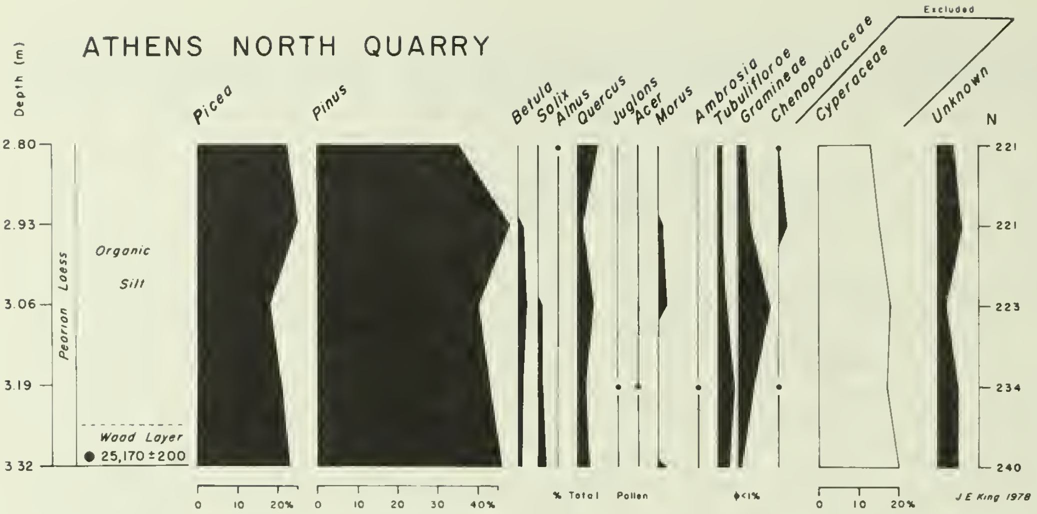


Figure 1. Diagram of relative frequency of pollen from Athens North Quarry, Menard County, Illinois.

florae (the sunflower group). The variation in the percentages of individual taxa between samples is relatively small and within the range of confidence limits for percentages based on an *N* of 200 (Rohlf and Sokal, 1969). Thus the fluctuations between levels of pine and spruce, the major plant types, are not statistically significant. A possible shift to slightly colder climatic conditions toward the top of this short pollen section may be suggested by the disappearance of *Betula* (birch), *Salix* (willow), and *Morus* (mulberry). Overall, however, the pollen evidence indicates rather stable vegetational conditions during the deposition of this portion of the lower Peoria Loess which occurred over approximately a two-thousand-year period.

The pollen in the Athens North Quarry section reflects a forest composed of pine and spruce with a grass and herb understory. Occasional oak trees may also have grown in the area, although the pollen grains of oak found in the section could have drifted in on the prevailing winds from source areas to the southwest. The pollen does not suggest any type of major climatic change between 23,000 and 25,000 years ago in the Springfield area.

GARDENA LOCALITY

The Gardena locality, about 1 km southeast of the Farm Creek section, contains two zones of palynological interest. The first is a thin layer of Woodfordian-age lacustrine clays and compressed moss located between the overlying glacial till and the gleyed Morton Loess. The second zone is the organic silt within the Robein Silt below the Morton Loess. See figure 7, p. 19 of this guidebook, for the stratigraphic diagram of the Gardena Section and the location of the pollen samples.

The moss zone at the top of the Morton Loess consists of two thin units: a 10-cm unit of finely laminated gray lacustrine clays that overlies a 3-cm unit of compact fibrous moss. The lacustrine clays contained little organic matter or moss fragments and only occasional broken pollen grains of spruce. This clay apparently formed as an outwash deposit of glacial flour; the absence of plant remains and pollen suggests that it accumulated during a brief interval of time. The underlying moss bed, however, contained abundant pollen (fig. 2) dominated by spruce and pine. This zone is dated at 19,680± 460 ^{14}C years B.P. The spruce pollen percentages in the moss bed are significantly higher, and the pine percentages lower, than those in the organic silt at Athens North Quarry and reflect a vegetation in which spruce was more abundant than pine. This pollen spectrum is similar to "classic" full-glacial spruce zones seen throughout the Midwest which often contain as much as 60 percent to 70 percent spruce pollen. The higher spruce values in the moss bed suggest increased moisture in the local environment. This interpretation is supported by the analysis of the moss fossils (Miller, p. 116 of this guidebook) which indicates a poorly drained relatively open environment at the site.

About 250 cm below the moss bed is a silty peatlike muck about 1 m in thickness. This unit is divided into an upper brown peaty muck within the lower Morton Loess and a lower dark-brown to black peaty muck formed in the Robein Silt (fig. 7, p. 19 of this guidebook). The Robein forms the O horizon of the Farmdale Soil. The upper peaty muck (Morton) contained very little pollen and only occasional broken spruce grains. The highly degraded condition of these grains suggests that this upper unit had undergone extensive oxidation. The lower dark-brown muck within the Robein, however, contained preserved pollen. The contact of the Morton with the Robein at this locality is radiocarbon dated between 25,370 ± 310 and 25,960±280 B.P. (fig. 7, p. 19 of this guidebook) and occurs 20 to 30 cm above the pollen-bearing sediments.

The pollen in the Robein muck, although slightly degraded and broken, yielded an assemblage dominated by pine and spruce (fig. 2) resembling the

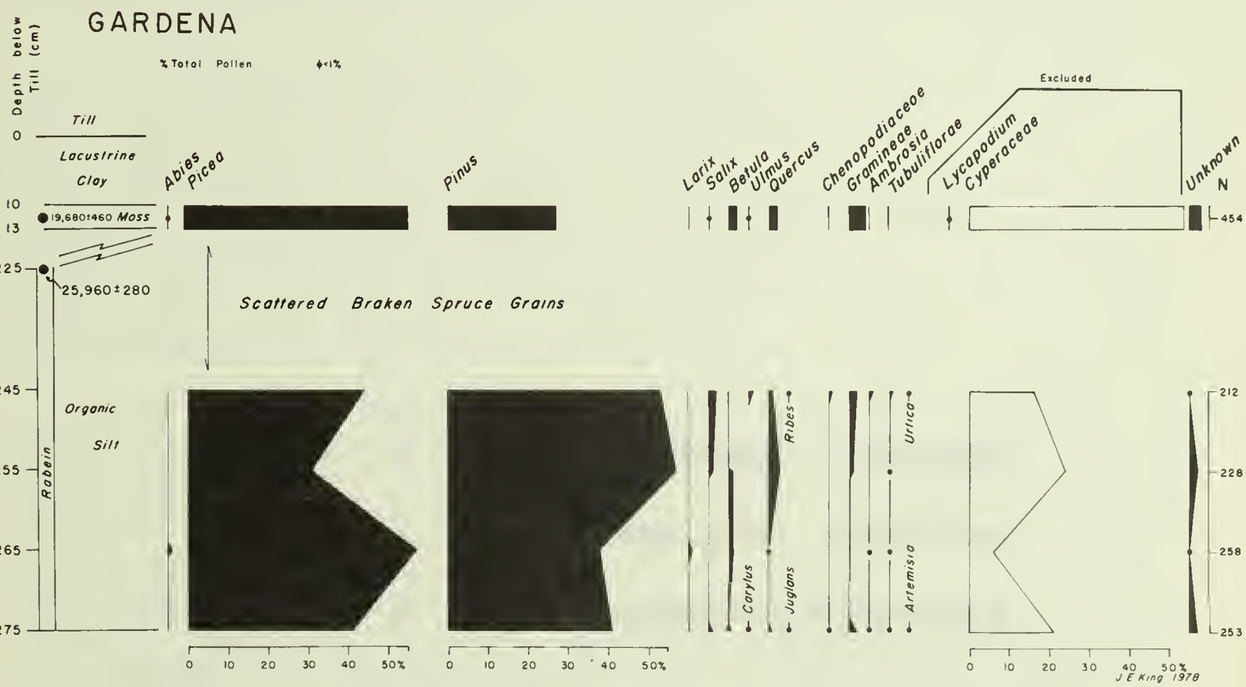


Figure 2. Diagram of relative frequency of pollen from the Gardena locality, Tazewell County, Illinois.

pollen assemblage found in the Robein sediments at Athens North Quarry. It differs from the Woodfordian-age moss bed 2 m higher in the section in that it contained less spruce and more pine pollen. The pollen assemblages in the Gardena Robein unit exhibit little variation between samples and are interpreted as indicating stable forest vegetation dominated by pine and spruce about 26,000 to 27,000 years ago.

FARM CREEK SECTION

Of the several exposures at the Farm Creek locality (see fig. 4, p. 10 of this guidebook), the easternmost (profile B) was selected for pollen and radiocarbon analysis because in that area the Robein Silt is present and is apparently better preserved. Throughout central Illinois, the Robein Silt is usually highly organic and in many localities has been found to contain preserved pollen in sufficient quantities to permit analysis.

Within the stratigraphic sequence at the east end of the massive Farm Creek bluff is a 55-cm-thick unit of black silty muck in the Robein that contained preserved pollen (see fig. 6, p. 12 for the stratigraphic section of profile B). Radiocarbon dates of 26,680±380 and 27,700±770 B.P. bracket this organic unit.

The pollen in the Robein muck at the Farm Creek Section (fig. 3) is dominated by pine and spruce and resembles both the lower Robein unit at Gardena as well as the organic silt at Athens North Quarry. The percentages of the various taxa in the three pollen spectra from Farm Creek are similar to each other and are interpreted as reflecting similar pine/spruce vegetation. The dates bracketing these pollen spectra indicate that the same pine- and spruce-dominated forest recorded at Gardena and Athens North Quarry also existed at Farm Creek for at least a thousand-year period 27,000 to 28,000 years ago.

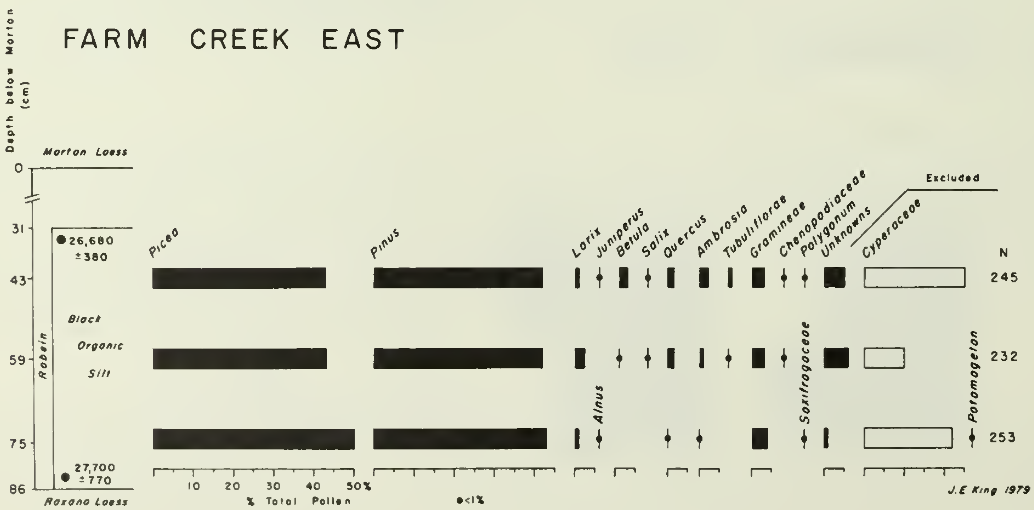


Figure 3. Diagram of relative frequency of pollen from profile B, Farm Creek East, Tazewell County, Illinois.

COMMENTS ON THE POLLEN DATA

The pollen evidence from these three sites spans parts of the period from approximately 19,680 to 27,700 years ago. This period includes the mid-Wisconsinan interstadial through the full-glacial climatic episodes—the Farmdalian and early Woodfordian Substages. The pollen evidence indicates that pine and spruce forest existed in the Peoria region of Illinois from at least 27,700 until sometime after 25,000 B.P. At Athens North Quarry, 45 km south, the same type of vegetation persisted until at least 23,000 B.P. The slightly lower spruce percentages in the Farmdalian deposits at the North Quarry locality may reflect its more southern location or possibly that the flat topography of the Illinoian till plain at Athens may have been less favorable for the growth of spruce.

The pollen from all three sites suggests that the Farmdalian interstadial vegetation was a mixture of pine and spruce. The herbaceous vegetation is not well represented, possibly because of differential pollen preservation; however, grass comprises about 5 percent of the pollen, suggesting that it was a common element in the interstadial vegetation. Other taxa having low but consistent percentages are *Quercus* (oak) and *Betula* (birch), both types that would also be expected in the interstadial flora.

The mixed assemblage of pine and spruce characterizing the Farmdalian reflects the milder climate of the interstadial. In contrast, the moss bed at Gardena is representative of a younger time, 19,600 B.P., and reflects the shift to the colder full-glacial Woodfordian climate. The higher spruce pollen percentages in the Gardena moss bed along with the decrease in pine indicate a shift to spruce dominance and a more glacial climate. The higher Cyperaceae (sedge) percentage in the moss also suggests increased local moisture during the Woodfordian.

Although the pine percentage in the Gardena moss bed is lower than in the older interstadial deposits, it is higher than pine values reported from other full-glacial pollen spectra in Missouri (King, 1973) and throughout the unglaciated eastern United States (Whitehead, 1973). These studies indicate that pine was mostly absent from parts of midwestern North America during the classic full-glacial. Boreal forest, containing little besides spruce, is recorded in late Pleistocene pollen diagrams from Illinois (King, unpublished), Missouri, Kansas (J. Grüger, 1973), and elsewhere in the Midwest (Wright, 1968). The only other full-glacial record containing pine pollen, up to 20 percent, is from south-central Illinois (E. Grüger, 1972).

Although the available pollen records are at present too sketchy for detailed statements, it appears that pine was present in the full-glacial vegetation of central Illinois at least until 19,680 B.P. After that time, climatic conditions may have become much more severe. The Gardena moss bed is overlain by a late-Wisconsinan glacial till, indicating that even colder, or at least more glacial, conditions existed after 19,680 B.P., and thus the moss bed may not have been deposited during the maximum cold full-glacial. During this later, colder period, pine could have been extripated from central Illinois, leaving spruce as the dominant arboreal form. A complete understanding of the late-Wisconsinan full-glacial vegetation of Illinois will have to await additional pollen studies from the critical time periods, especially the interval between 14,000 to 19,000 B.P.

PLANT MACROFOSSILS FROM THE ATHENS NORTH QUARRY

Frances B. King
Illinois State Museum, Springfield, IL 62706

Two collections of plant macrofossils from exposed walls of the Material Services Indian Point Quarry, Menard County, Illinois (Athens North Quarry Section), were examined. Both samples came from sediments in a thick organic-rich silt deposit in the basal part of the Peoria Loess (see fig. 23, p. 60 of this guidebook). One group of approximately 20 fragments of wood collected from the muck deposit at the contact between the Peoria Loess and the Robein Silt, in conjunction with sampling for pollen (J. King, p. 109-113 of this guidebook), was composed entirely of spruce (*Picea*). Wood from this contact is radiocarbon dated at 25,170±200 B.P. A bulk sample collected later from another exposure of the organic-rich zone included wood of both spruce and larch (*Larix laricina*), as well as needles of spruce and balsam fir (*Abies balsamea*), and cones of black spruce (*P. mariana*). The bulk sample also included seeds of sedge (*Cyperus*), St. John's-wort (*Hypericum*) and violet (*Viola*). All of these genera include species adapted to growth in bogs or under moist coniferous forest.

Black spruce currently grows on both organic and mineral soils and, in the southern part of its range, is confined largely to peat bogs, muck-filled seepages, and stream valleys (Fowells, 1965, p. 280). Larch, which can tolerate a wide variety of soil-moisture conditions, is most often found on moist organic soils, peats, and mucks. Balsam fir, an upland species, also grows in peat bogs, although comparatively slowly (Fowells, 1965, p. 11). These three tree species frequently occur together; the dominant species is determined by soil and moisture conditions.

Plant macrofossils reflect a more localized view of vegetation than the regional information gained through pollen analysis. Although fewer taxa are generally represented, those that do occur are positive indicators of their former presence at that site. The pollen profile (J. King, fig. 1, p. 110 of this guidebook) from Athens North Quarry indicates a pine- and spruce-dominated forest with an understory including at least grass and herbs. The macrofossils from the bulk sample support this interpretation but suggest a moister coniferous forest, although not one adequately wet to support the growth of mosses such as those in the moss zone at Gardena.

The organic-rich silt zone at Athens North Quarry extends about 80 cm above the uppermost pollen sample, and wood from near the top of the unit dates 22,170±450 ^{14}C years B.P. (fig. 23, p. 60 of this guidebook). The entire unit thus dates between 22,000 and 25,000 ^{14}C years B.P. The bulk sample collected for macrofossils was not collected in conjunction with the pollen profile, and its stratigraphic position is slightly higher in the section, near the top of the organic-rich silt. Thus, while the macrofossils may be contemporaneous with the upper portion of the pollen profile (J. King, fig. 1, p. 110 of this guidebook), their presence may also represent vegetation growing on the site at a slightly younger time than the pollen record, i.e., between about 23,000 and 22,000 B.P. Therefore, the presence of larch and fir macrofossils, as well as spruce, may represent the beginning of the shift from a mild interstadial climate to the colder and moister full-glacial conditions shown by the moss zone of Woodfordian age at Gardena dating 19,680. The presence of larch and fir in both the macrofossil assemblage from Athens North Quarry and the Gardena pollen profile further supports this interpretation.

PALEOECOLOGICAL COMMENTS ON FOSSIL MOSSES IN A BURIED ORGANIC BED NEAR PEORIA, TAZEWELL COUNTY, ILLINOIS

Norton G. Miller
Harvard University Herbaria, 22 Divinity Ave., Cambridge, MA 02138

The moss sample from the Gardena Locality (#9, coll. J. E. King, 22 Aug. 1978) consists of a blocky, compact, mineral-rich "peat" that contains mostly degraded plant matter. Associated with the "peat" but separate from it in the sample were small clumps of gray silty clay with embedded mosses. These clumps were removed from the sample and washed free of inorganics in a 250-µm sieve. Species discussed below are based on mosses identified from this subsample. The compact peat was soaked overnight in a 0.5% solution of sodium triphosphate and sieved as before, but few well-preserved mosses were present in the residue. The mosses in the clay were perhaps growing on soil that is preserved as the compact peat. The mosses may have become embedded as a result of ponding that led to deposition of the superimposed bed of banded lacustrine clay. A sample of this clay (#11, same data as for #9) yielded no mosses but contained other kinds of plant material.

The moss assemblage is dominated by fragments of *Drepanocladus revolvens* (Sw.) Warnst. Clearly subordinate in the assemblage is material of *Campylium stellatum* (Hedw.) C. Jens. A few leafy fragments of *Bryum pseudotriquetrum* (Hedw.) Gaertn., Meyer & Scherb., *Drepanocladus aduncus* var. *polycarpus* (Bland. ex Voit) Roth and *Mnium* cf. *rugicum* Laur. were also present. All are extant species and expected associates. These mosses currently grow on wet soil or humus in swamps, along streams, near springs, and at the margins of lakes. Although *Drepanocladus aduncus* var. *polycarpus* can occur in standing water, the other mosses are not aquatics, and it seems likely that the soil was simply poorly drained or perhaps was seasonally flooded. *Campylium stellatum* and the species of *Drepanocladus* may grow in wet calcareous habitats such as rich fens or in other settings where calcareous ground water is continually present. The moss assemblage indicates that surfaces at and near the site of deposition were relatively open, although forests of higher density could have stood nearby. The five species are currently distributed across the northern United States and southern Canada, and several have a substantial arctic component in their ranges. Northern Illinois is within the present range of all except *Drepanocladus revolvens,* which is known as far south as Michigan.

APPENOIX 1. Grain sizes, carbonate minerals, and clay mineralogy for sections.

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Oolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
FARM CREEK SECTION, PROFILE A										
Morton Loess	FCATZ1				1	20	21	44	36	20
	FCATZ2				1	21	22	47	33	20
	FCATZ3				1	20	21	47	33	20
	FCATZ4				5	20	25	46	36	18
	FCATZ5				3	19	22	46	37	17
	FCATZ6		See appendix 2		4	20	24	43	37	20
	FCATZ7		(pipette data)		4	24	28	40	38	22
	FCATZ8				3	25	28	31	45	24
	FCATZ9				2	23	25	34	43	23
	FCATZ10				3	22	25	34	41	25
	FCATZ11				1	23	24	34	43	23
	FCATZ12				2	23	25	32	43	25
	FCATZ13				3	22	25	35	40	25
	FCATZ14				3	24	27	36	42	22
	FCATZ15				3	20	23	34	46	20
	FCATZ16				1	21	22	36	41	23
	FCATZ17				1	20	21	39	38	23
	FCATZ18				2	23	25	37	43	20
	FCATZ19				2	24	26	38	40	22
	FCATZ20				1	27	28	34	44	22
	FCATZ21				1	27	28	31	46	23
	FCATZ22				2	27	29	29	49	22
	FCATZ23				1	27	28	25	50	25
	FCATZ24				2	35	37	25	50	25
	FCATZ25				2	32	34	25	51	24
	FCATZ26				2	32	34	41	38	21
	FCATZ27				2	30	32	41	38	21
	FCATZ28				3	31	34	39	38	23
Roxana Silt	FCATZ29				0	0	0	45	28	27
	FCATZ30				0	0	0	38	30	32
	FCATZ31				0	0	0	61	19	20
	FCATZ32		See appendix 2		0	0	0	66	18	16
	FCATZ33		(pipette data)		0	0	0	54	24	22
	FCATZ34				0	0	0	44	30	26
	FCATZ35				0	0	0	34	37	29
Radnor Till Member	FCATZ36				0	0	0	30	35	35
	FCATZ37				0	0	0	42	28	30
	FCA17				0	0	0	45	29	26
	FCA16	19	47	34	0	0	0	47	29	24
	FCA15	15	31	54	0	0	0	42	39	19
	FCA14	17	33	50	0	0	0	53	29	18
	FCA13	20	39	41	0	0	0	39	44	17
	FCA12	21	49	30	6	11	17	16	62	22
	FCA11			33	6	14	20	13	68	19
	FCA10			33	3	17	20	8	73	19
	FCA9	15	51	34	6	15	21	9	75	16
	FCA8	24	46	30	4	16	20	9	77	15
	FCA7	25	44	31	5	17	22	6	79	15
	FCA6	26	44	30	5	17	22	3	83	14
	FCA5	23	48	29	6	16	22	4	83	13
	FCA4	25	46	29	6	16	22	5	81	14
	FCA1	24	47	29	5	17	22	2	69	29
	FCA2	26	46	28	6	18	24	2	70	28
	FCA3	28	46	26	5	19	24	3	79	18
FARM CREEK SECTION, PROFILE 8										
Morton Loess	FC81				1	30	31	16	62	22
	FC82				3	33	36	14	68	18
	FC83				1	33	34	20	61	19
	FC84				3	29	32	23	57	20
	FC85				0	12	12	19	58	23
Robein Silt	FC86		See appendix 2		0	0	0	11	59	30
	FCB7		(pipette data)		0	0	0	9	62	29
	FCB8				0	0	0	9	58	33
Roxana Silt	FCB9				0	0	0	48	31	21
	FCB10				0	0	0	50	34	16

APPENDIX 1. *Continued.*

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
FARM CREEK SECTION, PROFILE B, *continued*										
Roxana Silt	FCB11				0	0	0	54	26	20
	FCB12				0	0	0	59	21	20
	FCB13				0	0	0	61	22	17
	FCB14				0	0	0	63	17	20
Radnor Till Member	FCB15				0	0	0	58	22	20
	FCB16				0	0	0	56	25	19
	FCB17				0	0	0	52	25	23
	FCB18				0	0	0	36	42	22
FARM CREEK SECTION, PROFILE C										
Richland Loess	FCC1				0	0	0	19	56	25
	FCC2	See appendix 2			0	0	0	59	29	12
	FCC3	(pipette data)			0	0	0	61	28	11
	FCC4				0	0	0	60	29	11
	FCC5				0	0	0	52	36	12
	FCC6				0	0	0	53	36	11
	FCC7				0	0	0	59	30	11
	FCC8				0	0	0	69	22	9
Henry Formation	FCC9	65	19	16	0	68	68	42	49	9
	FCC10	24	53	23	19	34	53	18	68	14
Delavan Till Membe	FCC11	17	41	42	5	19	24	17	71	12
	FCC12	24	37	39	9	19	28	14	70	16
	FCC13	24	37	39	8	19	27	17	72	11
	FCC14	20	42	38	8	19	27	16	71	13
	FCC15	28	30	42	8	19	27	17	70	13
	FCC16	24	40	36	9	20	29	14	73	13
	FCC17	25	39	36	9	20	29	11	69	20
	FCC18	26	40	34	9	20	29	9	70	21
	FCC19	26	39	35	9	20	29	10	65	25
	FCC20	24	41	35	9	20	29	10	66	24
	FCC21	28	38	34	9	21	30	13	65	22
	FCC22	26	38	36	8	21	29	13	65	22
	FCC23	29	39	32	9	20	29	13	67	20
	FCC24	28	39	33	7	21	28	12	67	21
	FCC25	27	40	32	6	22	28	14	67	19
	FCC26	27	39	34	7	21	28	12	67	21
	FCC27	29	36	35	8	21	29	13	66	21
	FCC28	28	38	34	7	21	28	11	68	21
	FCC29	31	36	33	7	21	28	11	67	22
	FCC30	28	39	33	7	21	28	13	66	21
	FCC31	26	40	34	6	20	26	12	67	21
	FCC32	26	42	31	7	21	28	12	67	21
	FCC33	28	41	31	7	21	28	12	67	21
	FCC34	8	59	33	4	16	20	13	67	20
	FCC35	40	9	51	3	17	20	15	65	20
Richland Loess	FCD1	33	42	25	*	*	*	59	31	10
Henry Formation	FCD2	46	26	28	*	*	*	43	48	9
Delavan Till Member	FCD3	24	38	38	*	*	*	21	69	10
	FCD4	31	34	35	*	*	*	19	69	12
	FCD5	26	40	34	*	*	*	21	69	10
	FCD6	26	35	39	*	*	*	18	71	11
	FCD7	25	40	35	*	*	*	15	73	12
	FCD8	24	36	40	*	*	*	18	69	13
	FCD9	25	36	39	*	*	*	15	73	12
Gravel	FCD10	50	7	43	*	*	*	12	76	12
Delavan Till Member	FCD11	27	35	38	*	*	*	17	68	15
Sand and gravel	FCD12	78	12	10	*	*	*	17	76	12
Sand	FCD13	88	4	8	*	*	*	11	78	11
Delavan Till Member	FCD14	27	38	35	*	*	*	23	65	12
	FCD15	27	41	32	*	*	*	10	66	24
FARM CREEK SECTION, PROFILE H										
Radnor Till Member	FCH8	32	42	26	7	19	26	4	78	18
	FCH7	31	44	25	7	19	26	3	78	19
	FCH6	24	42	34	6	21	27	3	76	20

*not run

APPENDIX 1, *Continued.*

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
FARM CREEK SECTION, PROFILE H, *continued*										
Radnor Till Member	FCH5	24	38	38	6	19	25	3	75	22
	FCH4	22	40	38	5	19	24	3	75	22
	FCH3	21	43	36	4	20	24	2	75	23
	FCH2	19	38	43	4	17	21	3	76	21
	FCH1	25	37	38	4	19	23	2	75	23
GARDENA SECTION										
Delavan Till Member	G+5	27	39	34	6	21	27	9	67	24
	G+4	27	40	33	6	22	28	10	67	23
	G+3	28	39	33	5	21	26	10	65	25
	G+2	24	44	32	3	17	20	11	67	22
	G+1	29	41	30	3	19	22	9	67	24
Silt and clay	G-0				5	10	15	4	69	27
Morton Loess (moss bed)	G1a				1	20	21	9	64	27
Morton Loess	G1b				1	21	22	20	52	28
	G2				2	24	26	21	52	28
	G3				1	23	24	24	50	26
	G4		See appendix 2		2	22	24	24	47	29
	G5		(pipette data)		3	23	26	19	56	25
	G6				2	23	25	19	57	24
	G7				3	22	25	32	44	24
	G8				2	23	25	30	43	27
	G9				3	21	24	35	42	23
	G10				3	21	24	32	41	27
	G11				2	19	21	33	41	26
	G12				1	20	21	43	37	20
	G13				2	18	20	40	35	25
	G14				2	13	15	40	36	24
	G15				2	16	18	40	36	24
	G16				2	20	22	38	38	24
	G17				4	21	25	38	38	24
	G18				2	22	24	35	43	22
	G19				4	24	28	32	46	22
	G20				2	24	26	12	58	30
	G21				1	31	32	19	53	28
	G22				1	17	18	16	57	27
	G23				1	29	30	14	58	28
	G24				0	24	24	16	53	31
	G25				0	22	22	13	57	30
	G26				2	17	19	10	60	30
Robein Silt	G27				1	1	2	9	59	32
	G28				1	1	2	12	64	26
	G29				1	1	2	21	34	45
Roxana Silt	G30				0	1	1	56	18	26
	G31				0	0	0	70	15	15
FARMDALE PARK SECTION, PROFILE A										
Radnor Till Member	FPA1	24	47	29	3	18	21	9	80	11
	FPA2	23	47	30	3	17	20	8	81	11
	FPA3	25	44	31	3	17	20	8	80	12
	FPA4	25	44	31	4	17	21	6	82	12
	FPA5	25	45	30	4	17	21	5	83	12
	FPA6	26	44	30	4	17	21	7	81	12
	FPA7	25	44	31	5	16	21	7	82	11
	FPA8	17	50	33	4	17	21	5	83	12
	FPA9	26	44	30	7	17	24	5	82	13
	FPA10	24	47	29	4	17	21	5	82	13
	FPA11	25	44	31	5	17	22	4	80	16
	FPA12	26	47	27	5	18	23	4	82	14
	FPA13	27	45	28	5	18	23	4	83	13
	FPA14	26	44	30	6	18	24	6	82	12
	FPA15	28	45	27	5	17	22	8	80	12
	FPA16	26	38	36	11	23	34	7	82	11
	FPA17	17	49	34	8	16	22	4	88	8
	FPA18	28	42	30	6	17	23	6	81	13
	FPA19	26	44	30	5	17	22	6	83	11
	FPA20	29	42	29	5	17	22	6	82	12

APPENDIX 1. *Continued*

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
FARMDALE PARK SECTION, PROFILE A, *continued*										
Radnor Till Member	FPA21	29	46	25	6	17	23	9	77	14
	FPA22	29	44	27	6	17	23	7	81	12
	FPA23	31	45	24	6	19	25	8	80	12
Vandalia Till Member	FPA24	38	43	19	7	24	31	7	82	11
	FPA25	42	40	18	5	24	29	6	83	11
	FPA26	35	46	19	5	25	30	7	82	11
	FPA27	44	36	20	6	24	30	8	82	10
	FPA28	40	43	17	7	23	30	7	81	12
FARMDALE PARK SECTION, PROFILE B										
Radnor Till Member	FPB1	31	43	26	5	19	24	7	77	16
	FPB2	30	43	27	5	19	24	8	75	17
	FPB3	30	44	26	5	20	25	5	71	24
	FPB4	30	48	22	5	19	24	7	78	15
	FPB5	38	42	20	6	23	29	4	82	14
GLENOALE SCHOOL SECTION										
Oelavan Till Member	GS5	28	41	31	5	20	25	9	67	24
Morton Loess	GS7	0	91	9	1	29	30	23	56	21
Roxana Silt	GS6	1	86	13	0	0	0	38	37	25
Radnor Till Member	GS1	30	48	22	5	22	27	3	71	26
	GS2	34	35	31	5	21	26	7	83	10
	GS3	24	47	29	5	17	22	7	77	16
	GS4	28	43	29	5	19	24	3	74	23
Gravel	GS8	*	*	*	*	*	41	*	*	*
GRAYBAR SECTION										
Delavan Till Member	G81	24	48	28	3	15	18	14	74	12
Morton Loess	GB1A	1	91	8	1	20	21	38	46	16
Roxana Silt	GB1B	3	89	8	0	2	2	62	23	15
Radnor Till Member	GB2	24	45	31	5	15	20	6	81	13
	GB3	25	45	30	5	16	21	5	82	13
	GB4	20	47	33	4	17	21	4	84	12
	GB5	21	48	31	4	16	20	4	82	14
	GB6	25	43	32	5	16	21	3	82	15
	GB7	27	44	29	5	18	23	3	70	27
	GB8	24	47	29	5	18	23	3	67	29
	GB9	27	45	28	6	18	24	4	80	16
Sand	GB10	1	70	29	7	16	23	7	79	14
Radnor Till Member	GB11	21	51	28	4	19	23	2	71	27
	G812	20	40	40	8	22	30	4	73	23
	GB13	28	47	25	5	18	23	4	67	29
	GB14	30	46	24	5	19	24	5	67	28
	GB15	28	45	27	5	19	24	6	76	18
	GB16	47	30	23	8	20	28	6	76	18
	GB17	32	42	26	6	18	24	6	78	16
	GB18	32	43	25	6	23	29	4	71	25
	G819	31	43	26	6	24	30	6	70	24
	GB20	30	42	28	6	23	29	5	67	28
	GB21	32	44	24	7	21	28	6	67	27
	GB22	31	44	25	6	24	30	3	71	26
	GB23	29	43	28	5	25	30	4	71	25
Silt	GB24	26	60	14	5	34	39	3	73	24
Radnor Till Member	GB25	31	42	27	5	23	28	3	74	23
	GB26	28	42	30	7	22	29	3	73	24
	GB27	23	50	27	4	20	24	3	76	21
Vandalia Till Member	GB28	49	29	22	6	24	30	4	83	13
	GB29	38	42	20	7	22	29	8	80	12
	G830	34	42	24	5	27	32	6	80	14
	GB31	31	43	26	6	28	34	7	75	18
	GB32	43	42	15	6	25	31	6	75	19
	GB33	42	36	22	7	24	31	6	68	26
	GB34	*	*	*	7	25	32	5	73	22
	GB35	*	*	*	6	27	33	4	70	26
Gravel	GB36	58	31	11	6	26	32	7	73	20
Sand	GB37	64	26	10	5	29	34	4	73	22
Silt	GB38	Tr	84	16	6	26	32	6	71	23

*not run

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Grain size (<2 mm) Silt (%)	Grain size (<2 mm) Clay (%)	Carbonate (<74 µm) Calcite (%)	Carbonate (<74 µm) Dolomite (%)	Carbonate (<74 µm) Total (%)	Clay minerals (<2 µm) Expandables (%)	Clay minerals (<2 µm) Illite (%)	Clay minerals (<2 µm) Kaolinite and chlorite (%)
GRAYBAR SECTION, *continued*										
Silt	G839	0	85	15	6	27	33	2	67	31
Vandalia Till Member	G840	41	39	20	9	27	36	5	66	29
	G841	39	40	21	7	28	35	8	67	25
	G842	38	41	21	7	27	34	7	70	23
	G843	39	40	21	7	28	35	10	65	25
	G844	40	38	22	7	28	35	7	68	25
	G845	37	42	21	7	28	35	8	69	23
	G846	38	40	22	7	29	36	6	69	25
	G847	31	48	21	6	29	35	7	72	21
	G848	*	*	*	8	28	36	7	72	21
	G849	*	*	*	7	29	36	7	73	20
TINDALL SCHOOL SECTION										
Radnor Till Member	P6720	29	46	25	5	20	25	9	79	12
Hulick Till Member	P6718	31	39	30	6	19	25	20	64	16
	P6719	39	37	24	6	18	24	20	64	16
	TS3	37	*	*	8	19	27	16	67	17
Kellerville Till Member	TS2	26	48	26	5	14	19	36	50	14
	P125	*	*	*	4	12	16	37	46	17
	TS1	28	44	28	4	13	17	35	52	13
Banner Formation	P123A	*	*	*	*	*	*	45	41	14
	P123	28	46	26	5	16	21	45	40	15
	P121A	*	*	*	*	*	*	28	43	29
	P121	*	*	*	*	*	*	26	48	26
	P120	*	*	*	*	*	*	39	44	17
	P119A	24	49	27	5	15	20	49	30	21
	P119	*	*	*	4	14	18	36	40	24
LEWISTOWN SECTION										
Hulick Till Member	L810	30	43	27	4	11	15	10	65	25
	L89	31	42	27	5	10	15	12	65	23
	L88	33	26	41	4	11	15	6	64	30
	L87	24	44	32	5	8	13	55	35	10
Duncan Mills Member	L86	12	48	40	0	2	2	79	12	9
	L85	18	45	37	0	0	0	63	28	9
	L84	24	38	38	0	0	0	68	23	9
	L83	9	46	45	0	2	2	80	13	7
Unnamed till member C	L82	21	37	42	0	1	1	61	29	11
	L81	22	48	30	0	3	3	68	21	11
	L811	27	48	25	4	15	19	10	59	31
	LA5	29	48	23	4	15	19	14	63	23
ARENZVILLE SECTION										
Peoria Loess	AZ1	*	*	*	1	27	29	22	55	23
	AZ2	*	*	*	1	28	29	*	*	*
	AZ3	*	*	*	1	30	31	15	63	22
	AZ4	*	*	*	1	28	29	*	*	*
	AZ5	*	*	*	1	24	25	22	53	25
	AZ6	*	*	*	*	*	*	*	*	*
	AZ7	*	*	*	1	25	26	20	53	27
	AZ8	*	*	*	*	*	*	*	*	*
	AZ9	*	*	*	0	24	24	23	52	25
	AZ10	*	*	*	*	*	*	*	*	*
	AZ11	*	*	*	1	23	24	34	48	18
	AZ12	*	*	*	*	*	*	*	*	*
	AZ13	*	*	*	1	24	25	27	54	19
	AZ14	*	*	*	*	*	*	*	*	*
	AZ15	*	*	*	1	22	23	25	54	21
	AZ16	*	*	*	*	*	*	*	*	*
	AZ17	*	*	*	1	24	25	37	43	20
	AZ18	*	*	*	*	*	*	*	*	*
	AZ19	*	*	*	1	25	26	32	48	20
	AZ20	*	*	*	1	21	22	*	*	*
	AZ21	*	*	*	1	20	21	50	37	13
	AZ22	*	*	*	0	25	25	*	*	*
	AZ23	*	*	*	1	26	27	46	40	14

*not run

APPENDIX 1. *Continued.*

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
ARENZVILLE SECTION, *continued*										
Peoria Loess	AZ24	*	*	*	1	31	32	*	*	*
	AZ25	*	*	*	1	32	33	43	38	20
	AZ26	*	*	*	1	36	37	*	*	*
	AZ27	*	*	*	0	31	31	50	33	17
	AZ28	*	*	*	1	29	30	*	*	*
	AZ29	*	*	*	1	33	34	46	39	15
Roxana Silt	AZ30	*	*	*	0	3	3	56	27	17
	AZ31	*	*	*	1	0	1	61	18	21
	AZ32	*	*	*	1	0	1	63	19	18
	AZ33	*	*	*	1	0	1	56	23	21
	AZ34	*	*	*	1	0	1	*	*	*
	AZ35	*	*	*	1	3	4	50	30	20
	AZ36	*	*	*	1	13	14	*	*	*
	AZ37	*	*	*	1	10	11	60	25	15
	AZ38	*	*	*	1	2	3	*	*	*
	AZ39	*	*	*	1	13	14	66	22	12
	AZ40	*	*	*	1	8	9	*	*	*
	AZ41	*	*	*	1	9	10	69	21	10
	AZ42	*	*	*	1	8	9	*	*	*
	AZ43	*	*	*	1	13	14	70	19	11
	AZ44	*	*	*	1	13	14	*	*	*
	AZ45	*	*	*	1	12	13	76	13	11
	AZ46	*	*	*	1	11	12	*	*	*
	AZ47	*	*	*	1	14	15	71	16	13
	AZ48	*	*	*	1	7	8	*	*	*
	AZ49	*	*	*	1	4	5	71	15	14
	AZ50	*	*	*	2	9	11	*	*	*
	AZ51	*	*	*	2	7	9	73	15	12
	AZ52	*	*	*	1	8	9	*	*	*
	AZ53	*	*	*	1	11	12	68	17	15
	AZ54	*	*	*	1	0	1	*	*	*
	AZ55	*	*	*	2	0	2	68	18	14
	AZ56	*	*	*	1	0	1	*	*	*
	AZ57	*	*	*	0	0	0	72	17	11
	AZ58	*	*	*	0	0	0	*	*	*
	AZ59	*	*	*	0	0	0	71	19	10
	AZ60	*	*	*	0	0	0	72	17	11
	AZ61	*	*	*	0	0	0	76	15	9
Unnamed till member	AZ62	*	*	*	0	0	0	72	16	12
	AZ63	*	*	*	0	0	0	49	31	20
	AZ64	*	*	*	0	0	0	44	36	20
	AZ65	*	*	*	0	0	0	31	51	18
	AZ66	*	*	*	0	0	0	35	48	17
	AZ67	*	*	*	0	0	0	43	42	15
	AZ68	*	*	*	0	0	0	44	44	12
	AZ69	*	*	*	0	0	0	49	36	15
	AZ70	*	*	*	2	16	18	49	39	12
	AZ71	*	*	*	0	17	17	42	44	14
	AZ72	*	*	*	3	16	19	36	50	14
	AZ73	*	*	*	2	16	18	37	50	13
	AZ74	*	*	*	2	17	19	32	53	15
Silt	AZ75	*	*	*	1	6	7	44	41	15
Silt	AZ76	*	*	*	1	18	19	46	36	18
Sand and gravel	AZ77	*	*	*	4	21	25	*	*	*
FAIRGROUND SECTION										
Peoria Loess	FG32				0	0	0	29	53	18
	FG31				0	0	0	*	*	*
	FG30				0	12	12	46	36	18
Roxana Silt	FG29				0	0	0	*	*	*
	FG28	See appendix 2			0	0	0	63	22	15
	FG27	(pipette data)			0	0	0	*	*	*
	FG26				0	0	0	61	24	15
	FG25				0	0	0	*	*	*
	FG24				0	0	0	55	26	19
	FG23				0	0	0	*	*	*

*not run

APPENDIX 1. *Continued.*

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay minerals (<2 μm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
FAIRGROUND SECTION, *continued*										
Vandalia Till Member	FG22				0	0	0	47	29	24
	FG21				0	0	0	*	*	*
	FG20				0	0	0	56	29	15
	FG19	See appendix 2			0	0	0	*	*	*
	FG18	(pipette data)			0	0	0	44	40	16
	FG17				0	0	0	*	*	*
	FG16				0	0	0	44	45	11
	FG15				0	0	0	*	*	*
	FG14				0	0	0	35	50	15
	FG13				0	0	0	*	*	*
	FG12				2	19	21	11	76	13
	FG11				4	19	23	*	*	*
	FG10	41	36	23	5	21	26	11	75	15
Silt	FG9	*	*	*	6	29	35	*	*	*
Vandalia Till Member	FG8	50	37	13	7	24	31	8	77	15
	FG7	*	*	*	7	22	29	*	*	*
	FG6	37	41	22	4	24	28	9	75	16
	FG5	*	*	*	5	25	30	*	*	*
	FG4	42	35	23	7	22	29	8	77	15
	FG3	*	*	*	8	22	30	*	*	*
	FG2	39	37	24	8	23	31	9	79	12
	FG1	*	*	*	7	23	30	*	*	*
ATHENS SOUTH QUARRY SECTION										
Peoria Loess	SQ35				0	21	21	49	38	13
	SQ34				1	17	18	51	34	15
	SQ33				1	17	18	64	23	13
	SQ32				0	13	13	63	24	13
	SQ31	See appendix 2			1	17	18	68	21	11
	SQ30	(pipette data)			1	14	15	60	27	13
	SQ29				0	8	8	60	27	13
Roxana Silt	SQ28				1	0	1	71	15	14
	SQ27				0	0	0	77	13	10
	SQ26				0	0	0	79	12	9
	SQ25				0	0	0	76	15	9
	SQ24				0	0	0	74	14	12
	SQ23				0	0	0	46	31	23
Vandalia Till Member	SQ22				0	0	0	43	31	26
	SQ21				0	0	0	41	32	27
	SQ20				0	0	0	47	30	23
	SQ19				0	0	0	60	24	16
	SQ18				0	0	0	61	23	16
	SQ17				0	0	0	57	31	12
	SQ16				0	0	0	68	22	10
	SQ15				0	0	0	70	21	9
	SQ14				0	0	0	40	52	8
	SQ13				0	0	0	23	68	9
	SQ12				0	0	0	16	75	9
	SQ11				7	21	28	*	*	*
	SQ10	41	33	26	7	21	28	14	75	11
	SQ9	*	*	*	7	21	28	*	*	*
	SQ8	46	31	23	7	21	28	13	77	10
	SQ7	*	*	*	8	21	29	*	*	*
	SQ6	37	35	28	8	20	28	12	79	9
	SQ5	*	*	*	8	20	28	*	*	*
	SQ4	34	38	28	8	20	28	15	74	11
	SQ3	*	*	*	4	15	19	*	*	*
	SQ2	36	35	29	13	14	27	20	71	9
Modesto Formation	SQ1	7	64	29	*	*	*	2	57	41
ATHENS NORTH QUARRY SECTION: PROFILE A										
Peoria Loess	NQA43				1	17	18	68	25	7
	NQA42				1	26	27	*	*	*
	NQA41	See appendix 2			1	21	22	*	*	*
	NQA40	(pipette data)			1	23	24	43	45	12
	NQA39				1	23	24	*	*	*
	NQA38				1	18	19	*	*	*

*not run

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 μm) Calcite (%)	Dolomite (%)	Total (%)	Clay mineral (<2 μm) Expandables (%)	Illite (%)	Kaolinite and chlorite (%)
ATHENS NORTH QUARRY SECTION: PROFILE A, *continued*										
Peoria Loess	NQA37				1	20	21	54	35	11
	NQA36				1	17	18	*	*	*
	NQA35				1	17	18	*	*	*
	NQA34				1	20	21	30	49	21
	NQA33				1	18	19	*	*	*
	NQA32				0	17	17	*	*	*
	NQA31				1	22	23	21	55	24
	NQA30				1	17	18	*	*	*
	NQA29	See appendix 2			1	10	11	*	*	*
	NQA28	(pipette data)			1	13	14	18	54	28
	NQA27				1	14	15	*	*	*
	NQA26				1	9	10	*	*	*
	NQA25				1	14	15	19	49	32
	NQA24				1	22	23	*	*	*
	NQA23				1	14	15	*	*	*
	NQA22				1	32	33	11	52	37
	NQA21				0	26	26	*	*	*
	NQA20				1	28	29	*	*	*
	NQA19				1	21	22	*	*	*
	NQA18				0	21	21	*	*	*
	NQA17				1	12	13	21	53	26
Robein Silt	NQA16				1	0	1	22	43	35
	NQA15				0	0	0	22	30	48
	NQA14				0	0	0	29	31	40
	NQA13				0	0	0	64	13	23
	NQA12				0	0	0	*	*	*
	NQA11				0	0	0	70	10	20
	NQA10				0	0	0	*	*	*
	NQA9				0	0	0	63	14	23
	NQA8				0	0	0	*	*	*
	NQA7				0	0	0	72	12	16
Roxana Silt	NQA6				0	0	0	*	*	*
	NQA5				0	0	0	80	10	10
	NQA4				0	0	0	*	*	*
	NQA3				0	0	0	75	14	11
	NQA2				0	0	0	*	*	*
	NQA1				0	0	0	70	18	12
ATHENS NORTH QUARRY: PROFILE B										
Roxana Silt	NQB22				0	0	0	75	9	16
	NQB21				0	0	0	76	11	13
	NQB20				0	0	0	79	11	10
	NQB19				0	0	0	79	11	10
	NQB18	See appendix 2			0	0	0	81	11	8
Berry Clay Member	NQB17	(pipette data)			0	0	0	81	11	8
	NQB16				0	0	0	83	9	8
	NQB15				0	0	0	79	12	9
	NQB14				0	0	0	83	8	9
	NQB13				0	0	0	70	16	14
	NQB12				0	0	0	67	16	17
	NQB11				0	0	0	28	50	22
Vandalia Till Member	NQB10				0	0	0	19	57	24
	NQB9				0	0	0	19	59	22
	NQB8				0	0	0	13	65	22
	NQB7				0	0	0	13	67	20
	NQB6				1	1	2	12	73	15
	NQB5				4	21	25	13	77	10
	NQB4				7	19	26	13	77	10
	NQB1				6	21	27	13	77	10
	NQB2				6	21	27	12	76	12
	NQB3				*	*	*	*	*	*
ATHENS NORTH QUARRY: PROFILE BB										
Vandalia Till Member	NQBB9	37	34	29	7	21	28	13	72	15
	NQBB8	*	*	*	6	23	29	9	72	19

*not run

Stratigraphic unit	Sample number	Grain size (<2 mm) Sand (%)	Silt (%)	Clay (%)	Carbonate (<74 µm) Cal-cite (%)	Dolo-mite (%)	Total (%)	Clay mineral (<2 µm) Expand-ables (%)	Illite (%)	Kaolinite and chlorite (%)
ATHENS NORTH QUARRY:	PROFILE 8B, *continued*									
Vandalia Till Member	NQ8B7	34	40	26	7	22	29	8	73	19
	NQB86	*	*	*	7	22	29	8	72	20
	NQ885	36	38	26	6	22	28	10	70	20
	NQ8B4	*	*	*	7	21	28	8	71	21
	NQB83	36	38	26	7	21	28	9	70	21
	NQBB2	*	*	*	7	22	28	10	72	18
	NQ8B1	3	55	42	27	6	33	3	50	47
JUBILEE COLLEGE SECTION										
Peoria Loess	P1937	*	*	*	*	*	*	70	18	12
	P1936	*	*	*	*	*	*	61	26	13
	P1935	*	*	*	*	*	*	72	16	12
	P1934	*	*	*	*	*	*	72	16	12
	P1933	*	*	*	*	*	*	72	16	12
	P1932	*	*	*	*	*	*	73	18	9
	P1931	*	*	*	*	*	*	72	18	10
Roxana Silt	P1930	*	*	*	*	*	*	70	13	17
	P1929	*	*	*	*	*	*	72	10	18
	P1928	*	*	*	*	*	*	70	9	21
	P1927	*	*	*	*	*	*	62	13	26
Radnor Till Member	P1924	*	*	*	4	13	17	8	67	25
	P6834	*	*	*	3	12	15	14	67	19
	P6833	23	49	28	4	13	17	16	66	18
	P1923	*	*	*	4	14	18	7	72	21
	P6832	19	49	32	4	16	20	11	74	15
	P6831	26	46	28	3	20	23	7	80	13
	JAL63	21	58	21	3	22	25	5	71	24
	P6830	*	*	*	5	16	21	14	70	16
	P1922	*	*	*	4	17	21	8	78	14
	P6829	*	*	*	5	19	24	*	*	*
Toulon Member	P6828	*	*	*	*	*	*	6	68	26
	P1921	*	*	*	*	*	*	35	44	20
	P6827	*	*	*	*	*	*	65	23	12
	P6826	*	*	*	*	*	*	29	51	20
Hulick Till Member	JAL62	25	42	33	5	9	14	4	73	23
	P19168	*	*	*	7	10	17	6	70	24
	P6822	*	*	*	4	7	11	*	*	*
	P1916A	*	*	*	6	8	14	2	77	21
	P1872	*	*	*	*	*	*	4	73	23
	P6821	*	*	*	4	8	12	*	*	*
	P6820	*	*	*	5	7	12	*	*	*
	P6819	*	*	*	5	7	12	*	*	*
	P6818	*	*	*	5	7	12	*	*	*
	P6817	*	*	*	5	7	12	*	*	*

*not run

APPENDIX 2. Pipette analysis data.

		Grain-size composition (% <2 mm)						
		Sand	Silt				Clay	Silt ratio
Stratigraphic unit	Sample number	2 mm to 62 µm	62 to 31 µm	31 to 16 µm	16 to 8 µm	8 to 2 µm	<2 µm	62 to 31 µm / 31 to 16 µm
FARM CREEK SECTION, PROFILE A								
Morton Loess	FCATZ1	0.5	24.0	37.2	18.2	10.9	9.7	0.7
	FCATZ4	0.8	21.3	35.6	23.6	11.1	8.4	0.6
	FCATZ7	0.4	21.0	37.3	22.7	9.9	9.1	0.6
	FCATZ10	0.5	28.7	39.3	16.8	7.6	7.6	0.7
	FCATZ13	0.6	24.2	41.4	19.9	6.9	7.6	0.6
	FCATZ16	0.7	26.2	42.3	17.4	7.9	6.2	0.6
	FCATZ19	0.4	31.1	36.2	16.3	8.4	8.0	0.9
	FCATZ22	0.4	25.7	41.2	18.0	8.4	6.7	0.6
	FCATZ25	0.3	22.4	41.4	21.9	8.0	6.3	0.5
	FCATZ28	0.4	41.1	26.7	18.7	6.3	7.2	1.5
Roxana Silt	FCATZ29	0.4	30.7	34.6	16.1	7.8	10.8	0.9
	FCATZ30	0.5	29.6	34.1	15.3	8.5	12.5	0.9
	FCATZ31	0.3	29.9	32.5	14.4	9.0	14.2	0.9
	FCATZ32	0.3	27.7	33.6	16.8	8.0	13.9	0.8
	FCATZ33	1.3	26.2	32.2	15.0	9.4	17.2	0.8
	FCATZ34	6.5	29.0	29.9	15.0	12.6	13.5	1.0
	FCATZ35	11.2	31.2	26.5	17.0	9.2	16.1	1.2
Radnor Till Member	FCATZ36	16.6	34.1	20.9	14.3	12.5	18.2	1.6
	FCATZ37	15.2	24.4	16.9	13.3	13.3	32.1	1.4
FARM CREEK SECTION, PROFILE B								
Morton Loess	FCB1	0.3	28.4	43.0	17.6	3.7	7.0	0.7
	FCB2	0.3	54.4	15.3	17.3	6.5	6.2	3.6
	FCB3	0.2	63.5	14.2	7.2	8.2	6.7	4.5
	FCB4	0.2	23.2	41.5	20.5	6.5	8.1	0.6
	FCB5	0.6	25.5	39.3	16.6	6.7	11.3	0.7
Robein Silt	FCB6	3.4	34.5	28.2	14.8	11.8	7.3	1.2
	FCB7	1.5	36.9	27.2	14.3	10.2	9.9	1.4
	FCB8	1.2	30.7	33.3	14.5	11.1	9.2	0.9
Roxana Silt	FCB9	1.0	31.2	31.3	15.4	6.8	14.3	1.0
	FCB10	0.2	32.9	32.4	15.4	7.7	11.4	1.0
	FCB11	0.9	26.4	33.3	14.3	9.0	16.1	0.8
	FCB12	0.7	21.1	33.2	17.2	12.3	15.5	0.6
	FCB13	2.5	25.4	32.2	15.2	8.9	15.8	0.8
	FCB14	7.8	27.0	27.9	12.2	10.7	14.4	1.0
Radnor Till Member	FCB15	17.2	20.9	19.4	13.5	11.6	17.4	1.1
	FCB16	18.8	22.0	17.8	13.8	9.5	18.1	1.2
	FCB17	16.0	17.3	15.2	10.9	11.5	29.1	1.1
	FCB18	18.7	11.6	11.3	7.7	10.2	40.5	1.0
FARM CREEK SECTION, PROFILE C								
Richland Loess	FCC1	4.1	14.5	23.6	23.5	16.7	17.6	0.6
	FCC2	0.8	14.8	18.8	18.9	14.2	32.5	0.8
	FCC3	0.6	14.4	20.7	18.2	11.8	34.3	0.7
	FCC4	0.8	12.3	27.4	16.5	10.6	32.4	0.5
	FCC5	1.8	13.0	31.2	16.8	9.8	27.4	0.4
	FCC6	3.0	17.4	27.4	18.1	8.7	25.4	0.6
	FCC7	2.8	15.4	25.9	17.9	12.4	25.6	0.6
	FCC8	3.9	17.3	25.9	19.5	10.0	23.4	0.7
GAROENA SECTION								
Morton Loess (moss)	G1a	2.3	39.2	34.7	14.9	4.7	4.2	1.1
Morton Loess	G1b	2.2	22.5	48.8	14.8	4.9	6.8	0.5
	G2	1.3	42.7	35.2	14.0	5.6	1.2	1.2
	G3	0.8	27.8	39.0	17.8	6.4	8.2	0.7
	G4	0.6	27.7	39.0	17.7	7.8	7.2	0.7
	G5	0.6	36.2	36.0	17.2	7.6	2.4	1.0
	G6	0.7	34.9	39.6	15.2	5.2	4.4	0.9
	G7	0.6	29.0	40.8	16.4	10.4	2.8	0.7
	G8	0.5	26.1	42.2	17.0	6.8	7.4	0.6
	G9	0.5	30.3	34.4	21.2	7.6	6.0	0.9
	G10	0.5	29.8	41.6	16.0	4.7	7.4	0.7
	G11	0.4	25.9	43.3	16.4	5.7	8.3	0.6
	G12	0.2	27.7	42.4	16.3	5.8	7.6	0.7
	G13	0.3	25.8	42.5	18.2	6.3	6.9	0.6
	G14	0.2	28.7	43.7	15.4	4.2	7.8	0.7
	G15	0.2	33.1	38.8	16.2	4.0	7.7	0.9
	G16	0.2	29.9	44.6	15.0	3.6	6.7	0.7

Stratigraphic unit	Sample number	Grain-size composition (% <2 mm) Sand 2 mm to 62 μm	Silt 62 to 31 μm	Silt 31 to 16 μm	Silt 16 to 8 μm	Silt 8 to 2 μm	Clay <2 μm	Silt ratio 62 to 31 μm / 31 to 16 μm
GAROENA SECTION, *continued*								
Morton Loess	G17	0.2	24.5	47.5	14.4	4.9	8.5	0.5
	G18	0.2	27.9	40.7	16.9	6.1	8.2	0.7
	G19	0.2	29.3	37.3	17.4	7.4	8.4	0.8
	G20	0.9	25.1	41.4	19.2	5.6	7.8	0.6
	G21	2.6	24.9	42.8	15.6	7.9	6.2	0.6
	G22	2.9	22.2	38.4	19.4	9.3	7.8	0.6
	G23	2.2	26.1	35.8	21.4	7.2	7.3	0.7
	G24	3.6	20.9	37.8	20.0	9.1	8.6	0.6
	G25	4.5	17.9	39.7	18.7	12.5	6.7	0.5
	G26	5.5	23.3	35.5	17.8	10.0	7.9	0.7
Robein Silt	G27	4.3	32.3	27.2	17.7	10.8	7.7	1.2
	G28	11.3	26.6	25.4	15.6	12.3	8.8	1.1
	G29	1.6	32.1	31.7	16.3	7.9	10.4	1.0
Roxana Silt	G30	0.5	28.6	33.2	16.4	9.2	12.1	0.9
	G31	0.8	25.8	31.5	15.7	8.3	17.9	0.8
GLENOALE SCHOOL SECTION								
Morton Loess	GS7	0.4	21.0	47.2	17.9	5.0	8.5	0.4
Roxana Silt	GS6	0.6	32.5	33.4	13.4	7.7	12.4	1.0
GRAYBAR SECTION								
Morton Loess	G81A	0.7	31.8	39.7	15.9	5.5	6.4	0.8
Roxana Silt	GB1B	3.4	38.2	29.9	16.3	5.6	6.6	1.3
FAIRGROUNO SECTION								
Peoria Loess	FG32	0.6	14.9	34.7	19.0	8.1	22.7	0.4
	FG30	0.6	22.6	38.2	18.3	7.5	12.8	0.6
Roxana Silt	FG28	3.0	27.3	26.6	16.0	8.4	18.7	1.0
	FG26	2.4	24.8	27.5	19.4	8.1	17.8	0.9
	FG24	4.9	24.4	26.5	16.0	8.5	19.7	0.9
Vandalia Till Member	FG22	7.5	22.8	25.3	14.8	8.4	21.2	0.9
	FG20	13.1	18.2	21.0	11.6	11.9	24.2	0.9
	FG18	8.9	14.3	14.4	9.7	9.6	43.1	1.0
	FG16	32.1	11.2	11.1	9.0	9.6	27.0	1.0
	FG14	21.6	14.6	14.2	8.8	12.4	28.4	1.0
	FG12	42.5	11.9	11.3	10.6	9.1	14.6	1.1
ATHENS SOUTH QUARRY SECTION								
Peoria Loess	SQ35	0.5	27.8	38.8	17.6	3.3	12.0	0.7
	SQ32	0.8	30.1	37.8	16.4	3.3	11.6	0.8
	SQ30	0.5	26.2	39.9	18.4	5.9	9.1	0.7
	SQ29	0.8	28.2	34.9	15.3	7.4	13.4	0.8
Roxana Silt	SQ28	1.8	28.5	32.0	14.4	9.4	13.9	0.9
	SQ26	1.8	23.5	33.7	15.4	7.2	18.4	0.7
	SQ24	3.3	27.7	31.2	15.1	7.3	15.4	0.9
Vandalia Till Member	SQ22	19.0	16.1	25.1	16.9	10.6	12.3	0.6
	SQ21	23.6	12.8	22.6	16.4	12.2	12.4	0.6
	SQ20	22.8	17.7	20.2	13.3	11.2	14.8	0.9
	SQ19	22.8	15.7	16.2	11.4	10.6	23.3	1.0
	SQ18	22.2	15.9	15.0	11.2	9.4	26.3	1.1
	SQ17	25.3	7.4	7.3	8.0	5.2	46.8	1.0
	SQ16	21.5	8.2	11.4	8.3	6.9	43.7	0.7
	SQ15	31.3	8.7	4.6	7.4	8.3	39.7	1.9
	SQ14	41.8	10.9	6.2	7.2	10.1	23.8	1.8
	SQ13	38.7	11.1	8.0	9.2	10.7	22.3	1.4
	SQ12	38.8	13.2	8.0	9.4	11.4	19.2	1.7
ATHENS NORTH QUARRY SECTION: PROFILE A								
Peoria Loess	NQA43	2.1	23.0	35.1	15.9	8.3	15.6	0.7
	NQA40	1.2	26.0	37.4	19.2	6.8	9.4	0.7
	NQA37	0.6	26.0	40.2	16.8	5.7	10.7	0.7
	NQA34	1.9	22.8	42.1	16.9	6.4	9.9	0.5
	NQA31	4.4	23.3	38.5	16.9	6.0	10.9	0.6
	NQA28	15.0	12.4	33.2	18.5	10.1	10.8	0.4
	NQA25	3.9	22.9	35.7	16.2	8.6	12.7	0.6
	NQA22	11.6	11.7	38.7	19.7	10.4	7.9	0.3

APPENDIX 2. *Continued.*

		Grain-size composition (% <2 mm)						
		Sand	Silt				Clay	Silt ratio
Stratigraphic unit	Sample number	2 mm to 62 µm	62 to 31 µm	31 to 16 µm	16 to 8 µm	8 to 2 µm	<2 µm	62 to 31 µm / 31 to 16 µm
ATHENS NORTH QUARRY SECTION: PROFILE A, *continued*								
Peoria Loess	NQA19	5.3	23.8	36.8	18.4	8.1	7.6	0.6
	NQA18	3.6	25.8	38.4	16.1	8.5	7.6	0.7
	NQA17	4.8	20.9	31.6	19.7	12.2	10.8	0.7
Robein Silt	NQA16	5.2	23.2	28.4	17.6	14.7	10.9	0.8
	NQA15	1.6	28.7	31.9	15.6	9.2	13.0	0.9
	NQA14	2.9	28.1	34.4	14.5	8.4	11.7	0.8
	NQA13	1.6	28.4	33.1	14.2	9.0	13.7	0.9
	NQA11	1.6	24.8	33.4	13.4	9.2	17.6	0.7
	NQA9	0.6	27.3	32.1	16.0	7.0	17.0	0.9
	NQA7	4.7	23.5	29.5	14.0	7.9	20.4	0.8
Roxana Silt	NQA5	9.5	23.3	25.8	12.9	7.5	22.0	0.9
	NQA3	10.7	20.2	23.8	13.2	7.9	24.2	0.9
	NQA1	9.6	14.8	20.2	13.4	9.6	32.4	0.7
ATHENS NORTH QUARRY SECTION: PROFILE B								
Roxana Silt	NQB22	6.5	21.0	27.7	14.2	7.8	22.8	0.8
	NQB20	10.5	18.5	22.8	14.3	8.3	25.6	0.8
	NQB18	8.4	17.0	25.2	12.5	7.7	29.2	0.7
Berry Clay Member	NQB16	8.7	19.9	21.2	13.7	8.1	28.4	0.9
	NQB14	9.3	15.9	19.5	13.3	8.4	33.6	0.8
	NQB12	13.6	15.4	20.9	13.3	9.2	27.6	0.7
Vandalia Till Member	NQB10	40.8	13.8	8.4	7.3	8.1	21.6	1.6
	NQB8	34.8	12.8	14.4	9.8	8.0	20.2	0.9
	NQB6	40.1	12.4	5.9	7.9	10.4	23.3	2.1
	NQB4	39.3	13.2	8.6	9.3	10.3	19.3	1.5
	NQB2	40.4	11.1	11.0	8.9	10.5	18.1	1.0

APPENDIX 3. Explanation of pedologic features and concepts used in the discussion of soils for this guidebook.

Soil horizon nomenclature

The standards set by the U.S. Department of Agriculture are used as much as possible. Roman numerals to designate different materials are not used in this guidebook because they are redundant with our format for stratigraphic information. The criteria used in identifying the morphological features of A and B horizons are used without modification; however, the C horizon is divided into four subhorizons that are useful for evaluation of the genesis of soils, particularly buried soils. The top and bottom of a buried soil are often difficult to determine because of diagenesis (loss of soil characteristics) and missing horizons. Therefore, identification of soil horizons from hand specimens, discontinuous cores, and partial profiles in outcrop is especially important. Proper identification allows for an estimation of depth below an original land surface as indicated by the soil horizon(s) and, in some cases, depending on the horizon(s) observed, forms a basis for predicting the type of soil that may be found in other equivalent stratigraphic positions. Some part of the C horizon is the part of a buried soil profile most commonly observed. In the C horizon certain changes take place with depth that always occur in order. All subhorizons may not occur in a given profile, but a departure from the order indicates a change in the geologic materials. Assuming a uniform material, subhorizons of the C horizon (weathering zones) occur in the order shown in table A.

TABLE A. Order of weathering zones in the C horizon.

Horizon	Mineralogy	Carbonates	Color	Structure
C1	Strongly altered	Leached	Uniform, mottled, or stained	Some soil structure, peds with cutans; structure of parent material—blocky, layered, or massive—common; often porous.
C2	Altered	Unleached	Uniform, mottled, or stained	Less soil structure, cutans in joints; structure of parent material—blocky, layered, or massive—dominant; often porous.
C3	Partly altered	Unleached	Uniform, rare stains	Massive, layered, or very large blocky; conchoidal fractures; dense.
C4	Unaltered	Unleached	Uniform	Massive or layered, conchoidal fractures, dense.

Diagenesis of buried soils

When a soil is buried by a younger geologic material, it is removed from the dynamics of the soil-forming environment. The buried soil then undergoes a change in which many soil-forming processes are reversed. The general process is referred to as *diagenesis* (Valentine and Dalrymple, 1976), *pedometamorphism* (Gerasimov, 1971), or *retrogressive development* (Johnson et al., 1972). The buried soil loses many of its properties and tends to regain some properties of the parent material, becoming more like a C horizon.

The most significant (diagenetic) changes in buried soils are a loss of organic carbon content, a loss of soil structure, and an increase in bulk density. Overburden pressures cause compaction, an increase in bulk density, and the healing of soil structure; however, when present, stains or cutans often outline the original ped surfaces. Better-drained buried soils are the most resistant to these changes but lose essentially all of their organic carbon content. Poorly drained buried soils lose most of the soil structure but often retain a portion of the original organic matter content.

Soil chemistry also changes. Concretions and other precipitates may form as a consequence of the postburial conditions. Base saturation of most buried soils in the glaciated Midwest is nearly 100 percent, which indicates resaturation from a base containing leachate from the overlying materials. Much care must be taken in order to distinguish the genuine soil characteristics from those that may have been acquired after burial.

Diagnostic soil profile characteristics

A soil profile contains a sequence of horizons. The occurrence of two or more horizons in proper sequence, compatible with the A-B-C horizon system, constitutes the prime diagnostic feature of a soil profile and indicates proximity to a ground surface. Important profile characteristics of all soils are color patterns and the structure components, referred to as soil *aggregates* or *peds*. In general, the color of an A horizon is uniform. Mottling or color segregations commonly reach maximum expression in the B or upper C horizons and grade back to a uniform color in the lower C2 to C4 horizons. The size of the peds or aggregates are smallest in the A horizon and steadily increase in size until the pedality disappears into a large blocky structure, controlled by jointing or other geologic structures in the C horizon. In the lower portion of soil profiles, the soil structure is polygonal in horizontal section and becomes larger and more weakly expressed with depth. The principal cause of soil structure is wetting and drying, although freezing and thawing can produce similar results.

The solum (A and B) is more porous than the C horizon and commonly has biologically generated channels; isolated pores, vesicles, or vugs; and root traces, stains, and cutans. All of these features are significantly reduced or disappear in the C horizon.

Diagnostic characteristics of buried soil horizons

A selected few morphologic features in combination serve as reasonable criteria for the identification of buried soil horizons. Some horizons are not readily recognized, whereas other horizons are reasonably distinctive. Uncertain horizons may be recognized only through deduction. The more diagnostic horizons and morphologic properties are:

1. O horizon
    a. Dark peat or muck
    b. Commonly massive or bedded; ragged or felted appearance
    c. Generally overlies a gleyed horizon.
2. Al horizon of poorly drained soils
    a. Dark, gray or black, uniform, commonly contains organic material
    b. Fine structure, healed granular or platy, forms blocks on disturbance.

3. A1 horizon of well-drained soils (deductive)
    a. Light colored, a shade of brown, uniform
    b. Fine structure, healed granular or platy
    c. Gradational upper boundary, or is contained in a zone of mixing with the overlying deposit.
4. A2 horizon
    a. Lighter color than adjacent horizons
    b. Fine structure, similar to A1 but often platy, common clean silt segregations (silans) separating aggregated material
    c. Less healed than A1, tends to break into plates and granules.
5. B2t horizon
    a. Generally brown or gray, sometimes red
    b. Common mottles, stains, or concretions
    c. Medium structure, commonly medium blocky, and somewhat healed when moist
    d. Appears plastic and massive when wet, but hard and structured when dry
    e. Common to many argillans delineating ped surfaces and channels
6. Bg horizon
    a. Gray, commonly with a green or blue hue
    b. No mottles (strong gley) or common mottles (pseudogley)
    c. Structure ranges from none to medium blocky (similar to B2t)
    d. Aggregation ranges from none to moderate
    e. Dark argillans delineating ped surfaces and channels range from none to few.
7. B3 and C1 horizons
    a. Mixed colors, commonly zone of maximum color segregations
    b. Coarse blocky structure, commonly healed
    c. Common thick discontinuous argillans
    d. Common black manganese staining
    e. Occasional carbonate concretions

Eluviation, aggregation, and soil structure in relation to buried soils

Eluviation—the movement of dissolved or suspended material from one place to another within a soil.

Aggregation—the organization of primary soil particles into discrete masses (aggregates or "peds"), which are separated from adjoining aggregates by contrasting material (cutans) or voids.

Soil structure—the organization of primary soil particles into compound particles or clusters (peds), which are separated from adjoining peds by surfaces of weakness (joints).

Soil-forming processes cause translocation of dissolved and suspended material. These processes affect the morphologic features of soil horizons. The source of the material can be a "zone," such as the A2 horizon, or point locations, such as mineral grains. The process is most effective along surfaces or joints in the soil material. The general process, commonly called *eluviation*, causes a depleted zone to be light in color, sometimes poorly structured, and low in aggregation. The localized phenomenon is commonly referred to as a result of a segregation process.

Colloidal-sized clay minerals and organic matter are the principal components of the suspended material and form the binder that causes the silt and sand to agglomerate and form aggregates. Soil-formed aggregates in the range of 1 to 100 mm are called *peds*. In the process of removal of colloids from soil material, zones, spots, or thin layers of clean silt or sand are formed. Concentrations of clean silt in spots and thin layers are called *silans*. A zone affected by this process generally has a bleached or blotchy appearance and a weak expression of granular or platy aggregates.

The eluviated materials move downward or into adjacent aggregates. The zone of maximum accumulation of the colloidal material underlying an A horizon is the B2t horizon. The accumulation principally takes place on ped surfaces, joints, or channels that have continuity to the source. Where the effects of this process are well expressed, the peds become completely coated with clay-rich material (argillans). When the peds become fully coated with argillans, aggregation has reached its maximum state, and the horizon is considered to have strong aggregation as well as strong structure.

Organic matter is the principal component in the granular material that gives A horizons stability. Upon burial of the A horizon, the organic matter source is cut off, and the organic material undergoes biological decomposition. The resulting loss of strength or stability of the aggregate allows the granular material to become more massive.

The strength or stability of the blocky peds of B horizons is generally less than in the A horizons; however, the B is more protected from physical disturbances that affect soils, and the peds are, to some degree, coated with highly contrasting argillans or other material. Upon burial of a soil profile, argillans are preserved, but the surfaces on which they formed become healed to some extent. This healing process is counter to ped formation. It operates in all soils and becomes dominant over ped-forming processes in buried soils. In contrast to argillan-coated peds, the noncoated peds in the A and B horizons heal to a greater degree after burial. Therefore, the degree of aggregation as expressed by argillans or other coatings that delineate discrete masses of soil material (peds) in buried soils actually expresses the original structures of the soil before burial.

In some cases, soil structures in buried soils do not experience much healing, whereas in other situations the healing is essentially complete and renders the soil material to a massive state. In either case, some degree of aggregation is commonly preserved in buried soils. The loss of morphologic expression (soil structure) in buried soils is largely dependent on depth of burial and hydrologic conditions before and after burial.

Soil structure and aggregation expressions are always parallel in a developing soil and are generally, but not always, parallel in buried soils. Where they are not parallel, the soil material may fracture indiscriminately through a mass of healed peds, but the shape and size of the peds may be evident from the stains or coatings that outline the ped. That is, the features that appear to be granular aggregates, blocks, and plates are considered in this context as aggregates. In this sense, the aggregates are not bound by the requirement that they separate along natural planes of weakness as are structural elements. This concept is useful in the study of buried soils in that it allows interpretation of blocky structures when in fact the blocks do not readily separate along obvious ped surfaces.

Moisture has an important influence on interpretation of soil structures. Conditions are best when the soil is moist and in process of drying. When the soil is wet, many soil horizons appear to be massive, particularly in buried soils. When a soil is air dry, soil structures are exaggerated and some color contrast is lost; however, in any moisture condition an assessment of aggregation can be made which is a reliable basis for interpreting soil structure.

In this guidebook soil structure is interpreted in the strict sense as much as possible. Relative assessments of the degree of aggregation are expressed as weak, moderate, or strong. This is a ranking of the distinctiveness of the "peds," healed or not. The degree of aggregation is very important in interpreting and classifying buried soil profiles.

Confounded soil characteristics

Soil materials that are subjected to a change in the soil horizon-forming processes respond in whole or in part to the new environmental conditions. Theoretically, a total response means that a change from one set of soil horizon characteristics to another is complete, such as an A changing to a B or vice versa; however, in many cases, the response to the new conditions is partial where old (relict) features are preserved among the younger features. The apparent mixture of soil features is a condition of confounded soil characteristics.

The interpretation of one set of horizon characteristics superposed on another set is admittedly subjective, but it permits an independent means for the geo-pedologic interpretation of a change in conditions that is important to the interpretation of the geo-pedologic history. Often the validity of such interpretation can be shown where rock-stratigraphic units in the parent material can be identified in a series of profiles. For example, where an A horizon has been buried by 50 cm of accreted material, the "old" A begins to take on characteristics of a B. Generally, in tracing the buried A up-slope, one can observe that the accreted deposits thin and the A horizon rises to its normal position at the surface.

Soil horizons can move up or down in response to slow burial, slow erosion, or a change in the other soil-forming factors. When a change in horizon characteristics is recognized and the horizon expresses typical features of two horizons, the confounded horizon can be designated as X/Y, which means X horizon features are superposed on Y horizon features. This concept is very useful in interpreting buried soils in that it allows age (paragenetic) relationships between soil features to be indicated.

Some confounded soil horizons result from the "normal forward" soil-forming processes, whereas others result from retrogressive processes. The following list of confounded soil horizons defines in general terms all the possible combinations.

A/B A horizon superposed on a B; typically granular to platy, weakly aggregated silty material surrounding clay-rich rounded peds (degraded B).

A/C A horizon superposed on a C; typically massive or layered, somewhat unweathered C horizon material that has porous zones of granular to platy aggregates, which may or may not be darkened with humus.

B/A B horizon superposed on an A; typically blotchy, platy to granular aggregates with clean silt segregations and voids within larger blocky peds, which are delineated by argillans or ped surfaces (blocky structure crosscutting platy structure is diagnostic).

B/C B horizon superposed on a C; typically blocky structure with coated peds that increase in size and become more massive with depth.

C/A C horizon superposed on an A; typically massive and porous; blotchy, healed (welded) granular or compressed platy aggregates with weak expression; joints, stains, and mottles are younger, postburial features.

C/B C horizon superposed on a B; typically massive with healed blocky aggregates outlined with cutans; moderate to strong aggregate expression.

REFERENCES

Alden, William C., and Morris M. Leighton, 1917, The Iowan drift: A review of the evidences of the Iowan Stage of glaciation: Iowa Geological Survey Annual Report, 1915, v. 26, p. 49-212.

American Commission on Stratigraphic Nomenclature, 1961, Code of stratigraphic nomenclature: American Association of Petroleum Geologists Bulletin, v. 45, no. 5, p. 645-665.

Bergstrom, Robert E., Kemal Piskin, and Leon R. Follmer, 1976, Geology for planning in the Springfield-Decatur region, Illinois: Illinois State Geological Survey Circular 497, 76 p.

Boellstorff, John, 1978, North American Pleistocene stages reconsidered in light of probable Pliocene-Pleistocene continental glaciation: Science, v. 202, no. 4365, p. 305-307.

Brophy, John A., 1959, Heavy mineral ratios of Sangamon weathering profiles in Illinois: Illinois State Geological Survey Circular 273, 22 p.

Chamberlin, T. C., 1896 [editorial]: Journal of Geology, v. 4, p. 872-876.

Cline, R. M., and J. D. Hays, eds., 1976, Investigation of Late Quaternary paleooceanography and paleoclimatology: Geological Society of America Memoir 145, 464 p.

Coleman, Dennis D., 1974, Illinois State Geological Survey radiocarbon dates V: Radiocarbon, v. 16, no. 1, p. 105-117.

Cushman, Joseph A., and Lloyd G. Henbest, 1940, Geology and biology of North Atlantic deep-sea cores between Newfoundland and Ireland; Part 2, Foraminifera: U.S. Geological Survey Professional Paper 196-B, p. 35-36.

Emiliani, Cesare, 1955, Pleistocene temperatures: Journal of Geology, v. 63, p. 538-578.

Fink, Julius, and Kukla, George J., 1977, Pleistocene climates in central Europe; at least 17 interglacials after the Olduvai Event: Quaternary Research, v. 7, p. 363-371.

Follmer, Leon R., 1970, Soil distribution and stratigraphy in the Mollic Albaqualf region of Illinois: Ph.D. thesis, University of Illinois, Urbana, 155 p.

Follmer, Leon R., 1978, The Sangamon Soil in its type area—A review, *in* W. C . Mahaney [ed.], Quaternary soils: Geo Abstracts, Norwich, England, p. 125-165.

Fowells, H. A., 1965, Silvics of forest trees: U.S. Department of Agriculture, Agriculture Handbook 271.

Frye, John C., Leon R. Follmer, H. D. Glass, J. M. Masters, and H. B. Willman, 1974a, Earliest Wisconsinan sediments and soils: Illinois State Geological Survey Circular 485, 12 p.

Frye, John C., H. D. Glass, John P. Kempton, and H. B. Willman, 1969, Glacial tills of northwestern Illinois: Illinois State Geological Survey Circular 437, 45 p.

Frye, John C., H. D. Glass, and H. B. Willman, 1962, Stratigraphy and mineralogy of the Wisconsinan loesses of Illinois: Illinois State Geological Survey Circular 334, 55 p.

Frye, John C., H. D. Glass, and H. B. Willman, 1968, Mineral zonation of Woodfordian loesses of Illinois: Illinois State Geological Survey Circular 427, 44 p.

Frye, John C., A. Byron Leonard, H. B. Willman, H. D. Glass, and Leon R. Follmer, 1974b, The late Woodfordian Jules Soil and associated molluscan faunas: Illinois State Geological Survey Circular 486, 11 p.

Frye, John C., P. R. Shaffer, H. B. Willman, and G. E. Ekblaw, 1960, Accretion gley and the gumbotil dilemma: American Journal of Science, v. 258, no. 3, p. 185-190.

Frye, John C., and H. B. Willman, 1960, Classification of the Wisconsinan Stage in the Lake Michigan glacial lobe: Illinois State Geological Survey Circular 285, 16 p.

Frye, John C., and H. B. Willman, 1963, Loess stratigraphy, Wisconsinan classification and accretion-gleys in central-western Illinois: Midwestern Section Friends of the Pleistocene, 14th Annual Meeting, Illinois State Geological Survey Guidebook Series 5, 37 p.

Frye, John C., and H. B. Willman, 1965a (Illinois part of) Guidebook for field conference C—Upper Mississippi Valley (R. P. Goldthwait, organizer; C. B. Schultz and H.T.U. Smith, eds.): International Association for Quaternary Research 7th Congress, Nebraska Academy of Science, p. 81-110; Illinois State Geological Survey Reprint 1966-B (supplemental data, J. P. Kempton and H. D. Glass, p. C-S1 to C-S11), 41 p.

Frye, John C., and H. B. Willman, 1965b, Illinois, *in* Guidebook for field conference G—Great Lakes-Ohio River Valley (R. F. Black and E. C. Reed, organizers; C. B. Schultz and H.T.U. Smith, eds.): International Association of Quaternary Research 7th Congress, Nebraska Academy of Science, p. 5-26; Illinois State Geological Survey Reprint 1966-B (supplemental data, H. D. Glass, p. G-S1 to G-S4), 26 p.

Frye, John C., and H. B. Willman, 1973, Wisconsinan climatic history interpreted from the Lake Michigan lobe deposits and soils, *in* Robert F. Black, Richard P. Goldthwait, and H. B. Willman [eds.], The Wisconsinan Stage: Geological Society of America Memoir 136, p. 135-152.

Frye, John C., H. B. Willman, and H. D. Glass, 1960, Gumbotil, accretion-gley, and the weathering profile: Illinois State Geological Survey Circular 295, 39 p.

Frye, John C., H. B. Willman, and H. D. Glass, 1964, Cretaceous deposits and the Illinoian glacial boundary in western Illinois: Illinois State Geological Survey Circular 364, 28 p.

Gerasimov, I. D., 1971, Nature and originality of paleosols, *in* D. W. Yaalon [ed.], Paleopedology: Jerusalem, Israel University Press, p. 15-27.

Glass, H. D., John C. Frye, and H. B. Willman, 1964, Record of Mississippi River diversion in the Morton Loess of Illinois: Illinois Academy of Science transactions, v. 57, no. 1, p. 24-27.

Glass, H. D., John C. Frye, and H. B. Willman, 1968, Clay mineral composition, a source indicator of Midwest loess, *in* Robert E. Bergstrom [ed.], The Quaternary of Illinois: University of Illinois College of Agriculture Special Publication 14, p. 35-40.

Grüger, E., 1972, Late Quaternary vegetation development in south-central Illinois: Quaternary Research, v. 2, p. 217-231.

Grüger, J., 1973, Studies on the late Quaternary vegetation history of northeastern Kansas: Geological Society of America Bulletin, v. 84, p. 239-250.

Hallberg, G. R., T. E. Fenton, G. A. Miller, and A. J. Luteneggar, 1978, Trip 2—The Iowan erosion surface: an old story, an important lesson, and some new wrinkles, *in* R. R. Anderson [ed.], 42nd Annual Tri-state Geological Field Conference Guidebook: Iowa Geological Survey, Iowa City, IA, p. 2-1 to 2-94.

Horberg, Leland, 1956, Pleistocene deposits along the Mississippi Valley in central western Illinois: Illinois State Geological Survey Report of Investigations 192, 39 p.

Jacobs, Alan M., and Jerry A. Lineback, 1969, Glacial geology of the Vandalia, Illinois, region: Illinois State Geological Survey Circular 442, 23 p.

Johnson, W. Hilton, 1964, Stratigraphy and petrography of Illinoian and Kansan drift in central Illinois: Illinois State Geological Survey Circular 378, 38 p.

Johnson, W. Hilton, Leon R. Follmer, David L. Gross, and Alan M. Jacobs, 1972, Pleistocene stratigraphy of east-central Illinois: Illinois State Geological Survey Guidebook Series 9, 97 p.

Jones, Robert L., and A. H. Beavers, 1964, Magnetic susceptibility as an aid in characterization and differentiation of loess: Journal of Sedimentary Petrology, v. 34, p. 881-883.

Kapp, Ronald O., and Ansel M. Gooding, 1964, Pleistocene vegetational studies in the Whitewater Basin, southeastern Indiana: Journal of Geology, v. 72, p. 307-326.

Kay, George F., 1916, Gumbotil, a new term in Pleistocene geology: Science, new series, v. 44, p. 637-638.

Kay, George F., and E. T. Apfel, 1929, The pre-Illinoian Pleistocene geology of Iowa: Iowa Geological Survey Annual Report, v. 34, p. 1-262.

Kay, George F., and Jack B. Graham, 1943, The Illinoian and post-Illinoian Pleistocene geology of Iowa: Iowa Geological Survey Annual Reports, 1940 and 1941, v. 38, p. 11-262.

Kay, George F., and Morris M. Leighton, 1933, Eldoran Epoch of the Pleistocene Period: Geological Society of America Bulletin 44, p. 669-674.

Kay, George F., and J. Newton Pearce, 1920, The origin of gumbotil: Journal of Geology, v. 28, no. 2, p. 89-125.

Kempton, John P., and David L. Gross, 1971, Rate of advance of the Woodfordian (Late Wisconsinan) glacial margin in Illinois: Stratigraphic and radiocarbon evidence: Geological Society of America Bulletin, v. 82, p. 3245-3250.

Kim, S. M., 1970, Illinois State Geological Survey radiocarbon dates II: Radiocarbon, v. 12, no. 2, p. 503-508.

King, James E., 1973, Late Pleistocene palynology and biogeography of the western Missouri Ozarks: Ecological Monographs, v. 43, p. 539-565.

Kleiss, H. J., 1973, Loess distribution along the Illinois soil-development sequence: Soil Science, v. 115, no. 3, p. 194-198.

Kleiss, H. J., and J. B. Fehrenbacher, 1973, Loess distribution as revealed by mineral variations: Soil Science Society of America Proceedings, v. 37, p. 291-295.

Kukla, G. J., 1977, Pleistocene land-sea correlations: I, Europe: Earth Science Reviews, v. 13, p. 307-374.

Leighton, Morris M., 1926, A notable type Pleistocene section: the Farm Creek exposure near Peoria, Illinois: Journal of Geology, v. 34, p. 167-174.

Leighton, Morris M., 1931, The Peorian loess and the classification of the glacial drift sheets of the Mississippi Valley: Journal of Geology, v. 39, p. 45-53.

Leighton, Morris M., 1933, The naming of the subdivisions of the Wisconsin glacial age: Science, v. 77, no. 1989, p. 168.

Leighton, Morris M., 1958, Principles and viewpoints in formulating the stratigraphic classifications of the Pleistocene: Journal of Geology, v. 66, p. 700-709.

Leighton, Morris M., 1959, Stagnancy of the Illinoian glacial lobe east of the Illinois and Mississippi Rivers: Journal of Geology, v. 67, p. 337-344.

Leighton, Morris M., 1960, The classification of the Wisconsin glacial stage of north central United States: Journal of Geology, v. 68, p. 529-552.

Leighton, Morris M., 1965, The stratigraphic succession of Wisconsin loesses in the Upper Mississippi River Valley: Journal of Geology, v. 73, p. 323-345.

Leighton, Morris M., and J. A. Brophy, 1961, Illinoian glaciation in Illinois: Journal of Geology, v. 69, p. 1-31.

Leighton, Morris M., and Paul MacClintock, 1930, Weathered zones of the drift-sheets of Illinois: Journal of Geology, v. 38, p. 28-53.

Leighton, Morris M., and Paul MacClintock, 1962, The weathered mantle of glacial tills beneath original surfaces in north-central United States: Journal of Geology, v. 70, p. 267-293.

Leighton, Morris M., and H. B. Willman, 1950, Loess formations of the Mississippi Valley: Journal of Geology, v. 58, p. 599-623.

Leverett, Frank, 1898a, The weathered zone (Sangamon) between the Iowan loess and Illinoian till sheet: Journal of Geology, v. 6, p. 171-181.

Leverett, Frank, 1898b, The Peorian Soil and weathered zone (Toronto Formation?): Journal of Geology, v. 6, p. 244-249.

Leverett, Frank, 1898c, The weathered zone (Yarmouth) between the Illinoian and Kansan till sheets: Iowa Academy of Science Proceedings, v. 5, p. 81-86.

Leverett, Frank, 1899, The Illinois glacial lobe: U.S. Geological Survey Monograph 38, 817 p.

Lineback, Jerry A., in press, Quaternary deposits of Illinois (1:500,000): Illinois State Geological Survey Map.

Lineback, Jerry A., and Jerry T. Wickham, 1977, Correlation of the Quaternary stratigraphic record of Illinois with marine paleoclimatic changes [abstract]: Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1071.

Lineback, Jerry A., and Jerry T. Wickham, 1978, Is the Illinoian a superstage? [abstract]: Geological Society of America Abstracts with Programs, v. 10, no. 7, p. 445.

MacClintock, Paul, 1926, Pre-Illinoian till in southern Illinois: Journal of Geology, v. 34, p. 175-180.

MacClintock, Paul, 1929, Physiographic divisions of the area covered by the Illinoian drift-sheet in southern Illinois. II. Recent discoveries of pre-Illinoian drift in southern Illinois: Illinois State Geological Survey Report of Investigations 19, 57 p.

MacClintock, Paul, 1933, Correlation of the pre-Illinoian drifts of Illinois: Journal of Geology, v. 41, p. 710-722.

McKay, E. Donald, 1977, Stratigraphy and zonation of Wisconsinan loesses in southwestern Illinois: Ph.D. thesis, University of Illinois, Urbana, 242 p.

Morrison, R. B., 1978, Quaternary soil stratigraphy, concepts, methods, and problems, *in* W. C. Mahaney [ed.], Quaternary soils: Geo Abstracts, Norwich, England, p. 77-108.

Norton, E. A., and R. S. Smith, 1928, Horizon designation: American Soil Survey Association Bulletin 9, p. 83-86.

Rohlf, F. J., and R. R. Sokal, 1969, Statistical Tables: W. H. Freeman and Company, San Francisco.

Rubin, M., and C. Alexander, 1960, U.S. Geological Survey radiocarbon dates V: American Journal of Science, radiocarbon supplement, v. 2, p. 129-185.

Ruhe, R. V., 1969, Quaternary landscapes in Iowa: Ames, Iowa State University Press, 255 p.

Ruhe, R. V., 1974, Sangamon paleosols and Quaternary environments in midwestern United States, *in* W. C. Mahaney [ed.], Quaternary environments: Geographical monographs no. 5, York University, Toronto, Ontario, p. 153-167.

Ruhe, R. V., 1976, Stratigraphy of mid-continent loess, U.S.A., *in* W. C. Mahaney [ed.], Quaternary Stratigraphy of North America: Dowden, Hutchinson, and Ross, Inc., Stroudsburg, PA, p. 197-211.

Ruhe, R. V., Meyer Rubin, and W. H. Scholtes, 1957, Late Pleistocene radiocarbon chronology in Iowa: American Journal of Science, v. 255, p. 671-689.

Ruhe, R. V., and W. H. Scholtes, 1959, Important elements in the classification of the Wisconsin glacial stage: a discussion: Journal of Geology, v. 67, p. 585-593.

Simonson, Roy W., 1954, Identification and interpretation of buried soils: American Journal of Science, v. 252, p. 705-732.

Smith, Guy D., 1942, Illinois loess: variations in its properties and distribution: a pedologic interpretation: University of Illinois Agricultural Experiment Station Bulletin 490, p. 139-184.

Thorp, J., W. M. Johnson, and E. C. Reed, 1951, Some post-Pliocene buried soils of the central United States: Journal of Soil Science, v. 2, p. 1-19.

Valentine, K.W.G., and J. B. Dalrymple, 1976, Quaternary buried paleosols: a critical review: Quaternary Research, v. 6, p. 209-222.

Wascher, H. L., R. P. Humbert, and J. G. Cady, 1948, Loess in the southern Mississippi Valley: identification and distribution of the loess sheets: Soil Science Society of America Proceedings, 1947, v. 12, p. 389-399.

Wascher, H. L., B. W. Ray, J. D. Alexander, T. B. Fehrenbacher, A. H. Beavers, and R. L. Jones, 1971, Loess soils of northwest Illinois: Illinois Agricultural Experiment Station in cooperation with Soil Conservation Service, USDA, Illinois Agricultural Experiment Station Bulletin 739, 112 p.

Whitehead, Donald R., 1973, Late-Wisconsin vegetational changes in unglaciated eastern North America: Quaternary Research, v. 3, p. 621-631.

Willman, H. B., and John C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204 p.

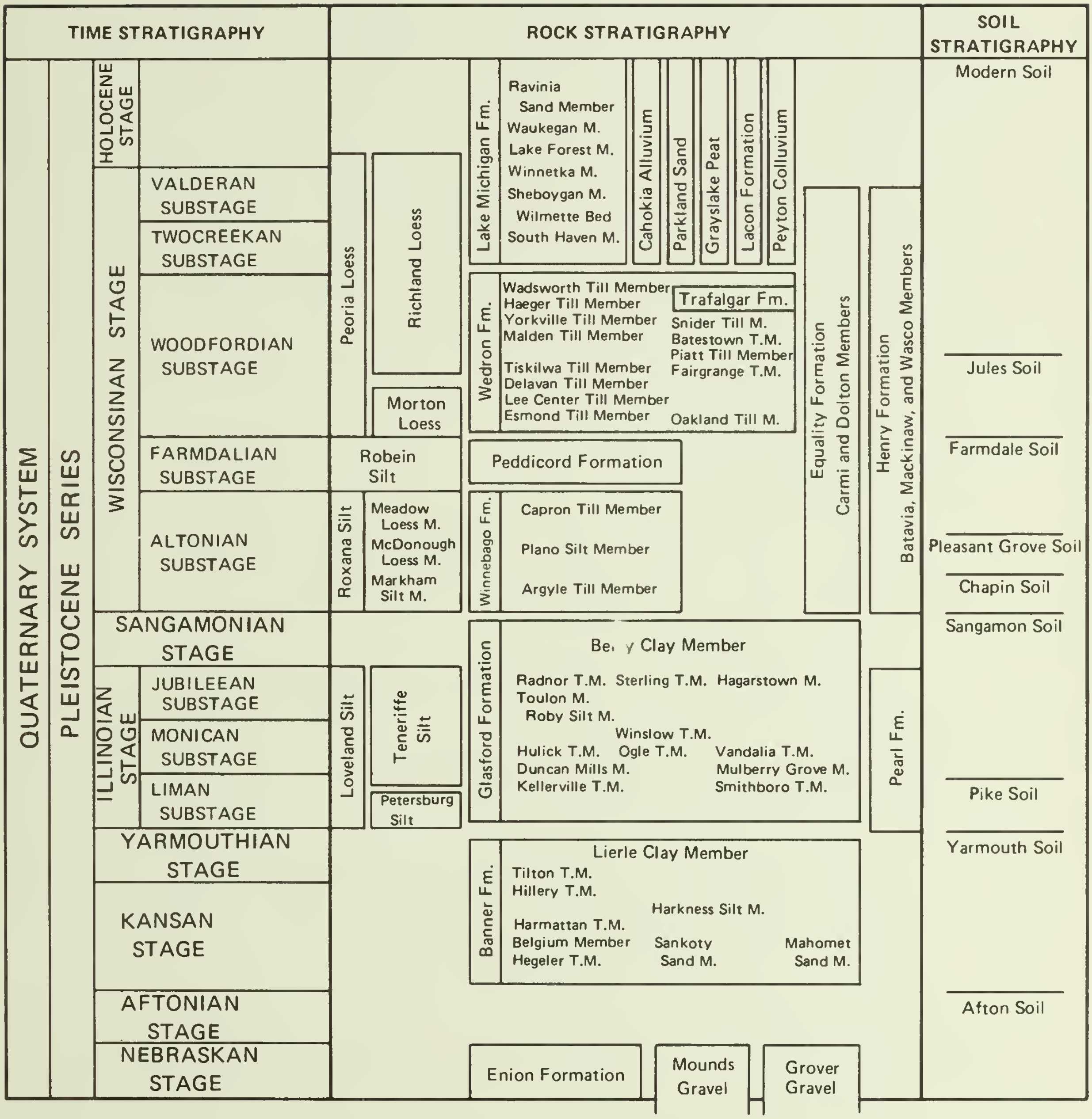
Willman, H. B., H. D. Glass, and John C. Frye, 1966, Mineralogy of glacial tills and their weathering profiles in Illinois. Part II. Weathering profiles: Illinois State Geological Survey Circular 400, 76 p.

Willman, H. B., David H. Swann, and John C. Frye, 1958, Stratigraphic policy of the Illinois State Geological Survey: Illinois State Geological Survey Circular 249, 14 p.

Worthen, A. H., 1870, Geology and palaeontology: Geological Survey of Illinois, v. IV, 508 p.

Worthen, A. H., 1873, Geology and palaeontology: Geological Survey of Illinois, v. V, 619 p.

Wright, H. E., Jr., 1968, The roles of pine and spruce in the forest history of Minnesota and adjacent areas: Ecology, v. 49, p. 937-955.



STRATIGRAPHIC CLASSIFICATION
OF THE PLEISTOCENE DEPOSITS OF ILLINOIS
(Modified from Willman and Frye, 1970.)