

43rd Annual

TRI-STATE GEOLOGICAL FIELD CONFERENCE

at Pere Marquette State Park
Grafton, Illinois

October 5-7, 1979

LEADERS:

Trip 1—Janis D. Treworgy

Trip 2—E. Donald McKay

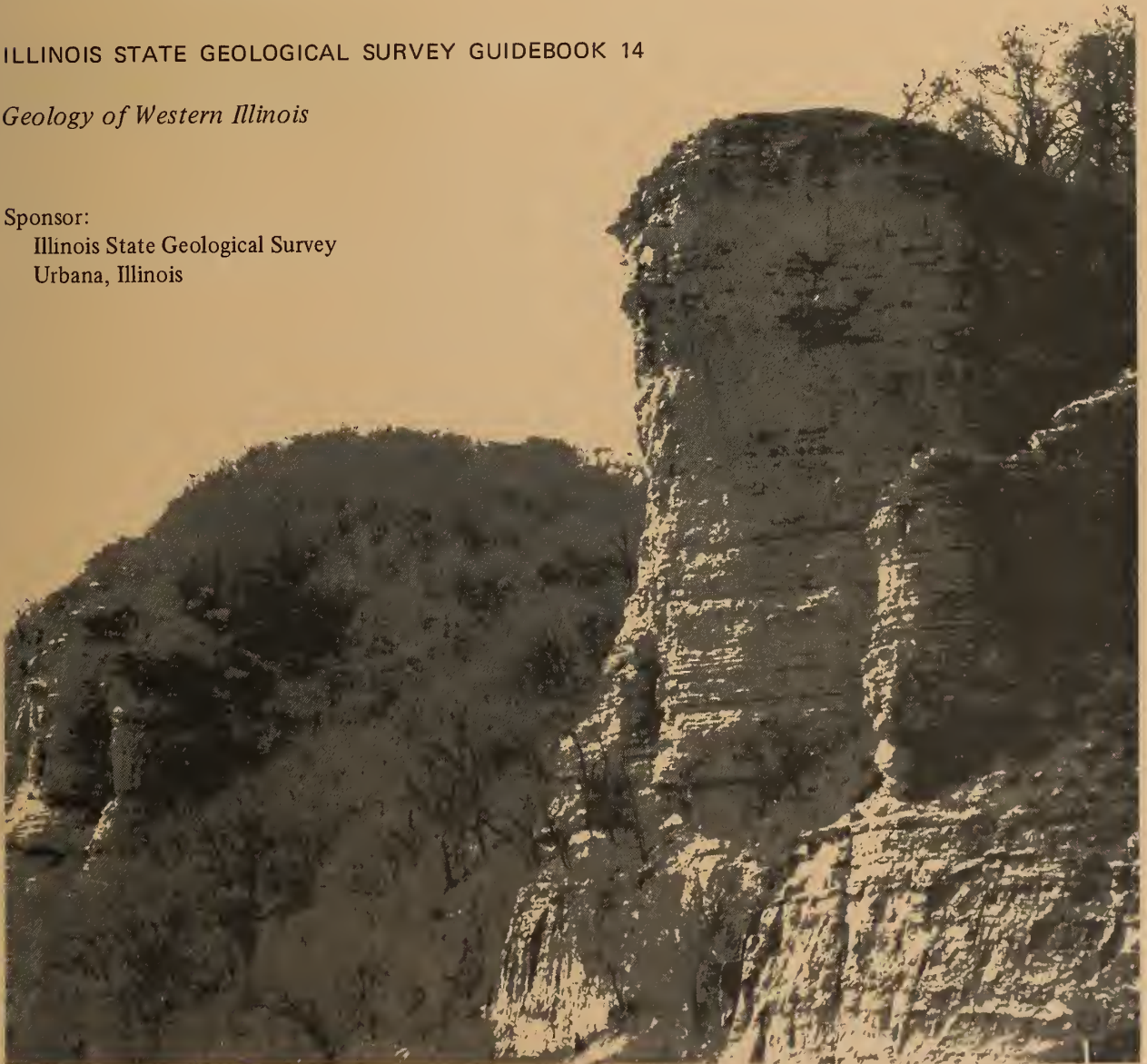
Trip 3—Jerry T. Wickham

ILLINOIS STATE GEOLOGICAL SURVEY GUIDEBOOK 14

Geology of Western Illinois

Sponsor:

Illinois State Geological Survey
Urbana, Illinois





Pere Marquette Lodge
 Conference Headquarters

Cover Photograph: Bluff of Mississippian strata along the Great River Road at Chautauqua, Jersey County, Illinois.

43rd Annual

TRI-STATE GEOLOGICAL FIELD CONFERENCE

Geology of Western Illinois

October 5-7, 1979

ILLINOIS STATE GEOLOGICAL SURVEY GUIDEBOOK 14

LEADERS:

Trip 1—Janis D. Treworgy

Trip 2—E. Donald McKay

Trip 3—Jerry T. Wickham

Sponsor:

Illinois State Geological Survey
Urbana, Illinois

Conference headquarters:

Pere Marquette State Park
Grafton, Illinois

Tri-State Geological Field Conference, 43, 1979.
Geology of western Illinois : Tri-State
Geological Field Conference at Pere Marquette
State Park, Grafton, Illinois, October 5-7,
1979 / sponsored by Illinois State Geological
Survey, Urbana, Illinois. -- Urbana : the
Survey, 1979.

90 p. : ill. ; 28cm. -- (Guidebook -- Illinois.
State Geological Survey ; 14)

1. Geology--Illinois, Western. I. Illinois State
Geological Survey. II. Title. III. Series: Illinois
State Geological Survey. Guidebook 14.


CONTENTS

Saturday, October 6 (full-day field trips)

Trip 1: Structure and Paleozoic Stratigraphy of the Cap au Grès	
Faulted Flexure in Western Illinois	1
Field trip overview	1
Stratigraphic relations in the field trip area	1
Structural features in the field trip area	6
Geomorphology	12
Stop 1. Alton Bluff	14
Stop 2. Riehl Quarry	20
Stop 3. Chautauqua West Section	22
Lunch Stop. Silurian quarry near Grafton	22
Stop 4. Pere Marquette State Park	24
Stop 5. Monterey School Section	31
Trip 2: Stratigraphy of Wisconsinan and Older Loesses in	
Southwestern Illinois	37
Introduction	37
Location	38
Regional stratigraphy	38
Laboratory data and techniques	38
Description of rock-stratigraphic units	40
Stop 1. Paddock Creek Section	46
Stop 2. Maryville Section	48
Stop 3. Pleasant Grove School Section	52
Stop 4. Caseyville Section	59
Stop 5. Canteen Creek Section	61
Stop 6. Falling Spring Section	64

Sunday, October 7 (half-day field trip)

Trip 3: Pre-Illinoian till stratigraphy in the Quincy, Illinois, area	69
Field trip overview	69
Stratigraphy	69
Stop 1. Zion Church Section	75
Stop 2. Harkness Creek Section	81
Stop 3. Mill Creek Section	84
Stop 4. Wand Spring Section	89



Digitized by the Internet Archive
in 2012 with funding from
University of Illinois Urbana-Champaign

<http://archive.org/details/43rdannualtrista14tris>

TRIP 1

STRUCTURE AND PALEOZOIC STRATIGRAPHY OF THE CAP AU GRÈS FAULTED FLEXURE IN WESTERN ILLINOIS

Saturday, October 6 (full-day field trip)

Janis D. Treworgy

FIELD TRIP OVERVIEW

On this field trip we will examine strata of the Mississippian, Devonian, Silurian, and Ordovician Systems that are exposed in bluffs and creek beds along the Mississippi and Illinois Rivers in Madison, Jersey, and Calhoun Counties, Illinois (fig. 1). Included in the trip are some of the best exposures of the Cap au Grès Faulted Flexure and smaller structural features, all of which are associated with the southern extremity of the Lincoln Fold (fig. 2).

The Mississippi River bluffs from Grafton to Alton in Illinois lie along the crest of the Lincoln Fold whose eastward plunge brings successively younger strata down to the bluffs. Exposed strata range in age from Ordovician and Alexandrian (lower Silurian) near Grafton to the upper part of the Valmeyeran (middle Mississippian) near Alton. Our trip will include three stops along this bluff line (stops 1, 2, and 3) to observe Mississippian strata that range from the Kinderhookian Chouteau Limestone to the upper Valmeyeran Ste. Genevieve Limestone (fig. 3). Our lunch stop will be at a Silurian quarry just east of Grafton where one can find well-preserved whole trilobites; the upper 2 meters of the quarry is in Devonian strata. Stop 4 will be at Pere Marquette State Park, where the Cap au Grès Faulted Flexure brings rocks ranging in age from Ordovician to Mississippian to the surface. Our final stop (stop 5) will be at the Monterey School Section on the north flank of the Lincoln Fold in eastern Calhoun County, where rocks ranging from the Ordovician Maquoketa Shale Group to the Mississippian Hannibal Shale are exposed.

STRATIGRAPHIC RELATIONS IN THE FIELD TRIP AREA

The oldest rocks exposed in the field trip area are Ordovician rocks along the crest of the Lincoln Fold (fig. 2) that belong to the Shakopee (Cotter dolomite of Rubey, 1952), St. Peter, and Joachim Formations; the Plattin, Decorah, and Kimmswick Subgroups; and the Maquoketa Shale Group (fig. 3). We will see only Kimmswick (stop 4) and Maquoketa (stops 4 and 5) strata on trip 1. The Kimmswick is typically a coarse calcarenite except in about the upper 7 m, where it becomes progressively finer grained. The relatively high depositional energy of the marine environment in which the calcarenite was deposited (Willman and Kolata, 1978, p. 16) abated toward the end of Kimmswick deposition. The abatement caused the carbonate rocks to be finer grained.

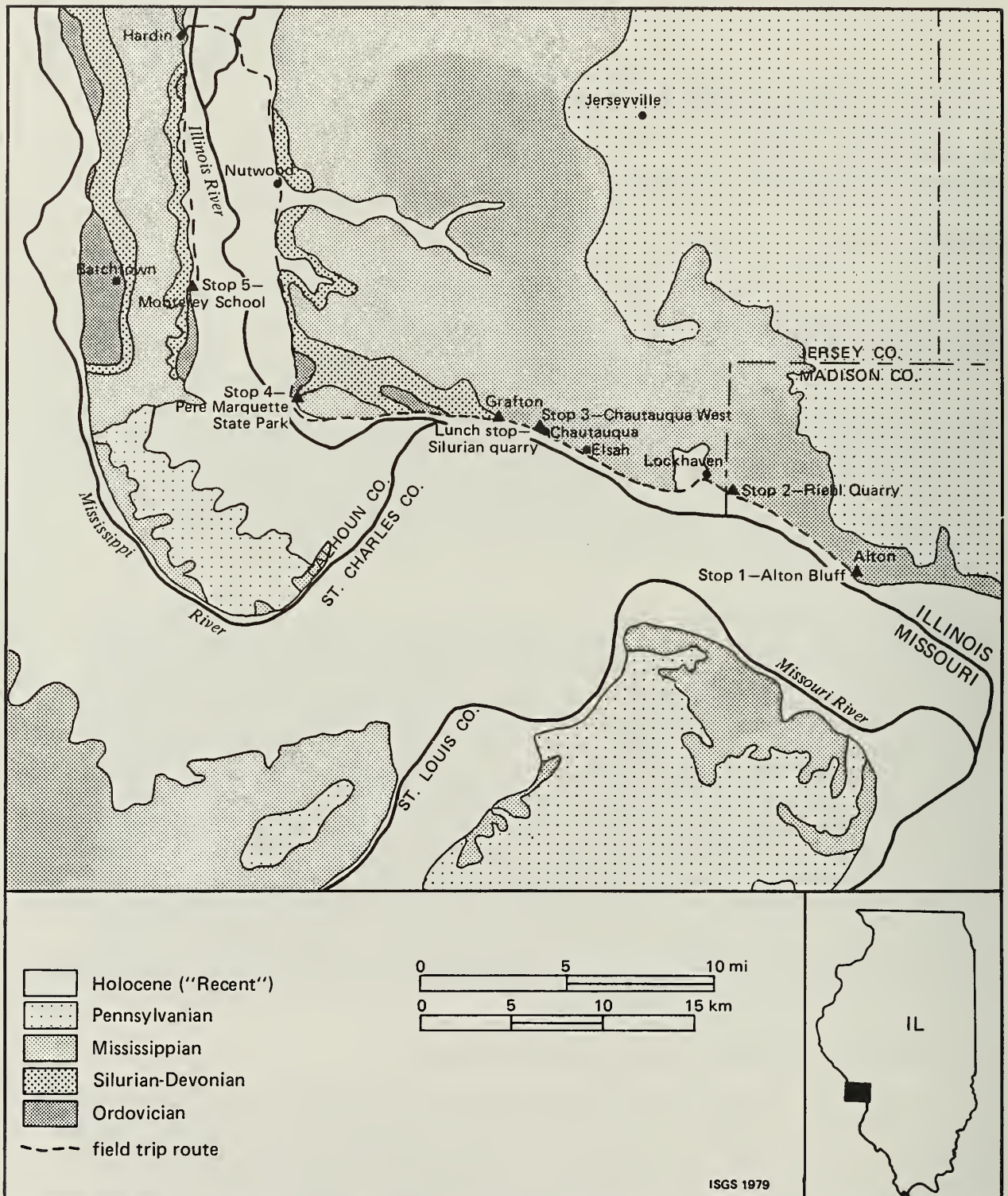


Figure 1. Geology of the field trip area. (Adapted from Illinois State Geological Survey and Missouri Geological Survey state geologic maps.)

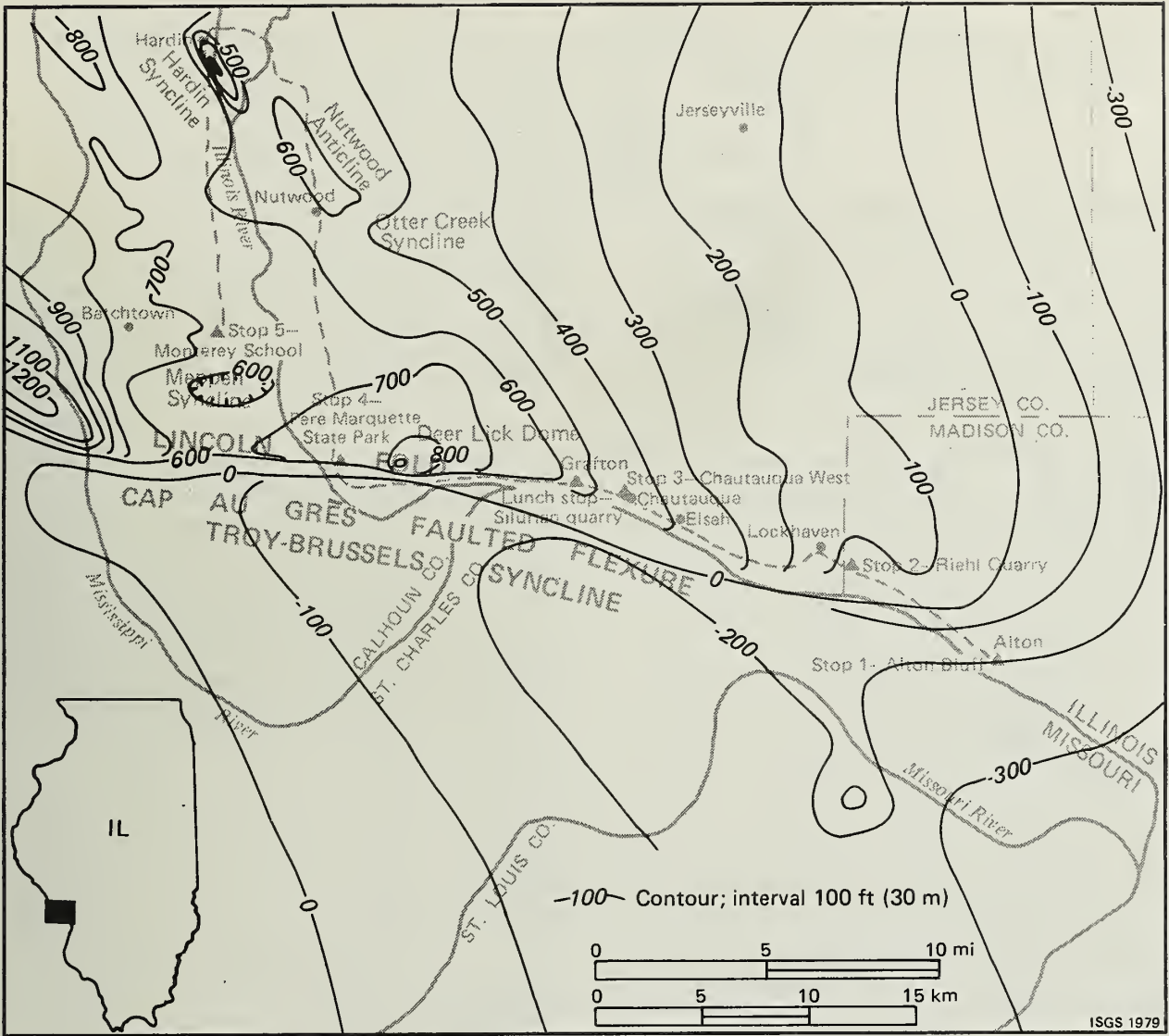


Figure 2. Structure of the top of the Chouteau Limestone. Datum mean sea level. (Adapted from Rubey, 1952, and Collinson et al., 1954.)

The Kimmswick is unconformably overlain by the Maquoketa Shale Group, which is dominantly shale in the area. The lower portion is an argillaceous dolomite and calcareous mudstone that grades upward into softer, noncalcareous mudstones and shales. The nonresistant Maquoketa rocks give way fairly easily to weathering and form slopes and broad valleys between highlands of the harder rocks (Rubey, 1952, p. 22). Uplift and erosion of the eastern United States during Cincinnati time, culminating in the Taconic disturbance, contributed large amounts of clastic sediment to this area (Willman et al., 1975, p. 47).

Unconformably overlying the Ordovician shales are the dominantly carbonate rocks of the Silurian System. They are well exposed at stops 4 and 5.

CENOZOIC

System	Series	Stage	Substage	Formation	Graphic Column	Thickness (m)
Quaternary	Pleistocene	Holocene		Cahokia Alluvium		0-46
			Woodfordian	Peoria Loess / Henry		0-23 0-15
		Wisconsinan	Farmdalian	Robein Silt		0-3
			Altonian	Roxana Silt		0-4
		Sangamonian				
		Illinoian		Loveland Silt / Pearl		0-30
				Glasford		
		Yarmouthian				
Kansan		Banner		0-14		
Tertiary	Pliocene			Grover Gravel		0-9

PALEOZOIC

System	Megagroup	Series	Group	Subgroup	Formation	Graphic Column	Thickness (m)	Stop No.					
Pennsylvanian		Desmoinesian	Kewanee		Carbondale		20-36	1					
					Spoon		0-26						
Mississippian	Mammoth Cave Limestone	Valmeyeran			Ste. Genevieve Ls.		0-9	2					
					St. Louis Ls.		52-73						
					Salem Ls.		16-24	3					
					Warsaw Sh.		15-24						
					Keokuk Ls.		18-21						
					Burlington Ls.		43-61						
										Fern Glen		0-9	4
										Meppen Ls.		0-6	
					Devonian	Knobs	Kinderhookian	New Albany Sh.	Upper	Chouteau Ls.		6-21	5
										Hannibal Sh.		3-21	
Horton Creek		0-8											
Louisiana Ls.		0-1											
Saverton Sh.		0-2											
Silurian	Hunton Ls.	Niagaran			Sylamore Ss.		0-0.1	lunch					
					Cedar Valley Ls. / Hoing Ss. Mbr.		0-12						
Ordovician		Champlainian			Joliet		0-8	6					
					Kankakee		0-9						
					Edgewood		3-15						
					Maquoketa Sh.		30-61						
					Galena	Kimmswick			21-27				
					Decorah		9						
					Platteville	Plattin			30				
	Ancell		Joachim Dol.		24								
			St. Peter Ss.		46								
	Knox Dol.	Canadian	Prairie du Chien	*Shakopee Dol.		3+							

*Only upper part exposed

ISGS 1979

Figure 3. Generalized stratigraphic column for the field trip area. The stratigraphic interval exposed at each stop is shown by the bars on the right.

The Silurian yields whole trilobite fossils in the bluffs near Grafton, which will be the lunch stop. The vertical similarity of the rocks make it difficult to determine stratigraphic relations of the formations that are present in the area (Edgewood, Kankakee, and Joliet). The difficulty is compounded by several unconformities within the formations and by abrupt thinning and thickening of beds caused by local warping during Silurian time.

A major unconformity, the sub-Kaskaskia unconformity, is at the top of the Silurian. Rocks of the Middle Devonian Cedar Valley Limestone rest directly on a beveled Silurian surface and combine with the Silurian to form a thick carbonate succession (Hunton Megagroup) between the Cincinnati (upper Ordovician) Maquoketa Shale Group and the Upper Devonian, Kinderhookian (lower Mississippian) New Albany Shale Group. The Cedar Valley varies in thickness throughout the area as a result of gentle crustal warping in Devonian time (Rubey, 1952, p. 31).

The Cedar Valley is one of the most fossiliferous formations in the area (stop 5). It grades from thin-bedded, fine-grained, cherty, argillaceous, sandy, somewhat fossiliferous limestone in the lower part to thick-bedded, crystalline, pure, highly fossiliferous limestone in the upper part (Willman et al., 1975, p. 116). Its basal member, the Hoing Sandstone, has only a patchy distribution. This sand and the basal Upper Devonian Sylamore Sandstone, a lag deposit which unconformably overlies the Cedar Valley at one locality on the field trip (stop 5), are thought to be reworked St. Peter (Ordovician) sands from the Ozark Uplift (Collinson et al., 1979, p. 9).

Unconformably overlying the Devonian is the Mississippian System, which has been divided into three series on the basis of faunal differences. All of the series have type localities in Illinois. The basal series, the Kinderhookian, is dominantly silty shale (Hannibal Shale—stops 4 and 5), which, in the field trip area, is underlain by the Horton Creek Formation (Horton Creek Member of the Hannibal Formation, Conkin and Conkin, 1973) and overlain by the Chouteau Limestone (stop 3). The middle series, the Valmeyeran (Osagean and Meramecian of others), is relatively thick and is mostly limestone. The Valmeyeran here includes the Meppen Limestone at the base, Fern Glen Formation, Burlington Limestone, Keokuk Limestone, Warsaw Shale, Salem Limestone, St. Louis Limestone, and, at the top, Ste. Genevieve Limestone (stops 1 through 4). The Chesterian Series (upper Mississippian), is also thick and consists of alternating units of limestone-shale and sandstone-shale (Willman et al., 1975, p. 125).

The following discussion of the Mississippian System is taken from Collinson et al., 1979, p. 8, 9: "The Mississippian represents a transition between the widespread carbonate deposition of the middle Devonian and the cyclic marine-nonmarine deposition of the Pennsylvanian. During late Devonian and Kinderhookian time, a large deltaic complex in eastern United States contributed fine clastics to the Mississippi Valley region providing the vast prodeltaic clay and siltstone sheets of the Grassy Creek and Saverton Shales," where they occur just outside the field trip area, and the Hannibal Shale. During late Kinderhookian and early Valmeyeran (Osagean) time, "the delta ceased to feed sediments into the Mississippi Valley area leaving the Illinois Basin in a starved condition..." The Chouteau and Meppen Limestones were deposited during this transition followed by "growth of the massive grain-supported crinoidal limestone of the Burlington Shelf over the western half of the basin covering all of the [Mississippian] stratotype area. During middle Valmeyeran time, the delta, now known as the Borden Delta, once again

filled the Illinois Basin with clastics from the east confronting the Burlington Shelf during deposition of the Keokuk Limestone and eventually covering it with the fine clays of the Warsaw Shale. During late Valmeyeran time (Mera-mecian) carbonate deposition once again returned with very shallow clear seas promoting the great accumulations of bryozoan and foraminiferal bioclastics, oolites and evaporitic deposits of the Salem, St. Louis and the Ste. Genevieve. At the end of the Valmeyeran time, sedimentation became dominated by the delta distributary system of the ancient Michigan River again feeding sediment from the northeast. Shifting of shore line and deltaic distributaries resulted in an alternation of limestone-shale units with sandstone-shale units, characteristic of Chesterian time and presaging the cyclothems of the Pennsylvanian. Sedimentational trends throughout the Mississippian were essentially from the east and northeast with little sediment contributed from the Mississippi River Arch, the Wisconsin Shield or the Ozark Dome."

The contact between the Mississippian and Pennsylvanian Systems is a major unconformity (sub-Absaroka unconformity) in Illinois. Pennsylvanian rocks, including shale, clay, sandstone, limestone, and coal of the Spoon and Carbondale Formations were deposited on the truncated Mississippian surface. Post-Pennsylvanian movement along the Cap au Grès Faulted Flexure and subsequent erosion have left about 45 m of these Pennsylvanian rocks on the structurally low, south side of the flexure and only scattered remnants on the north or high side.

The only stratigraphic record since Pennsylvanian time is the Grover Gravel, which is of Pliocene age. Thin remnants of this old stream gravel occur on the uplands in Calhoun County, both north and south of the Cap au Grès Faulted Flexure.

In Pleistocene time the eastern lobe of the Kansan ice sheet advanced from the northwest and crossed the Mississippi River at only one point in the field trip area, near Batchtown in western Calhoun County. The Illinoian ice sheet advanced from the northeast to the Illinois River, which forms the eastern boundary of Calhoun County. Today Calhoun County stands as an unglaciated, strongly dissected upland area. From the confluence of the Illinois and Mississippi Rivers eastward in our field trip area, the bedrock was overridden by the Illinoian glacier (inside back cover).

Flanking the Illinois River in this area are the Holocene floodplain and three river terrace levels—Brussels, Metz Creek, and Deer Plain. These can be observed from Pere Marquette State Park (stop 4, substops C, H, I, and J), and they are described in those discussions.

STRUCTURAL FEATURES IN THE FIELD TRIP AREA

Regional setting

In the Central Mississippi Valley area, strata dip gently away from the Ozark Uplift (southern Missouri) into the Forest City Basin to the northwest (northwestern Missouri and southwestern Iowa) and the Illinois Basin to the east and northeast (fig. 4). The Ozark Uplift was a positive area in early Croixan time (late Cambrian Period). It subsequently subsided and emerged again at various times throughout the Paleozoic Era, but has remained as a prominent landform since the Pennsylvanian Period (Buschbach and Atherton, 1979, p. 113).

North of the Ozark Uplift, the Lincoln Fold and the Mississippi River Arch, two other major positive features, separate the Forest City Basin on the west from the Illinois Basin on the east. The Mississippi River Arch is a very broad, flat, northward-trending structure that extends generally along the Mississippi River at the Iowa-Illinois state line. Development of the arch began during the Mississippian Period and continued into the Pennsylvanian Period (Edmund and Anderson, 1967; Atherton, 1971, p. 40). The Lincoln Fold is a broad anticline that trends generally northwestward, roughly paralleling the Mississippi River, in northeastern Missouri. It extends approximately to the Iowa-Missouri state line on the north and into Madison County, Illinois, on the south. Local warping of the fold began during the Ordovician Period in association with regional tilting away from the Ozark Uplift; however, at its southern end in Illinois, and perhaps along its entire extent, the fold did not develop as a positive feature until late Devonian-early Mississippian time. Episodes of erosion and deposition of strata in the fold have been recurrent and have been followed by final emergence of the fold during or after late Pennsylvanian time, contemporaneous with the Appalachian Revolution (McQueen, Hinchey, and Aid, 1941; Rubey, 1952).

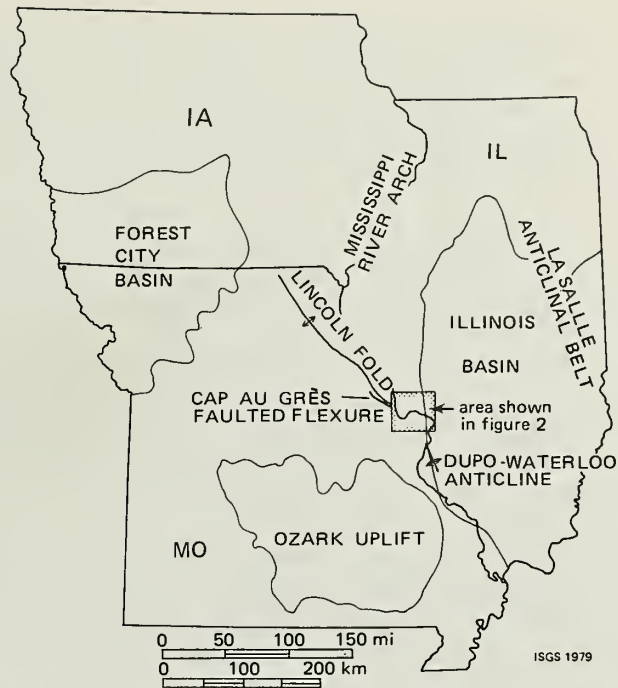


Figure 4. Major structural features in field trip area. Boundary of Ozark Uplift is the areal distribution of base of the Jefferson City Dolomite (Ordovician); Illinois Basin and Forest City Basin boundaries are the 500-foot contour of top of the Ottawa Megagroup (top of Galena Group [Ordovician] in Illinois).

The gentle dips of these broad regional features are locally interrupted by small folds and faults and narrow zones of intense deformation. The southeastern end of the Lincoln Fold where its strike curves sharply eastward as it enters Calhoun County, Illinois, has several smaller structural features superimposed upon its rather gently inclined northern flank. The southern flank of the fold in Illinois forms a steeply inclined, faulted monoclinial flexure known as the Cap au Grès Faulted Flexure (fig. 2).

Cap au Grès Faulted Flexure

The Cap au Grès Faulted Flexure is a narrow zone of strata that dip southward, up to 90°, and are penetrated by discontinuous vertical faults. The flexure extends east-southeastward through Lincoln County, Missouri, southern Calhoun and Jersey Counties, Illinois, and northwestern Madison County, Illinois; it dies out between Grafton and Alton beneath the broad alluvial valley of the Mississippi River. Its name derived from the Cap au Grès bluff (French for "sandstone headland") in western Calhoun County where the St. Peter sandstone crops out just north of the flexure.

The flexure forms the structural transition between the southeastern extremity of the Lincoln Fold to the north and the Troy-Brussels Syncline to the south. Structural relief on the flexure, between the anticlinal and

synclinal axes over a horizontal distance of about 1600 m, averages 300 m down to the south and varies along its strike from about 230 m to 370 m. The zone of dips greater than 5° is about 300 m to 450 m wide (Rubey, 1952). Strata ranging in age from Ordovician to Mississippian are exposed at the surface within this narrow zone of deformation.

The area of the Cap au Grès Faulted Flexure was recognized as one of considerable structural relief long before the turn of the century and was originally thought to be the result of a fault with displacement of at least 200 to 250 m (Worthen, 1870). Stuart Weller (1907, p. 220-221) described the structure in southwestern Jersey County (Pere Marquette State Park, stop 4) as a monoclinical fold, but interpreted the structural anomaly at Dogtown Hollow (described below) in western Calhoun County as a "great fault," attributing the folding there to drag movement. Krey (1924, p. 47) thought the extent of faulting along the flexure was much less than previously reported on the basis of steeply dipping beds that he found unfaulted in eastern Calhoun County. The most detailed work in this area was performed by Rubey (1952). Based on his extensive field studies, he ascribed the greater part of the structural relief to "folding" and indicates that vertical faults are by far subordinate.

Extent and continuity of existing faults are difficult to determine because of limited exposures in the area and the scarcity of subsurface data. Rubey mapped faults only where exposures required them. From calculations on the dips of strata, the distance between outcrops, and the thickness of a missing stratigraphic interval, Rubey determined whether a fault was required to account for apparent anomalies or whether folding would explain anomalies sufficiently. He discussed his methods in detail (Rubey, 1952, p. 140-141) and used Dogtown Hollow in western Calhoun County as an example.

The St. Peter Sandstone crops out and dips 12° to the south on the north side of the eastward-trending Dogtown Hollow, where it opens out into the Mississippi River. About 267 m to the south on the south side of the hollow, the Chouteau Limestone crops out, dipping 75° to the south. Between the outcrops, the alluvial valley of Dogtown Hollow obscures the critical part of the flexure. Rubey calculated that strata as much as 216 m thick could physically be included between the outcrops of St. Peter Sandstone and Chouteau Limestone without the necessity of "an abrupt change of dip or a fault," but that not more than 145 m of the stratigraphic section for this area are actually missing. He concluded that no fault was therefore necessary between the outcrops.

The outcrops at this locality of Dogtown Hollow had suggested to most geologists who had previously investigated the site that a fault would be buried beneath the alluvium, that the fault would extend for several kilometers east and west, and that most of the unusual stratigraphic relations were caused by faulting rather than by warping. Outcrops on trend with the flexure, however, generally exhibit unfaulted steeply dipping beds. Where faults do occur along the flexure, displacements of 1.5 m to 137 m have been observed at various places. Faults do not account for more than one-third of the total structural relief at any locality (Rubey, 1952, p. 141-142).

The best exposures of the Cap au Grès Faulted Flexure are in a series of

outcrops in Pere Marquette State Park along Route 100 (see description for stop 4). On the north side of the exposure, at road level, nearly flat-lying strata of the Ordovician Kimmswick Subgroup crop out. Only 450 m farther south, younger strata that dip steeply southward (up to 90°) are exposed in a series of outcrops. They range in age from Silurian (Edgewood Formation) on the north to Mississippian (St. Louis Limestone) on the south. Several vertical faults parallel to the strike of the structure (strike faults) can be observed or inferred at this locality that displace strata from 1.5 m to 76 m down to the south. The total structural relief at this point is about 260 m, most of which has been caused by warping rather than by faulting.

Detailed interpretation of the mechanics of the Cap au Grès structure by Rubey (1952, p. 146-150) are briefly summarized here. Rubey presents several arguments in support of the concept of a discontinuously faulted monoclinial flexure that discount the concept of drag along tensional normal faults:

1. Thick limestone beds like those along the Cap au Grès Faulted Flexure, are not ductile under ordinary pressures and so would tend to break along a fault rather than become steeply folded in response to fairly rapid tensional forces. "These rocks have much greater strength under compression than under tension, and the mere fact that they have formed steep folds under very light loads alone suggests compression rather than tension" (p. 146).
2. If drag movement along normal faults were the cause of folding, one would expect folding to be subordinate to faulting. The opposite is true, and faulting is everywhere subordinate to folding. In general, the flexure is unfaulted, and some minor faults show displacement down to the north. The inclination of the strata therefore cannot be explained by drag movement. "The relative amount of folding and faulting suggest not that the faulting preceded and caused the steep dips but that the monoclinial flexure came first and was broken somewhat later by strike faults here and there" (p. 146-147).
3. The concept of drag requires that the steepest dips occur immediately adjacent to the fault, but the steepest dips in the Cap au Grès Faulted Flexure occur at least 100 m south of the observed faults.
4. Rubey further explained that "if the Cap au Grès flexure were caused by drag along a normal fault, there must have been a net horizontal extension or pulling apart of the strata" (p. 147). Extension would require great stretching and thinning of the folded strata, or that shortening due to folding is compensated for by heave or horizontal pulling apart. Stretching and thinning can be ruled out by the fact that dips of 60° or more, like those along the flexure, require at least 50 percent thinning, and that all the rocks, except for two shale formations, maintain their normal thicknesses throughout the flexure. Calculations by Rubey on the minimum amount of shortening due to folding and the maximum amount of extension by faulting demonstrated that "extension by faulting at no place exceeded one-half of the...shortening by folding" along the flexure.

Rubey concluded that the Cap au Grès Faulted Flexure was caused by horizontal compression and not by tension. He noted that the above arguments do not refute the possibility of reverse faulting, but that some of the arguments strongly support it. Although observed faults along the flexure are

generally vertical, he suggested that they might be superficial features and that the steeply dipping flexure might reflect a deeply buried reverse fault or faults. He further stated that "the tilted-block character of the Lincoln anticline [Fold] and the Troy-Brussels Syncline and the straightness and abruptness of the intervening Cap au Grès flexure strikingly resemble the surface expression of two tilted blocks" (p. 147).

Another explanation of the nature and origin of the Cap au Grès Faulted Flexure is that upwarping or downwarping of strata over a long period of time occurred in response to slow tensional forces induced by movement of blocks in the basement. This hypothesis does not contradict most of Rubey's premises because tensional forces do not necessarily imply primary faulting and secondary folding or drag. Tensional forces exerted over a period of time would allow limestones to be ductile and thus to be folded or warped rather than sheared and brittly deformed. Regional warping—for example, downwarping or subsidence on the south side of the Cap au Grès Faulted Flexure and upwarping on the north side of the flexure—would exert essentially vertical forces on the strata that would produce the net effect of tensional forces (Krause, personal communication, 1979).

Another hypothesis was proposed by Cole (1961), who speculated that the structure is a left-lateral strike-slip fault that offset two northwest-trending anticlines—the Lincoln Fold and the Dupo-Waterloo Anticline—by a distance of about 50 km. On the basis of numerous borings in Missouri in the vicinity of the Lincoln Fold that penetrate Ordovician rocks and three that penetrate the Precambrian. Cole interpreted the southern end of the Lincoln Fold to terminate against the Cap au Grès "Fault." He also showed the Dupo-Waterloo Anticline to terminate against the "fault." Cole noted that the structural grain in the eastern part of Missouri is generally northwest, on trend with these two anticlinal features, and that this regional grain is broken by the "fault." Further evidence for left-lateral faulting, according to Cole, is that both the Lincoln Fold and the Dupo-Waterloo Anticline have relatively steep western flanks and more gentle eastern dips, and that they have "similar early histories."

Structural history of the Cap au Grès Faulted Flexure

The area of the Cap au Grès Faulted Flexure and southern portion of the Lincoln Fold has undergone recurrent deformation throughout the Paleozoic Era and into later times. Because of a lack of extensive exposures of early Paleozoic rocks and a scarcity of deep borings in Illinois, little is known about the structural tectonic history of that time. Thinning of the Maquoketa Shale to the southwest indicates contemporaneous tilting of the region north-eastward away from the Ozark Uplift. Stratigraphic relations and unconformable contacts provide evidence of continued regional tilting and of local warping of strata during Silurian and Devonian times in the area that was later to be the broad north-northeast flank of the Lincoln Fold just north of the Cap au Grès Faulted Flexure.

Before the Kinderhookian Epoch (Mississippian Period), local warping had given place to gentle structural movement over a broader area. The Troy-Brussels Syncline had begun to subside and the Lincoln Fold to rise and form a barrier between seas to the north and south. Evidence for the formation of these two structures and the transitional Cap au Grès Faulted Flexure includes:

1. Southwestward thinning and eventual absence of the Louisiana Limestone (Upper Devonian Series) and basal Horton Creek Formation (Kinderhookian Series) on the northern flank of the Lincoln Fold. (Rubey, 1952)
2. Overlapping on the north side of the fold of consecutively older strata southwestward by the Hannibal Shale (Kinderhookian Series, Rubey, 1952)
3. Occurrence of two distinct early Kinderhookian faunal provinces from the seas to the north and to the south of the fold, respectively (Weller, 1906)

Recurrent movement on the Lincoln Fold and Troy-Brussels Syncline after Kinderhookian time is evidenced, at least locally, by a slight angular unconformity at the top of the Kinderhookian Chouteau Limestone and the base of the Valmeyeran Meppen Limestone that is exposed at Chautauqua in Jersey County, Illinois (stop 3). Further evidence of movement during the Valmeyeran is thickening of the Meppen and Burlington Limestones northeastward from the crest of the fold down the northern flank.

Major warping along the Cap au Grès Faulted Flexure and associated Lincoln Fold and Troy-Brussels Syncline occurred near the end of the Mississippian Period. Rocks of the St. Louis Limestone are the youngest rocks that are steeply folded in the area, and the Spoon Formation (Desmoinesian Series) is the oldest formation of the Pennsylvanian System that unconformably overlies the previously deformed strata of the Mississippian System. If Mississippian Ste. Genevieve and Chesterian strata had been deposited in the area, and if they had been involved in the deformation, they were since eroded.

The late Mississippian, pre-Pennsylvanian movement on the Cap au Grès Faulted Flexure is thought to have been contemporaneous with other major tectonic events in the Eastern Interior Region, including subsidence of the Illinois Basin down to the south, initial development of the Mississippi River Arch, formation of the La Salle Anticlinal Belt, and uplift of the Nashville Dome (Atherton, 1971, p. 40).

Two later periods of relatively minor movements along the Cap au Grès Faulted Flexure can be determined from geomorphic and stratigraphic relations in the area. The first of these periods followed deposition of the Pennsylvanian strata onto the sub-Pennsylvanian erosional surface. Post-Pennsylvanian, pre-Pliocene erosion beveled tilted Pennsylvanian beds and left strata of the Spoon and Carbondale Formations, about 45 m thick, preserved on the south side of the flexure and only patchy remnants of the two formations on the structurally high north side.

The second period of relatively minor folding of the Cap au Grès Faulted Flexure occurred late in the Tertiary coincident with or immediately following deposition of the Grover Gravel (Pliocene; Willman et al., 1975) onto the flat post-Pennsylvanian erosional surface. The gravel is preserved on both the south and north sides of the Cap au Grès Faulted Flexure and has been displaced about 45 m. This late Tertiary movement is reflected in the upland topography in Calhoun County (stop 4, substop C).

There is no evidence in the area for movement along the flexure during the Pleistocene Epoch. Earthquakes during historic time have been felt in and around the St. Louis area (Heck, 1928). St. Louis University's Earth

and Atmospheric Sciences Department has records from a seismograph in the downtown St. Louis area from 1909 and established a seismic network in 1962 (Heigold, personal communication, 1979). On the basis of these monitoring capabilities, their seismologists at the university have determined that the Cap au Grès Faulted Flexure is an area of "infrequent earthquakes" (Heinrich, personal communication, 1979).

GEOMORPHOLOGY

Several interesting geomorphological features along the Cap au Grès Faulted Flexure are attributable to the structure. The most dramatic is the abrupt change in direction of the courses of the Mississippi and Illinois Rivers. The two rivers flow generally south-southeast, forming the west and east boundaries of Calhoun County, until shortly after they cross the area of the Cap au Grès Faulted Flexure. Then they loop back counterclockwise and flow as one river, the Mississippi River, east-southeast parallel to and superimposed upon the Cap au Grès Faulted Flexure. About 8 km beyond Alton, at Wood River, the Mississippi River curves southward again. As water seeks the path of least resistance, it is reasonable to postulate that the Illinois and Mississippi Rivers sought out the relatively weak zone of deformation along the Cap au Grès Faulted Flexure.

The reflection of the Cap au Grès Faulted Flexure in the upland topography in Calhoun County, already mentioned, can be observed from Lookout Point at Pere Marquette State Park (stop 4, substop C).

Another geomorphological feature that can be related to Cap au Grès Faulted Flexure is the cusped nature of the bluffs on the north side of the Mississippi River along the flexure between Chautauqua and Lockhaven, where the Burlington and Keokuk Limestones are present. (See Figure 5). The bluffs have been eroded in such a way that turretlike segments remain as protrusions, or cusps, while adjacent areas have been weathered back in a crescent shape. These receded areas are concave outward and have occasional zones that have been carved back so deeply as to form shallow caves. Travertine deposits have been found at one locality in the bluffs near Elsay. A possible explanation is that these features developed as subsurface solution cavities or caverns that were formed by ground water moving through the jointed zone of the Cap au Grès Faulted Flexure.



Figure 5. Bluff of Mississippian strata along the Great River Road at Chautauqua, Jersey County, Illinois.

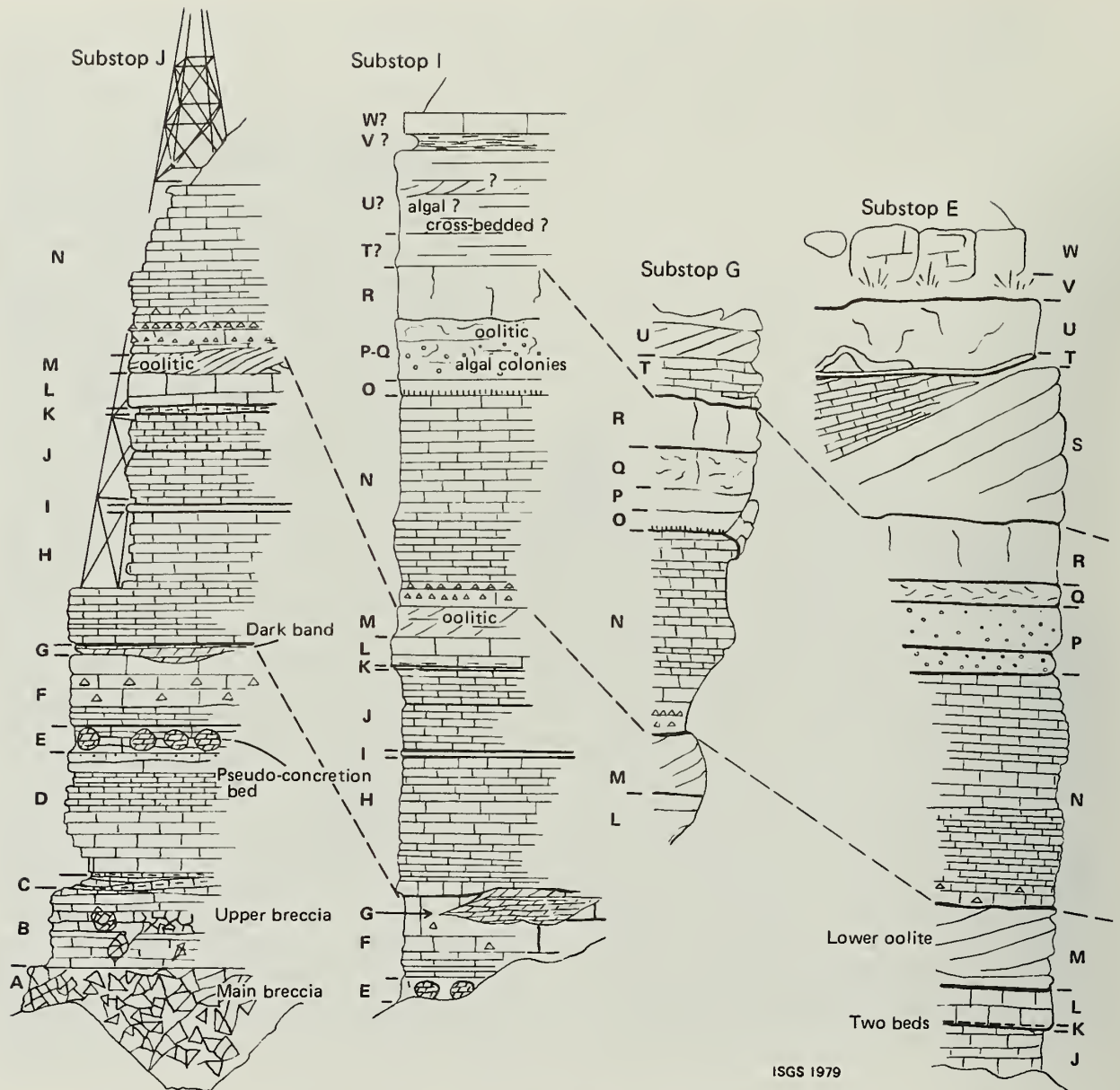


Figure 6. STOP 1, Alton Bluff. NW¼ NW¼ Sec. 14, SW¼ SW¼ Sec. 11, SE¼ SE¼ Sec. 10, T. 5 N., R. 10 W., Madison County, Illinois. (Modified from Collinson et al., 1954.)

STOP
1

STOP 1—Alton Bluff. St. Louis and Ste. Genevieve Limestones. NW¼ NW¼ Sec. 14, SW¼ SW¼ Sec. 11, SE¼ SE¼ Sec. 10, T. 5 N., R. 10 W., Alton Quadrangle, Madison County, Illinois (fig. 6). Modified from Collinson, Swann, and Willman, 1954.

Stratigraphy and sedimentary features of the upper part of the St. Louis and the lower part of Ste. Genevieve Limestones are well shown in the first kilometer of the Mississippi River bluff west of the Alton business district. Several small faults with throws of centimeters to about a meter, and some with horizontal displacements in the order of a few tens of meters, are also apparent. Features of interest at specific points along the bluff are designated as substops A to J. Stratigraphic and structural details at several of the substops are shown in figure 6. The characteristics of the units are briefly described on pages 16 and 17.

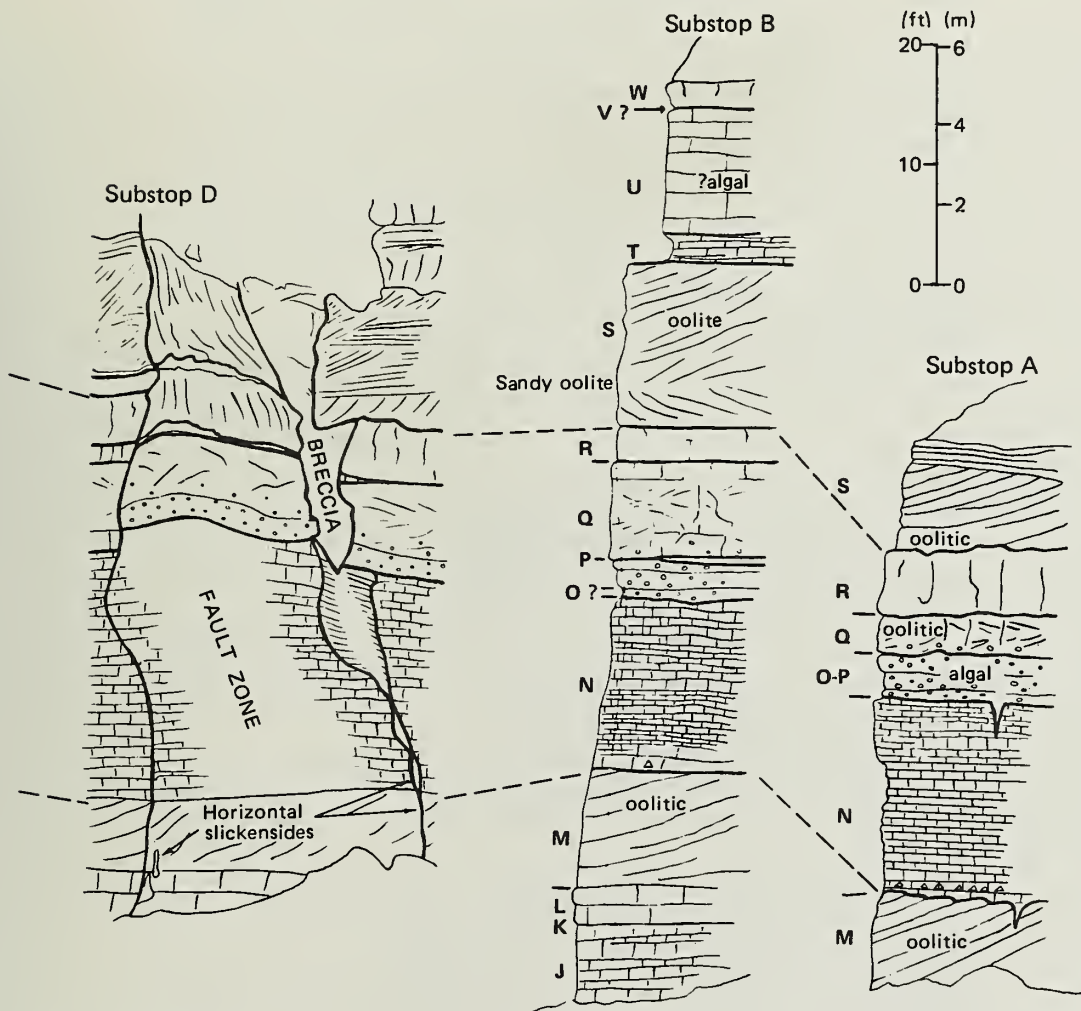
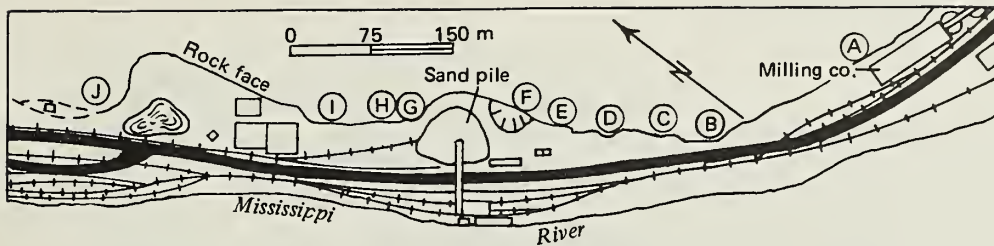


Figure 6. Continued.

STRUCTURAL SETTING

Structurally, we are on the eastward extension of the Cap au Grès Faulted Flexure, here represented by a dip of 3° nearly due south. This southward dip separates the low east end of the Lincoln Fold on the north from the Troy-Brussels Syncline on the south. As the northwest-southeast bluff line cuts the dip at an angle, the apparent dip is somewhat lower. The course of the Mississippi River for 25 km upstream follows the line of the Cap au Grès Faulted Flexure. As might be expected near the end of a major flexure, adjustment has involved minor faulting. Substops D, E, F, G, and J show at least four different varieties of minor faults.

COMPOSITE SECTION OF STRATA

	<u>Thickness (m)</u>
Ste. Genevieve Limestone	
W. Limestone, apparently algal; inaccessible.	1.5
V. Limestone, shaly, or shale, usually making vegetation-covered bench; inaccessible.	0-0.6
U. Limestone, extremely variable, sparingly cross-bedded within one or two 0.3 m beds, partly algal, with colonies a centimeter to a meter or more in diameter, partly calcarenitic, apparently partly oolitic; difficult to access.	1.5-6.1
T. Limestone, thin-bedded, shaly to silty, may be slightly sandy; difficult to access.	0.3-4.6
S. "Sandy oolite." Limestone, coarsely oolitic, sandy (20 percent insoluble), cross-bedded, scour surface with general relief of 15 cm at base with 0.3 m-cracks filled with sandy oolite.	0-5.5
St. Louis-Ste. Genevieve transition zone	
R. "White bed." Limestone, pure (99 percent soluble), "curdy" lithographic to pseudo-oolitic, sparingly fossiliferous, weathers very white; conodonts are rather scarce (5 to 10 per 1000 grams); basal contact varies from irregular (5 cm of relief) with no shale, to smooth with 1.3 cm shale.	0.5-1.8
Q. "Chevron bed." Limestone, oolitic, pure (99 percent soluble) to extremely sandy (50 percent), cross-bedded in thin units, algal colonies toward base; conodonts very scarce; locally prominent shale parting at base, but elsewhere the contact is gradational.	0.5-2.1
P. "Algal conglomerate." Limestone, partly silty and sandy near bedding planes but pure (98 to 99 percent soluble) within beds, fine to oolitic, with algal colonies (curdy, vaguely concentric, lithographic limestone) ranging from pseudo-oolites to 8-cm biscuits and a few 0.3-m cabbageheads, divided into 2 to 4 very prominent beds by shale partings which extend for a few hundred meters and reach thicknesses of 2.5 to 5 cm; where unit O is recognizable the basal contact is a prominent shale parting, elsewhere a scour surface with cracks up to a meter deep.	0.6-1.8
O. "Little White bed." Similar to unit R, lenticular base is scour surface.	0-0.5
N. "Bryozoan beds and chert marker." Limestone, pure (98.5 percent soluble), except for basal cherty zone, fine to lithographic with thin bands of fossils, especially bryozoa; thin bedded, with up to 4 irregular bands of fossiliferous replacement chert in lower 1.8 m, the next lowest band 0.3 m thick in places; conodonts relatively abundant and are of Salem-St. Louis aspect; base is a scour surface with 15 cm relief and cracks a meter deep where unit M is thick; a thin shale parting occurs at base where unit M is thin.	3.0-4.9

	<u>Thickness (m)</u>
M. "Lower oolite." Limestone, slightly silty, ranges from fine calcarenite to very slightly sandy (96 to 98 percent soluble), medium-grained cross-bedded oolite, thin smooth shale parting at base; worn conodonts are moderately abundant.	0.5-2.7
 St. Louis Limestone	
L. "Two beds." Limestone, two well-marked beds, lithographic at top to fine with some coarse fossil debris, slight shale parting at base.	0.9
K. Limestone, very silty, grading downward to prominent shale break.	0.2
J. Limestone, slightly silty (97 to 98 percent soluble), thin-bedded, lithographic to fine with some coarse fossil streaks, purer and thicker bedded at top and just below middle, more shale streaks just above middle and toward base.	2.6
I. "Five-inch bed." Limestone layer between two well-marked shale partings.	0.2
H. Limestone like unit J, slightly more silty (94 to 97 percent soluble).	3.8
G. "Dark band." Dolomite, silty (94 to 95 percent soluble), very finely crystalline, medium brownish gray, pseudoconcretionary; in some places the dolomite is an irregular 2.5 to 60-cm bed, its variations almost entirely compensated by variations in thickness of the underlying unit F; in other places bodies of dolomite up to 1.2 m thick replace the upper part of unit F with slight thickening of the section.	0-0.6
F. Limestone, slightly silty (96 percent soluble toward base to 98 percent soluble toward top), similar to unit J but more calcarenitic and with thicker beds.	1.8-2.1
E. "Pseudoconcretion bed." Limestone, shaly and silty (95 percent soluble), with numerous large oval 15-cm to 1-m silty dolomite pseudoconcretions.	0.9
D. Limestone, similar to unit J, more fossiliferous, purest toward top and base.	3.2
C. Limestone, very silty and argillaceous (90 percent soluble), very fossiliferous.	0.6
B. "Upper breccia." Limestone, much lateral variation, lithographic to detrital, partly fossiliferous, partly cross-bedded, partly evenly bedded, partly brecciated.	2.1
A. "Main breccia." Limestone, average 95 to 96 percent soluble, much brecciated, angular pebbles and boulders of lithographic to pseudo-oolitic limestone in somewhat silty calcarenite or clear calcite matrix; up to 6.7 m thick in quarries to northwest; exposed above low water level of pond near substop J.	3.4

Units A and B apparently vary considerably in thickness, although this variation may be due in part to correlation difficulties between brecciated and unbrecciated portions of the same beds.

The difficulties in placing the St. Louis-Ste. Genevieve boundary on the basis of oolitic limestone in the Ste. Genevieve and lithographic limestone in the St. Louis are well illustrated at this stop. On this bluff the contact has been placed by different workers at four different points, from the base of unit J to the base of unit S.

The situation is complicated by the "Lower oolite," unit M. If this unit is examined at its westernmost exposure near substop J, where it is a silty, very fine-grained calcarenite, little more than 0.3 m thick, with a few oolites scattered through the bottom few centimeters, and apparently conformable to beds above and below, there is little hesitation in calling it St. Louis. The boundary is then placed at some higher abrupt break to predominately oolitic limestone. If, on the other hand, the unit is examined farther east near substop B where it is 2.4-m cross-bedded, oolitic, medium-grained calcarenite, the tendency is to place it in the Ste. Genevieve.

Scour surfaces, sometimes called "unconformities" both above and below such beds as unit M, tend to be well developed where the bed is thick, but the relations fade to apparent conformity within a hundred meters or so as the bed thins. Such surfaces, comparable to those that are described in the literature as "the St. Louis-Ste. Genevieve unconformity," occur in this sequence beneath units C, G, M, N, O, and P; at points within units P and Q; and beneath units R, S, and U.

Substop A. Behind scale and western elevator cell. The beds placed without question in the Ste. Genevieve (units S through W) are rather inaccessible on the west side of Alton. The sandy oolitic limestone (unit S) fills cracks that occur at the top of the "White bed" (unit R). Both the upper and lower surface of the "White bed" are scour surfaces. Only one cherty zone is present in the base of the "Bryozoan beds" (Unit N) here.

The "Lower oolite" (unit M) is thick, and is relatively coarse-grained and slightly sandy. To the northwest it thins and becomes finer grained, and the scour surfaces at the top and bottom are replaced by smooth planes.

Reddish-brown Roxana Silt, overlain by buff Peoria Loess, covers the bluffs.

Substop B. Substop B is a joint face uncovered by road widening. Near the northwest end of the face is a small solution type of fault. The "Two beds" marker (unit L) and unit K are offset about 0.3 m on a high-angle plane, and the fault dies out near the top of the "Lower oolite" (unit M). There are a half-dozen similar faults along the bluff; one is at substop C and another at the small cave opening at substop H.

Substop C. Here is a good example of a solution type of normal fault—a small fault dying out upward and accommodating removal of beds by solution. Whereas there is a 35-cm displacement of the contact between the "Two beds" and the "Lower oolite," there is no displacement of the upper contact of the "Lower oolite."

Substop D. The strongly developed horizontal slickensides, the wide zone of shearing, the slight vertical movement, the curvature of the fault planes, and the variation in thickness of the stratigraphic units between opposite sides

of the fault zone suggest a large horizontal movement, perhaps in the order of 30 m. Note in particular the variation in the thickness of the "Bryozoan beds" (Unit N).

Substop E. The sandy Ste. Genevieve oolite (unit S) thins to disappearance in a very short distance, letting the overlying thin-bedded shaly oolitic limestone (unit T) rest on the "White Bed" (unit R). Note the algal head in the upper algal beds.

Substop F. The "Little White bed" (unit O) appears at the base of the lower algal beds (unit P) at the top of the tree-covered talus cone just south-east of the sand storage area. The lower part of the lower algal beds here grades laterally to sandstone.

Substop G. Complex faulting in the point just north of the sand pile apparently was caused by horizontal movement, probably along very irregular surfaces, as well as vertical movement. Note the apparent displacement of the chert marker. The horizontal movement may be on the order of 30 m.

Substop H. A small cave opening 24 m west of the fault at substop G is developed along a high-angle solution type of normal fault.

Substop I. Parking lot of Abbott Machine Company. Is the dolomite (unit G) primary or secondary? Note that the shale bed thins over it. Is the thinning a result of squeezing during compaction? The main dolomite pseudo-concretion bed (unit E) is a good marker from here northwest.

Substop J. The face is typical St. Louis Limestone—thin-bedded, fine-grained, and highly variable vertically but with little horizontal variation. Starting at the base of unit C, about 8 cycles of deposition are apparent. Each cycle starts with relatively shaly limestone at the base; the partings between the limestone beds are prominent and the beds thin. The beds gradually thicken upward and the shaly partings thin and become obscure. The change is commonly abrupt from the light-colored pure beds at the top of one cycle to the darker shaly beds at the base of the next cycle. The bases of the successive cycles are at the base of unit C, about 1.4 m below the top of unit D, the base of unit E, near the middle of unit F (quite weak), base of unit H, 1.7 m from top of unit H, base of unit I, 1.2 m from top of unit J, and base of unit K.

The breccia (units A and B) is better exposed at stop 4 (substop G), and the problem of its origin is briefly discussed at that point.

STOP 2—Riehl Quarry. Salem and St. Louis Limestones. NW¼ NW¼ NW¼ Sec. 31, T. 6 N., R. 10 W., Elsay Quadrangle, Madison County, Illinois (fig. 7).

Riehl Quarry represents the best exposed and thickest section of the Salem Limestone in western Illinois. The quarry was one of the principal sections considered by Stuart Weller (1906) when he differentiated the Salem for the first time in western Illinois.

Salem-St. Louis contact

The upper 4.4 m (unit J) of the bluff have been assigned to the St. Louis Limestone and are typically thin bedded and fine grained; however, the lower contact with the Salem is not marked by an unconformity or by a definite change in lithology, but rather by a transitional zone (units G, H, and I) in which the thick-bedded, coarse calcarenite of the Salem grades upward into the thin-bedded, fine-grained and lithographic limestone of the St. Louis. This transitional contact can be examined closely by following the private drive up the hill to the high level quarry, or by scaling the bluff at the north end of the quarry.

Northwestward from this place, the Salem becomes increasingly dolomitic and sandy, and near the type Warsaw area 175 km northwest of here it is entirely dolomitic sandstone. Average thickness for the Salem in this area is 16 to 21 m but the formation thickens eastward, attaining a thickness of 24 m near Alton; 30 m, 16 km east of Alton, and 60 m, 48 km east of the city.

Warsaw-Salem contact

Covered at the base of the bluff is about 3 m of bluish-gray, dolomitic Warsaw Shale. Shaly zones characteristic of the Warsaw are also present within the Salem (note units C, E, and I), making the contact between the Warsaw and the Salem gradational in this area. The contact is picked at the base of the predominantly calcarenitic beds typical of the Salem and at the top of the more dolomitic and shaly beds, which are typical of the Warsaw.

Fauna

Brachiopods, corals, occasional *Pentremites*, and foraminifera can be collected from unit D. Conodonts are found throughout the formation and are especially abundant in unit B.

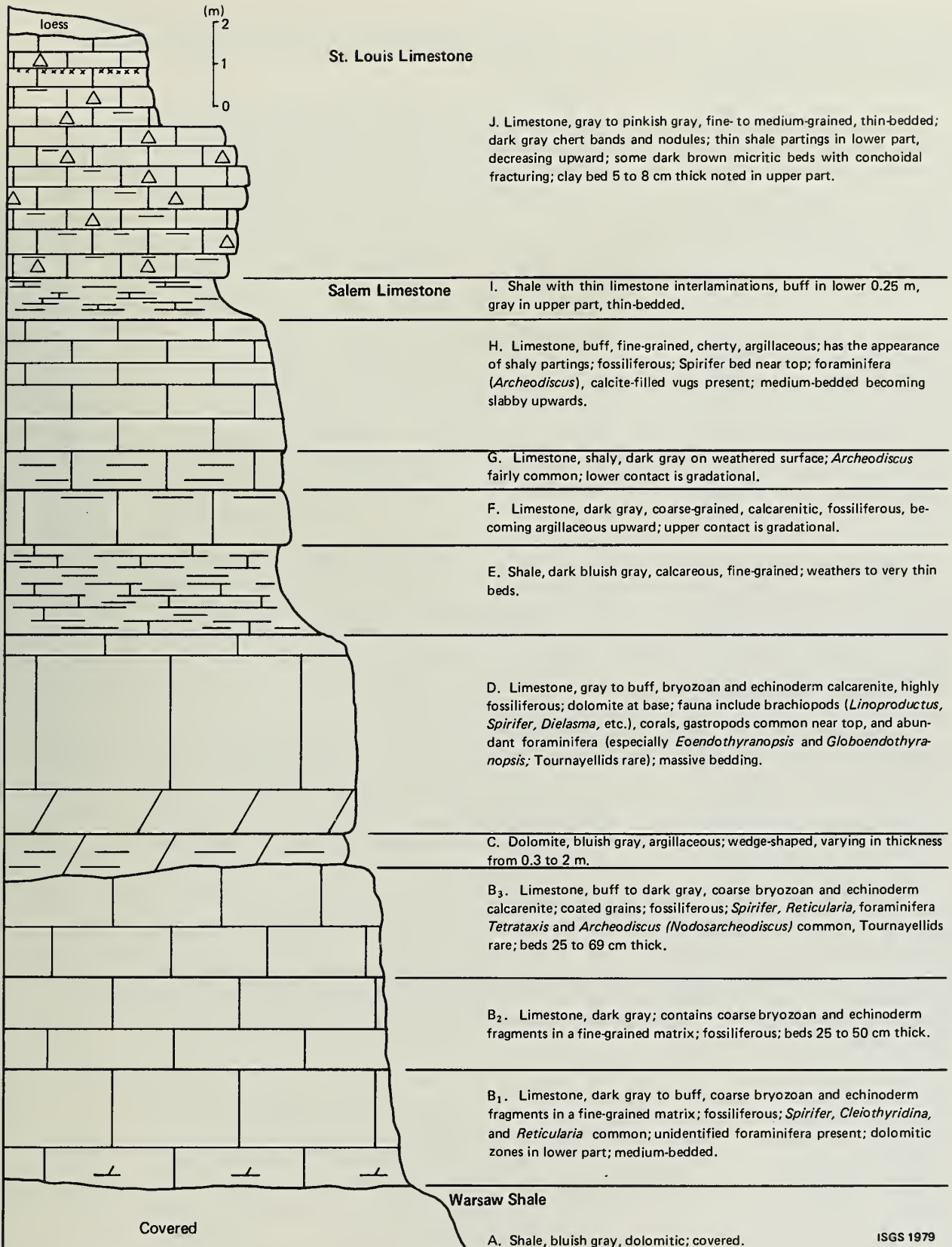


Figure 7. STOP 2, Riehl Quarry. NW¼ NW¼ NW¼ Sec. 31, T. 6 N., R. 10 W., Madison County, Illinois.

STOP 3—Chautauqua West Section. Chouteau, Meppen, Fern Glen, and Burlington Formations. NW¼ NE¼ SE¼ Sec. 13, T. 6 N., R. 12 W., Grafton Quadrangle, Jersey County, Illinois (fig. 8). Modified from Collinson, Swann, and Willman, 1954.

The Chautauqua West Section is of special interest, because it shows a good angular unconformity between the Chouteau Limestone of Kinderhookian age and the Meppen Limestone of Valmeyeran age. The Chouteau is a dense limestone containing macrofossils and conodonts. It is marked by irregular beds ranging from a few to less than 30 cm thick and by wavy bedding planes. The Meppen Limestone at Chautauqua attains its maximum thickness in Illinois (6 m), although only 0.8 km from the most easterly outcrop of the formation.

Chautauqua is the northernmost outcrop at which the Fern Glen Formation is both distinguishable from the overlying Burlington Limestone and well exposed. The Fern Glen is typically a green and red calcareous shale and limestone. At Chautauqua the shale grades upward very gradually through shaly buff limestone into the relatively pure crinoidal limestone of the Burlington. The contact with the Burlington is where the chert nodules lose their greenish color and the limestone becomes comparatively pure. The distinctive red color is not present here, although it can be seen in the bluffs only 0.8 km to the south-east.

An outcrop of the Fern Glen that occurs less than 5 km northwest of Chautauqua in Jerseyville Hollow consists of 6 m of light greenish-gray crinoidal limestone containing greenish-gray chert bands and is almost indistinguishable from the Burlington. Not far west of Jerseyville Hollow, the Fern Glen cannot be differentiated from the lower part of the Burlington, thus indicating that the Fern Glen is actually a shaly facies of the Burlington.

The Burlington Limestone is a shallow-water, largely clastic, carbonate sediment deposited on the western flank of the Illinois Basin while the Borden delta was expanding into the basin from the northeast (Willman et al., 1975).

LUNCH STOP. Silurian quarry near Grafton.

The Silurian dolomite, which is about 30 m thick here, is an excellent building stone and may be found in many local buildings. It is gray on a fresh surface and weathers to a light tan or buff. At this locality the Silurian yields complete, well-preserved trilobites, mostly *Calymene*. In places at the top of the bluff, the Devonian is present and has a maximum thickness of 2 m.

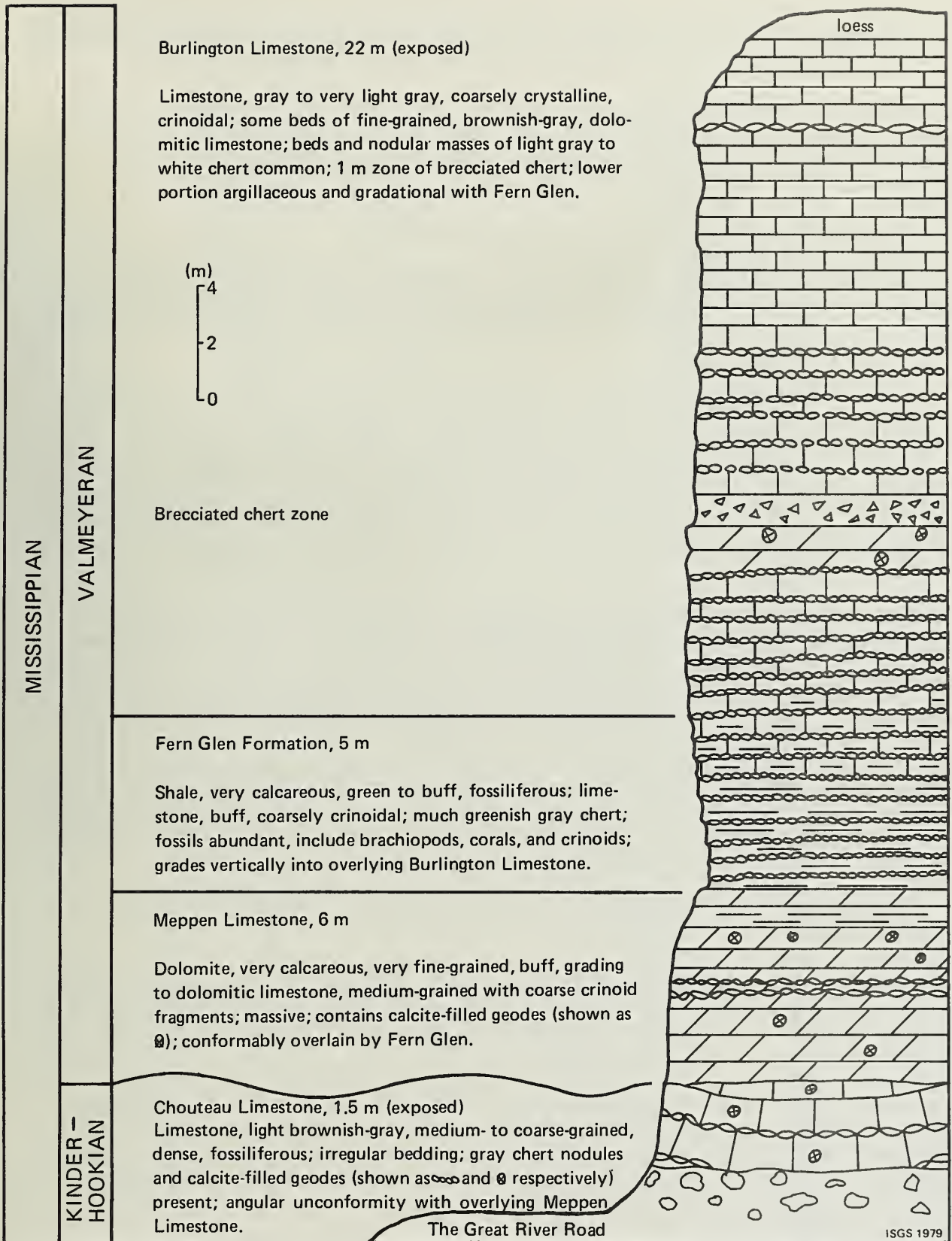


Figure 8. STOP 3, Chautauqua West. NW¼ NE¼ SE¼ Sec. 13, T. 6 N., R. 12 W., Jersey County, Illinois. (Modified from Collinson et al., 1954.)

STOP 4—Pere Marquette State Park. Cap au Grès Faulted Flexure; Ordovician, Silurian, Devonian, and Mississippian Strata; Geomorphology. NW¼ SE¼ Sec. 9, T. 6 N., R. 13 W., Brussels Quadrangle, Jersey County, Illinois (fig. 9). Modified from Collinson, Swann, and Willman, 1954.

The diagram in the lower half of figure 9 shows the organization of stop 4 into a series of substops lettered A through J. The cross section in the upper half of the figure was originally from Rubey (1952) and was later modified by Collinson et al. (1954); the substops are labelled.

Substop A. Kimmswick and Maquoketa (slumped).

Kimmswick Subgroup (Ordovician). The oldest rocks exposed in Pere Marquette State Park belong to the Champlainian (middle Ordovician) Kimmswick Subgroup, which crops out in three small exposures along Highway 100 at the base of the bluff.

The formation is about 21 m thick in the park, but only the uppermost 4.5 to 6 m of the formation can be seen here. Upon weathering, it develops a characteristically rough surface marked by rounded pits. The Kimmswick is typically a coarsely crinoidal, massively bedded, pure limestone; however, in about the upper 7 m it becomes finer grained, as can be seen at these outcrops. When freshly broken, the Kimmswick has a petroliferous odor. Some layers in the Kimmswick are very fossiliferous, and the index fossil *Receptaculites oweni* is locally common.

Maquoketa Shale Group (Ordovician). A 45-m, tree-covered slope of Maquoketa Shale crops out above the Kimmswick. The only exposures of the shale occur in small isolated patches along the bridle trail. The formation consists of greenish-gray, thin-bedded to platy, calcareous shale, which is interbedded with thin layers of argillaceous dolomite. Above the Maquoketa slope is Goat Cliff, a level, fairly continuous cliff a kilometer long that exposes a 24-m Silurian section. At the highest points on the cliff, the Hannibal Shale (Mississippian) can be seen in unconformable contact with the Silurian. At the south end of Goat Cliff, 180 to 240 m north of Twin Springs, Silurian strata start to dip southward into the Cap au Grès Faulted Flexure, and from there to Twin Springs they are covered by loess and slump.

Substop B. Twin Springs. Silurian, Devonian, and Mississippian Systems (fig. 10).

The Silurian reaches road level at Twin Springs, striking approximately east-west and dipping about 28° south. The Twin Springs outcrop is cut by at least 5 faults. The best-exposed fault planes also strike east-west but dip north at about 65°, nearly perpendicular to the beds. The main face (fig. 10) is slightly oblique to both bedding and faults. The minor faults—numbered 1, 2, and 5—are exposed, and the throw of faults 1 and 2 can be estimated visually from the obvious offsets. Drag on fault 1 can be seen best behind and above the balanced boulder. The planes of the two larger faults, 3 and 4, are not exposed. Determination of their throw is dependent upon stratigraphic recognition of the rocks on either side.

Stratigraphy. Five formations are seen in the outcrops above Twin Springs: the lower Silurian (Alexandrian) Edgewood and Kankakee dolomites, the middle Silurian (Niagaran) Joliet dolomite, the Middle Devonian Cedar Valley Limestone, and the lower Mississippian (Kinderhookian) Hannibal Shale.

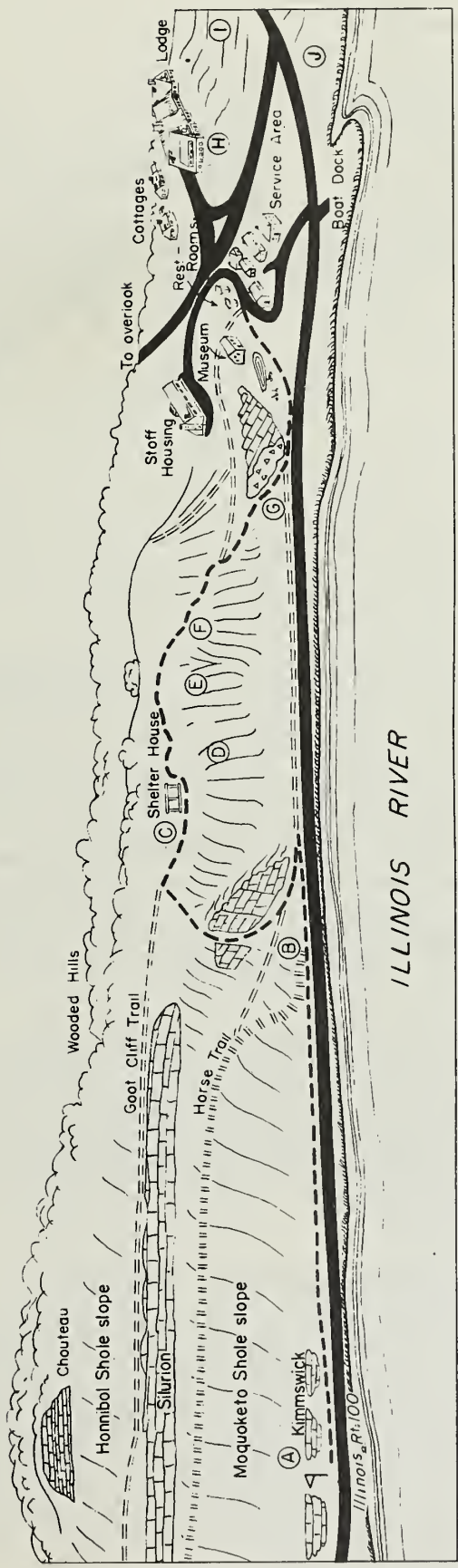
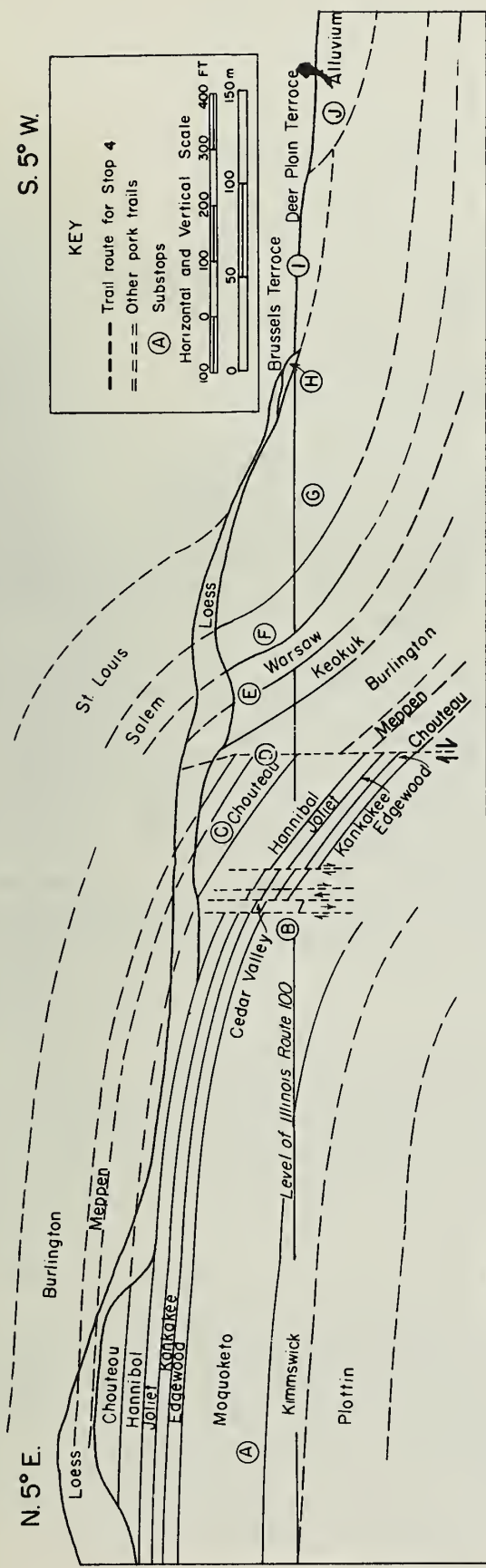


Figure 9. STOP 4, Pere Marquette State Park. Cross section (above) through Twin Springs showing Cap au Grès Faulted Flexure. Trail guide (below) to substops. (Modified from Rubey, 1952, and Collinson et al., 1954.)

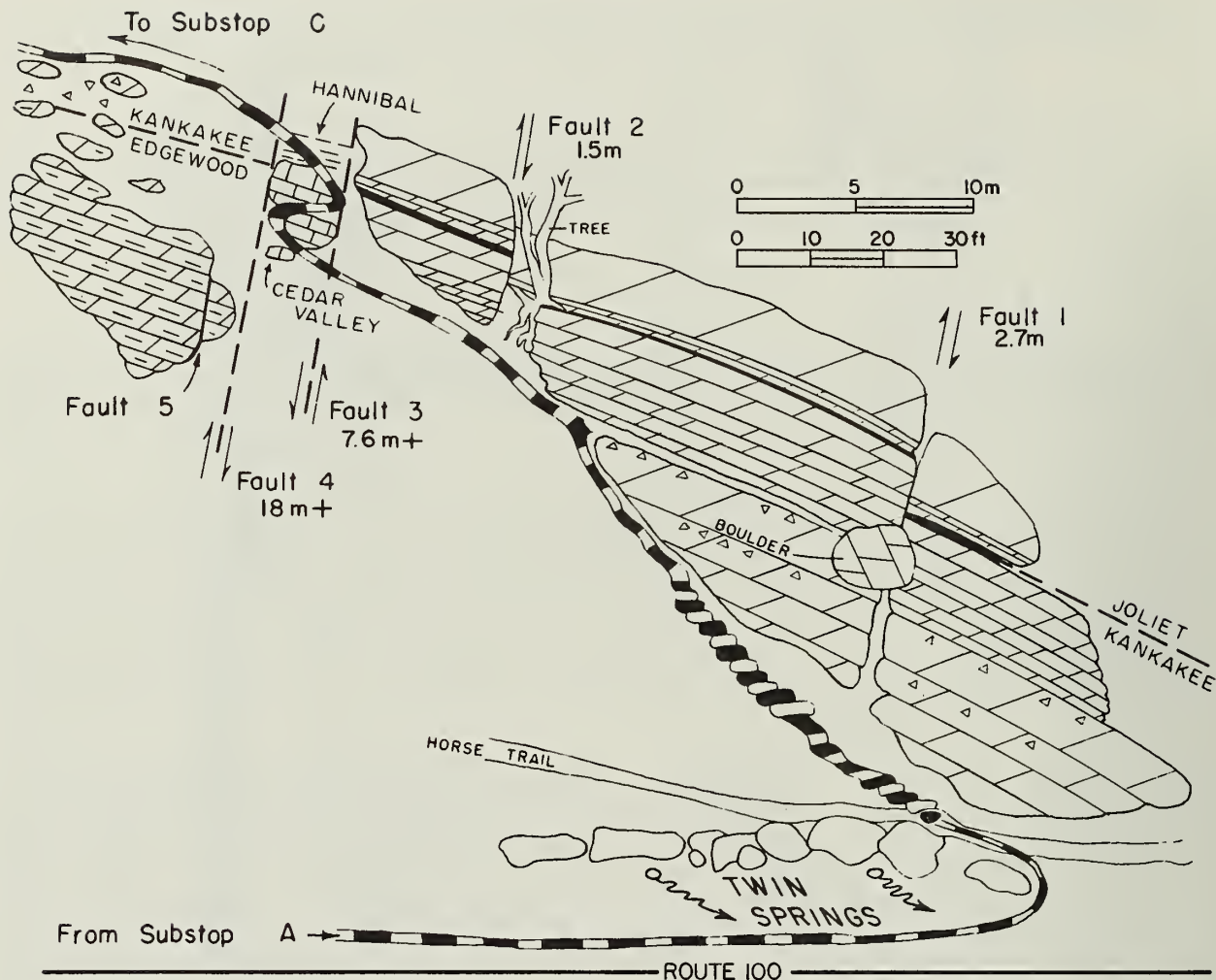


Figure 10. STOP 4, Substop B. Diagrammatic sketch of outcrop at Twin Springs, Pere Marquette State Park. (From Collinson et al., 1954.)

Edgewood Formation (Silurian). The Edgewood dolomite is exposed only to the left of fault 4 and is estimated to be about 12 m thick here. It is a soft, fine-grained, silty, light-gray dolomite which has little visible porosity, but high total porosity. It weathers to smooth yellow surfaces. The Kankakee-Edgewood contact can usually be found with fair assurance and in some spots is sharp and channeled. The two springs occur approximately at this contact.

Kankakee Formation (Silurian). The Kankakee has five recognizable zones:

Zones 1 and 2—A basal zone (1) similar to the underlying Edgewood but less silty, whiter in subsurface, browner on fresh quarried surface, with more visible porosity and coarser grain, weathering rougher, and not as yellow as the Edgewood. It contains nests of the guide fossil *Platymerella manniensis*, a plicate pentameroid brachiopod 2.5 to 3.8 cm long. It and an overlying cherty glauconitic zone (2) are poorly exposed at the top of the section to the left of fault 5, but are well exposed at stop 5.

- Zone 3 —The middle zone is the purest part of the Kankakee and is well exposed at the bottom two-fifths of the outcrop immediately above the springs. It is pure dolomite (over 98 percent soluble), porous, very slightly cherty, rough weathering, and grossly thick-bedded to massive. In detail, thin, wavy, green clay partings characterize this as well as the other Kankakee units, producing an undulatory bedding distinct from the even bedding more common in the Edgewood and Joliet.
- Zone 4 —This zone is distinguished by an abrupt increase in the number and prominence of the shaly partings and occurs above the prominent ledge. In this area of almost complete dolomitization, the unit has a tendency to remain calcareous.
- Zone 5 —About 2 m above the ledge the thin-bedded unit (4) fades gradually into a purer more massive zone (5).

Joliet Formation (Silurian). The basal meter of the Joliet is shaly, silty to very finely sandy, slightly glauconitic, and thinly laminated. This basal unit grades upward to a massive pure bed 3 to 4.5 m thick. This pure dolomite is massive, porous, rough-weathering, and overhangs at the top of the outcrop on all three blocks to the right of fault 3. The south side of the hogback spur appears to be essentially the stripped Hannibal-Joliet contact.

Cedar Valley Limestone (Middle Devonian). About 3 to 3.7 m of Middle Devonian Cedar Valley Limestone occurs between faults 3 and 4, and up to 0.3 m of it occurs on the dip slope of the blocks between faults 1 and 3. The Cedar Valley is a tan, fossiliferous sandy limestone, varying in texture from sub-lithographic to rather coarsely crystalline. It unconformably overlies the Silurian dolomite. The outcrop is very small here, but structurally important. There will be ample chance for collecting from extensive surfaces at stop 5.

Hannibal Shale (Mississippian). The unconformable contact with the Kinderhookian Hannibal Shale is poorly exposed in the path at the top of the Cedar Valley outcrop. The Hannibal is a green, rather pure clay-shale that contains some dark gray to black shale in outcrops both northwest and southeast of here.

Age of faulting. Although the age of the faulting cannot be dated with certainty, evidence for post-Middle Devonian, pre-Mississippian movement on fault 3, and possibly on fault 4, is very strong and is the most likely explanation of the Devonian block exposed on the trail. There seems little possibility of there being appreciable thicknesses of Devonian between Joliet and Hannibal in the blocks to the south of fault 3.

The Pre-Mississippian fault hypothesis requires a fault scarp or post-Hannibal movement along fault 3 to account for the 1.8 to 2.4 m offset in the base of the Hannibal. Development of either a vertical-walled valley or sink-hole on the post-Silurian surface filled with Devonian limestone seems unlikely. Where pre-Devonian karst topography is known—it is common in the subsurface 48 to 160 km east of here—the sediments filling the irregularities are largely shale and sand (such as the Hoing Sandstone, to be seen at stop 5), rather than limestone.

Substop C. Lookout Point. Geomorphology.

From this point you are looking due west across the valley of the Illinois River toward peninsular Calhoun County, Illinois, the crest of which rises about 120 m above the river. On the far side of the river the Deer Plain Terrace of Woodfordian age (Henry Formation) makes a low apron, about 1.5 km wide, which slopes gently (3 to 4 m per km) away from the base of the bluffs. Above it lies the Brussels Terrace of Illinoian age (Pearl Formation), which can be seen clearly in the middle of the large valley almost directly opposite us. The valley, Greenbay Hollow, is developed in the crest of the Lincoln Fold.

The steeply dipping beds of the Cap au Grès Faulted Flexure, on which we are standing, cross the Illinois River valley and transect the opposite bluffs in the small conical hill on the left (south) side of Greenbay Hollow. As can be seen from this point, the upland surface of Calhoun County north of the Cap au Grès Faulted Flexure is about 50 m higher than the south side. Brown chert gravels of the Grover Gravel, which is Pliocene in age, occur on both surfaces. Rubey (1952, pp. 64-66) attributes these relations to renewed movement along the Cap au Grès Faulted Flexure late in Tertiary time following deposition of the gravels.

The crests of the spurs that slope from the upland surface in Calhoun County, when projected eastward into the Illinois River Valley, meet about 38 m above the floodplain and form a submature erosion surface, which Rubey (1952, pp. 109-110) calls the Intermediate Upland Surface. This surface was trenched to a depth of about 45 m below the present floodplain of the Illinois River before Pleistocene time. At that time the valley carried the combined waters of the pre-glacial Mississippi River, which flowed from the upper Great Lakes region, and the Mahomet-Teays River, which headed on the west slopes of the Appalachian Mountains. A major river has occupied this valley for more than a million years, probably several million. The Mississippi River was not permanently diverted to its present position west of the Calhoun County divide until early in Wisconsinan time.

Calhoun County and the southwest corner of Jersey County are unglaciated. The Kansan ice from the northwest reached only as far as the western bluff of Calhoun County, except for a small area near Batchtown, and the Illinoian ice from the northeast advanced to about 5 km east of here. This strongly dissected nonglaciated area, which also includes Pike County north of Calhoun County, is known as the Lincoln Hills Section of the Ozark Plateaus Province (Leighton, Ekblaw, and Horberg, 1948). Pleistocene loess deposits overlie the Grover Gravel in Calhoun County.

Substop D. Fault in Mississippian rocks.

This substop is on the steep slope about 60 m below the shelter house of substop C. The fault is not well exposed but evidence of it is apparent upon careful stratigraphic correlations.

Two different interpretations of this fault may be made, depending on the identification of the strata on the south side of the fault. The first is given by Rubey, who wrote (1952, pp. 141-142) that "the actual fault is exposed as a chert breccia that cuts across the Burlington and Meppen Formations and curves down the steep hillside....This fault is downthrown on the south side; the stratigraphic displacement is only about 65 feet [20 m] and the vertical throw is probably about 150 feet [46 m]" (fig. 9).

A second interpretation may be made if the formation on the downthrown side of the fault is identified as Keokuk Limestone. Such identification is based on the character of the chert breccia in and south of the fault zone. The brecciated chert has dolomitic mottling and banding, which is also a distinguishing feature of some 9 m of extremely cherty brecciated limestone and dolomite in the lowermost part of the Keokuk of this area and northward. Furthermore, the proximity of Warsaw geodes on a nearby slope to the south (substop E) causes some doubt as to whether there is enough space for both the Keokuk and part of the Burlington to be present between the Warsaw and the fault. If the second interpretation is accepted, the stratigraphic displacement on the fault is about 53 m and the vertical throw 76 m.

Substop E. Valley in Warsaw Shale.

South of the shelter house promontory there is a deep re-entrant in the bluff which marks the position of the Warsaw Shale. The shale does not crop out, but its presence is shown by Warsaw geodes, which are scattered over the hillside below the trail. The geodes here are not the type prized by collectors but are largely filled.

Substop F. Salem and basal St. Louis Limestones.

The Salem Limestone is represented in the section along this trail by a long, narrow, steeply dipping outcrop of calcarenitic limestone on the promontory just south of the Warsaw re-entrant. The outcrop is below the brow of the bluff and extends to the base of the bluff, where it includes some oolitic limestone.

Beyond the Salem ridge is a more prominent spur exposing the lower part of the St. Louis Limestone.

Substop G. St. Louis Limestone breccia; upper part of St. Louis, possible Ste. Genevieve Limestone.

St. Louis Limestone Breccia. At this substop the trail descends a series of steps past a nearly complete section of the main St. Louis breccia which was seen at Alton, stop 1, substop J. The breccia, dipping 26° south, is composed mainly of angular fragments of finely calcarenitic to lithographic limestone ranging in size from pebbles to boulders with a matrix of finely calcarenitic limestone which is slightly argillaceous and silty. Some of the fragments are partly rounded, and the deposit is called a conglomerate in some reports. The breccia has a wide distribution extending from southeastern Iowa through western Illinois and northeastern Missouri.

Numerous papers have been written on the origin of the breccia, and a variety of theories have been proposed. The uniform lithology and large size of many of the blocks in the breccia and the lack of sorting suggest an intraformational origin and slight transportation of the blocks. The wide distribution of the breccia suggests the possibility of submarine fracturing of the beds by wave erosion during severe storms. The presence of anhydrite and gypsum in the St. Louis only a few kilometers east of Alton introduces the possibility that the deposit is a collapse breccia resulting from solution of soluble beds. No anhydrite or gypsum has been found associated with the breccia in the outcrop area. Several small faults which die out upward in the section above the breccia were noted at Alton and might be related to the formation of a

collapse breccia; however, the overlying beds are not notably disturbed, and the possibility that the soluble beds were dissolved and that brecciation occurred before the deposition of overlying beds merits consideration. Wave and current action might account for some rounding of the fragments and for infiltration of a uniform calcareous mud which became the matrix of the breccia.

Upper part of St. Louis, possible Ste. Genevieve Limestone. Overlying the breccia, about 21 m of limestone is exposed along the trail that leads to the park museum. Although none of the beds above the breccia can as yet be definitely correlated with beds at Alton, the same type of cyclical deposition is apparent. The top 3 m of the section consists of very sandy coarsely oolitic limestone, which may be Ste. Genevieve or may occur in the St. Louis-Ste. Genevieve transition zone at Alton.

Substops H, I, J. Pleistocene and geomorphology.

The lodge is situated on the Brussels Terrace (substop H) which slopes down in front of the lodge to the surface of the Deer Plain Terrace (substop I), which the main highway crosses. Beyond it there is a drop of only about 3 m to the floodplain level (substop J), which is largely inundated by backwater from the dam at Alton.

The Brussels Terrace (Rubey, 1952, pp. 82-87) consists of interbedded sand and silt (Pearl Formation) deposited in a lake formed by Illinoian ice blocking the river at St. Louis. The water-laid deposits are overlain by 6 m or more of Wisconsinan loess. This terrace is equivalent to the Quiver Terrace described by Robertson (1938) in the Mississippi and Missouri Valleys.

The Deer Plain Terrace (Rubey, 1952, pp. 90-96) is a valley-train of Woodfordian glacial outwash (Henry Formation) heading in the upper reaches of Mississippi Valley. It consists of gravel, sand, and silt. It was the latest valley train in the Mississippi Valley and is not loess covered. Deer Plain aggradation in the Mississippi Valley greatly exceeded that in the Illinois Valley. As a result, the lower Illinois was ponded, and sand and silt were swept into the valley from the Mississippi. The deposits grade up the Illinois Valley from sand to silt, and the terrace surface declines gradually until it passes beneath the Holocene floodplain about 24 km above the mouth of the valley.

The Illinois River is entrenched in the Deer Plain Terrace, but the terrace still occupies about one-third of the width of the valley floor at its mouth. Even before the construction of the navigation dams, the Illinois River was not actively widening its valley, and there were almost no changes in its channel. Aggradation at the mouth of the valley has reduced the river's gradient to 2 cm per km, which is so low that high-water stages at Grafton are as high as low-water stages at Starved Rock State Park, some 375 km north near La Salle, Illinois.

In contrast, the Mississippi River channel has been constantly changing by the formation of new bars and the lateral erosion of its floodplain. In this region Pleistocene terraces have been almost entirely cut from the floor of the Mississippi Valley and are preserved only in the tributary valleys. The composition of the flood plains and the regimen of the rivers were given special study by Rubey (1952, pp. 98-101, 122-136).

STOP 5—Monterey School Section. Ordovician, Silurian, Devonian, and Mississippian Strata. NE¼ NE¼ SW¼ Sec. 11, T. 12 S., R. 2 W., Nutwood Quadrangle, Calhoun County, Illinois (fig. 11). Modified from Collinson, Swann, and Willman, 1954.

At the end of the ridge immediately north of the red house (formerly Monterey School), the section from the Ordovician Maquoketa Shale to the Mississippian Hannibal Shale is continuously exposed except for the covered Maquoketa-Edgewood contact. Structurally this section is on the crest of a very low unnamed subsidiary anticlinal nose plunging gently eastward parallel to, and 4.8 km north of, the crest of the Lincoln Fold (fig. 2).

Maquoketa Shale Group (Ordovician)

The Maquoketa Shale is about 38 m thick in this vicinity. Only the upper 8 m is present here, forming the slope at the base of the ridge. The shale, a greenish-gray nonfossiliferous clay-shale, is occasionally exposed on both sides of the east-west fence just south of the nose of the bluff.

Edgewood Formation (Silurian)

The 14.5 m of buff Silurian dolomite exposed here is referred to two Alexandrian (lower Silurian) formations, the Edgewood and Kankakee.

The dominant lithology of the Edgewood is yellowish-buff, smooth-weathering, fine-grained, silty dolomite (80 to 85 percent soluble) with high true porosity, low naked-eye porosity, and low permeability. The top meter or more are relatively pure. Fossils in the dolomite facies are few—occasional small brachiopod molds, and a few silicified stromatoporoids in the upper part.

Kankakee Formation (Silurian)

Only the lower 4.5 m of the Kankakee is present here; the upper part was removed by pre-Devonian erosion. Beveling of the Silurian is fairly sharp beneath the unconformity. At this outcrop there is no well-defined unconformable surface between the Edgewood and Kankakee Formations, and the exact position of the contact within about a meter of transitional beds can be questioned.

The beds 0.9 to 1.8 m above the base of the Kankakee are pure (up to 98 percent soluble), hard, permeable dolomite. These grade upward to a cherty, very slightly sandy dolomite, which extends from 1.8 to 2.4 m above the base to the top of the Kankakee. Although both Silurian formations are buff dolomite, there is a contrast between the smooth-surfaced, smooth-bedded, yellow-weathering Edgewood and the rough-surfaced, wavy-bedded, grayer Kankakee.

The guide fossil of the lower part of the Kankakee, the oval plicate pentameroid brachiopod, *Platymerella manniensis*, about 2.5 to 3.8 cm long, can be found, together with a few other fossils, on the floor of the small quarry and on loose blocks. It is not common in this exposure.

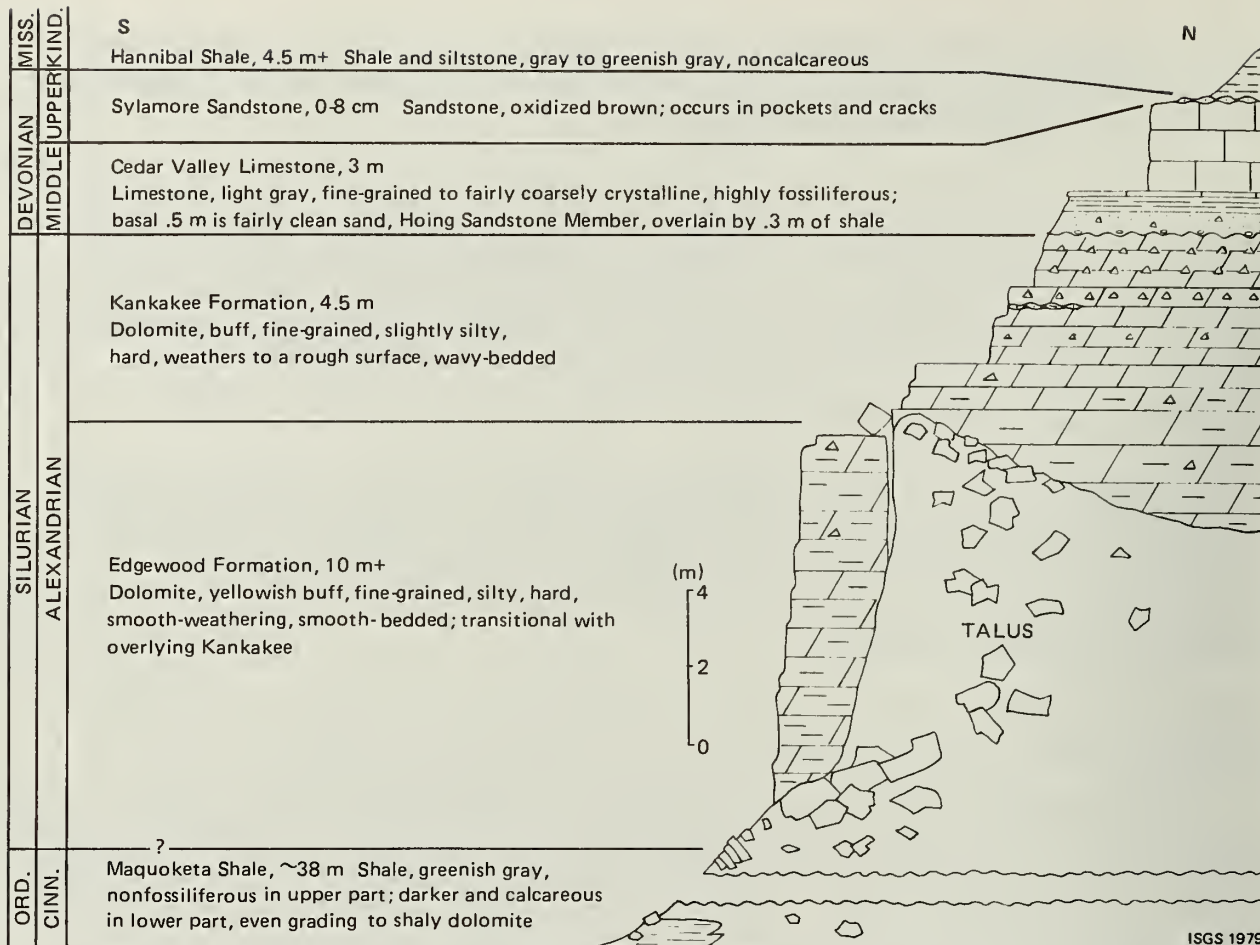


Figure 11. STOP 5, Monterey School Section. NE¼ NE¼ SW¼ Sec. 11, T. 12 S., R. 2 W., Calhoun County, Illinois. (Modified from Collinson et al., 1954.)

Cedar Valley Limestone (Middle Devonian)

The Devonian of Calhoun and Jersey Counties is assigned to the Cedar Valley Limestone, which is late Middle Devonian. Older beds, though still Middle Devonian, are overlapped within a few kilometers both east and north of here, and it is possible that some poorly fossiliferous beds at the base of this and other sections may be outliers of the older Wapsipinicon Limestone.

Here at Monterey School the basal few centimeters of Devonian are extremely varied; dolomite, shale, sandstone, and chert conglomerate immediately overlie the unconformity within a meter or more laterally. Fairly clean sand is abundant enough in the lower 0.6 m to assign it to the basal Hoing Sandstone Member of the Cedar Valley Limestone. The Hoing is the productive sandstone in the Colmar-Plymouth oil field 145 km north. About 0.3 m of shale overlies the Hoing Sandstone, followed by 2.1 to 2.4 m of fossiliferous, fine- to medium-grained, very light gray to tan limestone, which is well exposed in the upper bench of the quarry. A large fauna has been described from lower beds of this limestone at an outcrop a few kilometers north of here (Cooper and Cloud, 1938). The Cedar Valley is the most fossiliferous formation in the field trip area, and the upper beds in this section contain numerous brachiopods, crinoids, bryozoans, and corals represented by the following species:

SPONGES

Astraeospongiium hamiltonensis Meek and Worthen. Saucer-shaped, indistinguishable from *A. meniscus*, the Niagaran guide.

CORALS

- Alveolites*. Honeycomb tabulate; massive, incrusting or ramose. Corallites inclined.
- Aulacophyllum*. Slenderly conical to horn-shaped, solitary rugose corals. Cardinal septum extremely short, leaving fossula empty.
- ?*Cyathophyllum*. Solitary rugose corals, probably close to *Heliophyllum*.
- Cystiphyllodes*. Rugose coral; solitary or weakly aggregate with septa represented only by radiating striae in calice. Vesicular structure. Horn-shaped to cylindrical.
- Favosites*. Honeycomb tabulate; corallites prismatic.
- Heliophyllum* cf. *H. halli* Edwards and Haime. Corallites large, aggregated or weakly compound. Fossula present.
- Hexagonaria*. Compound rugose coral. Massive corallum in which walls of adjacent polygonal corallites are closely united.
- Striatopora*. Twiglike or ramose tabulate.
- Tabulophyllum*. Small solitary rugose coral; corallites turbinate to cylindrical; tabulae flat-topped domes.

CRINOIDS

Numerous stems and isolated plates; occasionally a crown of *Dolatoocrinus*.

BRYOZOANS

- Fenestella*. The lacelike cryptostome.
- Sulcoretrepora*. A straplike branching cryptostome.

BRACHIOPODS

- Athyris* spp. Biconvex, transverse or elongate shells, with or without dorsal fold and ventral sulcus. Broad lamellar expansions developed at growth lines may bear fine radially arranged spines.
- Atrypa* spp. Costate biconvex or convexi-plane shells with brachial valve more convex. Dorsal fold and ventral sulcus present or absent. Costae intersect growth lamellae to give a reticulate appearance.
- Chonetes* sp. Shell small semicircular to semielliptical; concavo-convex; spines along margin of straight hinge.
- Cranaena*. Small to moderate-sized, smooth, ovoid; curved beak.
- Cyrtina* cf. *C. umbonata* Hall. Small, nearly plano-convex; strongly curved pedicle valve; generally nonangular fold and sulcus. Plications simple, gently rounded.
- Orthospirifer iowensis* (Owen). (Formerly called *Spinocyrtia* or *Platyrachella*). Shell large, subequally biconvex; cardinal angles greatly extended. Fold and sulcus strongly developed, rounded to angular, bald. Lateral plications numerous.
- Orthospirifer cedarensis* (Owen). Much like *O. iowensis* but with fold and sulcus distinctly rounded instead of angular. Cardinal angles slightly less extended than in *O. iowensis*.
- Orthospirifer capax* (Hall). Shell medium-sized to large, wider than long, strongly biconvex; broadly rounded antero-lateral margins; generally nonextended cardinal angles.
- Orthospirifer euruteines* (Owen). Shell medium-sized to large, subquadrate, subequally biconvex; lateral slope marked by simple, broad, low plications; fold and sulcus not plicate. Fine radiating costae on fold and sulcus and on plications of lateral slopes.
- Pentamerella arata* (Conrad). Small subcircular costate pentameroid; shallow ventral sulcus and dorsal fold also costate.
- Schizophoria iowensis* (Hall). Transversely elliptical; convex brachial valve; less convex or resupinate pedicle valve; low dorsal fold and ventral sulcus common. Surface covered with fine radial ribs or costellae.
- Schuchertella* sp. Semicircular; hinge line slightly less than greatest width; plano-convex to biconvex; finely costellate; dorsal interarea linear.
- Strophodonta halli* (Cleland). Semicircular to subrectangular, concavo-convex, finely costellate. Several species of *Strophodonta* are probably present.
- Tylothyrus*. Small spiriferoid; lateral slopes plicate; fold and sulcus smooth or with median ridge in sulcus and median groove on fold.

TRILOBITES

- Phacops*. Glabella broad and notably inflated; compound eye well developed, large.
- Proetus*. Cephalon semicircular, vaulted; genal angles rounded or with short spines. Smooth eye, large rims on cephalon and pygidium.

Sylamore Sandstone (Upper Devonian)

Unconformably overlying the Cedar Valley Limestone is the Sylamore Sandstone, an oxidized brown sandstone up to 7.5 cm thick that lies in pockets on and infiltrates cracks in the limestone. At some localities, beds within or at the top of the Cedar Valley are sandy, even to the point of becoming calcareous, fossiliferous sandstone. Northeast of Nutwood the Sylamore Sandstone rests directly on the sandstone of the Cedar Valley. At Monterey School, however, the upper limestone beds are quite pure and the break to the Sylamore is sharp.

Hannibal Shale (Mississippian)

The Kinderhookian Hannibal Shale, the only representative of the New Albany (Chattanooga) Shale Group exposed at our stops, is here almost entirely noncalcareous gray to greenish gray siltstone and shale. Only the basal 3 to 3.6 m can be seen here.

At Pere Marquette State Park the Hannibal Shale rests directly on Silurian or Devonian strata, while here a few centimeters of Sylamore Sandstone separate the Hannibal from the Cedar Valley. North and east of these stops, older Kinderhookian units are intercalated beneath the Hannibal Shale but above sandstones that are similar to the Sylamore. In the Illinois Basin farther east and south, units of the New Albany black shale are found at this position.

ACKNOWLEDGMENTS

Diagrams and discussions of the stops are taken largely from Collinson, Swann, and Willman, 1954, with modifications. Lois S. Kent updated the Devonian fossil list (stop 5), and James W. Baxter contributed the foraminiferal data (stop 2).

REFERENCES

- Atherton, Elwood, 1971, Tectonic development of the Eastern Interior Region of the United States, *in* Background materials for symposium on future petroleum potential of NPC Region 9 (Illinois Basin, Cincinnati Arch, and northern part of Mississippi Embayment): Illinois State Geological Survey, Illinois Petroleum 96, p. 29-43.
- Buschbach, T. C., and Elwood Atherton, 1979, History of the structural uplift of the southern margin of the Illinois Basin, *in* Palmer, James E., and Russell R. Dutcher [eds.], Depositional and structural history of the Pennsylvanian System of the Illinois Basin, Part 2: Invited papers: Field Trip 9/Ninth International Congress of Carboniferous Stratigraphy and Geology, p. 112-115.
- Cole, Virgil B., 1961, The Cap au Grès Fault: Kansas Geological Society Guidebook, 26th Annual Field Conference, p. 86-88.
- Collinson, Charles, R. D. Norby, T. L. Thompson, and J. W. Baxter, 1979, Stratigraphy of the Mississippian Stratotype—Upper Mississippi Valley, U.S.A.: Ninth Carboniferous Congress of Carboniferous Stratigraphy and Geology Field Trip 8 Guidebook, p. 8-9.
- Collinson, C. W., D. H. Swann, and H. B. Willman, 1954, Guide to the structure and Paleozoic stratigraphy along the Lincoln Fold in western Illinois: 39th Annual Convention of the American Association of Petroleum Geologists, 75 p.
- Conkin, J. E., and B. M. Conkin, 1973, The paracontinuity and the determination of the Devonian-Mississippian boundary in the type Lower Mississippian area of North America: University of Louisville Studies in Paleontology and Stratigraphy, no. 1, 36 p.
- Edmund, R. W., and Richard C. Anderson, 1967, The Mississippi River Arch: evidence from the area around Rock Island, Illinois: 31st annual Tri-State Field Conference, 64 p.
- Heck, N. H., 1928, Earthquake history of the United States, Department of Commerce U.S. Coast and Geodetic Survey Special Publication No. 149, 61 p.
- Krey, Frank, 1924, Structural reconnaissance of the Mississippi Valley area from Old Monroe, Missouri, to Nauvoo, Illinois: Illinois State Geological Survey Bulletin 45, 86 p.
- Leighton, M. M., G. E. Ekblaw, and C. L. Horberg, 1948, Physiographic divisions of Illinois: Illinois State Geological Survey Report of Investigation 129, 19 p.
- McQueen, Henry S., N. S. Hinchey, and Kenneth Aid, 1941, The Lincoln Fold in Lincoln, Pike, and Ralls Counties, northeastern Missouri: Kansas Geological Society Guidebook, 15th Annual Field Conference, p. 99-110.
- Rubey, William W., 1952, Geology and mineral resources of the Hardin and Brussels Quadrangles (in Illinois): U.S. Geological Survey Professional Paper 218, 179 p.
- Weller, Stuart, 1906, Kinderhook faunal studies, IV; The fauna of the Glen Park limestone: St. Louis Academy of Science Transactions, vol. 16, p. 468.
- Weller, Stuart, 1907, Notes on the geology of southern Calhoun County: Illinois State Geological Survey Bulletin 4, p. 219-233.
- Willman, H. B., Elwood Atherton, T. C. Buschbach, Charles Collinson, John C. Frye, M. E. Hopkins, Jerry A. Lineback, and Jack A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.
- Willman, H. B., and D. R. Kolata, 1978, The Platteville and Galena Groups in northern Illinois: Illinois State Geological Survey Circular 502, p. 16
- Worthen, A. H., 1870, Geology of Calhoun County, *in* Geology and Paleontology: Worthen Report IV, p. 1-23.

TRIP 2

STRATIGRAPHY OF WISCONSINAN AND OLDER LOESSES IN SOUTHWESTERN ILLINOIS

Saturday, October 6 (full-day field trip)

E. Donald McKay

INTRODUCTION

The principal objectives of this field conference are (1) to show representative sections of the Pleistocene stratigraphy of southwestern Illinois, (2) to examine the Pleasant Grove School Section, the type section for the Roxana Silt, Meadow and McDonough Loess Members, and the Pleasant Grove Soil, (3) to examine some aspects of Wisconsinan loess stratigraphy and mineral zonation, and (4) to present preliminary findings of some current research on the stratigraphy of pre-Wisconsinan loesses and tills along the Mississippi Valley in southwestern Illinois.

Careful selection of study area is required for investigations of the stratigraphy of loess deposits, particularly old loess deposits. Thick loesses in the midwest generally occur only in a narrow band along the large river valleys that acted as loess sources. Because loesses are deposited across upland areas, they are particularly susceptible to erosion, and the most complete loessial record is usually preserved near the source and where the depositional thickness is greatest.

Repeatedly during the Pleistocene, the Mississippi Valley in southwestern Illinois was a major source for loess deposits. The valley in the area visited by the field conference is up to 20 km wide, one of the widest valley segments north of Cairo, Illinois. It lies south of the confluence of the Missouri, Illinois, and upper Mississippi Rivers, and outwash from glaciers in each of these river basins has contributed to the composition of loesses derived from the valley. Two Wisconsinan loesses, the Peoria Loess and the Roxana Silt, exceed a total thickness of 30 m in portions of the valley's eastern bluff. At least three pre-Wisconsinan loesses occur along the valley, but they are preserved only very near the valley.

The Wisconsinan loesses in southwestern Illinois have been studied by many different workers during the past 40 years (Smith, 1942; Leighton and Willman, 1950; Frye and Willman, 1960, 1963, 1965; Leighton, 1960; Leonard and Frye, 1960; Frye, Glass, and Willman, 1962, 1968; Jones and Beavers, 1964; Willman and Frye, 1970; Frye et al., 1974b; McKay 1977, 1979). The stratigraphic relations exhibited by these deposits are generally understood, though uncertainties remain about some details of the timing of depositional and weathering events, the interpretation of which has great significance to our understanding of the history of Wisconsinan glaciation in the Midcontinent. Some of these problems will be examined.

Of perhaps broader interest is recent work on the stratigraphy of some very old loesses that occur in the region. Though the existence of pre-Wisconsinan loesses in the area was long ago confirmed (Leighton and Willman, 1950; Leighton and Brophy, 1961), only recently have data come to light that allow characterization of these units and elucidate their stratigraphic relations to the till record.

Along the Mississippi Valley beyond the glacial margin, three major loess units have traditionally been identified (Wascher, Humbert, and Cady, 1948; Leighton and Willman, 1950; Willman and Frye, 1970). Two of these, the Peoria Loess and Roxana Silt, are Wisconsinan in age, and the third, the Loveland Silt, has been presumed to be Illinoian in age. Evidence from recent studies in southwestern Illinois identifies at least three Illinoian or older loesses in the glacial record along the Mississippi Valley, and raises serious questions about the placement of the Loveland Silt in the Illinoian Stage. The thickest and apparently most widespread of the old loesses in southwestern Illinois occurs on bedrock beneath two glacial tills and a loess, each with a major soil developed in it. This old loess, by virtue of its thickness, is the most likely correlative of the major portion of the Loveland Silt to the south and, by virtue of its stratigraphic position, is the most likely to be pre-Illinoian in age.

LOCATION

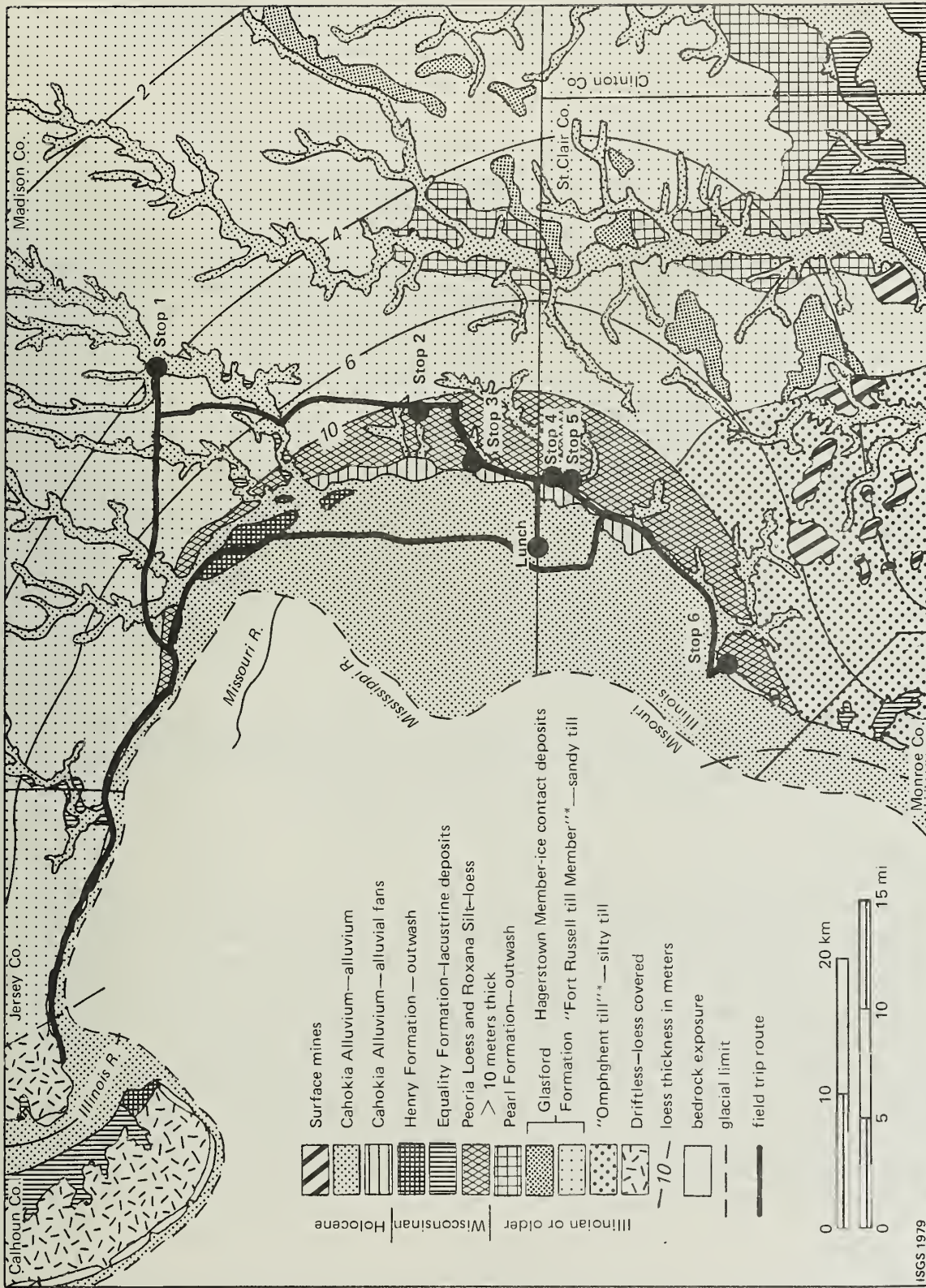
The field conference will convene at Pere Marquette State Park, Jersey County, and proceed eastward and southward along the eastern bluffs of the Mississippi Valley in Madison and St. Clair Counties (fig. 1). We will traverse an area traditionally referred to as the Illinoian till plain, and near the bluffs will cross a dissected thick loess terrain. The final stop will be near the city of Dupou at the south end of the broad Mississippi alluvial plain called the American Bottoms.

REGIONAL STRATIGRAPHY

This field conference will draw heavily on data derived from research programs currently in progress. Some rock-stratigraphic units seen on this trip have only recently been identified and have not been formally named pending further efforts to correlate them with previously named units. For this reason, only informal rock-stratigraphic names have been used for these units, and the following discussion of the informal units should be considered preliminary pending completion of current studies.

LABORATORY DATA AND TECHNIQUES

In certain field situations, many glacial tills, loesses, and other deposits are very similar in appearance, making definite stratigraphic identification difficult. Most units, however, have one or more distinctive textural or compositional characteristics that can be determined in the laboratory and then used with other data to confirm the stratigraphic interpretation. Table 1 lists the analyses used to obtain data for this conference. These data are summarized in the discussion of stratigraphic sections.



* Informal name introduced in this report.

Figure 1. Surficial Quaternary deposits of southwestern Illinois.

TABLE 1. Analytical techniques used in the study of Quaternary deposits

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	E. D. McKay, and others
Radiocarbon dating	Benzene liquid scintillation counting		D. D. Coleman

DESCRIPTION OF ROCK-STRATIGRAPHIC UNITS

The following rock-stratigraphic units are pertinent to or will be viewed on the field trip. This discussion summarizes descriptions of units and places them in stratigraphic order for reference during the field conference (fig. 2).

Enion Formation

The Enion Formation (Willman and Frye, 1970) was said to consist of glacial tills, outwash, and intercalated silts occurring below the base of the Banner Formation or the top of the Afton Soil; it overlies bedrock or the Grover Gravel. The Enion Formation was considered Nebraskan in age. Current studies of Illinoian and pre-Illinoian stratigraphy in central and western Illinois (Lineback and Wickham, 1977; Lineback, 1979; Wickham, this volume) have demonstrated that the pre-Wisconsinan time and rock-stratigraphy is much more complex than is represented by the terms "Glasford Formation" (Illinoian), "Banner Formation" (Kansan), and "Enion Formation" (Nebraskan). In light of these studies, the usefulness of the formational designations, particularly the Banner and Enion Formations in western and southwestern Illinois, is now in question.

Banner Formation

Willman and Frye (1970) include glacial tills and intercalated outwash and silt overlying the Enion Formation or the Afton Soil in the Banner Formation. The Banner was bounded at the top by the Petersburg, Pearl, or Glasford Formations or by the top of the Yarmouth Soil. The same uncertainties of age and

TIME STRATIGRAPHY		14c YR. B.P.	ROCK STRATIGRAPHY		SOIL STRATIGRAPHY			
QUATERNARY SYSTEM	Pleistocene Series	Holocene Stage			Modern Soil			
		Wisconsinan Stage	Valderan Substage	7000	Cahokia Alluvium	Equality Formation Henry Formation	Jules Soil	
			Twocreekan Substage	11000				
			Woodfordian Substage	12500				Zone p-5
				Zone p-4				
				Zone p-3				
		Farmdalian Substage	25000	Peoria Loess	Zone p-2	Zone p-1		
		Altonian Substage	28000	Robein Silt	Zone r-4	Zone r-3	Farmdale Soil	
		Sangamonian Stage	50-75000?	Beyond radiocarbon dating	Roxana Silt	Zone r-2	Zone r-1	Sangamon Soil
			Illinoian Stage		Teneriffe Silt	Glasford Formation	Berry Clay Member	
		"Fort Russell till mbr," *				Pike Soil?		
		"Chinatown silt" *				Unnamed soil C		
Illinoian or older			"Omphgent till" *	Unnamed soil B				
			"Burdick loess" *	Unnamed soil A				

ISGS 1979

* Informal names introduced in this report

Figure 2. Time-stratigraphic, rock-stratigraphic, and soil-stratigraphic units and absolute dating of Quaternary deposits in south-western Illinois. The nomenclature is that used in this guidebook.

correlation that apply to the Enion Formation preclude at present the usage of the Banner for rock-stratigraphic units in southwestern Illinois.

"Burdick loess" (new-informal)

The "Burdick loess" is named for the Burdick Branch, Madison County, Illinois, and is described from two cores in the city of Maryville, Illinois, located in the SE SE SE Sec. 3, T. 3 N., R. 8 W., and the SE NW SW Sec. 2, T. 3 N., R. 8 W. The "Burdick loess" consists of leached massive yellowish brown loessial silt that is high in expandable clay minerals and occurs below the base of the "Omphghent till" or the top of unnamed soil A; it overlies bedrock or residuum. The interpretation of the unit as a loess and the presence of a well developed soil in its upper part suggest that the "Burdick" represents loess deposited during a glacial advance that did not reach southwestern Illinois, and which was separated by at least one period of interglacial warmth from the glaciation that deposited the overlying "Omphghent till."

"Omphghent till" (new-informal)

The "Omphghent (Om'jent) till" is named for Omphghent Township, Madison County, Illinois, and is described in the Paddock Creek Section (Stop 1) located in the SW SW SE Sec. 1, T. 5 N., R. 8 W., Madison County, from cores in Maryville, Illinois (Stop 2) and from other sections and cores in Madison and St. Clair Counties. The "Omphghent till" is a gray, silty till that occurs stratigraphically between the "Burdick loess" beneath and the "Chinatown silt" above. It is the surficial till beyond the margin of the "Fort Russell till member" in western St. Clair and Monroe Counties (fig. 1). The "Omphghent till" characteristically contains a large number of shale and wood fragments, is finer textured, and contains less illite and less dolomite than the overlying "Fort Russell till" (table 2). A strongly developed soil referred to here as unnamed soil B occurs in the upper part of the "Omphghent till" in the borings in Maryville (Stop 2) and is partially truncated in the Paddock Creek Section (Stop 1).

"Chinatown silt" (new-informal)

The "Chinatown silt" is named for Chinatown, Madison County, Illinois, and is described in the Maryville Section (Stop 2) in the SE SE SE Sec. 3, T. 3 N., R. 8 W., and from cores in the city of Maryville. The "Chinatown" consists of massive non-calcareous yellowish brown to grayish brown silt and silty clay loam and is strongly weathered where it contains the profile of unnamed soil C. The upper part of the unit is loessial and grades downward into locally derived colluvium or slopewash material. In the Maryville Section, the "Chinatown silt" overlies the "Omphghent till" and is overlain by the "Fort Russell till." Like the "Burdick loess," the "Chinatown" and the soil developed in it appear to record a glacial-interglacial cycle, the glacial advance stopping short of the southwest Illinois region.

Glasford Formation

The Glasford Formation (Willman and Frye, 1970) includes glacial tills, intercalated outwash deposits, and overlying accretion-gley deposits deposited in Illinois during the Illinoian Stage. It overlies the Petersburg Silt, or in the absence of the Petersburg Silt, rests on the Yarmouth Soil; it is bounded

Table 2. Average textural and mineralogical data for tills in southwestern Illinois, values in percent.

Till unit	Grain-size				Clay mineralogy			Carbonate mineralogy			
	Sand	Silt	Clay ($< 4 \mu\text{m}$)	n	Expand- ables	Illite	Kaolinite & Chlorite	n	Calcite	Dolomite	n
"Fort Russell"	33	43	24	30	27	54	19	18	5	16	29
unnamed till C (Lineback 1979)	35	39	26	21	20	55	25	45	5	15	17
"Omphgent"	23	45	32	8	25	48	27	16	6	5	9

at the top by the Sangamon Soil. The Glasford Formation may contain as many as eight till members in central and western Illinois, and within this till succession five major interstadial or interglacial paleosols have been tentatively identified (Lineback, 1979). The multiplicity of glacial-interglacial cycles that may occur within the Illinoian makes field recognition of a Yarmouth Soil or Kansan drift impossible in southwestern Illinois until rock-stratigraphic correlations are more firmly established. Only the "Fort Russell till member" and Berry Clay Member in southwestern Illinois can be correlated with certainty to the Glasford Formation.

"Fort Russell till member" (new-informal)

The "Fort Russell till member" is named for Fort Russell Township, Madison County, Illinois. The "Fort Russell till" includes illitic dolomitic gray sandy till that is the surficial till over most of Madison and St. Clair Counties (fig. 1 and table 2). It has been described in the Paddock Creek (Stop 1), Maryville (Stop 2), Pleasant Grove School (Stop 3) and Caseyville (Stop 4) Sections where it overlies the "Chinatown silt" or the "Omphgent till" and is overlain by the Teneriffe Silt, Berry Clay Member, or the Roxana Silt. The Sangamon Soil is developed in its upper part or in the overlying Teneriffe Silt where the Teneriffe is present. A soil developed in till beneath Teneriff was described in the Pleasant Grove School Section and correlated with the Pike Soil by Willman and Frye (1970). However, the till at Pleasant Grove School, which Willman and Frye correlated with the Kellerville Till Member, the lowermost till member of the Glasford Formation, is here correlated with the "Fort Russell till." The soil is no longer exposed and has not been found elsewhere. The "Fort Russell till" in southwestern Illinois is probably equivalent to Lineback's (1979) unnamed unit C, which is stratigraphically in the middle of the Glasford Formation and is the fourth till above the Kellerville in central and western Illinois. Unit C and the "Fort Russell till" have almost identical average compositions (table 2). Pending further work on correlation of overlying and underlying units to the Glasford Formation to the north; the "Fort Russell till" in southwestern Illinois remains an informal unit that may be upgraded to a member of the Glasford Formation.

Berry Clay Member

The Berry Clay Member of the Glasford Formation consists of gray accretion-gley of clay, silt, and sparse small pebbles that accumulated in late Illi-

noian and Sangamonian time during the formation of the Sangamon Soil (Willman and Frye, 1970). In the Maryville Section (Stop 2) the Berry Clay Member overlies the "Fort Russell till" and is overlain by the Roxana Silt.

Teneriffe Silt

The Teneriffe Silt consists largely of silt but contains beds of sand and clay deposited during the Illinoian Stage (Willman and Frye, 1970). It may contain outwash as well as eolian deposits. In this report, the Teneriffe Silt is described in the Pleasant Grove School (Stop 3) and Caseyville Sections (Stop 4) and is considered predominantly loessial in origin.

Roxana Silt

The Roxana Silt is largely loess deposited during the Altonian Substage of the Wisconsin Stage. In its type section, the Pleasant Grove School Section (Stop 3), the Roxana is a thick dolomitic loess containing abundant fossil snails and some thin sand layers. It is separable into four zones, r-1 (base), r-2, r-3, and r-4, on the basis of color (Frye and Willman, 1960, 1963; Frye, Glass, and Willman, 1962; McKay, 1977, 1979). These zones are also identifiable with laboratory analyses of carbonate, clay mineral, and grain-size compositions. Differences in composition between zones reflect changes in outwash composition during the Altonian Substage.

The Roxana Silt rests on the top of the Sangamon Soil, and its upper limit is the top of the Farmdale Soil or the base of the Robein Silt or Peoria Loess. The Altonian Substage, the oldest subdivision of the Wisconsin in Illinois (fig. 2), was based on the succession of Roxana Silt exposed in the Alton Quarry Section (Frye and Willman, 1960), and the base of the Wisconsin Stage in Illinois is defined as the base of the Roxana Silt on the A horizon of the Sangamon Soil. Available radiocarbon dates from the Roxana range from $30,980 \pm 400$ (ISGS-400) at the top of zone r-3 to $40,200 \pm 1500$ (ISGS-393) at the base of zone r-3. The base of the Roxana has not been dated directly. It is certainly older than 40,000 radiocarbon years B.P., but estimates of 75,000 radiocarbon years B.P. (Willman and Frye, 1970) may be excessive. The top of the Roxana Silt is estimated at about 28,000 radiocarbon years B.P.

The Roxana Silt has been divided into three members (Willman and Frye, 1970): the Markham Silt (lower part of zone r-1), McDonough Loess (upper part of zone r-1), and the Meadow Loess (zones r-2, r-3, and r-4). The Chapin and Pleasant Grove Soils are developed in the Markham and McDonough Members, respectively. The Meadow Loess Member includes 80 to 90 percent of the total Roxana thickness. The type Roxana Silt, Meadow Loess Member, McDonough Loess Member, and Pleasant Grove Soil will be examined at the Pleasant Grove School Section (Stop 3), and the Roxana will also be seen at the Paddock Creek (Stop 1), Maryville (Stop 2), Caseyville (Stop 4) and Falling Spring (Stop 6) Sections.

Peoria Loess

The Peoria Loess is a thick yellowish brown to gray dolomitic loess that comprises approximately 60 percent of the total Wisconsin loess thickness

along the Mississippi Valley in southwestern Illinois, the remainder being Roxana Silt. The Peoria Loess overlies the Farmdale Soil developed in Roxana Silt or Robein Silt and has the Modern Soil developed in its upper part (fig. 2). The Peoria spans the Woodfordian Substage of the Wisconsin Stage, and it locally may contain deposits of Valderan age, or younger, in its uppermost part. Recent studies of the loess in southwestern Illinois and central Illinois have suggested that the age of the base of the Peoria Loess and its stratigraphic equivalent beneath Woodfordian till, the Morton Loess, is about 25,000 radiocarbon years B.P. From this evidence, the age of the base of the Woodfordian Substage and the top of the Farmdalian Substage have been revised to 25,000 radiocarbon years B.P. from the previously accepted 22,000 radiocarbon years B.P. (McKay, 1979).

Within the Peoria Loess, four clay mineral zones (Frye, Glass, and Willman, 1968) and six dolomite zones (McKay, 1979) have been recognized. Mineral zonation in the Peoria in southwestern Illinois, where five of the dolomite zones are present, records compositional changes in Woodfordian outwash caused by glacial activity upstream. The ages of zones in the Peoria have been determined by extrapolation within loess sections containing wood and other datable material (table 3). The only zone boundary recognizable in the field is the contact of zone p-4 on zone p-3. At this contact there is occasionally found a 2- to 15-cm thick waterlaid bed of clay that records a very high water level in the Mississippi Valley at about 20,000 radiocarbon years B.P. This bed will be seen at the Pleasant Grove School (Stop 3) and Canteen Creek (Stop 5) Sections. The high water level and coincident mineral-zone boundary probably record the blockage of the Ancient Mississippi River by ice of the Lake Michigan Lobe and diversion of the river from its former course through central Illinois to its present course.

Within dolomite zone p-5 along the Illinois Valley and the Mississippi Valley in southwestern Illinois, there occurs a prominent dark band, the Jules Soil (Willman and Frye, 1970). In the Canteen Creek Section (Stop 5), this soil has been dated at 16,020 ± 260 (ISGS-421). The Jules Soil probably formed during a pause in loess accumulation caused by retreat of the Lake Michigan Lobe (Frye et al., 1974b).

Table 3. Mineral zonation in the Peoria Loess in southwestern Illinois

Clay mineral zones	Dolomite zones	Percentage total Peoria thickness	Radiocarbon age
IV (low illite)	p-5 (high dolomite)		12,500 B.P.
III (high illite)		50	
			18,000 B.P. —
? (low illite)	p-4 (low dolomite)	15	
			20,200 B.P. —
II (intermediate illite)	p-3 (intermediate dolomite)	25	
	p-2 (high dolomite)	5	23,400 B.P. —
I (low illite)	p-1 (low dolomite)	5	24,000 B.P. —
			25,000 B.P. —

DESCRIPTIONS OF SECTIONS

STOP
①

STOP 1—Paddock Creek Section. SW¼ SW¼ SE¼ Sec. 1, T. 5 N., R. 8 W., Madison County, Illinois, Prairietown 7.5-minute Quadrangle (fig. 1).

The section, a large stream-cut exposure located 15 km east of the Mississippi bluffs on the outside of a meander loop of Paddock Creek, offers one of the best exposures in the field trip region of the two principal till units in the area (figs. 3, 4). The section has not been previously described.

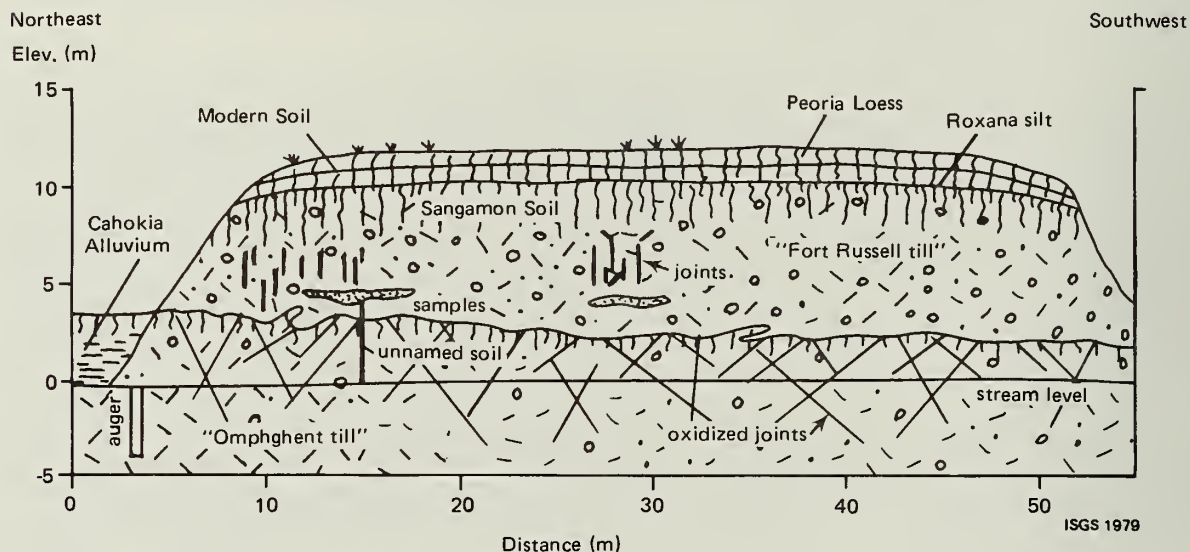


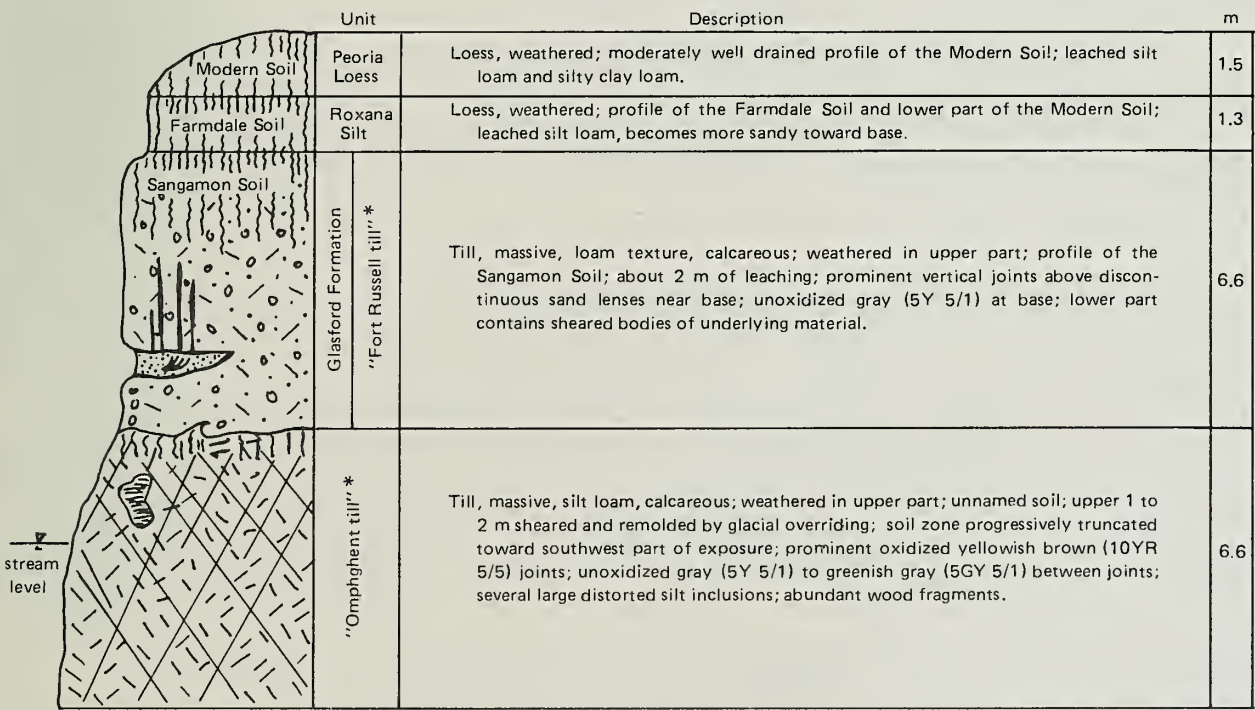
Figure 3. Sketch of the Paddock Creek Section, Stop 1.

The two tills exposed at Paddock Creek are the "Omphgent till" (lower part) and the "Fort Russell till." If formalized, both units will have the Paddock Creek Section as their type section. The "Omphgent till" is a gray calcareous silty to clayey till exposed from stream level to about 3 m above stream level. An auger hole at stream level at the north end of the section penetrated an additional 4 m of "Omphgent till." Deep oxidation along joints truncated by the overlying "Fort Russell till" indicates that a strongly developed soil probably existed on the "Omphgent till" prior to deposition of "Fort Russell." This soil in the absence of the "Chinatown Toess" would represent the combined development of unnamed soils B and C (fig. 2). The soil is progressively truncated to the south in the exposure where the "Fort Russell" rests directly on calcareous "Omphgent till." At the north end of the exposure, a severely distorted B horizon is still present on the lower till.

The "Omphgent till" at Paddock Creek has a grain-size composition of 23 percent sand, 54 percent silt, and 23 percent < 4 μm clay, an average unoxidized clay mineral composition of 24 percent expandable clay minerals, 47 percent illite, and 29 percent kaolinite plus chlorite, and a carbonate mineral composition of 8 percent calcite and 9 percent dolomite. High illite and high calcite tills with compositions like the "Omphgent till" have not been identified within the Illinoian of central and western Illinois (Lineback, 1979). However, similar tills do occur in east-central Illinois (Johnson et

al., 1972) where they are included in the Banner Formation and were probably deposited by ice from the Erie or Saginaw Bay Lobes (Johnson, 1976). The "Omphghent till" occurs in the subsurface in much of Madison and St. Clair Counties and extends beyond the limit of the "Fort Russell till" in western St. Clair and Monroe Counties (fig. 1). Borings for Alton Lock and Dam No. 26 penetrated "Omphghent till" in the bottom of the Mississippi Valley beneath 20 to 25 m of alluvium and outwash, indicating that deep incision of the valley into bedrock preceded deposition of the "Omphghent till." The "Fort Russell till" is a sandy illitic dolomitic till that is 6.6 m thick in the Paddock Creek Section. The "Fort Russell" has a grain-size composition of 34 percent sand, 42 percent silt, and 24 percent < 4 μm clay, an average unoxidized clay mineral composition of 24 percent expandable clay minerals, 55 percent illite, and 21 percent kaolinite plus chlorite, and a carbonate composition of 4 percent calcite and 18 percent dolomite. The "Fort Russell till" is tentatively correlated with Lineback's (1979) unnamed till C (table 2) and on that basis is included in the Glasford Formation (fig. 2). The "Fort Russell" is the surficial till unit over most of Madison County and has been found at one site on the west bluff of the Mississippi Valley near Larimore, Missouri, in St. Louis County. In the eastern part of Madison County the "Fort Russell" may be overlain by a sandier, more illitic and more dolomitic till. Tills with high illite and high dolomite contents in central Illinois are generally considered to have been derived from a Lake Michigan Lobe source.

A moderately well drained profile of the Sangamon Soil is developed in the upper part of the "Fort Russell till." The Sangamon Soil and overlying loesses are not accessible in the main exposure but can be seen along the shallow roadcut just to the south. Wisconsinan loess thicknesses of 3.3 to 3.9 m occur on upland areas in the vicinity of the section. The 2.8-m loess thickness at Paddock Creek is partially truncated by erosion on the hill slope.



* Informal name introduced in this report

ISGS 1979

Figure 4. Generalized description of stratigraphic units exposed in the Paddock Creek Section.

STOP 2—Maryville Section. SE¼ SE¼ SE¼ Sec. 3, T. 3 N., R. 8 W., Madison County, Illinois, Collinsville 7.5-minute Quadrangle (fig. 1, 5).

The Maryville Section is a stream-cut exposure 3 km east of the Mississippi bluffs along the south bank of a small tributary to the Burdick Branch. The composite stratigraphic column (fig. 6) from the Maryville region is the most complete Quaternary record known in southwestern Illinois. The outcrop section exposes only a portion of the column, the lower part of the Roxana Silt, the Berry Clay Member, the "Fort Russell till," and the "Chinatown silt" (fig. 5) and has been supplemented by several deep cores and auger borings in the vicinity. Two cores, MV6 located approximately 550 m northeast of the section in the SE NW SW Sec. 2, T. 3 N., R. 8 W. and core MV8 located approximately 180 m northeast of the section in the SE SE SE Sec. 3, T. 3 N., R. 8 W., penetrated 26.5 and 24.7 m of Quaternary deposits over Pennsylvanian siltstone and sandstone of the Modesto Formation. Both cores penetrated each of the units shown in figures 6 and 7. The purposes of this stop are to introduce two Illinoian or pre-Illinoian loesses, the "Chinatown silt" and "Burdick loess," to show the occurrence of the "Chinatown silt" beneath the "Fort Russell till," and to discuss the problems of classification posed by the multiple loesses, tills, and buried soils found in the Maryville area.

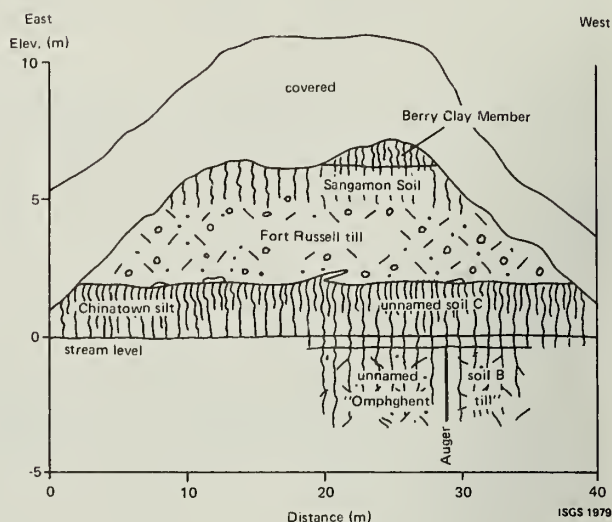
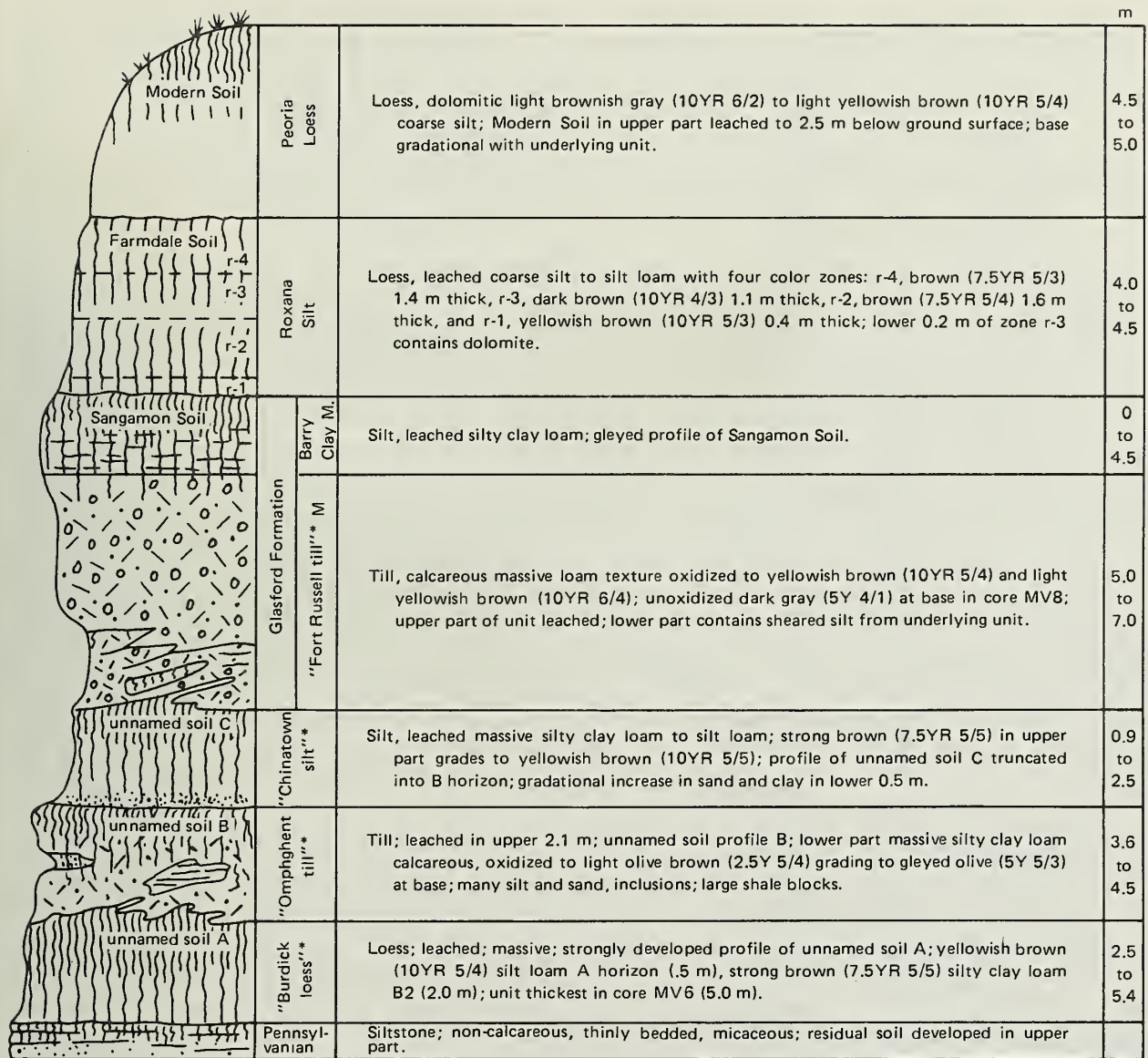


Figure 5. Sketch of the Maryville Section.

For the geologist who goes so far as to identify a loess in the subsurface, there is an added burden of proof requiring solid evidence that the silt deposit is not something else, especially a lacustrine or alluvial deposit. In the subsurface, the perspective of the occurrence of the silt across a landscape that makes surficial loesses so identifiable is lost, and other parameters—grain size, mineralogy, and physical appearance—must suffice.

The "Burdick loess" is the oldest and lowermost Quaternary deposit in the Maryville area. It is described from occurrences in cores MV6 and MV8 where it ranges in thickness from 2.5 to 5.4 m. The "Burdick loess" is a leached, unbedded silt loam to silty clay loam. Grain-size analyses of the "Burdick" (fig. 7) show uniformly high silt and low sand contents through the deposit. A ratio of coarse silt (62-31 μm) to medium silt (31-16 μm) averages about 0.9 and is typical of Wisconsinan loesses 2 to 5 km from the valley in this area. Clay mineral analyses (fig. 7) indicate that the "Burdick loess," like the Peoria Loess and Roxana Silt, contains a high proportion of expandable clay minerals, and relatively low amounts of illite and kaolinite plus chlorite in the less-than 2 μm fraction. In addition, the clay mineral composition of the loess differs markedly from that of the underlying kaolinitic bedrock or the overlying illitic "Omphgent till," indicating that the "Burdick" could not have been derived locally from these units.



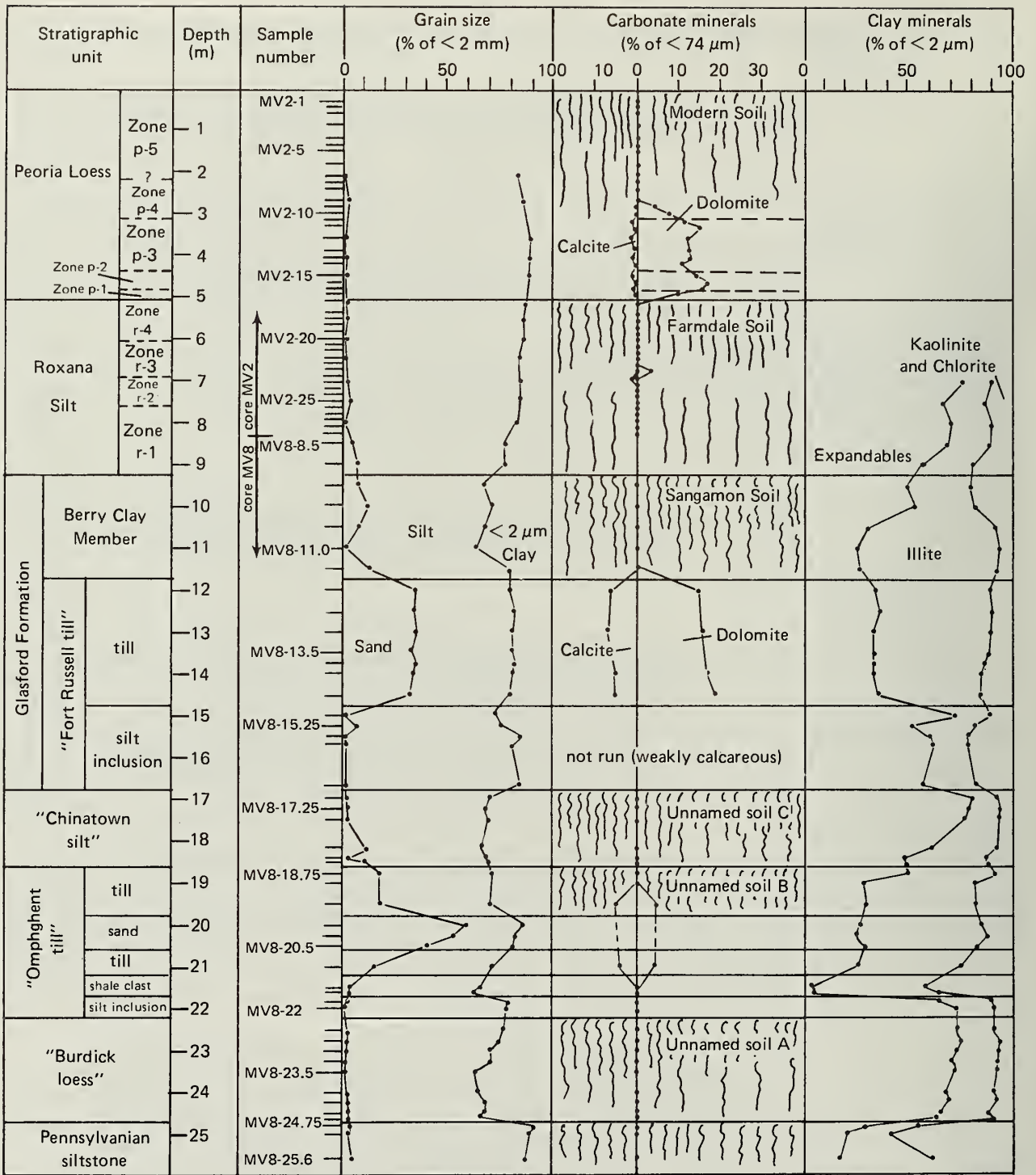
*Informal names introduced in this report

ISGS 1979

Figure 6. Generalized description of stratigraphic units in the Maryville region.

There is a well developed soil profile, unnamed soil A, developed in "Burdick loess." In core MV6 the B2t horizon of this soil is 1.6 m thick and contains as much as 38 percent < 2 μm clay. The soil is as strongly developed as both the Modern and Sangamon Soils and was probably formed during at least one period of interglacial warmth that followed the glaciation that produced the loess deposit. The ages of the "Burdick loess" and the subsequent soil-forming interval are not known, but available data indicate that the "Burdick loess" may record the first glacial event of the Pleistocene that produced a loess deposit along the Mississippi Valley in southwestern Illinois.

The "Omphghent till" (the lower till at Paddock Creek, Stop 1) overlies the "Burdick loess" and ranges in thickness from 3.6 to 4.5 m in the Maryville cores. It has an average grain-size composition of 18 percent sand, 45 percent silt, and 37 percent < 4 μm clay, is richer in clay than at Paddock



ISGS 1979

Figure 7. Grain size, clay mineral, and carbonate mineral data for Quaternary deposits in the Maryville area.

Creek, and contains large shale and silt inclusions and beds of sand. It averages lower in total carbonate content than the "Omphgent till" at Paddock Creek, but like the till at Paddock Creek contains approximately equal amounts of calcite and dolomite. It has an average unoxidized clay mineral composition of 25 percent expandable clay minerals, 49 percent illite, and 26 percent kaolinite plus chlorite, almost identical to that at Paddock Creek. A hand auger boring at the base of the stream-cut exposure

penetrated 3.0 meters of "Omphgent till" from 0.5 to 3.5 m below the base of the exposure. The upper 2.0 m of the till are leached and contain the profile of unnamed soil B. This soil has a 0.9-m thick yellowish brown silty clay B2t horizon, a 0.75-m thick silty clay loam B3 horizon, and a 0.45-m thick leached Clg. The "Omphgent till" and unnamed soil B represent the second glacial-interglacial cycle recorded by the drift succession at Maryville.

The "Chinatown silt" overlies the "Omphgent till" and is overlain by the "Fort Russell till" (upper till at Paddock Creek, Stop 1) in the Maryville Section (fig. 5). The thickness of the "Chinatown silt" in the Maryville area ranges from 0.9 m in core MV6, to 1.8 m in core MV8, and 2.5 m in the stream-cut exposure. Like the "Burdick loess," the "Chinatown silt" has a clay mineral composition that is high in expandable clay minerals and contrasts strongly with the illitic clay mineral compositions of the underlying and overlying tills. The upper, loessial, part of the unit has a uniform silt and low sand content, but in the lower 0.5 m of the "Chinatown" sand and clay increase as the loessial silt grades into a colluvium or pedisegment resting on the underlying B2 horizon of unnamed soil B. The profile of unnamed soil C is developed through the entire thickness of the "Chinatown silt" in the stream-cut exposure. In the exposure the soil is truncated into the strong brown silty clay loam B2 horizon, and zones of B-horizon material have been sheared and incorporated into the overlying till. Like the "Burdick loess," the "Chinatown silt" and unnamed soil C probably represent a glacial interval followed by at least one interglacial, and the "Chinatown" represents the third glacial recorded at Maryville.

The "Fort Russell till" in the Maryville area overlies the "Chinatown silt" and ranges in thickness from 5.0 to 7.0 m. Its grain-size and mineral compositions are statistically inseparable from the upper till at Paddock Creek (fig. 7). The "Fort Russell" represents the fourth glacial deposit represented in the Maryville drift succession and is overlain in the stream-cut by the Sangamonian Berry Clay Member of the Glasford Formation, an accretion gley that may include some lacustrine sediment in its lower part. The gray leached accretionary silt and silty clay loam are within the Sangamon Soil. The Berry Clay is overlain by the Roxana Silt, but only the lower part of the Roxana is exposed.

Borings on drainage divides in Maryville indicate that the Peoria Loess and Roxana Silt average respectively, 4.8 and 4.5 m thicknesses. Four color zones are present in the Roxana, and dolomite zones p-1, p-2, p-3, and p-4 are distinguishable in the Peoria.

The Peoria Loess and Roxana Silt represent the fifth glacial cycle recorded in the Maryville drift succession. The number of glacials and interglacials not recognized or not recorded in the deposits and soils is not known. It would be unreasonable to suggest that each soil in the succession represents a single period of interglacial warmth, just as it would be unreasonable to assume that every glacial cycle that affected the Mississippi River basin produced deposits in the Maryville area. So, for the present, the interpretation must be that the Pleistocene record at Maryville contains Wisconsinan, Sangamonian, Illinoian, and Illinoian or older deposits and soils.

STOP 3—Pleasant Grove School Section. SE¼ Sec. 20, T. 3 N., R. 8 W., Madison County, Illinois, Monks Mound 7.5-minute Quadrangle (fig. 1).

The Pleasant Grove School Section is a borrow pit exposure in the bluff of the Mississippi Valley. The section is the type section for the Roxana Silt, Meadow Loess Member, McDonough Loess Member, and the Pleasant Grove Soil (Frye and Willman, 1960; Willman and Frye, 1970; Frye et al., 1974a), and it exposes a thick section of Peoria Loess at the top (figs. 8 and 9). Willman and Frye's (1970) description is reproduced below.

The purposes of revisiting the much described Pleasant Grove School Section are to examine an exposure typical of thick Wisconsin loess bluffs along the Mississippi Valley, to show the Farmdale Soil in the upper

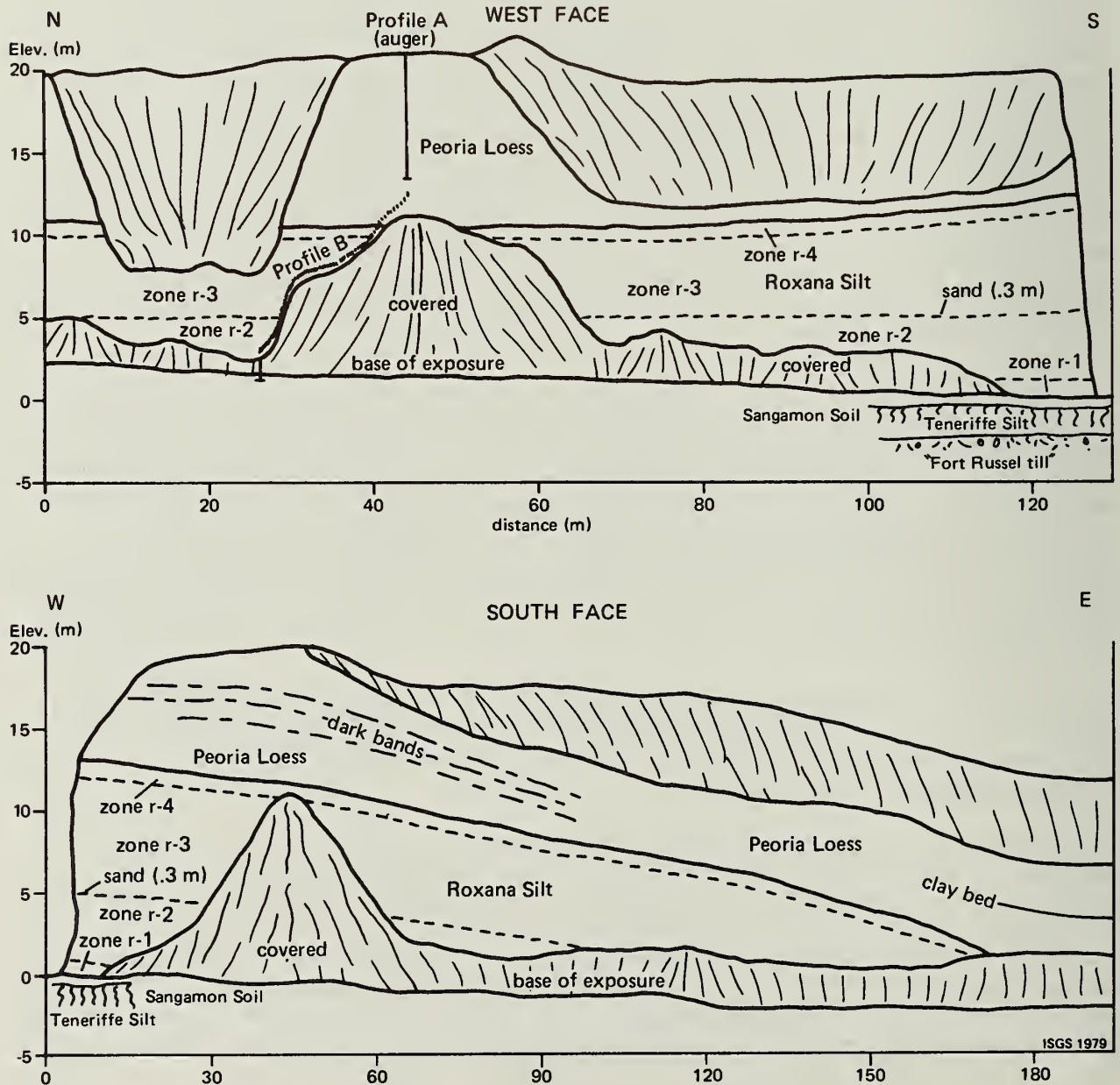


Figure 8. Sketch of the west and south faces of the Pleasant Grove School Section as they appeared in June, 1979. Datum is base of exposure.

PLEASANT GROVE SCHOOL SECTION

Measured in borrow pits and access roadcuts in the SE Sec. 20, T. 3 N., R. 8 W., Madison County, Illinois, 1958, 1959, 1961, 1962, 1964, 1966; all elements of the section as described have not been exposed simultaneously.

	<i>Thickness (ft)</i>
<i>Pleistocene Series</i>	
<i>Wisconsinan Stage</i>	
<i>Woodfordian Substage</i>	
<i>Peoria Loess</i>	
9. Loess, medium to coarse; loose and friable in upper part; calcareous except for very thin surface soil at top; light yellow-tan including some streaks and mottling of tan-brown and gray; contains several weakly developed A-C soils in upper part (P-2268 through P-2260 at 8-inch intervals downward from top; P-2259 1.5 feet lower; P-2258 through P-2255 downward at 3-foot intervals)	25.0
8. Loess, medium to coarse, massive, compact, calcareous, gray-tan to yellow-tan; contains fossil snail shells throughout; radiocarbon date from a quarter of a mile south determined on wood, 17,950 ± 550 (W-1055); radiocarbon date from 1 mile north determined on fossil snail shells, 17,100 ± 300 (W-730) (P 11 base)	15.0
<i>Altonian Substage</i>	
<i>Roxana Silt (type section)</i>	
<i>Meadow Loess Member (type section)</i>	
7. Loess, medium to coarse, massive, pink-tan, leached in upper part but weakly calcareous at base; truncated Farmdale Soil; sharp erosional contact at top but gradational at base (Zone IV in previous reports) (P-12 base)	11.0
6. Loess, medium to coarse, massive, gray-tan to gray, weakly calcareous throughout; contains fossil snail shells in lower part (Zone III in previous reports) (P-10A)	12.0
5. Loess, coarse, massive, pink-tan; contains fossil snail shells throughout; radiocarbon date on fossil snail shells from upper part of the unit, 35,200 ± 1,000 (W-729); in 1958 when face was at position of original bluff-line, a 1.5-foot bed of gray-tan fine to medium sand occurred in middle of unit (Zone II	

in previous reports); (P-10 7 feet below top; P-9 from middle bed of sand; P-8 base)

20.0

*McDonough Loess Member
(type section)*

- 4. Silt, coarse, massive, gray, weakly calcareous in middle with very sparse etched fragments of fossil snail shells; Pleasant Grove Soil (type section) at top; dark gray, organic-rich A-zone but no well differentiated B-zone; basal 6 inches may be A-zone of Chapin Soil resting directly on A-zone of Sangamon Soil below (Zone I in previous reports); contains a few "pods" of *Celtis occidentalis* (P-8B, P-8BB upper part; P-8A, P-8AA lower part)

5.0

*Illinoian Stage
Jubileean and Monican Substages
Teneriffe Silt*

- 3. Silt, coarse, massive, leached; Sangamon Soil; A-zone tan-brown, granular. 8 inches thick; B₂-zone thin and gradational; B₃-zone red-brown, clayey, tough, columnar, 2 feet thick; gradational downward with B₃-zone, tan-brown becoming tan and gray-tan downward in the CL-zone, friable, massive; the basal 6 inches is weakly calcareous, gray, massive; 100 feet northward the silt thickens to 18 feet and rests on calcareous till where the Pike Soil has been removed from the till by erosion; (P-6B, A-zone of soil; P-6, P-6A, B₂-zone of soil; P-5, P-5A lower B₃-zone of soil; P-1497 1 foot above base where silt rests on Pike Soil; P-4, P-1496 6 inches above base where silt rests on Pike Soil; P-7 15 feet below top of unit 100 feet farther north where silt fills erosional low on the till surface)

10.5

*Liman Substage
Glasford Formation
Kellerville Till Member*

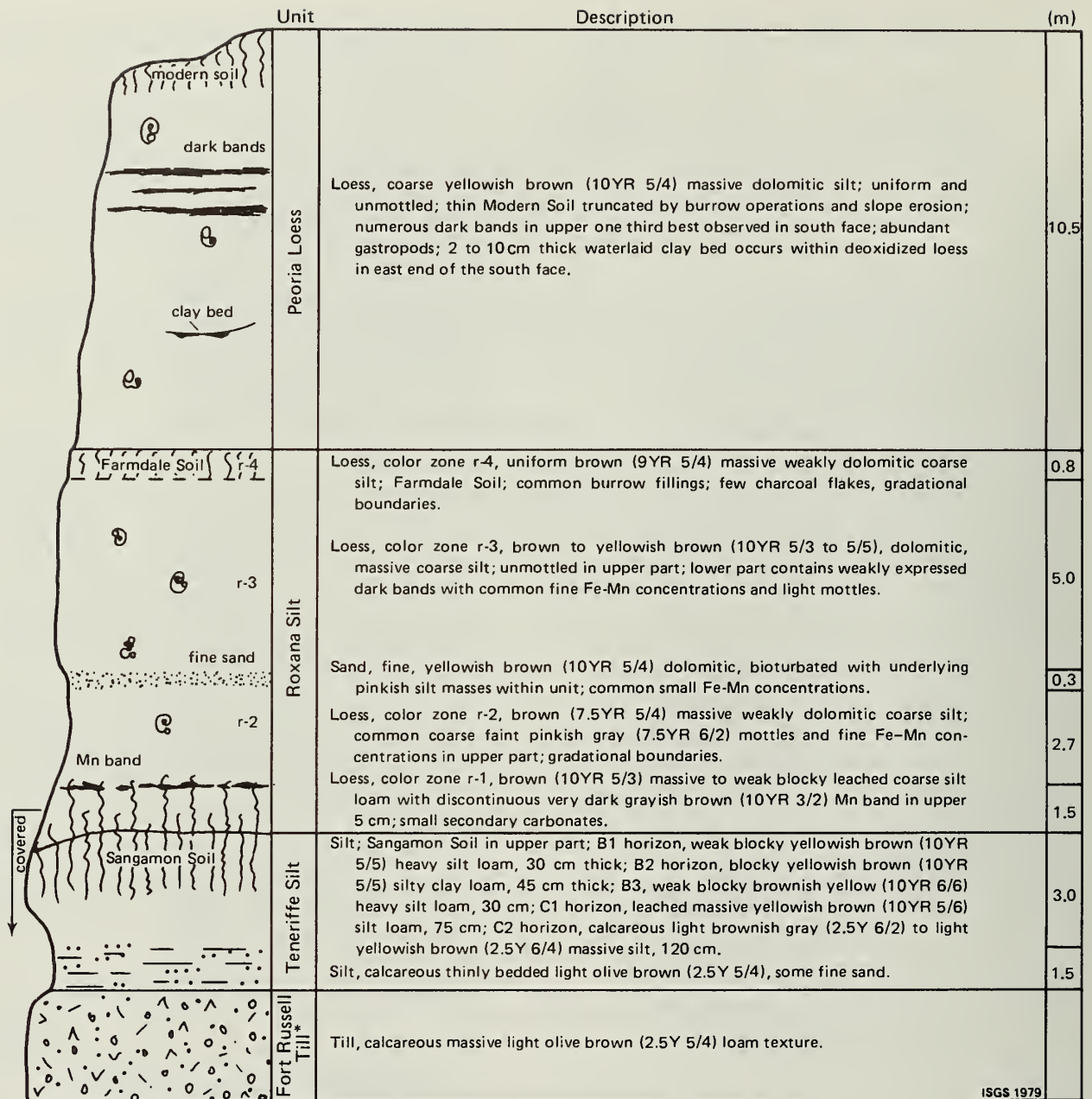
- 2. Till, leached, gray-brown to tan-brown, massive; Pike Soil; little structure or clay accumulation in B-zone; some Mn-Fe staining and small pellets (P-1495 through P-1488 downward from top at 6-inch intervals)
- 1. Till, calcareous, tan to tan-gray, massive, pebbly, compact (P-1, P-1498 6 inches below top; P-1A lower part)

4.0

7.5

Total 110.0

part of the Roxana, to examine the four color zones of the Roxana, to examine the clay bed in the Peoria, and to examine the soil- and rock-stratigraphic relations in the lower part of the Roxana.



*Informal name introduced in this report.

Figure 9. Generalized description of stratigraphic units exposed in the Pleasant Grove School Section.

Auger borings to depths of about 4.5 m in the floor of the borrow pit near the base of the vertical face penetrate the "Fort Russell till," called the Kellerville Till Member by Willman and Frye (1970). Their data for the till correlate well with the unit now called "Fort Russell" and are very different from the silty, high expandable clay mineral Kellerville Till Member of Lineback (1979). Their unoxidized sample of the unit, sample P-1A, has a grain-size composition of 36 percent sand, 40 percent silt, and 24 percent < 4 μm clay, a clay mineral composition of 22 percent expandable clay minerals, 58 percent illite, and 20 percent kaolinite plus chlorite, and a carbonate composition of 6 percent calcite and 19 percent dolomite, values very close to the average composition of the "Fort Russell till" (table 2).

The Pike Soil, which Willman and Frye (1970) identified in the top of their Kellerville at Pleasant Grove, is stratigraphically below the "Fort Russell till," unit C. It is inappropriate to apply the name Pike Soil to a soil on the "Fort Russell." Soil profiles in the top of the "Fort Russell" beneath the Teneriffe Silt have not been described in the study area; however, exposures with thick Teneriffe over "Fort Russell" are rare and a soil profile in the upper part of the "Fort Russell" would normally be merged with the Sangamon Soil.

The Teneriffe Silt overlies the "Fort Russell till." In its lower part the Teneriffe is bedded, has a moderately high illite content, and appears to be an outwash or lacustrine sediment related to the underlying till. In its upper part, however, the Teneriffe appears loessial, contains over 70 percent expandable clay minerals (sample P-4), and becomes uniform and unbedded. A correlative silt interpreted as a loess will be seen at the Caseyville Section (Stop 4).

The base of the Roxana Silt rests conformably on the Sangamon Soil developed in Teneriffe Silt. Color zone r-1, the lower tan or gray zone, contains by definition the record of deposition of the first Wisconsinan sediments on the Sangamonian landscape of Illinois. The zone is thin and pedologically complex, and its interpretation is critical to the reconstruction of geologic history. Within the zone, Willman and Frye (1970) and Frye et al. (1974a) have recognized two depositional units, the Markham Silt and McDonough Loess Members, and two soil-forming intervals represented by the Chapin and Pleasant Grove Soils.

The lower zone of the Roxana Silt at the Pleasant Grove Section is leached of carbonates, shows weakly expressed soil structure, and contains more clay than the overlying loess of zone r-2 (fig. 10). The lower zone of the Roxana at Pleasant Grove School and at many other sites studied in southwestern Illinois is texturally and mineralogically gradational upward from the top of the highly weathered Sangamon Soil to the unweathered dolomitic loess of zone r-2 (McKay, 1977, 1979). The upward change in composition is accompanied by a gradational decrease in the expression of soil characteristics. This uniform upward change toward less weathered loess can be interpreted as resulting from an upward decrease in (1) the degree of mixing of the loess with underlying soil material and (2) the decreasing ability of weathering to keep pace with sedimentation. This sequence probably represents the accelerating 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.

These interpretations have some important consequences for stratigraphic nomenclature and interpretation of the geologic history of the early part of the Wisconsinan Stage in Illinois. First, the difficulty of recognition of either the two depositional units or the two soil profiles in the lower zone of the Roxana makes the Markham Silt and McDonough Loess Members and the Chapin and Pleasant Grove Soils marginally useful stratigraphic units in this area. These units are not differentiated in sections described for this guidebook. Second, the interpretations of the early Wisconsinan sedimentation and weathering events in southwestern Illinois are somewhat sim-

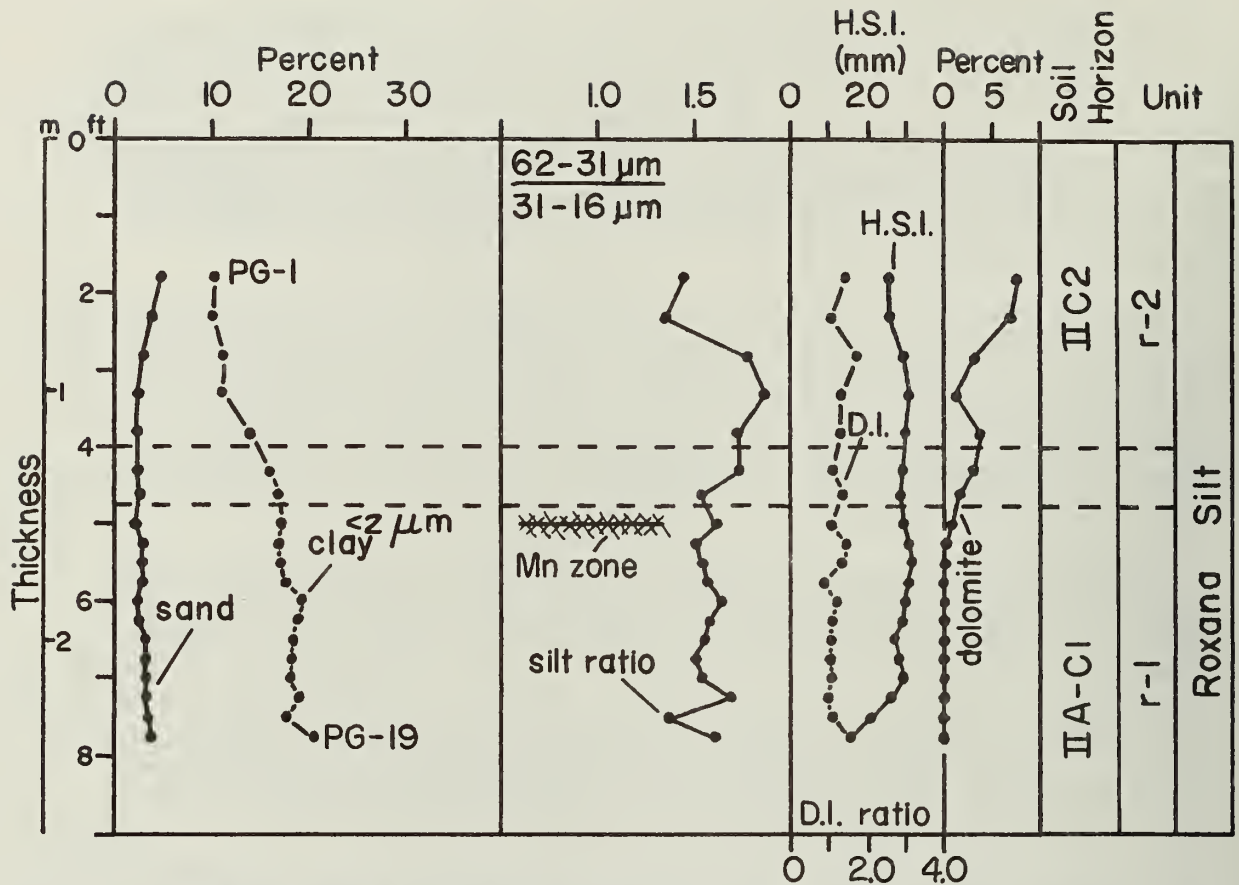


Figure 10. Grain size, clay mineral, and carbonate mineral data for the lower part of the Roxana Silt in the Pleasant Grove School Section (from McKay, 1977).

plified. The long intervals of time, up to 35,000 years, previously estimated for the accumulation and weathering of the Markham and McDonough Members (Frye et al., 1974a) are shortened in the present interpretation, and previous estimates of 75,000 radiocarbon years B.P. for the age of the base of the Roxana are probably excessive. An age of about 50,000 B.P. might be more in line with available evidence.

The color difference between zone r-2 and zone r-3 probably represents a change in the color of the Altonian outwash in the Mississippi Valley. The boundary between them coincides with a carbonate mineral (fig. 11) and grain-size discontinuity. Zone r-3 is higher in dolomite and finer grained. It has a lower proportion of coarse silt to medium and fine silt than does zone r-2. Shell material from zone r-2 in the Pleasant Grove School Section has been dated at $35,200 \pm 1000$ years B.P. (W-729) (Frye and Willman, 1960). Radiocarbon age determinations on organic carbon in the clay fraction of loess from zone r-2 are being run.

The Farmdale Soil at Pleasant Grove School consists of little more than a slight reddening, partial leaching, minor charcoal accumulation, and burrow disturbance of the upper 1.0 m of the Roxana Silt. It is similar to that found in core G39, 2.75 km to the northeast of Pleasant Grove (fig. 11). The minimal development apparent in the Farmdale Soil in near-valley areas suggests that the pause in loess accumulation during the Farmdalian was very brief.

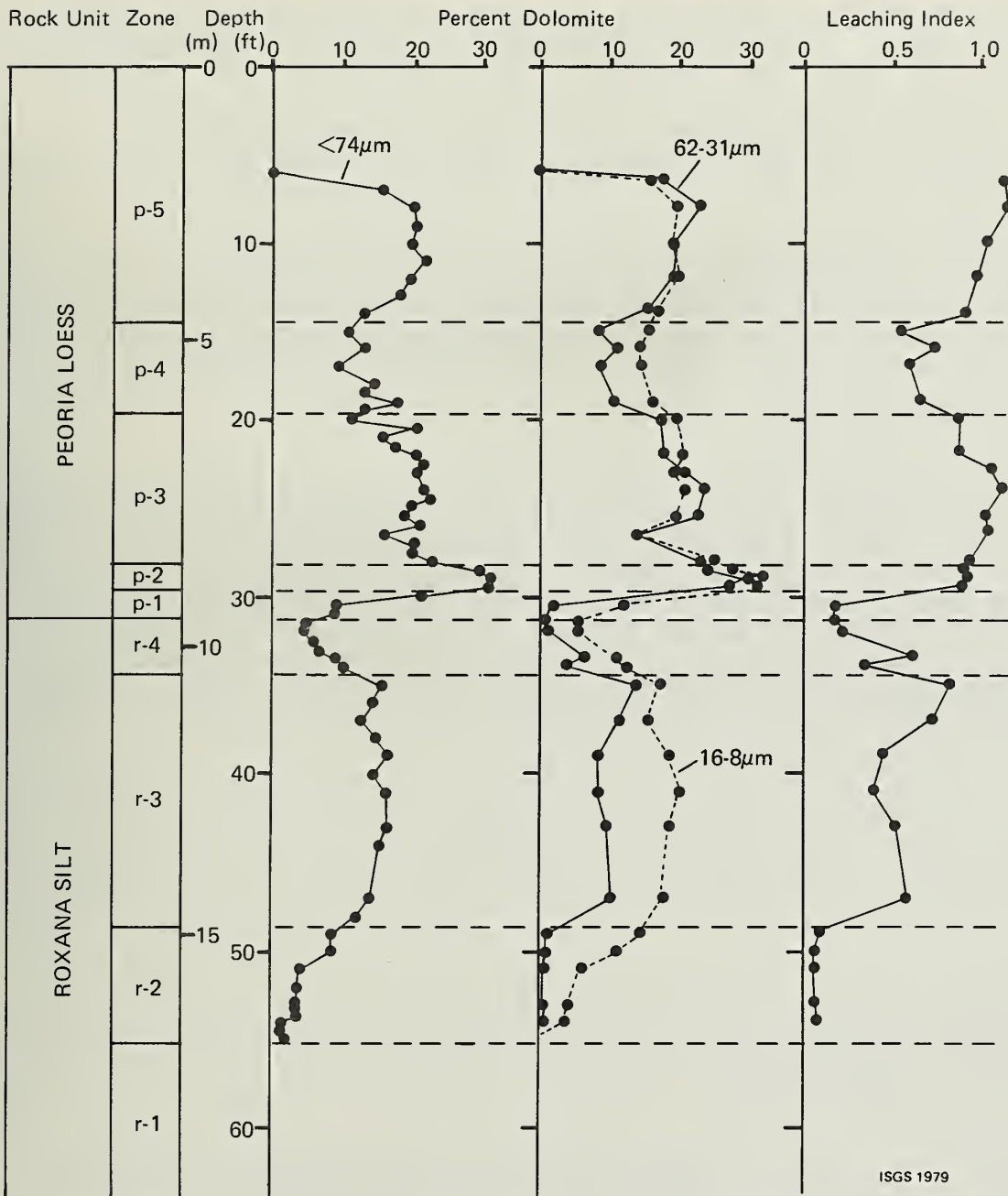


Figure 11. Carbonate mineral data for the $< 74 \mu\text{m}$, and $16-8 \mu\text{m}$ fractions of Peoria Loess and Roxana Silt in core G39, 2.75 km northeast of the Pleasant Grove School Section.

The Peoria Loess now exposed at Pleasant Grove School is over 10 m thick along the west face (fig. 8). It is a uniform, coarse, dolomitic, yellow brown silt and contains several dark bands that can be seen in the west end of the south face. The Peoria contains a complex dolomite zonation like that encountered in core G39 (fig. 11). These zones record major compositional changes in the Woodfordian valley train. Peoria Loess accumulation along the Mississippi Valley in southwestern Illinois began about 25,000 years B.P. (table 3). The first increments were, in a fashion common to loess, mixed with the underlying deposits, in this case Roxana Silt. The resulting transition zone is included in zone p-1. As the Roxana was buried below the effective depth of mixing, a very high dolomite, zone p-2, was deposited.

Zone p-2 probably represents high dolomite outwash derived from the Lake Michigan Lobe as it encroached on the Silurian dolomites of northeastern Illinois and southeastern Wisconsin. Zone p-2 gave way to a lower dolomite zone p-3 about 23,400 years B.P. as the Lake Michigan Lobe advanced onto the lower carbonate content Pennsylvanian bedrock in central Illinois and as the first influx of low dolomite outwash entered the Mississippi Valley northwest of Illinois.

Zone p-3 accumulated along the Mississippi Valley in southwestern Illinois until about 20,200 years B.P. when the Ancient Mississippi was blocked in north-central Illinois by ice from the Lake Michigan Lobe and diverted to its modern course. Immediately after the blockage, the Mississippi Valley in southwestern Illinois yielded a low dolomite, high expandable clay mineral loess, zone p-4, that gave way to high dolomite loess, zone p-5, about 18,000 years B.P.

The contact of zones p-3 and p-4 where it occurs at an elevation of about 151 m (495 ft) is marked by a clay bed and occasionally some bedded fine sand. The clay bed contains as much as 52 percent < 2 μm clay. These deposits are waterlaid and probably represent a very high water level that occurred about the time that the Ancient Mississippi River was blocked by the Lake Michigan Lobe and diverted to its modern course. They occur nearly 11 m above the next highest Woodfordian outwash and lacustrine deposits in the area. The clay bed is exposed at the east end of the south face at Pleasant Grove.

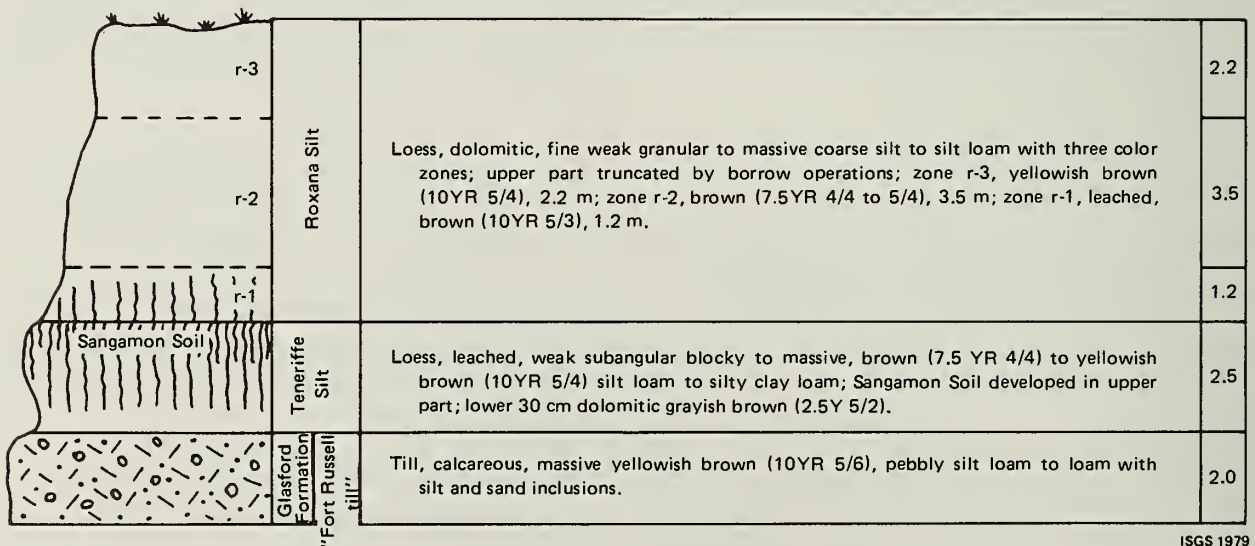


Figure 12. Generalized description of stratigraphic units in core G34(C10846), Caseyville Section.

The Caseyville Section is a borrow pit exposure in the bluff of the Mississippi Valley supplemented by an 11-m core from the floor of the pit. The core has been previously described (McKay, 1977) and the number C10846 refers to the permanent file number for the core in the Illinois State Geological Survey Samples Library. Penetrated in the core are the Roxana Silt, Teneriffe Silt, and "Fort Russell till" (figs. 12 and 13). The purposes of the stop are to examine loessial Teneriffe Silt resting on calcareous "Fort Russell till," to examine a Sangamon Soil developed in the Teneriffe Silt, and to show the relations of the lower part of the Roxana to the Sangamon Soil.

The "Fort Russell till" in Core G34 averages 32 percent sand, 47 percent silt, and 21 percent $< 4 \mu\text{m}$ clay, 3 percent calcite, and 15 percent dolomite. Unoxidized till was not recovered, and the average clay mineral composition of the oxidized till is 39 percent expandable clay minerals, 51 percent illite, and 10 percent kaolinite plus chlorite. The effect of oxidation on this till is a destruction of chlorite, an increase in the expandable clay mineral content, with little change in the calculated value for illite.

Dolomitic Teneriffe Silt overlies the "Fort Russell till" on an abrupt contact. The underlying till shows no evidence of soil formation prior to silt deposition. The C horizon of the Teneriffe contains an average of 74 percent expandable clay minerals, 17 percent illite, and 9 percent kaolinite plus chlorite, a composition very similar to that of the Peoria Loess in the area. Its uniform silty texture, and very low calcite, high dolomite carbonate composition are typical of a loess deposit (fig. 13). At this site, the Teneriffe Silt is predominantly loess and is the third Illinoian or older loess identified on this trip.

The Sangamon Soil is developed in the upper part of the Teneriffe Silt and is leached of carbonates to a depth of 2.2 m below its top. It contains a 38-cm thick silt loam A horizon, a 61-cm thick silty clay loam B2 horizon with a maximum $< 2 \mu\text{m}$ clay content of 33 percent, a 38-cm thick heavy silt loam B3 horizon, and an 85-cm thick silt loam C1 (leached) horizon (fig. 13).

The base of the Roxana Silt is gradational with the underlying Sangamon Soil. The contact of the Roxana and the Teneriffe occurs through a diffuse, pedogenically altered zone in the upper horizon of the Sangamon Soil. Textural and mineralogic characteristics belonging to both loesses are blended through a zone 60-cm thick, and no two parameters designate the same point as the contact.

A ratio of the amount of coarse silt (62 to $31 \mu\text{m}$) to the amount of medium silt (31 to $16 \mu\text{m}$) can be used to distinguish contributions from the two loesses (fig. 13). The silt ratio is a clay-free textural parameter. Its value is about 1.1 for the lower part of the Teneriffe and it remains unchanged through the Sangamon B2 horizon. The silt ratio shows clearly the mixing of the two loesses as the ratio gradually increases to over 1.5 in the lower part of the Roxana.

Zones r-1, r-2, and r-3 are present in the portion of the Roxana Silt penetrated by the core. As at Pleasant Grove School, zone r-1 is leached of carbonates and is compositionally gradational between zone r-2 and the underlying Teneriffe. Zone r-3 (not shown in fig. 13) has a dolomite content of about 15 percent, similar to that zone in G39 north of Pleasant Grove.

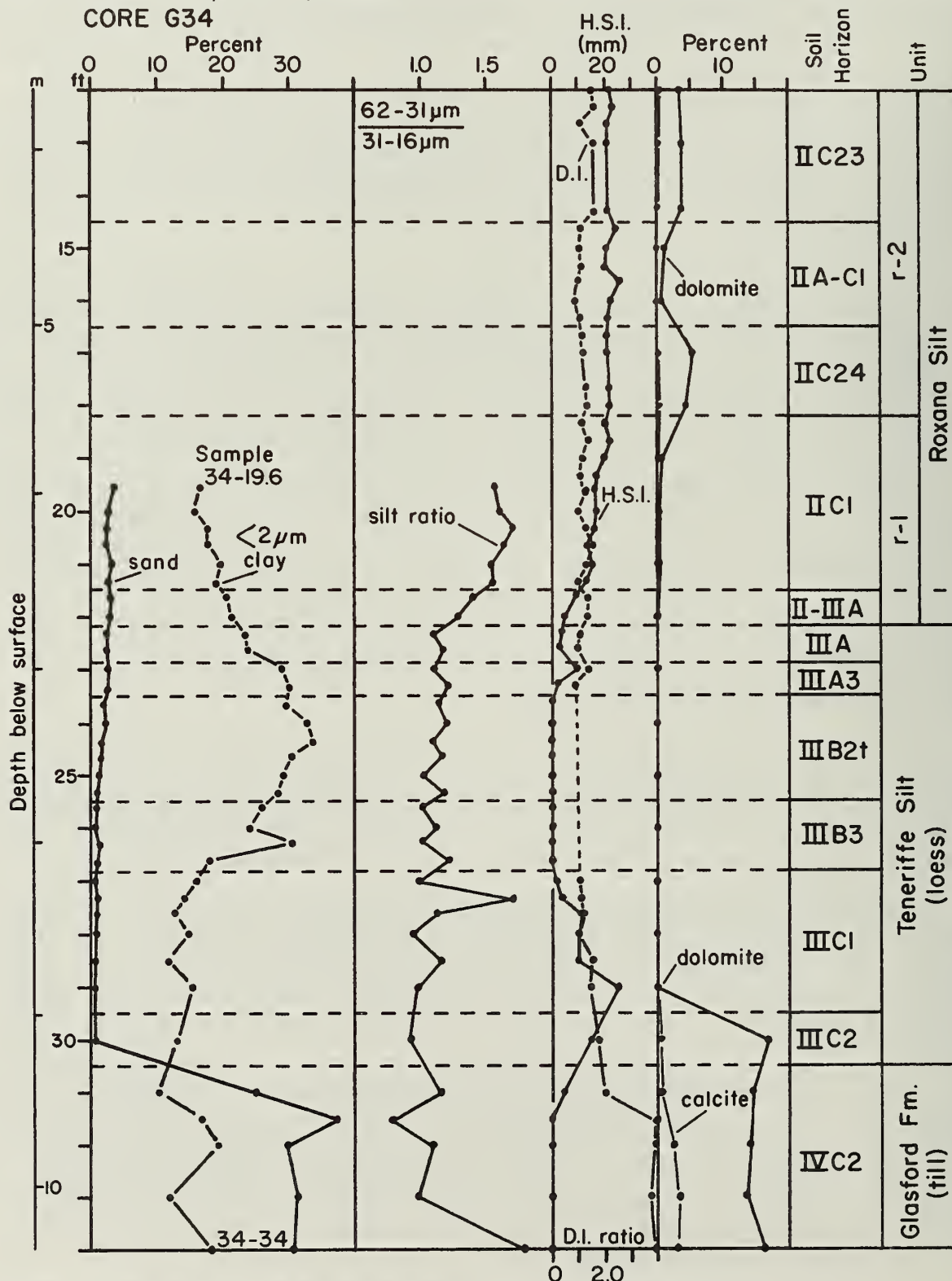


Figure 13. Grain-size, clay mineral, and carbonate data for core G34(C10846) Caseyville Section (from McKay, 1977).

The Canteen Creek Section is a borrow pit exposure in the bluff of the Mississippi Valley in the northern part of the city of Caseyville, along Canteen Creek. The section and a core from the floor of the pit have been previously described (McKay, 1977). The purposes of the stop are to examine a thick near-source section of Peoria Loess, to see a second exposure of the clay bed in the Peoria, to examine an exposure of a dark band correlated with the Jules Soil, to examine some unusual pipestems in the Peoria, and to discuss the significance of two radiocarbon dates of the Roxana Silt from a core taken at this site (figs. 14-16).

A core, number C10682, in the floor of the borrow pit penetrated 6.3 m of Peoria Loess, 8.5 m of Roxana Silt, and bottomed in zone r-2 of the Roxana (figs. 14-16). At a depth of 6.7 m below the floor of the pit, a 30-cm thick bed of peat and gray silt was sampled. The peat occurs at the contact of zones r-3 and r-2, and is overlain by a 0.4-m thick fine silty sand that is probably correlative with the sand at the zone r-3/r-2 contact in the Pleasant Grove School Section 6 km to the north. A radiocarbon age determination on wood fragments from the peat yielded a date of $40,200 \pm 1500$ (ISGS-393) years B.P. An age determination on organic carbon in the $< 4 \mu\text{m}$ clay fraction from the same zone yielded a date of $36,100 \pm 550$ (ISGS-392) years B.P. The wood date, which was run on a sample pretreated with hot NaOH to remove soluble organics, is judged the more reliable age determination on the peat horizon.

Data from studies in the region indicate that about 60 percent of the

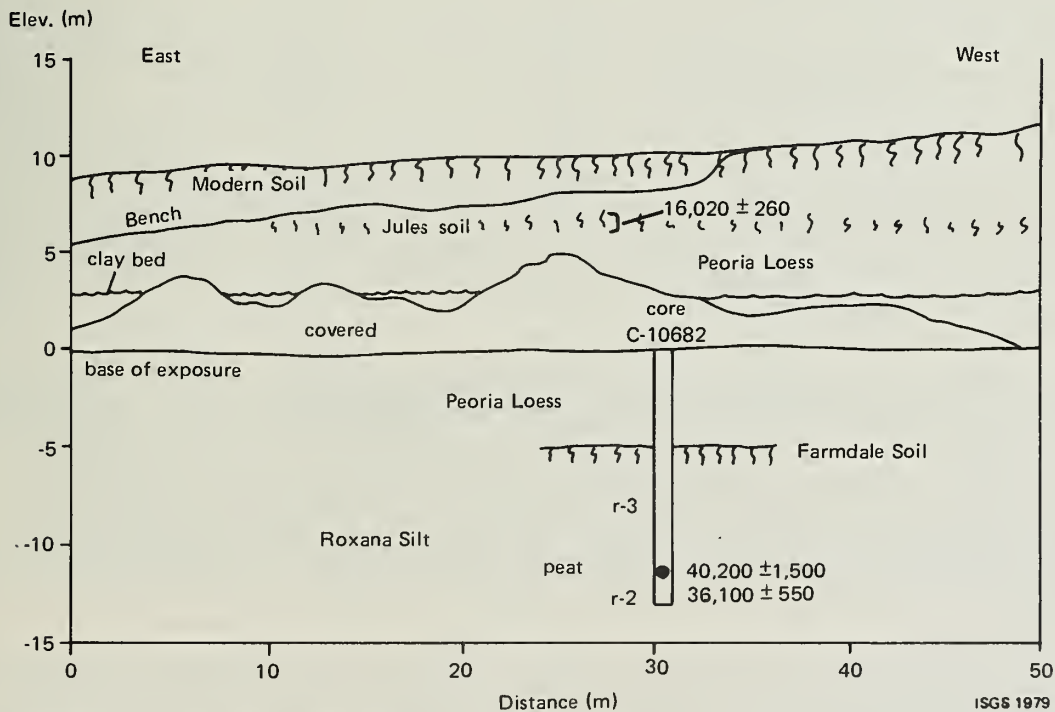
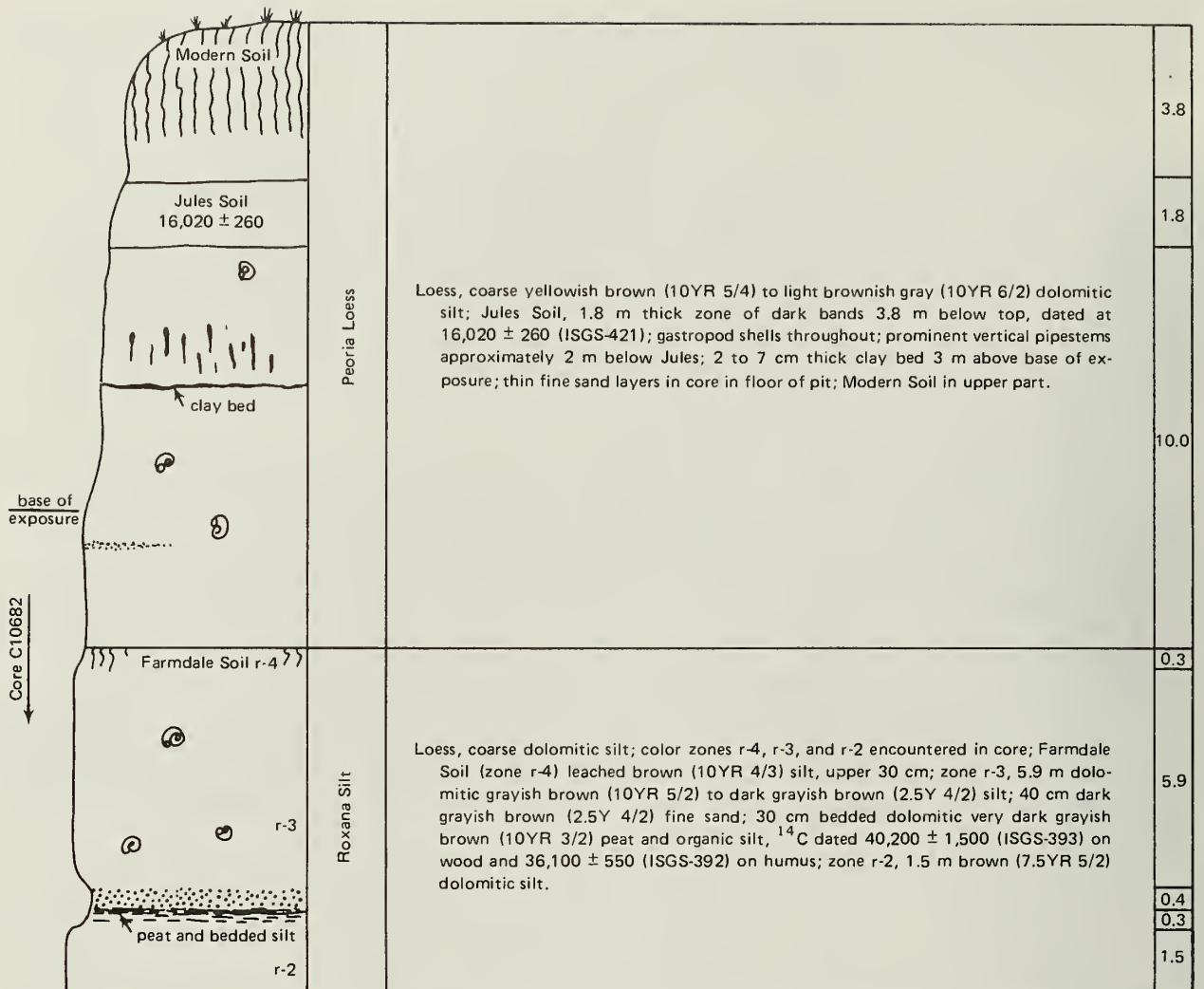


Figure 14. Sketch of the Canteen Creek Section. Datum is base of exposure.



ISGS 1979

Figure 15. Generalized description of stratigraphic units in the Canteen Creek Section and core C10682.

Roxana Silt overlies the contact of zones r-3 and r-2 and is thus younger than about 40,000 years B.P. If the top of the Roxana is dated at about 28,000 years B.P. (Frye and Willman, 1960), then the upper 60 percent of the Roxana accumulated during a 12,000-year interval, and, by extrapolation, the age of the base of the Roxana is about 48,000 years B.P. if a uniform sedimentation rate is postulated.

A clay bed at the contact of zones p-3 and p-4 occurs in the lower part of the 11.6-m-thick Peoria Loess exposed at Canteen Creek (figs. 14-16). Dolomite content in the Peoria drops from an average of about 20 percent in zone p-3 below the clay bed to about 10 percent in zone p-4 above it. The clay bed is correlated to the clay bed at Pleasant Grove School and probably represents a high water level in the Mississippi Valley associated with the diversion of the Mississippi River about 20,200 radiocarbon years B.P.

A 1.8-m-thick zone containing several merged dark bands with incipient soil characteristics occurs within dolomite zone p-5 about 3 m above the clay bed. A bulk sample of the zone contained 0.36 percent organic carbon and

yielded a radiocarbon date of $16,020 \pm 260$ (ISGS-421) years B.P. The soil is correlated with the Jules Soil, which has an estimated age of 15,500 to 16,500 radiocarbon years B.P. in its type area in the Illinois Valley (Frye et al., 1974b).

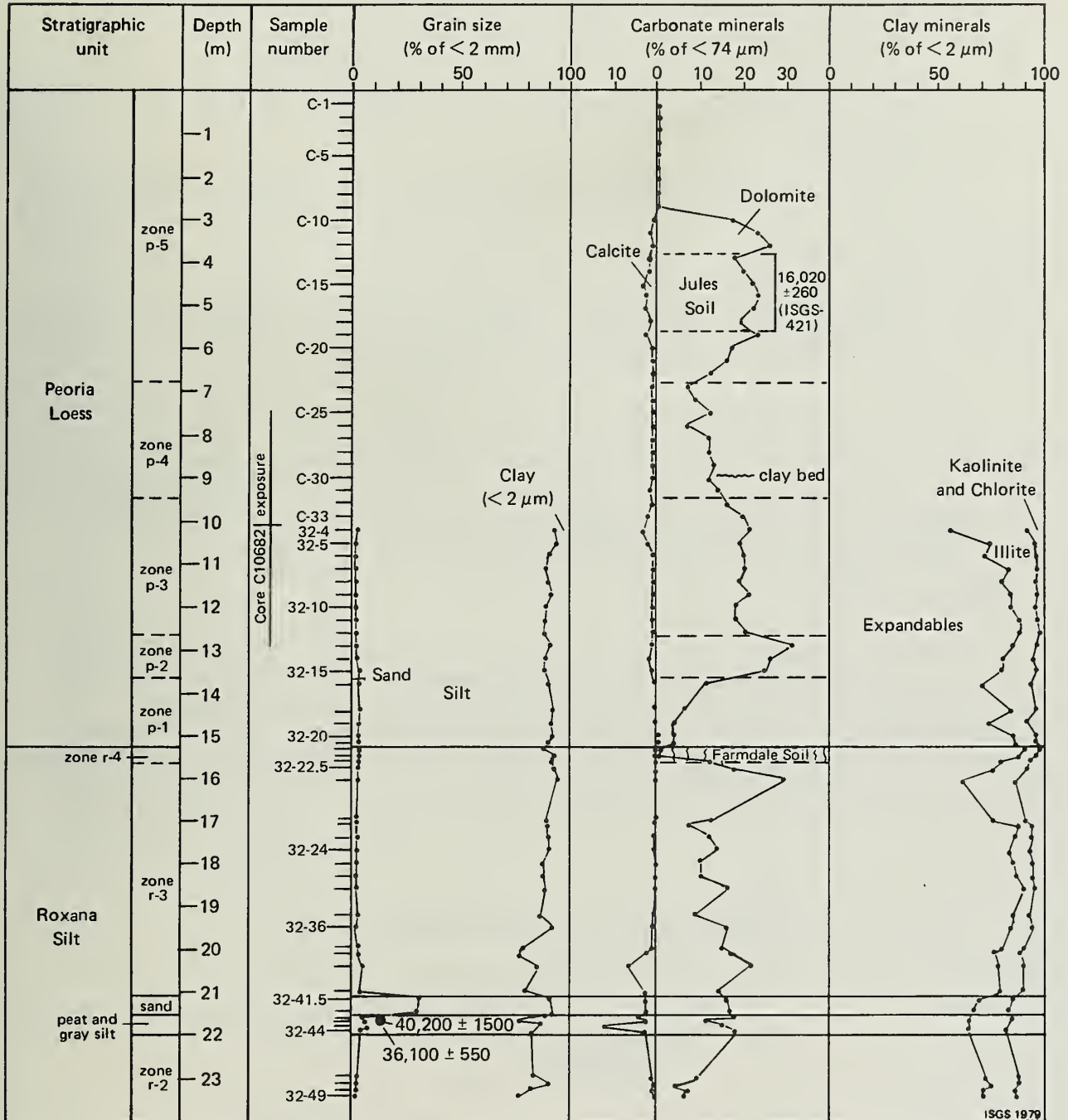


Figure 16. Grain size, clay mineral, and carbonate mineral data for the Peoria Loess and Roxana Silt in the Canteen Creek Section.

STOP 6—Falling Spring Section. SE¼ SW¼ NE¼ Sec. 14, T. 1 N., R. 10 W., St. Clair County, Illinois, Illinois, Cahokia 7.5-minute Quadrangle (fig. 1).

The Falling Spring Section is a highwall exposure in the Casper Stolle Stone Quarry. The exposure is within 500 m of the bluff and shows thick Peoria Loess and Roxana Silt over units tentatively correlated with the "Omphghent till" and "Burdick loess" (figs. 17-19). The principal purpose of the stop is to examine the only known exposure of thick dolomitic Illinoian or older loess in the area.

A 3-m thick, dolomitic, yellowish-brown to gray, uniform, unbedded silt in the lower portion of the Falling Spring Section is interpreted as loess. The silt has an average clay mineral composition of 57 percent expandable clay minerals, 34 percent illite, and 9 percent kaolinite plus chlorite, and an average carbonate content of less than 1 percent calcite and 8 percent dolomite. It contains occasional gastropod shells and common roughly spherical calcium carbonate concretions up to 5 cm in diameter.

Because of its stratigraphic position, the old loess at the Falling Spring Section is tentatively correlated with the "Burdick loess" (lower loess) at Maryville. However, unlike the "Burdick" at Maryville, the loess at Falling Spring is dolomitic and lacks the strongly developed profile of unnamed soil A. The irregular contact of the overlying till on the loess, and the presence of large masses of strongly weathered silt in the till suggest that a strongly developed soil has been incorporated into the overlying till by subglacial erosion.

The Falling Spring Section is located approximately 10 km west of the limit of the "Fort Russell till" in an area where the "Omphghent till" is the surficial till unit (fig. 1). At Falling Spring the "Omphghent" is more silty and higher in expandable clay minerals than at either Paddock Creek or Maryville. Just a few kilometers east of the quarry the "Omphghent" has its typical composition, and the change in composition at the bluff is

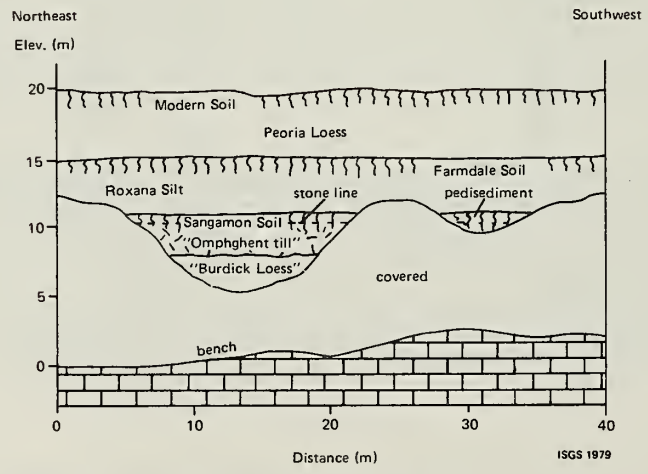
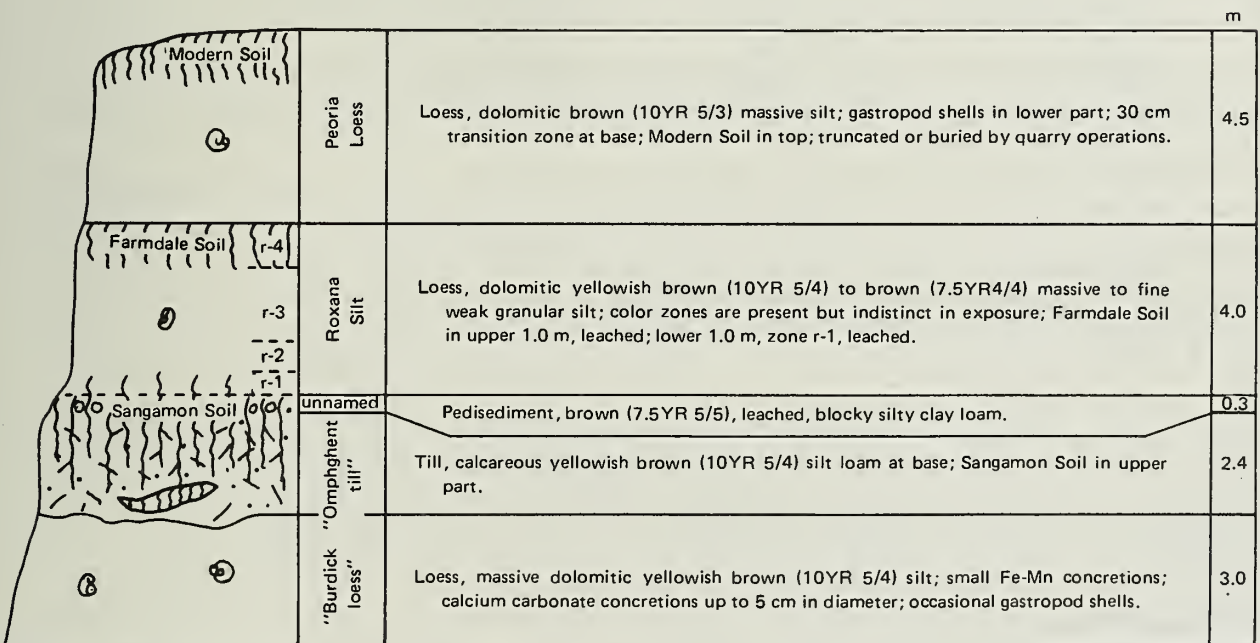


Figure 17. Sketch of the Falling Spring Section.

probably the result of incorporation of large quantities of the underlying loess.

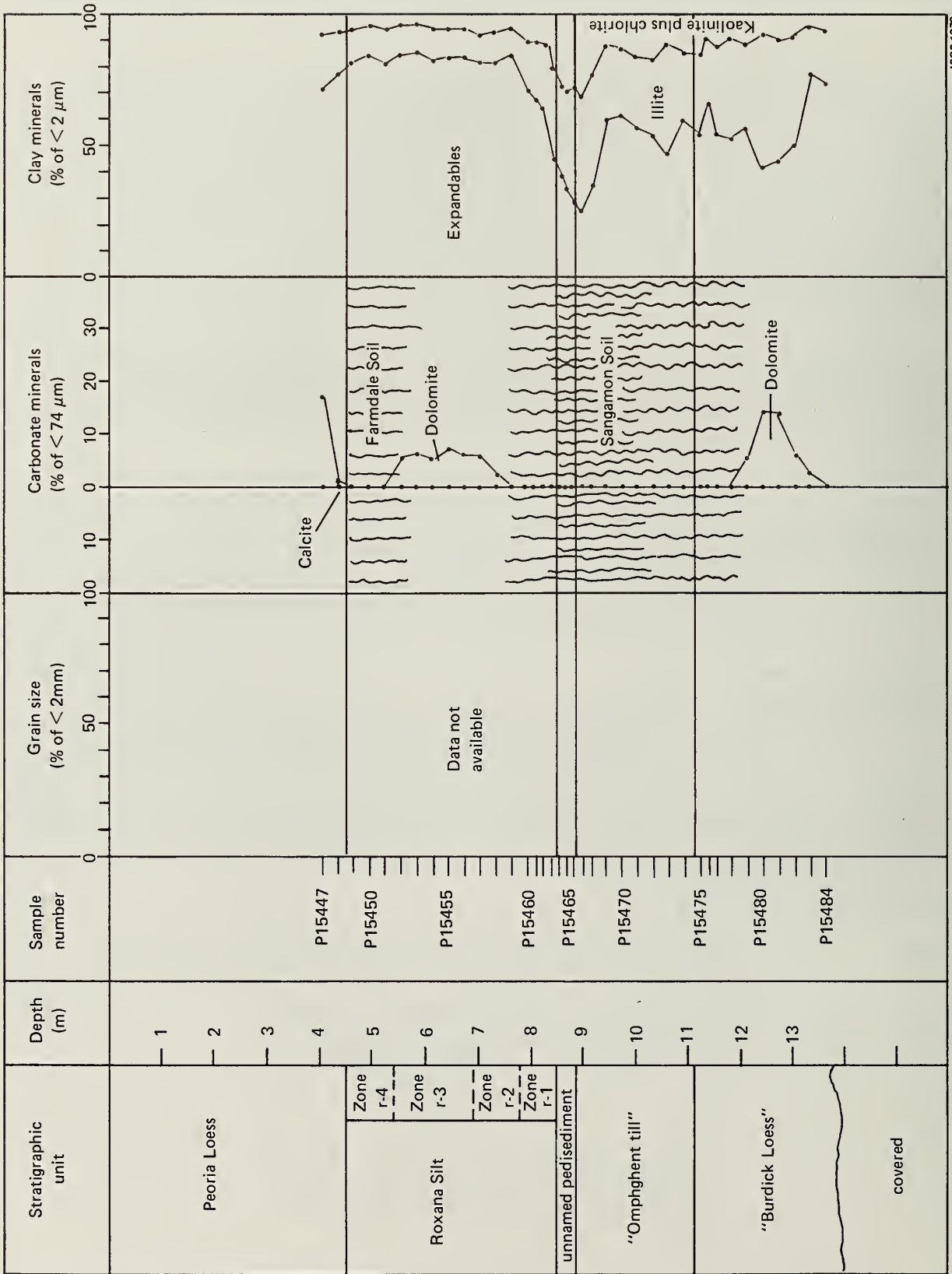
The Sangamon Soil at Falling Spring is a polygenetic profile that contains evidence for at least two intervals of soil formation separated by a period of erosion and pediment deposition. The upper part of the "Omphgent till" contains a soil profile truncated into the B2 horizon along a prominent stone line. The stone line is overlain by 20 to 30 cm of pediment which is also strongly weathered. Clay mineral data, which show no unweathered loessial contributions to the pediment, suggest that the pediment is pre-Wisconsinan in age. Stratigraphic position would suggest that weathering during the formation of soils B and C and during the Sangamonian could have contributed to formation of the profile.

The Sangamon Soil is overlain by approximately 4 m of Roxana Silt in which the color zones are indistinct. The upper 1 m of the Roxana contains a Farmdale Soil profile which is leached of carbonates and is overlain by 4.5 to 5.0 m of dolomitic Peoria Loess.



ISGS 1979

Figure 18. Generalized description of stratigraphic units in the Falling Spring Section.



ISGS 1979

Figure 19. Clay mineral and carbonate mineral data for stratigraphic units exposed in the Falling Spring Section.

REFERENCES

- Frye, J. C., L. 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, J. 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, J. 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, J. C., A. B. Leonard, H. B. Willman, H. D. Glass, and L. R. Follmer, 1974b, The late Woodfordian Jules Soil and associated molluscan faunas: Illinois State Geological Survey Circular 486, 11 p.
- Frye, J. 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, J. 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, J. C., and H. B. Willman, 1965, 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-51 to G-54), 26 p.
- Johnson, W. H., 1976, Quaternary stratigraphy in Illinois: Status and current problems: *in* Quaternary Stratigraphy of North America (W. C. Mahaney, ed.), Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA, p. 161-196.
- Johnson, W. H., L. R. Follmer, D. L. Gross, and A. M. Jacobs, 1972, Pleistocene stratigraphy of east-central Illinois: Illinois State Geological Survey Guidebook Series 9, 97 p.
- Jones, R. 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.
- Leighton, M. M., and J. A. Brophy, 1961, Illinoian glaciation in Illinois: *Journal of Geology*, v. 69, p. 1-31.
- Leighton, M. M., and H. B. Willman, 1950, Loess formations of the Mississippi Valley: *Journal of Geology*, v. 58, no. 6, p. 599-623.
- Leonard, A. B., and J. C. Frye, 1960, Wisconsinan molluscan faunas of the Illinois Valley region: Illinois State Geological Survey Circular 304, 32 p.
- Lineback, J. A., 1979, The status of the Illinoian glacial stage: Midwest Friends of the Pleistocene 26th Field Conference, Illinois State Geological Survey Guidebook 13.
- Lineback, J. A., and J. 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, J. A., and J. T. Wickham, 1978, Is the Illinoian a superstage? [abstract]: *Geological Society of America Abstracts with Programs*, v. 10, no. 7, p. 445.
- McKay, E. D., 1977, Stratigraphy and zonation of Wisconsinan loesses in southwestern Illinois: Ph.D. thesis, University of Illinois, Urbana, 242 p.
- McKay, E. D., 1979, Wisconsinan loess stratigraphy of Illinois: Midwest Friends of the Pleistocene 26th Field Conference, Illinois State Geological Survey Guidebook 13.
- Smith, G. D., 1942, Illinois loess--Variations in its properties and distribution: a pedologic interpretation: *University of Illinois Agricultural Experiment Station Bulletin* 490, p. 139-184.
- 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.
- Wickham, J. T., 1979, Pre-Illinoian till stratigraphy in the Quincy Illinois, area: *in* 43rd annual Tri-State Geological Field Conference, Illinois State Geological Survey Guidebook 14.
- Willman, H. B., and J. C. Frye, 1979, Pleistocene stratigraphy of Illinois: *Illinois State Geological Survey Bulletin* 94, 204 p.

TRIP 3

PRE-ILLINOIAN TILL STRATIGRAPHY IN THE QUINCY, ILLINOIS, AREA

Sunday, October 7 (half-day field trip)

Jerry T. Wickham

FIELD TRIP OVERVIEW

The purpose of this field trip is to examine exposed sections of pre-Illinoian tills and related deposits in the region of Quincy, Illinois, and to discuss the significance of the existing stratigraphic breaks. We will not be able to examine the entire pre-Illinoian sequence which occurs in the region but will see till members from each of the two formations which are present regionally.

STRATIGRAPHY

The time-stratigraphic designation "pre-Illinoian" is used in this report in place of the classic terms "Kansan" and "Nebraskan." "Kansan" and "Nebraskan" are not formally used because of evidence of widespread miscorrelation to the type "Kansan" and "Nebraskan" deposits in southwestern Iowa and eastern Nebraska (Hallberg and Boellstorff, 1978; Boellstorff, 1978). Until the time-stratigraphic classification problems are resolved, the general term pre-Illinoian will be used. The terms "Kansan" and "Nebraskan" may be referred to in this report when discussing previous work.

The current understanding of the glacial stratigraphy of the Quincy region has developed through the cumulative efforts of many Quaternary geologists. Geologists first questioned whether the region was glaciated during the Illinoian. Leverett (1899) originally extended the Illinoian glacial boundary west of Quincy, drawing the boundary along the bluffs of the Mississippi River. Leighton and Brophy (1961) shifted the Illinoian boundary eastward to Quincy but still included the field trip area within the Illinoian. The boundary was moved 15 mi (24 km) northeast to its present position shown on the "Glacial Map of Illinois" (see back cover) by Frye, Willman, and Glass (1964).

The glacial map shows the surficial deposits, exclusive of overlying loesses in the field trip area, as "Kansan Till Plain." In Illinois the classic Kansan glaciation is separated into a western Kansan representing glaciation from a source to the northwest and an eastern Kansan representing glaciation from the northeast or east. Willman and Frye (1970) suggested that the western Kansan and eastern Kansan glaciations did not overlap at the boundary along the Illinois Valley. Lineback (1979) has suggested that many of the deposits previously identified as eastern Kansan may fall within the Illinoian Stage. Further work is needed to firmly

establish the age relationships of the eastern Kansan glaciations. In the Quincy area, we will be restricted exclusively to the western Kansan.

Previous stratigraphic studies in western Illinois (Leverett, 1899; Horberg, 1956; Frye, Willman, and Glass, 1964; and Willman and Frye, 1970) have considered western Kansan to be one major glaciation that deposited a single till. Western Kansan till has been recognized by its stratigraphic position and by its contrast in mineralogy to the overlying Illinoian tills. Willman and Frye (1970) applied the rock-stratigraphic term "Banner Formation" to all Kansan till in Illinois (fig. 1). No subdivision into till members was made in western Illinois.

The term "Enion Formation" (Willman and Frye, 1970) was used for Nebraskan deposits in Illinois (fig. 1). Willman and Frye (1970) have used stratigraphic position to identify the Enion Formation in a small number of exposures. No characteristic mineralogy or physical appearance was recognized in the Enion Formation. Basically, any glacial deposit having a paleosol developed in it underlying the Banner Formation was included in the Enion Formation.

This basic two-fold subdivision of pre-Illinoian deposits into Kansan and Nebraskan has been a key concept in all previous stratigraphic studies in western Illinois. Furthermore, the deposits have been described and differentiated mainly on the basis of inferred age relationships. Where a weathering zone existed between two pre-Illinoian deposits, the term "Kansan" or "Banner Formation" has been applied to the upper deposit and "Nebraskan" or "Enion Formation" to the lower deposit.

Recent investigations of pre-Illinoian till stratigraphy have utilized not only physical stratigraphy but have also characterized the mineralogy of the tills. Stratigraphic studies in Adams and Hancock Counties in western Illinois (Wickham and Lineback, 1978) and in southeast Iowa (Hallberg, in press) have demonstrated that the pre-Illinoian tills can be separated into at least four distinct rock-stratigraphic units that can be traced over large distances. A more complex pre-Illinoian stratigraphy than the classic "Kansan and Nebraskan" is evolving. These recently recognized rock-stratigraphic units correlate to named units in Iowa. Figure 1 illustrates the pre-Illinoian till stratigraphy as developed in Iowa (Hallberg, in press; Hallberg et al., 1978) and its relationship to previous Illinois Geological Survey nomenclature. The use of discreet units to identify specific rock-stratigraphic intervals within the pre-Illinoian is a marked improvement over the broad use of the terms "Banner Formation" or "Kansan" and "Enion Formation" or "Nebraskan." Therefore, the terms Wolf Creek Formation with its attendant members and Alburnett Formation are adopted for use in the remainder of this report (fig. 1).

These changes in nomenclature are the direct result of changes in research methods and represent a natural evolution based on much additional information. Each of the rock-stratigraphic units has been characterized quantitatively by its texture, and carbonate content clay mineral composition (table 1). These data have aided in correlating units from site to site. Ideally, we are able to extrapolate from sites where the physical stratigraphy is relatively complete to other sites where stratigraphic intervals have been removed. We have placed less importance on the presence or absence of marker horizons (paleosols) and the completeness of physical sequences to choose stratigraphic units. At this point, a word of caution seems necessary con-

Figure 1. Stratigraphic column for Quaternary deposits in the Quincy, Illinois, region. The lower part of the diagram compares the pre-Illinoian stratigraphic column adapted for use in this report to the previous pre-Illinoian stratigraphic nomenclature of Willman and Frye (1970).

WILLMAN and FRYE, 1970			
TIME STRATIGRAPHY	ROCK STRATIGRAPHY	SOIL STRATIGRAPHY	
QUATERNARY SYSTEM, PLEISTOCENE SERIES	Holocene Stage	Modern Soil	
			Wisconsinan Stage
	Valderan Substage	Peoria Loess	
	Two creekan Substage		Equality Formation
	Woodfordian Substage	Henry Formation	
	Farmdalian Substage	Robein Silt	Farmdale Soil
		Altonian Substage	
	Sangamonian Stage		Sangamon Soil
	Illinoian Stage	Loveland Silt	Yarmouth Soil
		Pearl Formation	
Yarmouthian Stage	Banner Formation	Yarmouth Soil	
			Lierle Clay Member
Kansan Stage	Banner Formation	Yarmouth Soil	
			Harkness Silt Member
Aftonian Stage		Afton Soil	
Nebraskan Stage	Enion Formation	Afton Soil	

THIS REPORT (adapted from Hallberg et al., 1978)		
TIME STRATIGRAPHY	ROCK STRATIGRAPHY	SOIL STRATIGRAPHY
QUATERNARY SYSTEM, PLEISTOCENE SERIES	Wolf Creek Formation	Yarmouth Soil
Pre-Illinoian	Lierle Clay Member	Dysart Soil
	Hickory Hills Till Member	
	Aurora Till Member	
	Harkness Silt Member	
	Winthrop Till Member	
	Alburnett Formation	Westburg Soil

Table 1. Analytical techniques used in the study of Quaternary deposits for this field trip

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	R. Bianchini and H. Radis
Detailed distribution of grain sizes	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	R. Bianchini
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. T. Wickham

cerning the use or possible misuse of quantitative data. Wholesale "number crunching" of data without regard to weathering effects and other field evidence can lead to major errors. The most important factor is the variability of the glacial deposits. In a regional sense, tills are not uniform deposits but instead show minor, or in some cases major, lateral and vertical compositional variations. Calculating one mean composition for a unit and applying it over a large area as a means of correlation may in some cases be unrealistic. In correlating from site to site, the relative values of the data along with stratigraphic position are most significant. Also, post-depositional alteration of materials must always be a primary consideration in interpreting quantitative data. Another factor may be the methods themselves. Clay mineral percentages, although extremely useful, are semiquantitative. Splitting out units on the sole basis of small differences in clay mineral percentages is a questionable practice.

The type sections for the Wolf Creek and Alburnett Formations (fig. 1) are in east-central Iowa (Hallberg, in press). Throughout their area of occurrence, the two till formations maintain a distinct mineralogy, allowing them to be traced through surface exposures and subsurface borings into southeastern Iowa and western Illinois. Contrasts in physical appearance are such that in most cases the units can be readily separated in the field.

Alburnett Formation

The Alburnett Formation is stratigraphically the lowest till unit found in western Illinois. In Iowa, the Alburnett Formation consists of a number of

unnamed till members. Herbert D. Glass has noted variations in the clay mineral composition within vertical sections of the Alburnett in Illinois. In Illinois, the overall trend appears to be an upward increase in expandable clay content. Further work is needed to tie these observations to field evidence and ultimately to determine whether the Alburnett Formation can be subdivided into till members in Illinois.

Typically, the Alburnett Formation is a jointed, blocky, very firm, dark gray to very dark gray (unoxidized colors) silty till. Clay mineral data for the till show the presence of roughly equal percentages of expandable clays, illite, and kaolinite and chlorite. Kaolinite is the predominant clay mineral composing the kaolinite and chlorite percentage (Herbert D. Glass, personal communication). This composition contrasts with the Wolf Creek Formation that is dominated by a high expandable clay content and the Illinoian tills that have a low percentage of kaolinite and chlorite. Also, the Illinoian tills that have a source to the northeast (Lake Michigan Lobe) have much more chlorite than kaolinite (H. D. Glass, personal communication).

Carbonate contents from the Chittick apparatus have been variable for the Alburnett Formation. The $< 74 \mu\text{m}$ fraction has a range in total carbonate content of 9 to 16 percent with dolomite being higher than calcite.

Wolf Creek Formation

Most of the previously mapped Kansan in western Illinois and southeastern Iowa falls into the Wolf Creek Formation. In the type sections in Iowa, the Wolf Creek Formation consists of three till members (fig. 1). Three units have also been identified within the Wolf Creek in western Illinois and are correlated with the three till members in Iowa. The three till members have similar field characteristics, but the upper two may be distinguished by textural differences. In the Quincy region, the Hickory Hills Till Member has approximately 8 percent more sand in its matrix than the Aurora Till Member. Only a few samples of a lower till tentatively correlated with the Winthrop Till Member are available from the Quincy area. This lower till has a texture that is similar to the overlying Aurora Till.

The clay mineral compositions of all three till members of the Wolf Creek Formation are nearly identical, each one having a high content (60 to 70 percent) of expandable clays in the $< 2 \mu\text{m}$ fraction. One parameter which has been consistently useful in separating the three till members has been the $< 74 \mu\text{m}$ carbonate content as determined by the Chittick apparatus. The sandier Hickory Hills Till Member contains a mean of 4 percent calcite and 5 percent dolomite in comparison to 7 percent calcite and 7 percent dolomite in the finer-grained Aurora Till Member. The few calcareous samples of the Winthrop Till Member in the Quincy region have had a low percentage of $< 74 \mu\text{m}$ carbonates.

Separating the Wolf Creek and Alburnett Formations is the Westburg Soil (Hallberg, in press; Hallberg et al., 1978). We will examine a strongly-developed, oxidized example of this paleosol at Stop 2. Paleosols also occur between the members of the Wolf Creek Formation; however, we will not see these paleosols on the field trip. The Dysart soil (fig. 1) has been recognized extensively in Iowa (Hallberg et al., 1978) but has not been found in exposures in western Illinois. The contact between the Hickory

Hills and Aurora Till Members in western Illinois is usually a till—that is, a till contact having no intervening paleosol. A boring in northern Adams County does show calcareous Hickory Hills Till over leached Aurora Till; however, no solum could be recognized in the samples.

An "unnamed peat and organic paleosol" (Hallberg et al., 1978, p. 2-25) occurs between the Aurora and Winthrop Till Members in south-central Iowa. In western Illinois, a paleosol has been noted between the Aurora Till and a till tentatively correlated to the Winthrop Till. Further sampling of this lower till is needed to confirm correlations. The lower till has a mineralogy which definitely fits into the Wolf Creek Formation and occurs in the stratigraphic position of the Winthrop. Therefore, the till is tentatively correlated with the Winthrop Till but with the reservation that it could be a separate unnamed till member of the Wolf Creek Formation. We will not be able to examine the Winthrop Till on this field trip.

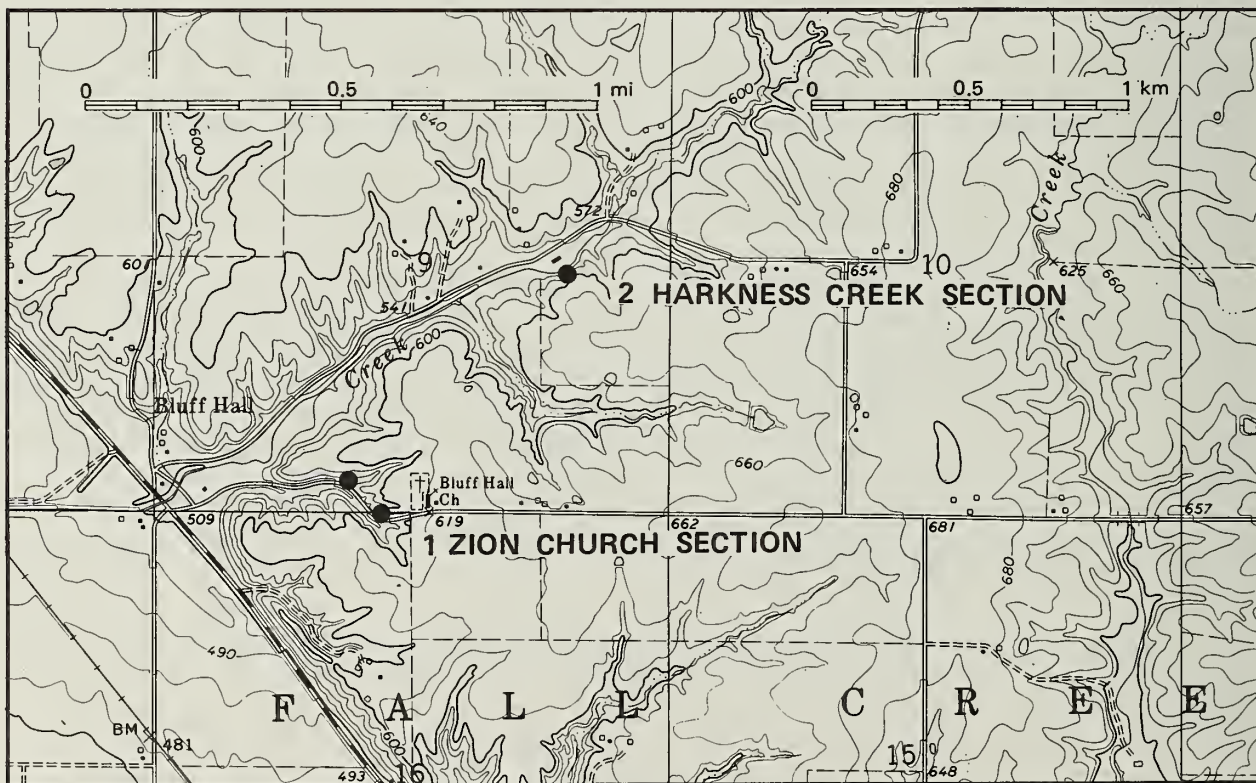


Figure 2. Locations of the Zion Church and Harkness Creek Sections.

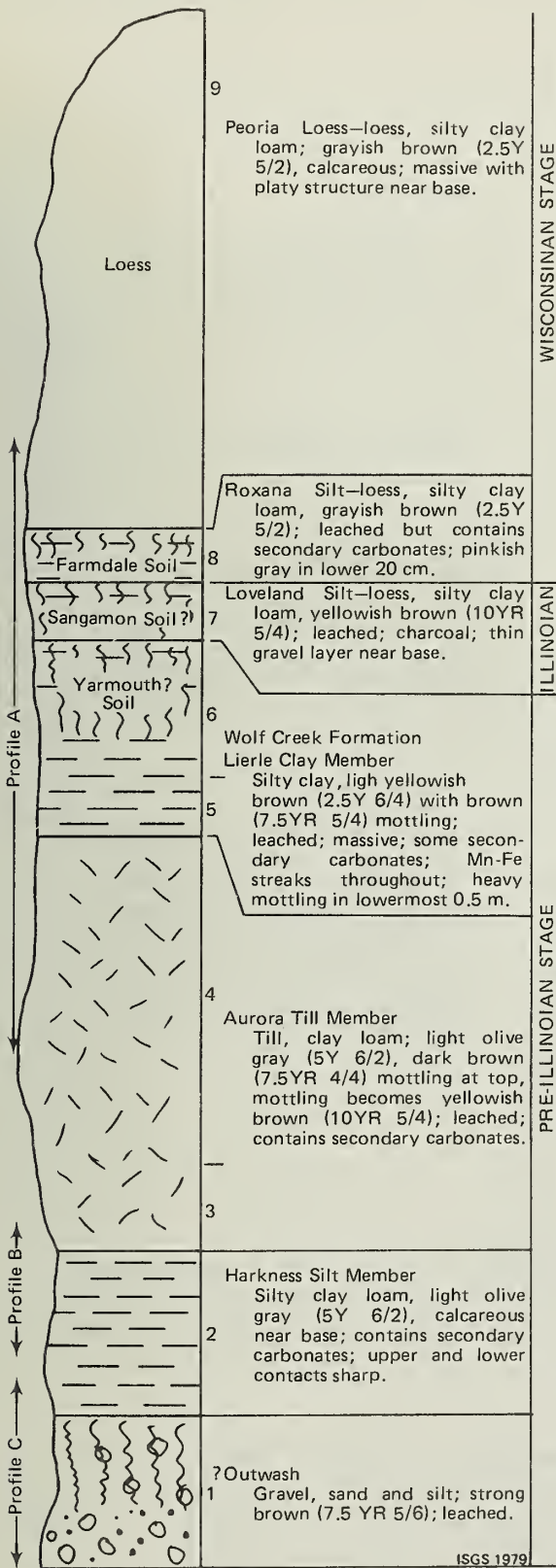


Figure 3. Stop 1. Zion Church Section.

The Zion Church Section is a composite section compiled from roadcuts and was first described by J. C. Frye and H. B. Willman in 1963. Further work was performed in 1964, 1965, and 1969. Published section descriptions appear in Frye, Willman, and Glass (1964), Frye and Willman (1965), and Willman and Frye (1970). Their most recent section description from Pleistocene Stratigraphy of Illinois (Willman and Frye, 1970) follows on the next page.

Willman and Frye suggested that all stages of the Pleistocene were represented by the deposits and soils of the Zion Church Section. The Zion Church Section is a reference section in Illinois for the Kansan Stage and Afton Soil. It is one of the few exposures in western Illinois where the Enion Formation has been described and is also the type section for the Harkness Silt Member of the Banner Formation. The numerous citations of Zion Church as a reference or type section illustrate the important considerations given to this section in the past.

The section is now much overgrown and the exposures are limited to only parts of the section. We will examine the section at three profiles, each profile exposing a different part of the section. Profile A is the uppermost exposure and extends from the base of the Peoria Loess down into the Wolf Creek Formation (fig. 3). Profile B exposes the base of the Aurora Till Member and its contact with the underlying Harkness Silt Member (fig. 3). Profile C is a small exposure along the ditch showing the contact of the Harkness Silt Member by Willman and Frye (1970).

Profile A

Only the basal portion of the Peoria Loess is present in Profile A. The remainder of the Peoria Loess occurs at higher elevations to the east and progresses up the road grade. In Profile A, two interpretations of the position of the Roxana Silt must be considered. Willman and Frye (1970)

ZION CHURCH SECTION

Measured in roadcuts in SE SE SW Sec. 9,
T. 3 S., R. 8 W., Adams County, Illinois, 1963,
1964, 1965, 1969.

	<i>Thickness (ft)</i>
<i>Pleistocene Series</i>	
<i>Wisconsinan Stage</i>	
<i>Woodfordian Substage</i>	
<i>Peoria Loess</i>	
9. Loess, massive, gray and yellow-tan, calcareous below the Modern Soil; contains limonite tubules and CaCO ₃ concretions below soil (P-1982 8 feet below top of loess and 2 feet below top of calcareous zone; P-1981 13 feet below top; P-1980 17 feet below top)	19.0
8. Loess, yellow-tan, massive, weakly calcareous; gradational contacts...	1.5
<i>Altonian Substage</i>	
<i>Roxana Silt</i>	
7. Loess, pinkish tan to light brown, leached; Farmdale Soil in top; CaCO ₃ nodules in middle; Chapin Soil in lower 1 foot; Mn-Fe pellets in lower part (P-1979 top; P-1978 1 foot above base)	4.0
<i>Illinoian Stage</i>	
<i>Loveland Silt</i>	
6. Silt, clayey, massive, leached, gray-tan; Sangamon Soil at top, uppermost foot accretion-gley; B-zone below accretion-gley 3 feet thick with Mn-Fe streaks and pellets, blocky to microblocky, mottled with gray, brown and black; contains some sand (P-2090 accretion-gley; P-2089 base)	8.0
<i>Yarmouthian Stage</i>	
<i>Banner Formation</i>	
<i>Lierle Clay Member</i>	
5. Accretion-gley (clay and silt), leached, blocky when dry; some sand and sparsely dispersed pebbles of chert and quartz; gray-tan with reoxidized zone at top; Yarmouth Soil (P-2088)	3.0
<i>Kansan Stage</i>	
<i>Banner Formation (continued)</i>	
4. Till, leached, blocky, gray, brown; a few pebbles and cobbles of chert, quartz, quartzite, granite, and other igneous rocks; Mn-Fe streaks and pellets below accretion-gley	22.0
3. Till, calcareous, gray and tan, massive; consists of clay, silt, and sand, with scarce pebbles, cobbles, and boulders (P-1746)	5.0
<i>Harkness Silt Member (type section)</i>	
2. Silt, calcareous, gray with tan-brown streaks, massive with indistinct color zonation; contains a few dispersed small pebbles and very scarce fragmentary snail shells; upper contact with till sharp but irregular; basal contact sharp (P-1745)	6.0
<i>Nebraskan Stage</i>	
<i>Enion Formation</i>	
1. Gravel, sand, and silt outwash, yellow-tan to red-brown, indistinctly bedded; pebbles include chert, quartz, quartzite, weathered granite and other igneous rocks; Afton soil (paratype); B-zone at top strongly developed, red-brown, clayey, tough; becomes less clayey downward (P-1744 top; P-1743 middle; P-7101 base)	5.5
Total	
74.0	

described a "weakly calcareous...transition zone" (unit 8) that they interpreted to be the base of the Peoria Loess. A 4-foot (1.2 m) thick "pinkish tan to light brown" loess (unit 7) having a soil developed in it was correlated with the Roxana Silt. Willman and Frye (1970) correlated the soil at the top of unit 7 with the Farmdale Soil.

An alternative interpretation, and the one tentatively used in this report, is that Willman and Frye's unit 8 is the Roxana Silt and unit 7 is the Loveland Silt, or at least a pre-Wisconsinan deposit. The contact between unit 8 and 9 is marked by a subtle color change to a darker value in unit 8 and by a change from calcareous to leached loess. Although unit 8 is leached, it has abundant secondary carbonates that may cause it to react to HCl. Chittick analyses of the < 74 μm fraction were performed across the boundary, and the

results show lower dolomite in the basal 7 cm of unit 9 with a sharp break into leached loess in unit 8.

The changes from Willman and Frye's section to the stratigraphy shown in figure 3 were initiated following discussions in the field with Leon R. Follmer and are based on reinterpretation of the positions of the Sangamon and Farmdale Soils. The soil at the top of unit 7, which Willman and Frye (1970) correlated to the Farmdale Soil, has definite B-zone characteristics and is a moderately well-developed soil. In the thick loess areas along the Ancient Mississippi Valley, the Farmdale Soil is a weakly developed weathering zone lacking a structural B horizon (McKay, 1979). The soil developed in unit 7 appears to be too well-developed to be correlated with the Farmdale Soil, however, the different glacial histories of the upper Mississippi Valley in western Illinois and the Ancient Mississippi Valley must be considered in correlating between valleys. The Roxana Silt is much thinner in the upper Mississippi Valley than along the Illinois and Mississippi Valleys. The early Wisconsinan weathering interval may have been longer in the upper Mississippi Valley because of earlier cessation of Roxana deposition and a later beginning of Peoria deposition. Further work on loess stratigraphy is needed along the Mississippi Valley in the Quincy region to resolve some of the immediate correlation problems.

The 0.65 m silty clay loam (unit 7) beneath the Roxana Silt is correlated to the Loveland Silt on the basis of its stratigraphic position. Near the base of the Loveland Silt is a thin gravel layer which may mark a former local erosion surface developed on a valley slope. The Zion Church Section parallels a branch of Harkness Creek (fig. 2) and traverses the bluff of the Mississippi Valley. The surfaces of the lower units appear to have a gradient toward the Mississippi Valley.

Below the Loveland Silt of figure 3 is the Lierle Clay Member, which is a leached silty clay loam, 2.1 m thick, containing secondary carbonates. Willman and Frye (1970) split this silty clay into two units and termed the upper one the Loveland Silt and lower one the Lierle Clay Member of the Banner Formation. Their subdivision was based on the presence of a Yarmouth Soil at the top of the Lierle Clay, 3 feet (0.9 m) above the top of till. In this report, the silty clay is considered one unit and is placed within the Wolf Creek Formation. No break is evident in the grain size or clay mineral data for the section (fig. 4). The basal part of the Lierle Clay Member, which Willman and Frye (1970) identified as the top of the Yarmouth Soil, has a more mottled appearance, but this does not appear to represent a significant break. The Lierle Clay probably accumulated slowly, either as a loessial or accretionary deposit, and the soil-forming process transgressed upward with the accumulation of new material. The more mottled appearance may be merely a function of multistory soil development.

The Hickory Hills Till Member of the Wolf Creek Formation is absent in the Zion Church Section. Erosion of the pre-Illinoian surface may have removed the upper part of the Wolf Creek Formation and the Yarmouth Soil and possibly the Hickory Hills Till was not deposited this far south; however, the till is known to be present only 8 km to the north. If the pre-Illinoian deposits have not been significantly eroded, the soil developed in the top of the Wolf Creek Formation is a compound soil, the Yarmouth-Dysart Soil.

The till in this section is tentatively correlated to the Aurora Till Member. The absence of unleached till at Zion Church makes it difficult to

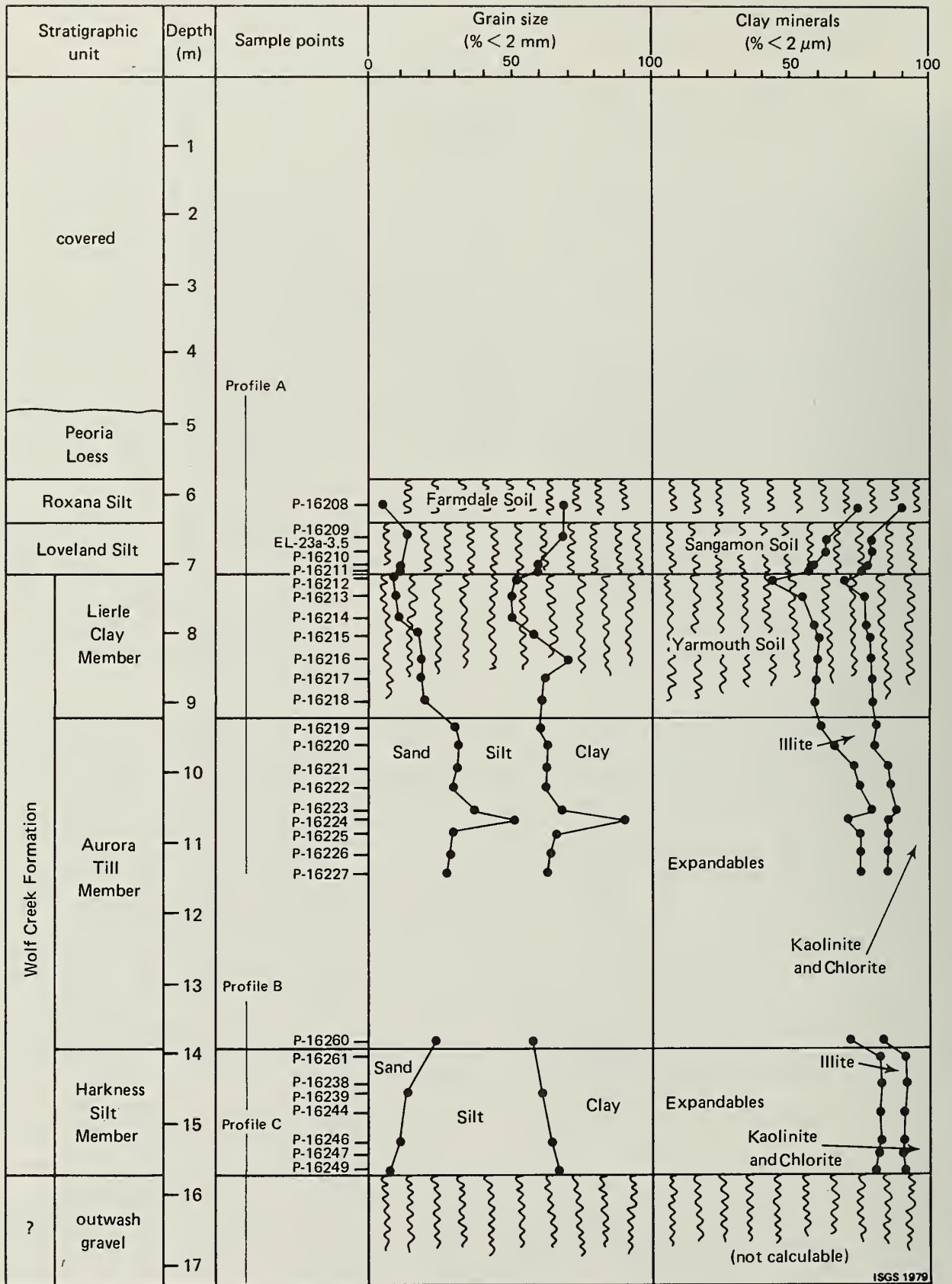


Figure 4. Stop 1, Zion Church Section.

determine whether the till correlates to the Aurora or the Winthrop Till Member because the two units are very similar in both their texture and clay mineral composition. The till at Zion Church has a mean matrix texture of 29 percent sand, 35 percent silt, and 36 percent clay, somewhat more clayey than the Aurora Till found in sections to the north (table 2). However, the textural differences are small enough (2 to 4 percent) to fall within the expected areal variations of the Aurora Till. Additional data are needed for the Winthrop Till Member in the Quincy area to better characterize the Winthrop Till in exposures.

Profile B

Profile B is a small exposure located approximately 90 m northwest of Profile A. A sharp contact between the till and the Harkness Silt Member is marked by a concentration of secondary carbonates in the base of the till. The underlying silt loam has alternating zones of reduced and oxidized colors. Figure 4 illustrates the very high expandable clay content (more than 80 percent) that is consistent throughout the Harkness Silt Member. Willman and Frye (1970) used the Zion Church Section as a type section to name the Harkness Silt Member, which they considered to be a proglacial silt deposited in front of the western Kansan glacier.

Profile C

Profile C is a ditch exposure that shows a sharp color boundary between the overlying light gray Harkness Silt and the underlying orange-brown outwash gravel. The paleosol developed in gravel at Zion Church has previously been considered a paratype for the Afton Soil (Willman and Frye, 1970). The gravel that Willman and Frye (1970) previously called the Enion Formation (Nebraskan) contains fine sand, silt, and clay in its matrix. Quartzite, granite, and various other igneous pebbles occur in the gravel; this indicates that the gravel was glacial outwash or was derived from glacial material. In either case, the gravel is a Quaternary deposit that occurs either at the base of the Wolf Creek Formation in the position of the Winthrop Till Member or lower in the section in the position of the Alburnett Formation.

TABLE 2. Analytical data for till units at each stop on the field trip

Section	Wolf Creek Formation					Alburnett Formation		
	Hickory Hills Till Member		Aurora Till Member			Texture ¹	Minerals ²	Carbonate content ³
	Texture ¹	Clay minerals ²	Texture ¹	Clay minerals ²	Carbonate content ³			
1. Zion Church	Not present		29-35-36 (13 spls.)	71-14-15 ⁰ (14 spls.)	—			Not present
2. Harkness Creek	Not present		27-41-32 (12 spls.)	73-12-15 ⁰ (12 spls.)	—	32-44-24 (6 spls.)	33-32-35 ^u (6 spls.)	5-8 ^u (5 spls.)
3. Mill Creek	37-30-33 (3 spls.)	70-11-19 ⁰ (3 spls.)	27-39-34 (21 spls.)	74-13-13 ⁰ (21 spls.)	—			Not present
4. Wand Spring	Not present		29-38-33 (10 spls.)	68-15-17 ⁰ (11 spls.)	6-6 ⁰ (9 spls.)			Not present

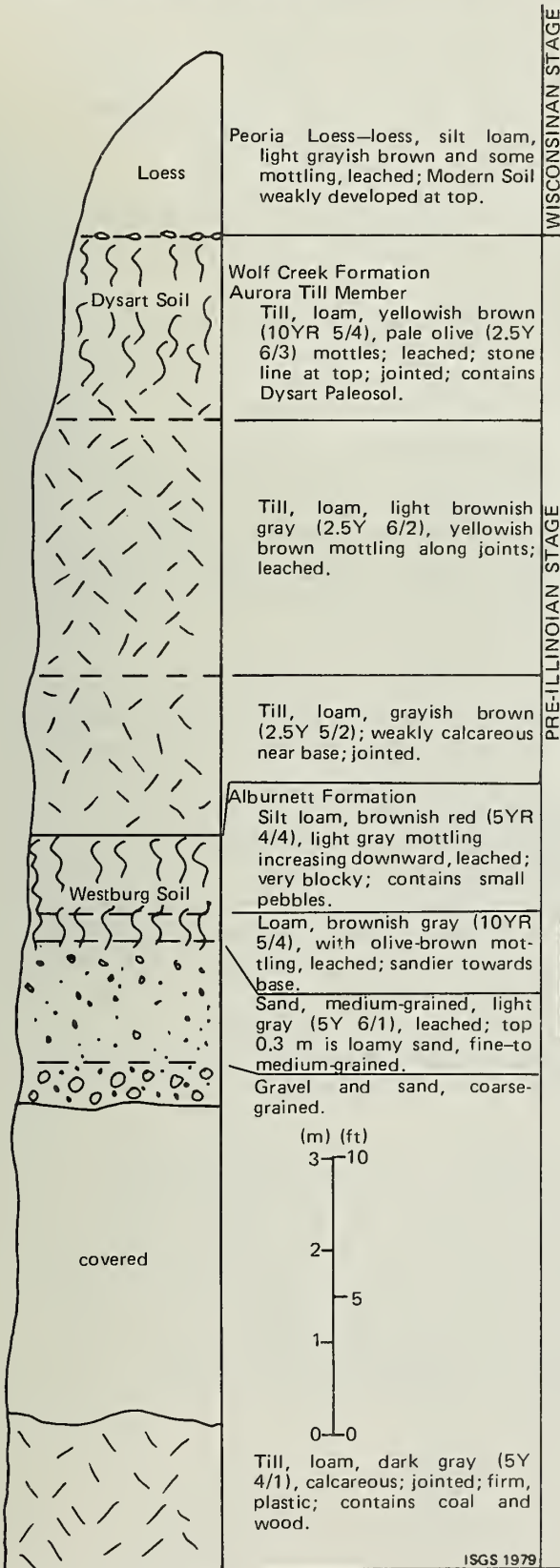
NOTE: ⁰ = oxidized samples used in calculations; ^u = unoxidized samples used in calculations

¹Texture = % sand - % silt - % clay (.004 mm clay)

²Clay minerals = % expandables - % illite - % chlorite and kaolinite

³Carbonate content = % calcite - % dolomite in the < 74 μm - fraction

Exposures at elevations below Profile C can be found in the creek banks on the opposite side of the road. These isolated exposures contain fine, leached sand. Two Illinois State Geological Survey geologists, Jerry A. Lineback and Alan M. Jacobs, discovered a till below the Enion gravels in an exposure located 150 m west of Profile C near the base of the bluff. The till has a high content of expandable clays similar to the Wolf Creek Formation; however, some question remains concerning the genetic classification of the material.



The Harkness Creek Section is in a cut-bank of Harkness Creek. The section described is the south bank of Harkness Creek behind the home of William Arp. This section was originally described in Wilson et al. (1966).

This is the only stop on the field trip where we will see the Alburnett Formation. Good exposures of the Alburnett Formation are rare, particularly in Adams County. Farther north in Hancock County (see inside back cover) the Alburnett Formation is thicker and can be found at the lowest levels of the landscape in a number of stream valleys. An important aspect of the Harkness Creek Section is the superposition of the Wolf Creek Formation over the Alburnett Formation with an intervening paleosol.

The loess-till contact near the top of the section is typical of the erosional contacts in the valley slopes. Here the Peoria Loess directly overlies a soil developed in the Aurora Till Member of the Wolf Creek Formation (fig. 5). A stone line at the contact represents an erosion surface that has truncated at least the Roxana Silt (early Wisconsinan loess) and the Loveland Silt (Illinoian loess). In dealing with an isolated exposure such as the Harkness Creek Section, it is impossible to determine how much of the upper part of the stratigraphic succession has been removed. Therefore, we cannot assume that the exposed till is the uppermost till in the area. At the next stop, located 6 km to the north, we will observe a thin till unit, the Hickory Hills Till Member of the Wolf Creek Formation, overlying the Aurora Till Member. The Hickory Hills Till may also be present at higher landscape positions in the immediate vicinity of the Harkness Creek Section, but it has been eroded at the section itself.

Figure 5. Stop 2. Harkness Creek Section.

Below the loess and stone line is a strongly developed paleosol in the Wolf Creek Formation. The soil is correlated to the Dysart Soil (Hallberg, in press; Hallberg et al., 1978), which occurs between the Hickory Hills and Aurora Till Members of the Wolf Creek Formation (fig. 1). Figure 6 shows the clay enrichment in the upper 1.5 m of till. Iron segregation along joints is especially prominent in the middle and lower portions of the Aurora Till. The brownish-gray color of the till matrix contrasts sharply with the orange-brown oxidation rinds surrounding the joints. Typically, the joints have a 3-cm rind of oxidized orange-brown till having a very thin (1 to 3 mm) central coating of gray secondary fine material.

The Aurora Till is homogeneous texturally and mineralogically below the Dysart Soil. In this section, the Aurora Till has a mean matrix texture of 27 percent sand, 41 percent silt, and 32 percent clay and standard deviations of 1.3 percent, 1.9 percent, and 1.3 percent, respectively. The till has few pebbles, the > 2-mm fraction ranging from less than 1 to 3 percent of the total sample. Clay mineral composition shows small changes upward in the weathering profile. The overall upward trend is decreasing illite with a corresponding increase in expandable clay content. The changes in calculated percentages are relatively small, only a seven percent increase in expandables was noted from the basal till sample to the sample just below the clay enrichment in the Dysart Soil (fig. 6).

The till matrix is leached of carbonates throughout the Aurora Till in this section. Near the base of the Aurora Till, the matrix becomes weakly calcareous, but Chittick analyses of the < 74- μ m fraction show a very low carbonate content. As mentioned previously in the introduction, the carbonate content is one of the diagnostic parameters that is used for till identification within the Wolf Creek Formation. Because the carbonates have been leached in this section, till identification was based on texture and clay mineral composition. The high expandable clay content is a distinctive characteristic of the Wolf Creek Formation; however, the till members within the Wolf Creek Formation have nearly identical clay mineral compositions and cannot be separated on that basis. The texture of the Aurora Till in the Harkness Creek Section corresponds closely to the textures of Aurora Till that are identified in sections farther to the north (table 2) and was the main consideration in correlating the till with the Aurora Till Member.

The most conspicuous feature in this exposure is the contact between the grayish-brown Aurora Till and the underlying reddish-brown Westburg Soil. The Westburg Soil (Hallberg, in press; Hallberg et al., 1978) is developed in a fining-upward sequence of outwash deposits that are apparently related to the Alburnett Formation. Intense weathering of the finer grained outwash in the upper part of the paleosol has severely altered the clay mineral composition (fig. 6). For this reason, clay mineral data for the outwash do not correspond to data for unoxidized, unleached till exposed at the base of the section.

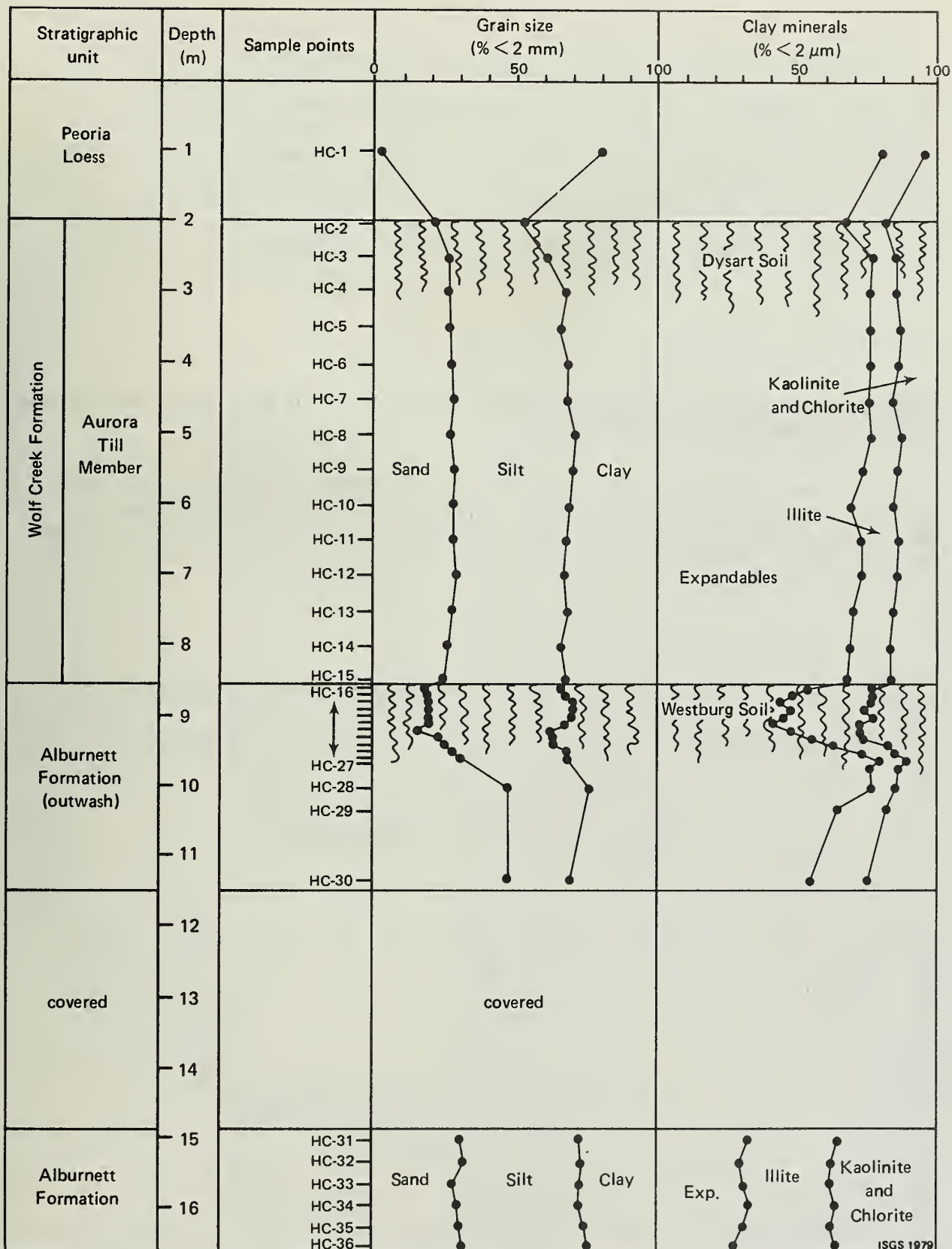


Figure 6. Grain sizes and clay mineralogy of the Harkness Creek Section.

A covered interval hides the contact of outwash on till; however, probe holes into the covered zone encountered oxidized till at a level 4 m below the top of outwash. No significant stratigraphic break was evident between the outwash and till of the Alburnett Formation. Correlation of the unoxidized till with the Alburnett Formation is not difficult in this section, based on the physical appearance of the till and the analytical data. Along Harkness Creek, the Alburnett Formation is dark gray, jointed, and blocky; this is typical of the Alburnett Formation in exposures. The high content of kaolinite in the clay fraction is particularly diagnostic of the Alburnett Formation (fig. 6).

STOP 3—The Mill Creek Section. SW¼ SW¼ SW¼ Sec. 22, T. 2 S., R. 8 W., Quincy East 7.5-minute Quadrangle, Adams County, Illinois (fig. 7).

The Mill Creek Section is a cutbank along Mill Creek that is located due south of the Halfpap Trailer Court. The section has previously been described by Horberg (1956) and was visited by J. C. Frye and H. B. Willman in 1961, 1964, and 1965.

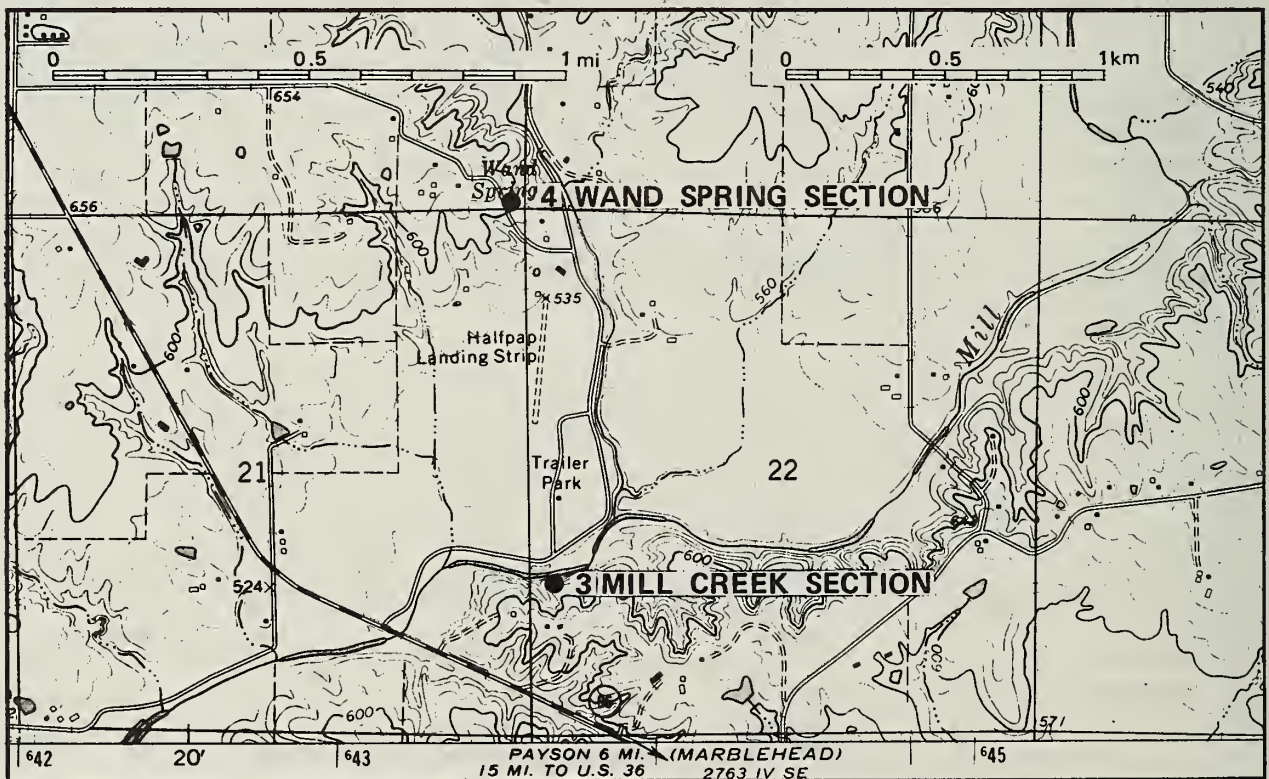


Figure 7. Locations of Mill Creek and Wand Spring Sections.

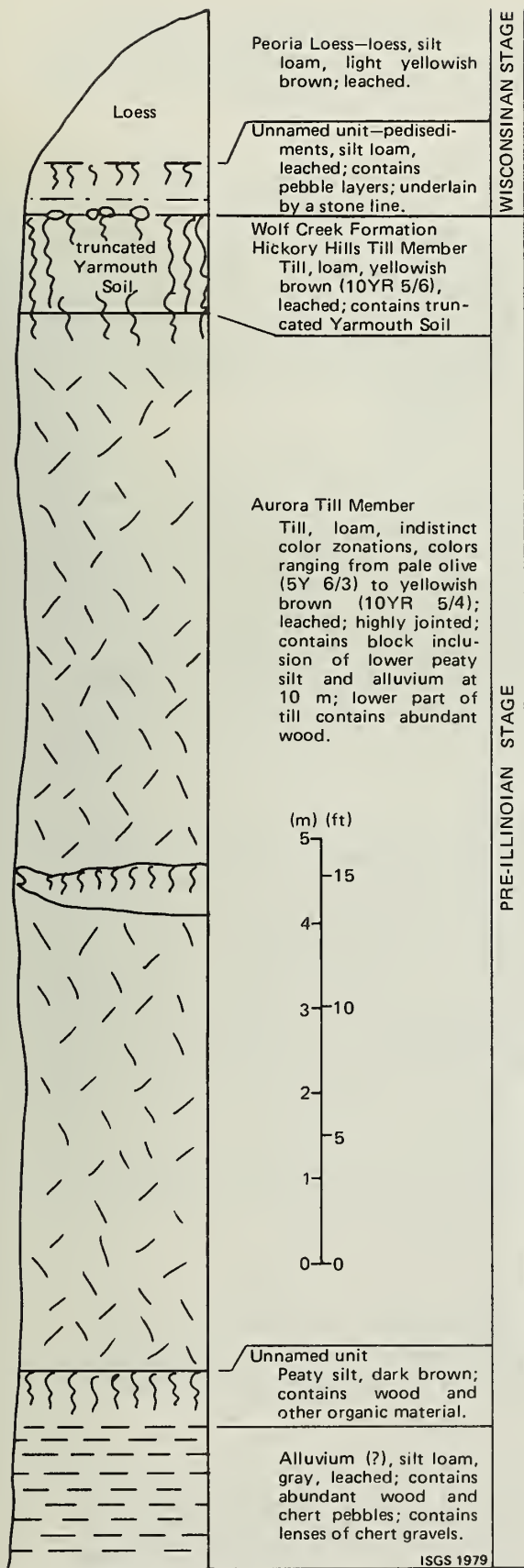


Figure 8. Stop 3. Mill Creek Section.

Large exposures occur along Mill Creek but are subject to frequent large-scale slumping. The author and Lineback (ISGS) first visited and sampled the Mill Creek Section in 1977. The section was revisited in 1979 and was described and sampled again because of slumping over the original site. The lower part of the section is unstable; different areas along the exposure have periodically been exposed and then slumped over.

The upper part of the section contains an incomplete stratigraphy, which again illustrates the problems in dealing with isolated exposures located at low levels in the landscape. At lower levels of the landscape, erosion surfaces may truncate progressively larger stratigraphic intervals (Ruhe, 1969).

Only 2.4 m of Peoria Loess are exposed at the top of the bluff. Underlying the loess in places is a zone of pedisements which in turn overlies a stone line. The stone line represents an erosion surface which has truncated the Hickory Hills Till (fig. 8) and has completely eroded the Loveland and Roxana Silts. The pedisements are material deposited on the erosion surface during the slope-forming process. Where the pedisements are absent, the Peoria Loess directly overlies the erosion surface on till.

The age of the pedisements and erosion surface is problematic in this case. We can definitely state that the erosion surface developed sometime between deposition of the Hickory Hills Till Member and the Peoria Loess. We may be able to refine this by noting the missing stratigraphic intervals. Both the Loveland Silt and Roxana Silt are missing; this suggests that an erosion cycle occurred after deposition of the Roxana Silt (Altonian) and prior to deposition of the Peoria Loess (Woodfordian). Deposition of the Roxana probably ceased approximately 30,000 radiocarbon years B.P. (McKay, 1979), and the Peoria Loess was deposited along the upper Mississippi Valley between approximately 20,000 and 13,000 radiocarbon years B.P. (McKay, 1979). Hence, the erosion surface

falls within an interval between 30,000 and 13,000 radiocarbon years B.P. The Iowan erosion surface located to the northwest was undergoing its major period of development between about 21,000 and 17,000 radiocarbon years B.P. (Hallberg et al., 1978).

Beneath the pedisediments and erosion surface is 1.2 m of Hickory Hills Till (fig. 8). In a section 5 km north of the Mill Creek Section, the Hickory Hills Till is 6.5 m thick, indicating that the till is not uniformly thin in this region. A truncated Yarmouth profile extends through the Hickory Hills Till and into the underlying Aurora Till. The till boundary between the Hickory Hills and Aurora Till Members is marked by a textural break from the sandier Hickory Hills Till into the siltier Aurora Till (fig. 9). A color change to a grayer Aurora Till also occurs across the contact. The Dysart Soil is absent at this section.

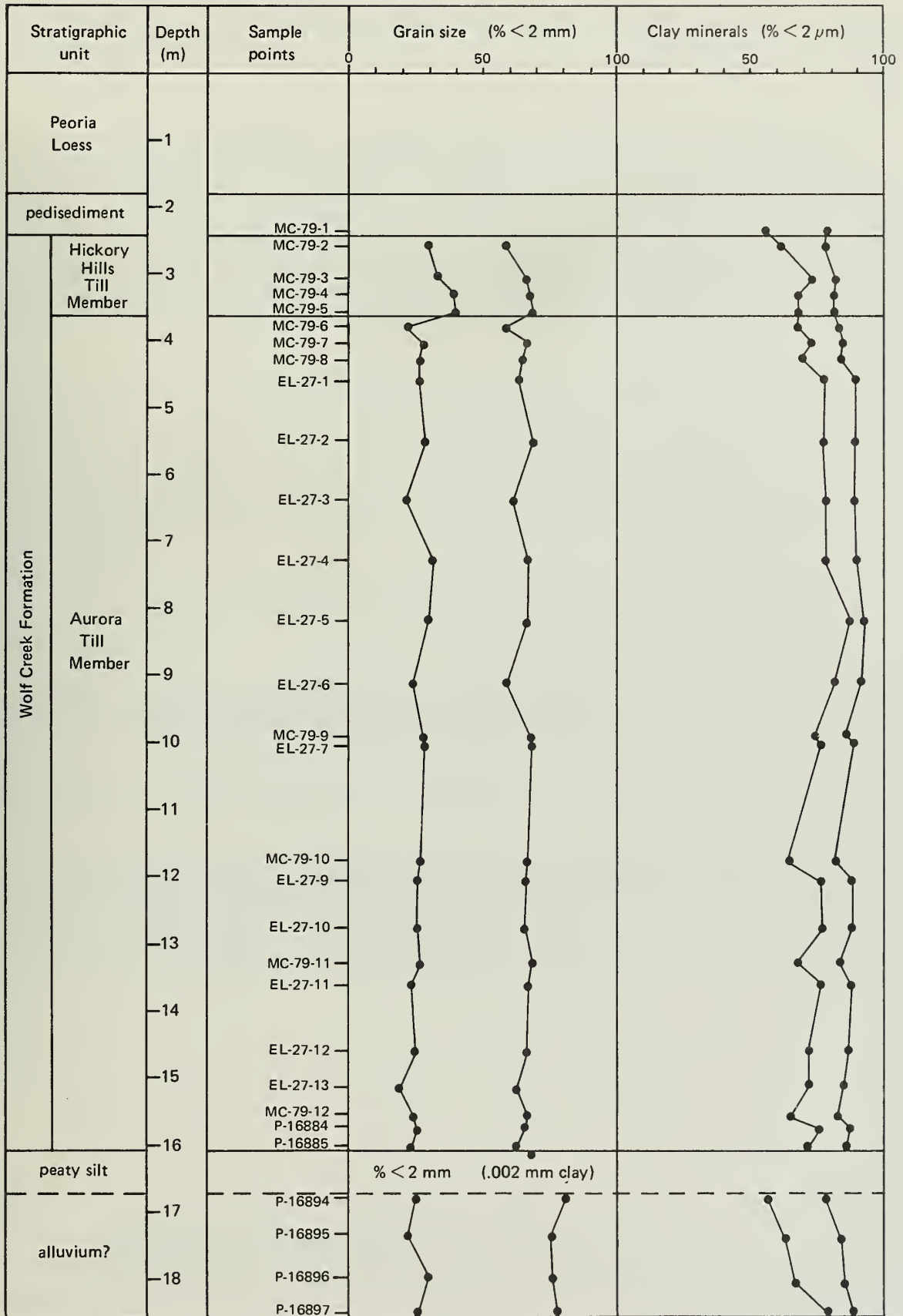
Here the Hickory Hills Till Member can be distinguished from the rest of the Wolf Creek Formation by its higher sand content. The absence of calcareous till causes the same correlation problems within the Wolf Creek Formation as at Stops 1 and 2. Separation of the lower two till members of the Wolf Creek Formation by texture alone is very difficult. At Stop 4, which is only 1.2 km to the north, calcareous till is present that has a carbonate content, texture, and clay mineral composition that closely resembles that of the Aurora Till in the Quincy region. Analytical data and field characteristics from the tills at Stops 3 and 4 are similar enough for both tills to be considered the same unit and both are therefore correlated with the Aurora Till Member.

More than 12 m of Aurora Till are present at the Mill Creek Section. Chittick analyses of weakly calcareous till in the lower part show only 2 to 3 percent total carbonates in the $< 74 \mu\text{m}$ fraction, much below the original carbonate content of any members of the Wolf Creek Formations. Carbonates have been at least partially leached throughout the entire thickness of till. An additional consideration that may affect the apparent depth of leaching in a nonvertical exposure is the paleotopography of the hillslope. If the exposed section is subparallel to the paleosurface of the hillslope, leaching near the base of the section may be related to a surface that was much closer to the base of till than the measured 12 m.

The Aurora Till is highly jointed throughout the Mill Creek Section. Note the stress release deformation in vertical cuts which has caused the joints to bend outward at the top. A block inclusion of the underlying organic silts and alluvium can be found at a depth of 10 m.

A complex zone of organic silts underlies the Wolf Creek Formation. In places, this zone may be 3 m thick and consists of stratified organic silt, sandy silt, and/or silty clay. A gray, leached silt loam extends from below the organic zone to the creek bed where Burlington Limestone (Mississippian) is exposed.

The gray silt loam is a poorly sorted till-like deposit that is interpreted to be an alluvium. The texture of the alluvium is more variable than that of the overlying Aurora Till; however, distinct stratification is not present. The large majority of pebbles in the alluvium are chert



ISGS 1979

Figure 9. Stop 3. Mill Creek Section.

with some sparse igneous pebbles also occurring. Isolated lenticular bodies of chert pebbles and cobbles within the alluvium resemble gravel bars; this suggests that the deposit accumulated in a fluvial environment. Wood is very abundant within the alluvium.

In its physical appearance, the alluvium is somewhat similar to the Alburnett Formation which we saw at Stop 2. The alluvium is not correlated with the Alburnett Formation; this assumption is based on field evidence indicating that the deposit is not till and, also, that the high expandable clay content of the alluvium contrasts with the Alburnett Formation. The presence of sparse igneous pebbles may indicate that glacial deposits were present in the region at the time the alluvium was deposited, but most of the deposit is probably derived locally from within the Mill Creek drainage system.

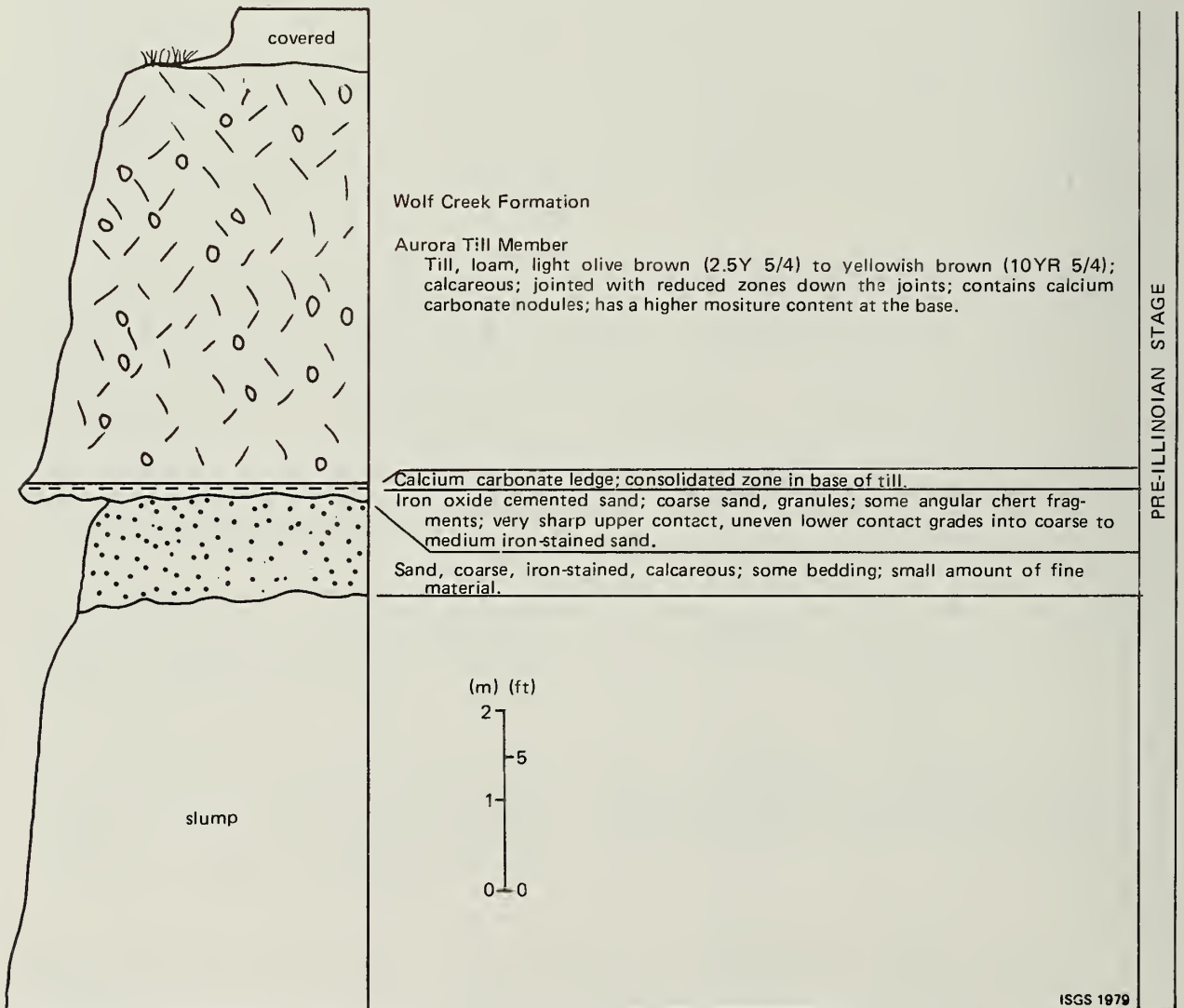


Figure 10. Stop 4. Wand Spring Section.

The Wand Spring Section is a roadcut on the west side of Highway 336. The exposure described on figure 10 is partially within a sinkhole in the Burlington Limestone (Mississippian) (fig. 11). Sampling began at the level of a bench cut into till. The bench follows the bedrock surface for most of the length of the roadcut and an overgrown slope in till occurs above the bench. The bedrock surface remains at a relatively constant level throughout the southern and middle portions of the roadcut, but in the northern end, till truncates the upper part of the bedrock (fig. 11).

The exposed till in this roadcut is part of the Wolf Creek Formation and is correlated with the Aurora Till Member (fig. 12). A calcium carbonate cemented zone 2 cm thick marks the base of till and traverses the sinkhole at a level close to the level of the bedrock surface on either side of the sinkhole. A 4 to 10 cm thick iron-cemented zone in coarse sand is in contact with the overlying carbonate cemented base of the till. Filling the sinkhole is a coarse- to medium-grained, iron-stained, well-rounded sand.

The sinkhole was probably filled by sand early in its development. The till across the top of the sinkhole shows no sign of local incorporation of sands.

Two other large sinkholes filled with dark red clay and chert residuum are located on the west side of the roadcut. Large joints adjacent to the sinkholes contain dark red clay and also have sand in fillings. The dark red clay is not found above the bedrock surface and is confined to joints and sinkholes within the Burlington Limestone. Again, no signs of local incorporation of the dark red clay are evident within the superjacent till.

Based on evidence at this section, two conclusions seem apparent. The glacier did not erode material within the sinkholes, yet till lies directly on the bedrock surface in adjacent areas. Apparently, the glacier did not have the capacity to erode small depressional areas. Secondly, material which was eroded from the surface was homogenized and transported.

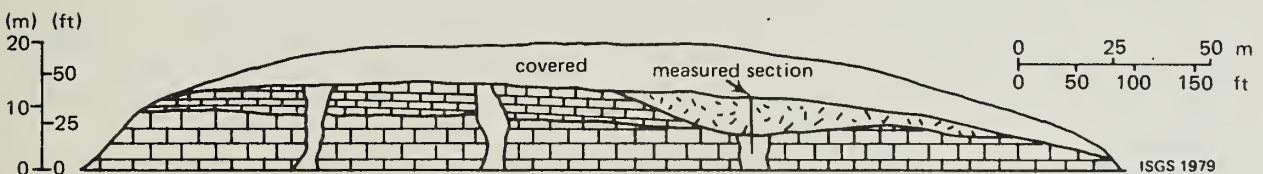
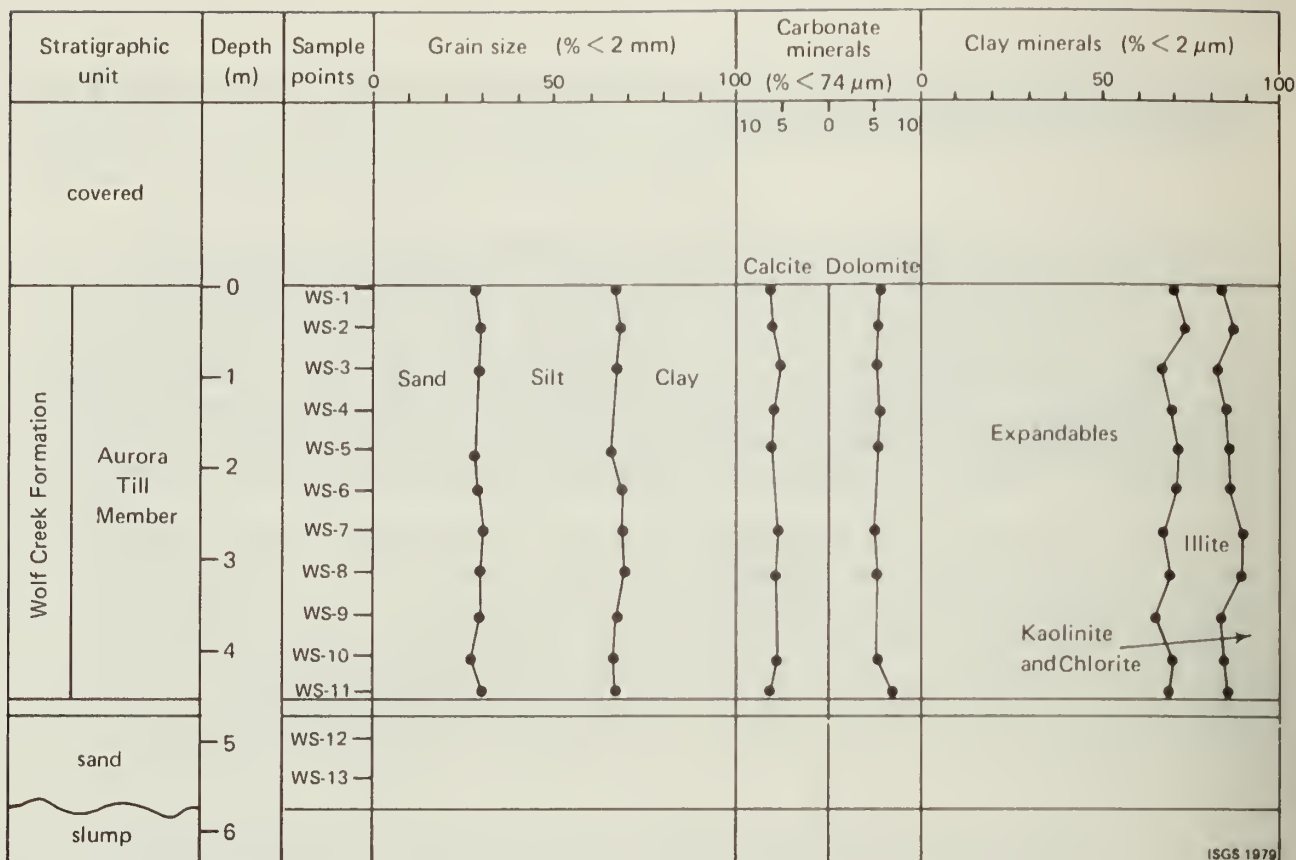


Figure 11. Diagram of Wand Spring Section. Datum is road level.



ISGS 1979

Figure 12. Stop 4. Wand Spring Section.

REFERENCES

Boellstorff, J. D., 1978, Proposed abandonment of pre-Illinoian Pleistocene Stage terms: Geological Society of America Abstracts with Programs, v. 10, no. 6, p. 247.

Frye, J. 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.

Frye, J. C., and H. B. Willman, 1965, Illinoian section, R. P. Goldthwait, organizer; C. B. Schultz and H.T.U. Smith, [eds.] in Guidebook for field conference C—Upper Mississippi Valley: International Association of Quaternary Research 7th Congress, Nebraska Academy of Science, p. 81-110; Illinois State Geological Survey Reprint 1966-B (supplemental data, H. D. Glass, p. G-S1 to G-S4), 26 p.

Hallberg, G. R., T. E. Fenton, G. A. Miller, and A. J. Lutenecker, 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, Iowa, p. 2-1 to 2-94.

Hallberg, G. R., in press, Pleistocene stratigraphy in East-Central Iowa: Iowa Geological Survey.

Hallberg, G. R., and J. D. Boellstorff, 1978, Stratigraphic "confusion" in the region of the type areas of Kansan and Nebraskan deposits: Geological Society of America Abstracts with Programs, v. 10, no. 6, p. 255.

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

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

Leverett, Frank, 1899, The Illinoian glacial lobe: United States Geological Survey Monograph 38, 817 p.

Lineback, J. A., 1979, The status of the Illinoian glacial stage: Midwest Friends of the Pleistocene 26th Field Conference, Illinois State Geological Survey Guidebook 13.

McKay, E. Donald, 1979, Wisconsinan loess stratigraphy of Illinois: Midwest Friends of the Pleistocene 26th Field Conference, Illinois State Geological Survey Guidebook 13.

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

Wickham, J. T., and J. A. Lineback, 1978, Multiple glacial advances of western Illinois: Geological Society of America Abstracts with Programs, v. 10, p. 287.

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

Wilson, George, David Reinertsen, William Cote, and Robert Major, 1966, Quincy area geological science field trip: Illinois State Geological Survey Guide Leaflet 1966 B, 17 p.

GLACIAL MAP OF ILLINOIS


H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899),
 Ekblow (1959), Leighton and Brophy (1961),
 Willman et al. (1967), and others

EXPLANATION


HOLOCENE AND WISCONSINAN


 Alluvium, sand dunes,
and gravel terraces

WISCONSINAN

 Lake deposits

WOODFORDIAN

 Moraine


 Front of morainic system

 Ground moraine

ALTONIAN

 Till plain

ILLINOIAN

 Moraine and ridged drift

 Ground moraine

KANSAN

 Till plain

DRIFTLESS



