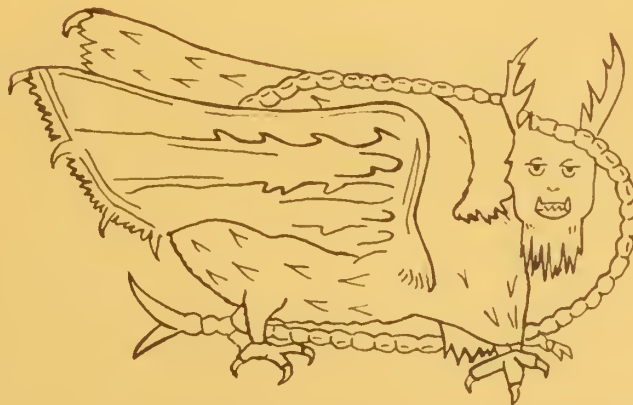


GUIDE BOOK

FOR THE FIELD CONFERENCE HELD IN CONNECTION WITH
THE 39TH ANNUAL CONVENTION OF THE
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
AT ST. LOUIS, MISSOURI
April 16, 1954

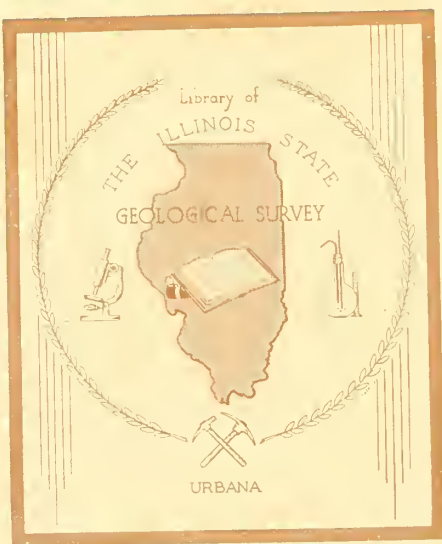


Piasa Bird
From an Indian pictograph on a cliff at St. Louis
limestone northwest of Alton, Illinois

*Guidebook Series
no. 3*

Field conference sponsored by

THE ILLINOIS STATE GEOLOGICAL SURVEY



ILLINOIS STATE GEOLOGICAL SURVEY



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Guide to the
STRUCTURE AND PALEOZOIC STRATIGRAPHY
ALONG THE LINCOLN FOLD
IN WESTERN ILLINOIS

Prepared by

C. W. Collinson, D. H. Swann, and H. B. Willman, Leaders

William W. Rubey, Honorary Leader

A. A. P. G. Field Conference
April 16, 1954

HONORARY LEADER

William W. Rubey

Research Geologist, U. S. Geological Survey
Washington, D.C.

Mr. Rubey is the author of the detailed report, "Geology and Mineral Resources of the Hardin and Brussels Quadrangles (Illinois)," U. S. Geological Survey Professional Paper 218, 1952, which describes the geology of the area in which most of the present field trip takes place. Mr. Rubey's report is outstanding because of his fine analysis of the many problems in stratigraphy, structure, and physiography. The study was cooperative between the U. S. Geological Survey and the Illinois State Geological Survey. The indebtedness of the writers of this guidebook to Mr. Rubey's report is evident from the many references to it.

The Field Trip Committee and the Illinois Geological Survey are happy to welcome Mr. Rubey as Honorary Leader.

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THE PIASA BIRD
(on the cover)

In 1673 the Jesuit priest Father Jacques Marquette, in his journey down the Mississippi, saw a pictograph on the rocky bluff near the site of Alton. He described it as "two painted monsters which at first made us afraid, and upon which the boldest savages dare not rest their eyes. They are as large as a calf; they have horns on their heads like those of a deer, a horrible look, red eyes, a beard like a tiger's, a face like a man's, a body covered with scales, and so long a tail that it winds all around the body, passing above the head and going back between the legs, ending in a fish's tail." One of the figures, commonly known as the Piasa (Pi-a-saw) Bird, drawn from Marquette's description, was published in 1887 in Records of Ancient Races of the Mississippi Valley by William McAdams. McAdams interviewed people who had seen the original pictographs and also had two rough drawings made from the originals.

According to Indian legend, the Piasa Bird was an evil spirit who devoured the warriors of the Illini. One legend tells how Chief Quatoga, armed with an invulnerable shield, prepared an ambush for the Piasa Bird atop a high bluff. After a terrible struggle, Quatoga and his warriors slew the bird and returned to their people as heroes.

The original paintings which Marquette discovered were defaced by fragments of rock falling away from the cliff face and were pock-marked by thousands of bullets fired by Indians who considered firing upon it a religious ritual. The remaining part was finally blasted away a century ago. Recently the figure seen at Substop 1D, copied from McAdams' book, was painted at a point which overlooks the approach to the broad recreational parkway which bears his name.



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FIELD TRIP ORGANIZATION

CENTRAL COMMITTEE for the 39th Annual Meeting at St. Louis
of the

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Society of Exploration Geophysicists
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ILLINOIS STATE GEOLOGICAL SURVEY

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C. W. Collinson

D. H. Swann

H. B. Willman

TRIP PLAN

Please read your guidebook before arriving at each stop, or as soon as you arrive, Note the time limitations and instructions. There is more here than you can see, and you may wish to concentrate on some features.

All the information needed is given in the guidebook. Consequently, introductory talks will be limited to a brief orientation.

Leaders (identified by red arm bands) will be stationed at the various exposures at each stop to point out major features and answer questions.

At some stops the buses will be moved after unloading, so take your guidebooks with you.

Prompt loading of the buses on signal will enable us to spend more time on the outcrops.

Remember your bus number. Please return to the same seat in the same bus. That is the only way we can be sure that no one will be left behind.

ACKNOWLEDGMENTS

In addition to information taken from published reports, as acknowledged in the text, this guidebook contains unpublished data from current studies by the Illinois Geological Survey. It is not considered a publication. Interpretations are subject to change and must not be quoted without verification.

Table 1. - STRATIGRAPHIC SECTION

CENOZOIC

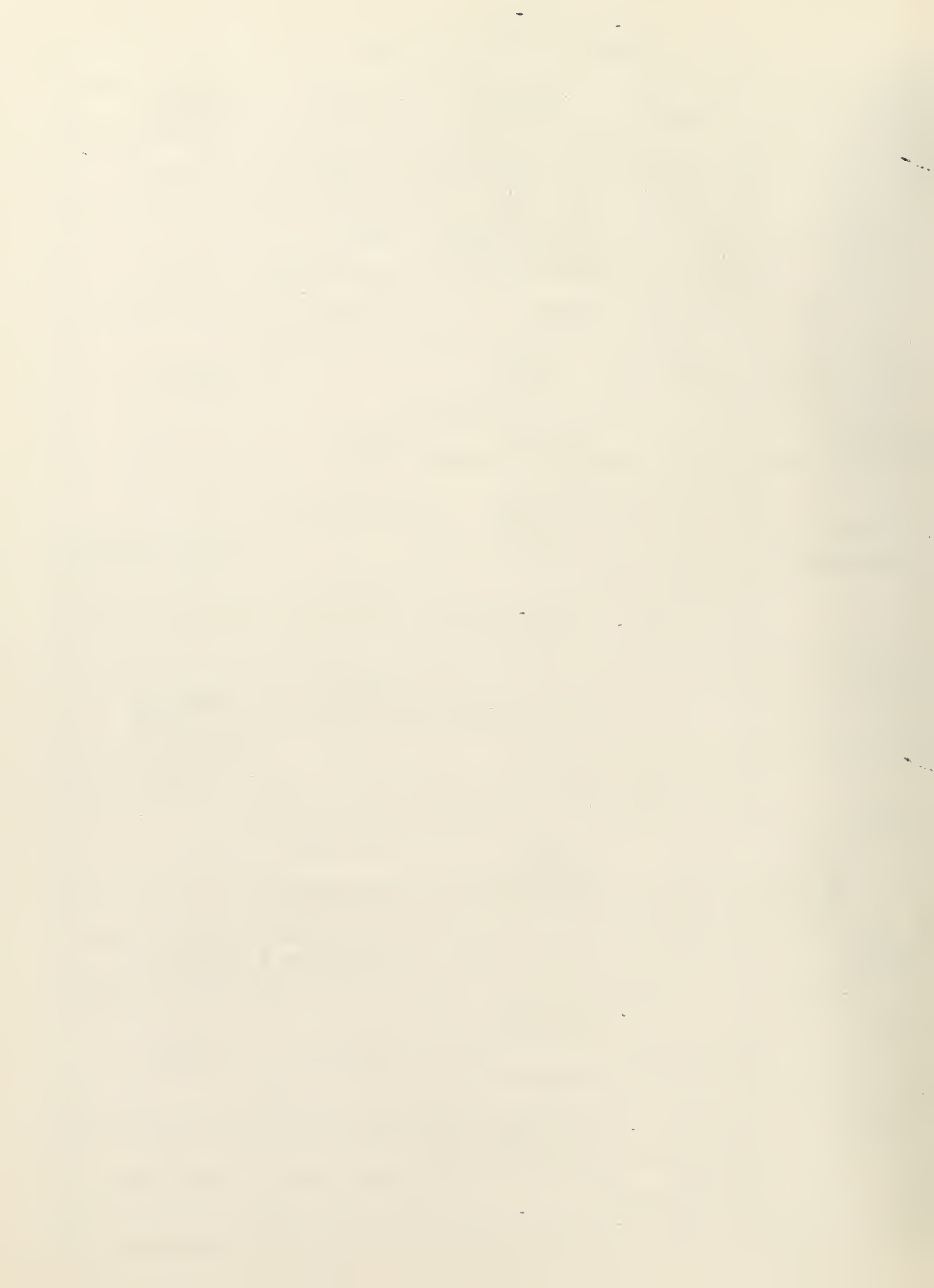
System	Series	Stage	Substage	Thick.	Dominant Material
Quaternary	Pleistocene	Recent		0-150	Alluvium
		Wisconsin	Mankato	0-50	Deer Plain gravel, sand
			Cary		Peorian loess
			Tazewell	0-75	Peorian loess
			Iowan		Peorian loess
		Farmdale	0-20	Loess	
		Sangamon		Soil	
Illinoian		0-100	Till, Loveland loess, Brussels silt, sand		
Yarmouth			Soil		
Kansan			0-45	Gravel, till?	
Tertiary	Pliocene			0-30	Grover gravel

PALEOZOIC

System	Series	Group	Formation	Thick.	Dominant Material
Pennsylvanian		McLeansboro		0-28	Clay, limestone
		Carbondale		65-90	Shale, clay, coal
		Tradewater		0-85	Clay, sandstone
Mississippian	Iowa	Meramec	Ste. Genevieve	0-30	Oolite, coarse, sandy
			St. Louis	170-240	Limestone, fine, variable
			Salem	70-95	Calcarenite
		Osage	Warsaw	50-80	Shale, dolomite, geodes
			Keokuk	60-70	Limestone, crinoidal, cherty, argillaceous
			Burlington	140-200	Limestone, crinoidal, cherty, pure
			Fern Glen	0-30	Limestone, crinoidal, cherty, shaly
			Sedalia	0-20	Dolomite, fine
		Kinderhook	Chouteau	20-70	Limestone, argillaceous
			Hannibal	10-70	Shale, siltstone
			Glen Park	0-25	Limestone, shale, oolite
			Louisiana	0-4	Limestone, lithographic
Saverton	0-1		Shale, blue-green		
Grassy Creek	0-1/3		Shale, black		
Sylamore	0-2	Sandstone			
Devonian	Middle		Cedar Valley	0-40	Limestone, calcarenite, "Hoing" sandstone
Silurian	Niagaran		Joliet	0-60	Dolomite, massive to medium bedded
	Alexandrian		Kankakee	0-30	Dolomite, thin wavy green partings
			Edgewood	10-50	Dolomite, argillaceous
Ordovician	Cincinnatian		Maucketa	100-200	Shale
	Mohawkian		Kimmswick	70-90	Limestone, crinoidal
			Decorah	30	Limestone, shaly
			Plattin	100	Limestone, fine, variable
	Chazyan		Joachim	80	Dolomite, silty
		St. Peter	150	Sandstone	
		Everton	10+	Dolomite, sandstone	

Table 2c - CORRELATION CHART

	Mid-Continent	Field Trip Area	Indiana-Kentucky	Tennessee	New York-Virginia
M	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Ste. Genevieve	Greenbriar
	St. Louis	St. Louis	St. Louis	St. Louis	
I	Spergen	Salem	Salem (Spergen)	Warsaw	Maccrady
	Cowley	Warsaw	Harrodsburg		
S	Boone	Keokuk	Borden	Fort Payne	Pocono
		Burlington			
I	St. Joe	Fern Glen	New Providence	Maury	Hatched
		Sedalia			
S	Sycamore	Chouteau	Rockford	Hardin	Hatched
	Woodford- "Chattanooga"	Hannibal	N E W A L B A N Y		
Glen Park					
Louisiana					
Saverton					
Grassy Creek					
I	Misener	Sylamore	Blackiston	Chattanooga	Hatched
D	Hatched			Trousdale	Bradfordian Chautauquan Senecan
	Hatched				
E	Cedar Valley			A B L O C H E R	Tully
	Hatched				
V	Hunton	(Low Middle Silurian to high Middle Devonian.)			
	St. Clair	Joliet	Laurel Osgood		
Chimney Hill		Kankakee	Brassfield	Prassfield	Medina
	Edgewood	Hatched			
O	Sylvan	Maquoketa	Cincinnati	Cincinnati	Queenston
	Viola	Hatched		Nashville	Trenton
Kimmswick		Cynthiana Perryville			
S	Simpson	Decorah	Lexington	Stones River	Black River
		Plattin	High Bridge		
I	Joachim				
		St. Peter			



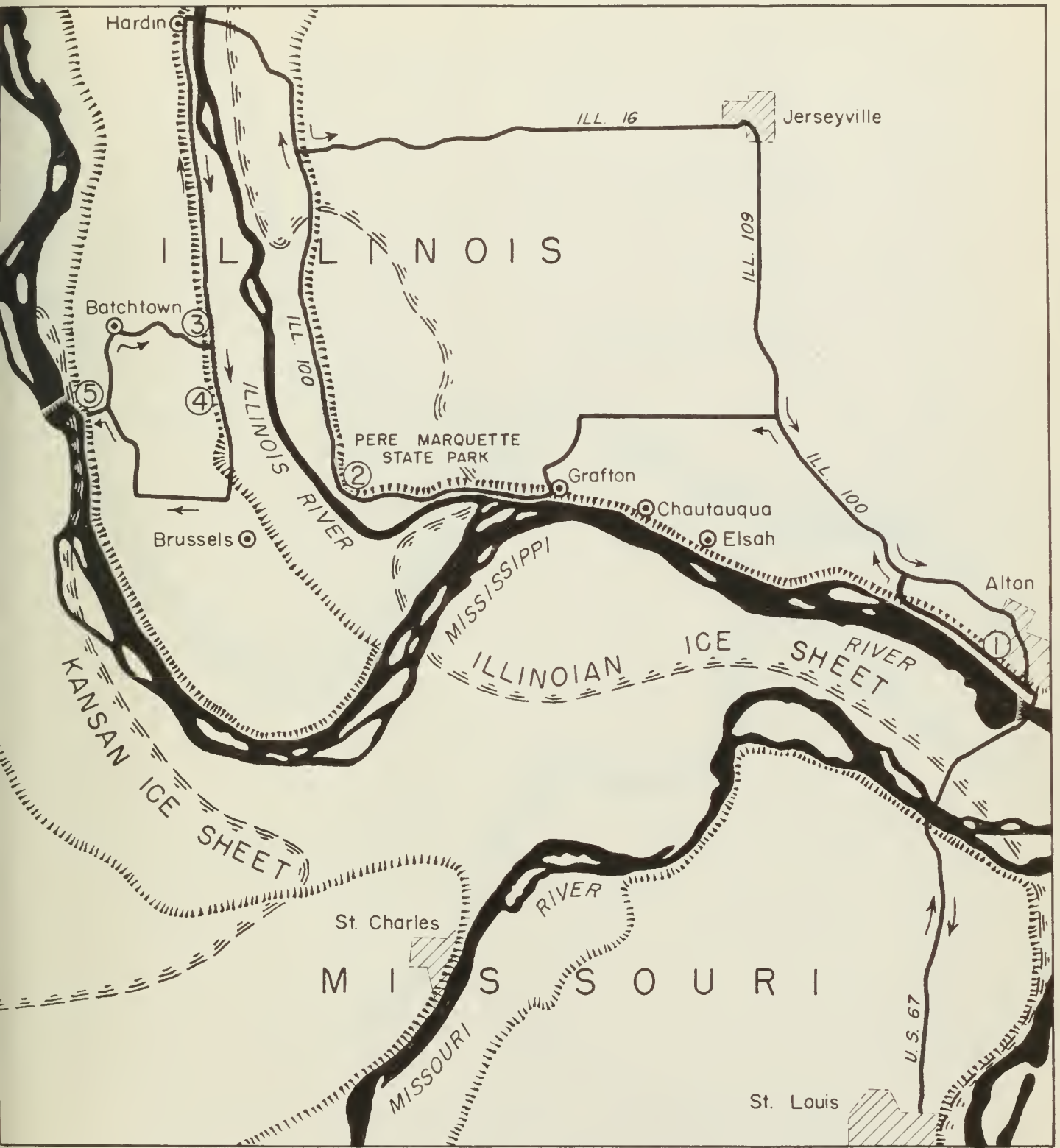

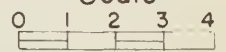


Figure 1 - Physiography and Route Map

 Upland
 Bottomland

 Boundaries of Ice sheets

 Route and Stop

Scale

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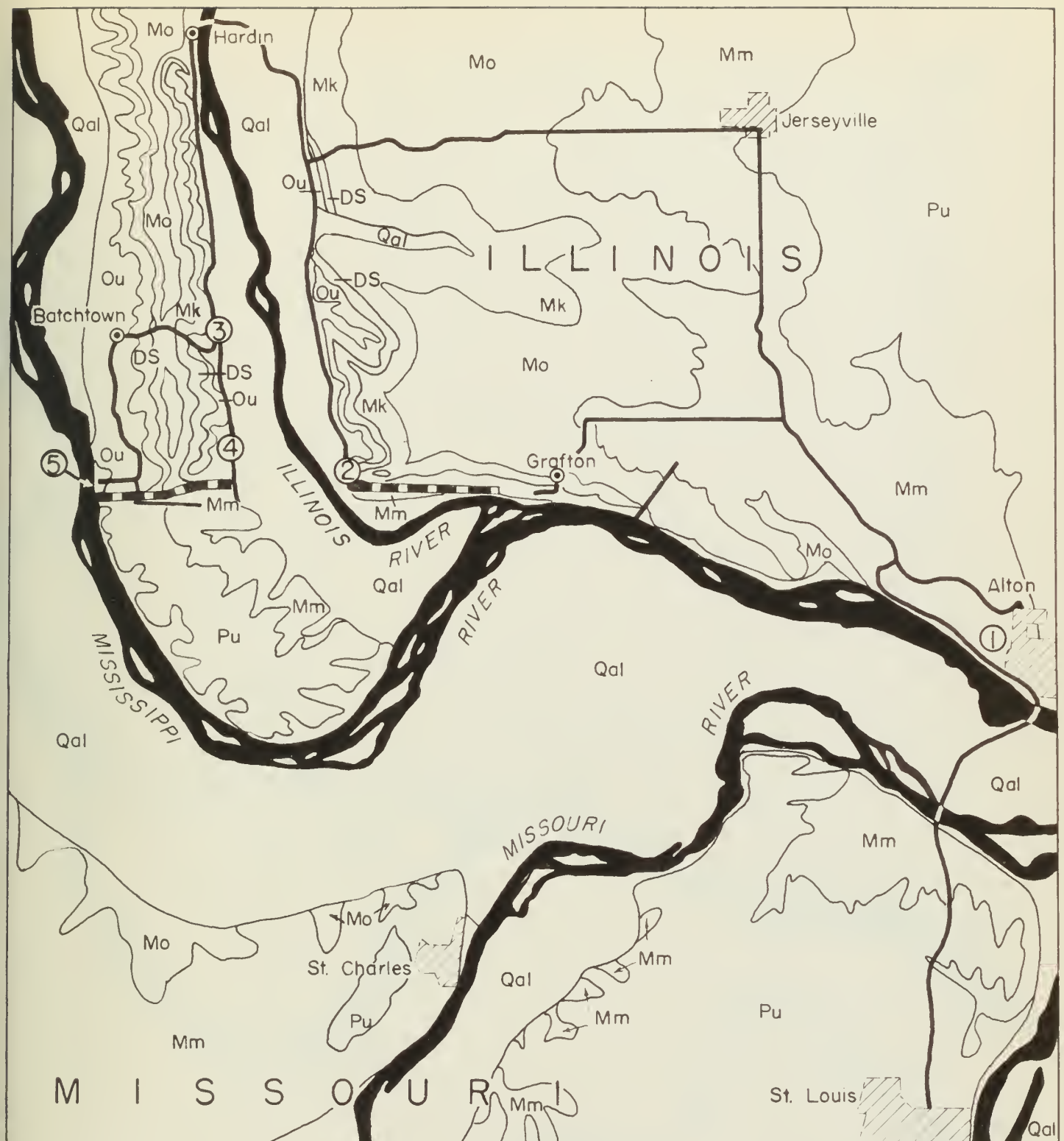


Figure 2 - Generalized Geologic Map
 Adapted from Illinois State Geological Survey and
 Missouri Geological Survey Geologic Maps

- | | | | | | | | |
|-----|---------------|------------------|---------|---|------------------------|------------------------------|------------|
| Qal | Alluvium | Mm | Meramec | Mk | Kinderhook | Ou | Ordovician |
| Pu | Pennsylvanian | Mo | Osage | DS | Devonian -
Silurian | Scale
0 1 2 3 4 MILES
 | |
| ③ | Stop number | Field trip route | | Cap au Gres flexure (Ordovician to Pennsylvanian) | | | |



Adapted from Collingwood, Krey, Rubey

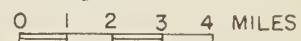
Figure 3 - Structure Map

Contours on top of Chouteau limestone.

Contour interval, 50 feet. Intermediate contours omitted on Hardin Syncline (lowest contour 300 feet) and along Cap au Gres flexure, (highest contour 1100 feet.)

④ Field trip route and stop

Scale



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ROAD LOG

ASSEMBLY POINT: East (12th Street) door of the Jefferson Hotel.

TIME: Buses will leave at 7:30 A.M. (Central Standard Time) and will return to starting place at 6:30 P.M.

Mileage

0.0 Leave Jefferson Hotel, 12th and Locust Blvds., downtown St. Louis.

There are many possible routes out of St. Louis, the best depending upon traffic conditions and the current status of St. Louis' changing traffic control patterns. The alternative routes converge at the junction of U.S. 67 and 66, 11.3 on our log. The route logged starts north on 12th Street Boulevard at the Jefferson Hotel and follows U. S. City 66 for 5.5 miles, largely on 12th Street and Florissant Avenue.

3.9 O'Fallon Park on right.

At this point the route is less than one-half mile west of the Mississippi River bluffs. Exposures of Illinoian till in the park and elsewhere along the bluffs show that the Illinoian ice, advancing from the northeast, crossed Mississippi valley in this area. The ice dammed the river and formed a lake which extended many miles up the Mississippi, Missouri, and Illinois valleys. Sand and silt deposited in the lake now occur in the Brussels terrace, the surface of which is at an elevation of 520 to 540 feet, 70 to 90 feet above the present flood plain.

5.5 Continue ahead on Florissant Avenue, staying west of cemetery. Do not follow U. S. City 66 to the right through the cemetery.

6.6 Turn right from Florissant Avenue onto Riverview Blvd. (U. S. 67) at stop light immediately beyond the cemetery.

7.8 Traffic circle at 6-point intersection. Remain on U. S. 67 by turning right onto circle, passing two intersections, turning right on the third.

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Mileage

- 9.9 Pass over Chambers Road.
- 11.3 Pass under U. S. 66 - Bypass 40.
- 14.5 Cross-bedded Ste. Genevieve oolite in banks of Coldwater Creek both sides of highway, but most visible on right.
- 14.8 Bridge over railroad. The St. Louis-Ste. Genevieve contact is exposed beneath railroad bridge over Coldwater Creek about 400 yards to right.
- 15.7 Cuts along the railroad west (left) of the highway show the typical sequence of loess deposits which blanket the region outside the area covered by Illinoian ice (see fig. 1). The sequence is particularly well exposed above the rock face just before the bridge over the Missouri River. The loess deposits can be differentiated readily by differences in color. The upper 25 feet of the exposures is yellowish-buff Peorian loess. The underlying darker-colored, chocolate-brown Farmdale loess is about 8 feet thick. Below the Farmdale loess is red Loveland loess, about 10 feet thick. The Loveland loess rests on the Ste. Genevieve limestone, but in places in the quarry east of the highway it is separated from the limestone by patches of the Tertiary "Lafayette-type" brown chert gravel, called Grover gravel by Rubey (1952, pp. 61-74).

The loess deposits consist of glacial silt carried by wind from valley-train deposits along the major valleys and deposited on the bluffs and uplands. The Loveland loess was blown from the valley train of the advancing Illinoian ice sheet and owes its red color and clayey character to deep weathering during the Sangamon interglacial stage. The Farmdale loess was derived from the valley train of the earliest ice sheet of the Wisconsin glacial stage, and the Peorian loess is an undifferentiated deposit blown from all later Wisconsin valley trains (Leighton and Willman, 1950).

- 16.2 Fort Bellefontaine quarry of Missouri Portland Cement Co., on right, is largely in St. Louis limestone, though Ste. Genevieve caps some parts of quarry face. We are on the east nose of the dome on whose crest, about 2 miles west of here, the Florissant oil field is located. The field was discovered in 1953 during test drilling of the Florissant structure for possible use in a gas storage project. Production is from the Trenton (Kimmswick) limestone (Middle Ordovician) at about 1000 feet. The field

Mileage

is not quite drilled out; about 40 completions prove some 700 acres. The generalized section penetrated in the drilling (table 3) and the structure map (fig. 4) were made available by Dr. Edward L. Clark, Director, Missouri Geological Survey.

- 16.5 Missouri River. Clark Bridge.
- 16.9 Recent flood plains of the Missouri and Mississippi Rivers.
- 18.5 Bluffs visible across the Mississippi River to left. Stop 1 will be immediately to left of the large grain elevators.
- 20.8 Mississippi River. Lewis Toll Bridge.
- 21.0 Enter Illinois. U. S. Dam No. 26 to left with lock against Illinois shore.
- 21.5 Junction with U. S. Alt. 67, Illinois 111, and Illinois 100 at foot of bridge. Turn left (west) on Broadway, following U. S. 67. Alton (pop. 32,500) is the northern outpost of the St. Louis industrial complex with oil refineries, lime and stone quarries, flour mills and other processing and manufacturing plants. The town was first settled in 1783 on the site of a fur trading post. It was developed by Col. Rufus Easton and named for one of his sons. Shurtleff College (founded in 1827) is located here.
- 21.9 After passing the large parking area on the left (south), continue straight ahead (west) on W. Broadway along the north (right) side of the "Occident Flour" elevators. Do not follow the numbered highways which turn right up the hill.
- 22.0 Stop sign at blind intersection with State Street. Continue ahead on Broadway.
- 22.2 Buses will unload at the parking lot immediately beyond the milling company buildings on the right. They continue to parking place (mileage 22.6) in front of abandoned quarry.

Table 3. - GENERALIZED STRATIGRAPHIC COLUMN

FLORISSANT DOME

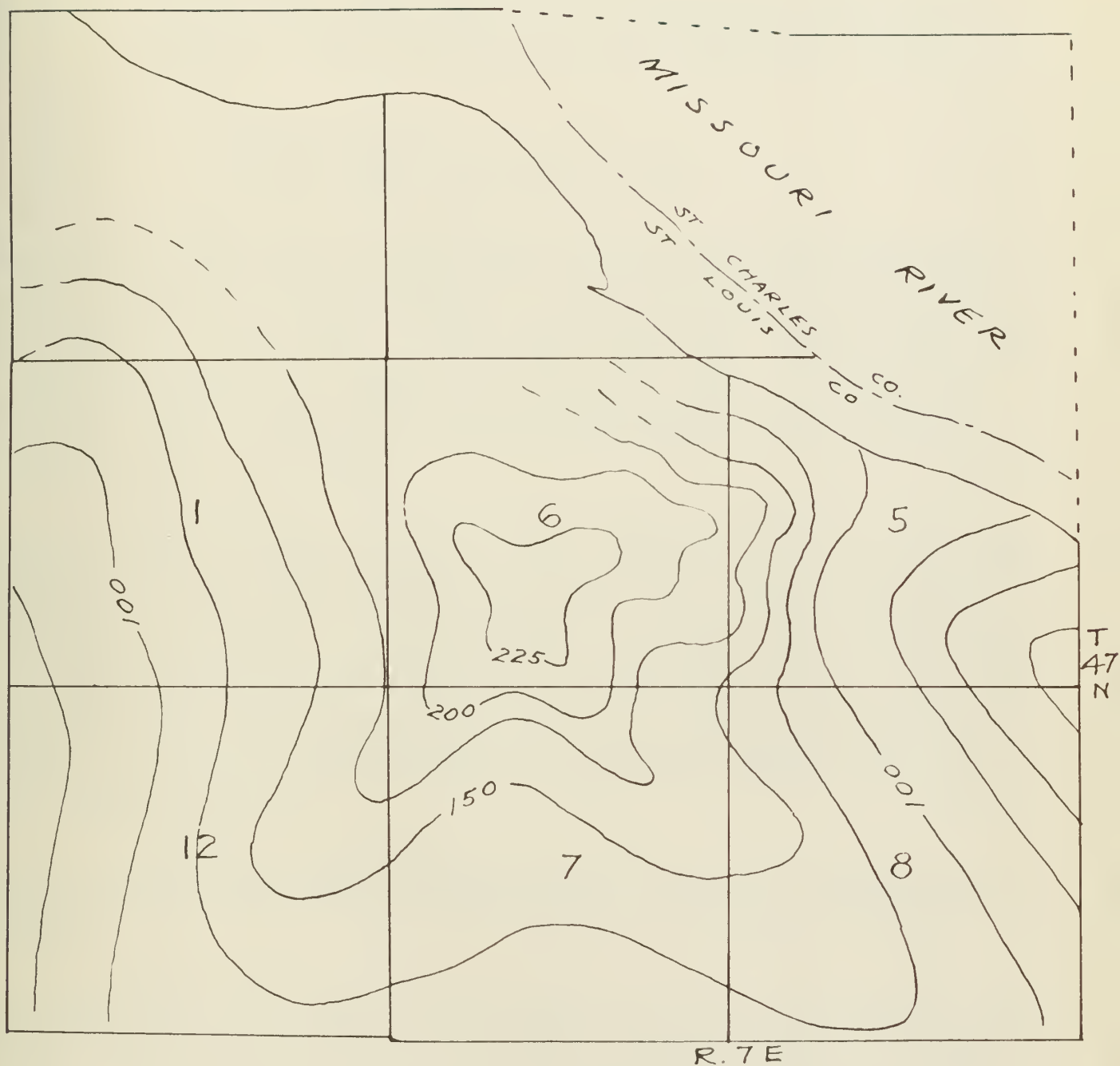
By Earl McCracken

Missouri Geological Survey

Pleistocene loess	0-30
Mississippian	
Ste. Genevieve*	30-75
St. Louis*	75-165
Spergen	165-315
Warsaw	315-390
Burlington-Keokuk	390-585
Fern Glen	585-660
Chouteau	660-700
Grassy Creek (Chattanooga)	700-730
Silurian (undifferentiated)	730-840
Ordovician	
Maquoketa	840-965
Kimmswick	965- T.D, Producing formation (30-50 foot penetration)

* The Ste. Genevieve is eroded from the top of the dome and the St. Louis is partly truncated.

Figure 4



FLORISSANT DOME (Generalized)
Contour Interval 25 feet
Datum - Top of Warsaw Shale
EARL McCracken, MO. GEOL. SURVEY, 1954.

STOP 1 - Alton Bluff, St. Louis and Ste. Genevieve formations.
NW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 14, SW $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 11, SE $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 10, T. 5 N.,
R. 10 W., Alton 7.5 and 15 minute quadrangles, Madison
County.

Substops - 15
Walking distance -- one-half mile
Leaving time - 10 A.M.

Stratigraphy and sedimentary features of the upper part of the St. Louis and the lower part of Ste. Genevieve formations* are well shown in the first half-mile of the Mississippi River bluff above the Alton business district. Several small faults with throws of inches to a few feet, and some with horizontal displacements in the order of several tens of feet, are also seen. Attention is called to features of interest at specific points along the bluff by the device of substops, 1A to 1N (index map on the fold-in, fig. 5). Stratigraphic and structural details at several of the substops are shown on figure 5.

Structurally, we are on the eastward extension of the Cap au Gres faulted flexure (fig. 3), here represented by a dip of three degrees nearly straight south. This south dip separates the low east end of the Lincoln anticline 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 18 miles upstream follows the line of the Cap au Gres flexure. Hidden beneath the river, the flexure becomes higher and steeper to accommodate the westward-rising anticline to the nearly flat syncline. The flexure emerges west of Grafton with 700 to 900 feet of structure in a half mile, and dips are locally vertical.

As might be expected near the end of a major flexure, there has been adjustment involving minor faulting. Substops 1D-E, 1F, 1G, and 1J show at least four different varieties of minor faults.

All continuous beds more than two inches thick at this stop are limestones, but some beds are represented on figure 5 by patterns indicative of weathering characteristics, composition, or bedding, rather than the conventional limestone brickwork. Units M, Q, and S are oolites whose cross-bedding is suggested in the patterns. Algal colonies are indicated in units P and Q, and are also present in the largely inaccessible units U and W. The "white beds," units O and R, are composed almost entirely of "curdy" lithographic limestone indistinguishable from the material forming the algal "heads"

* The problem of the St. Louis-Ste. Genevieve contact is discussed on page 26.

DESS



MIS



Oolite"



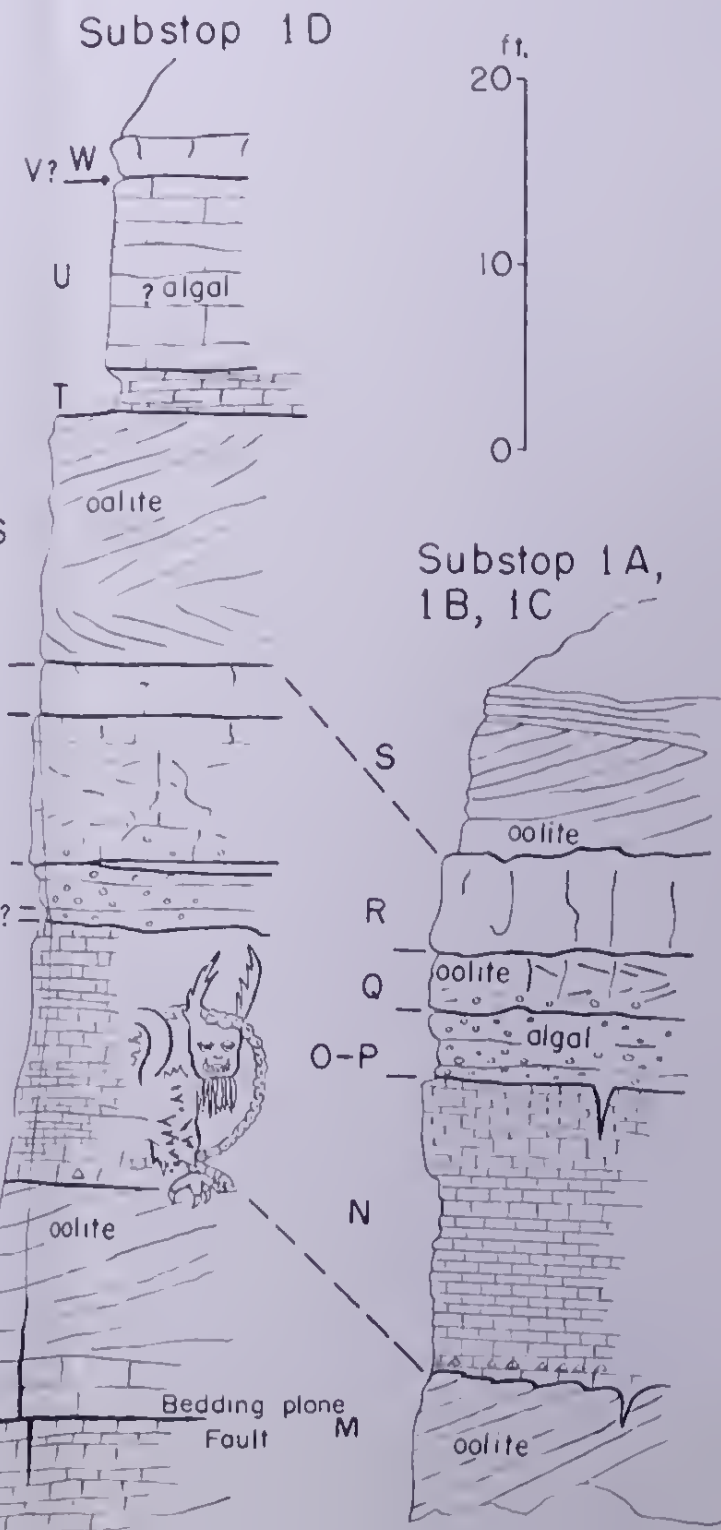
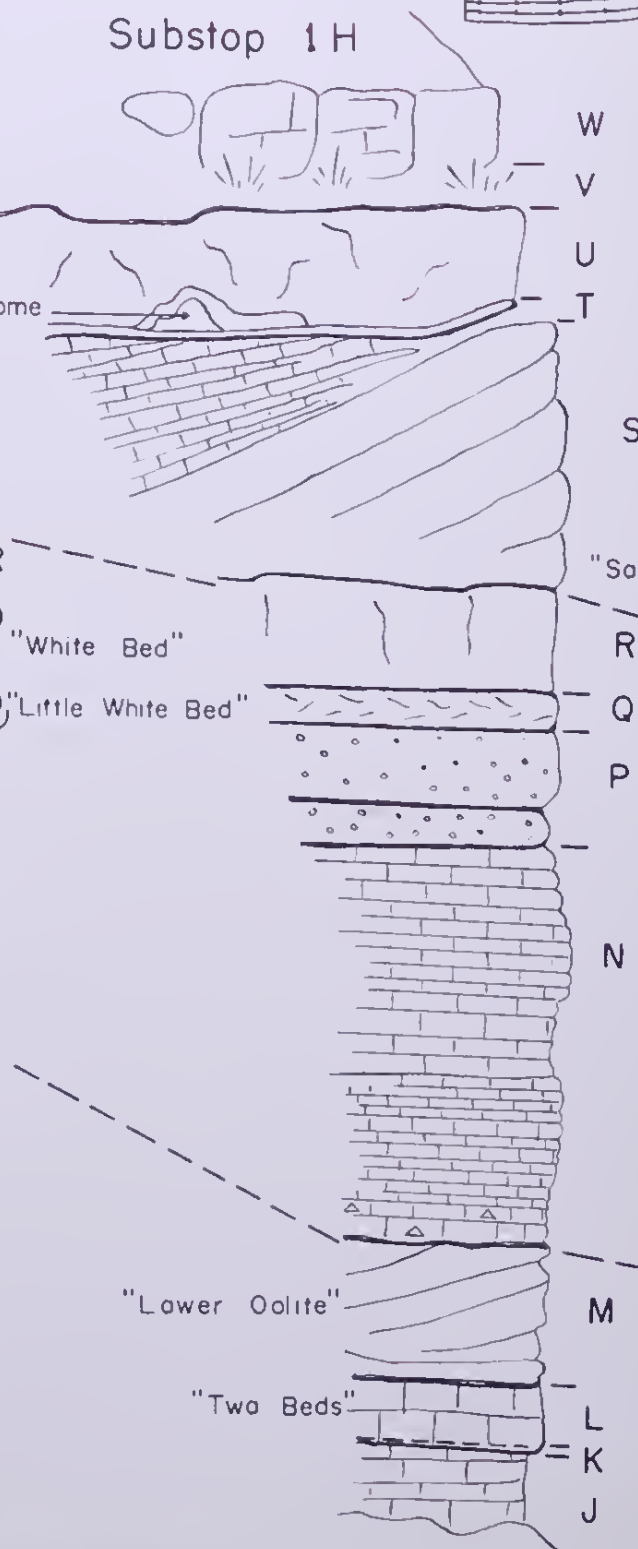
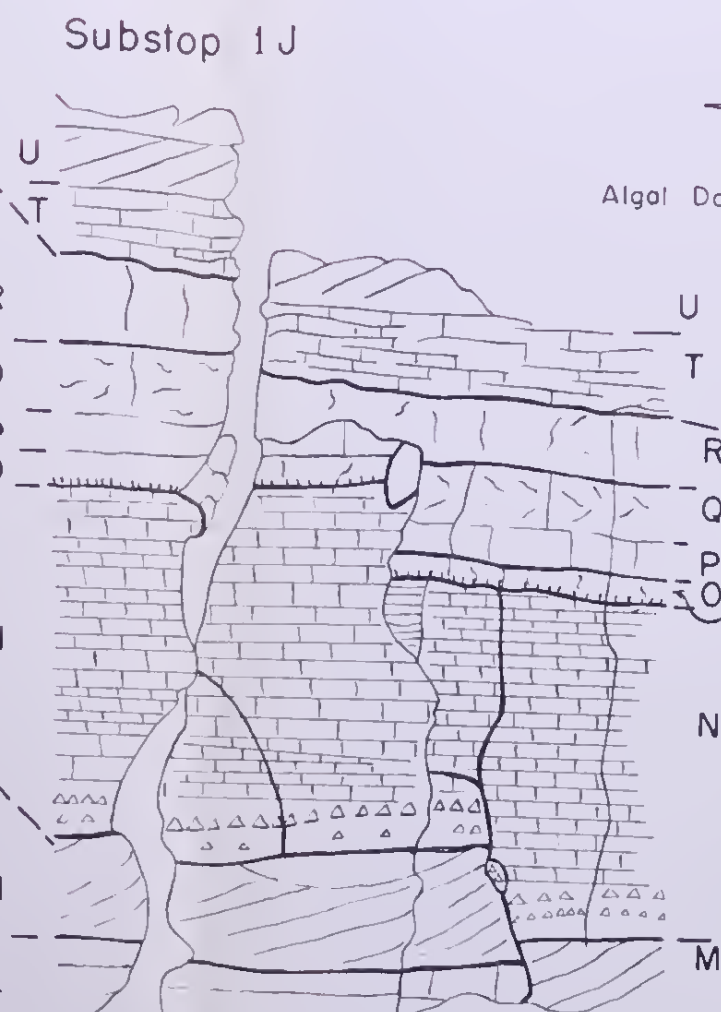
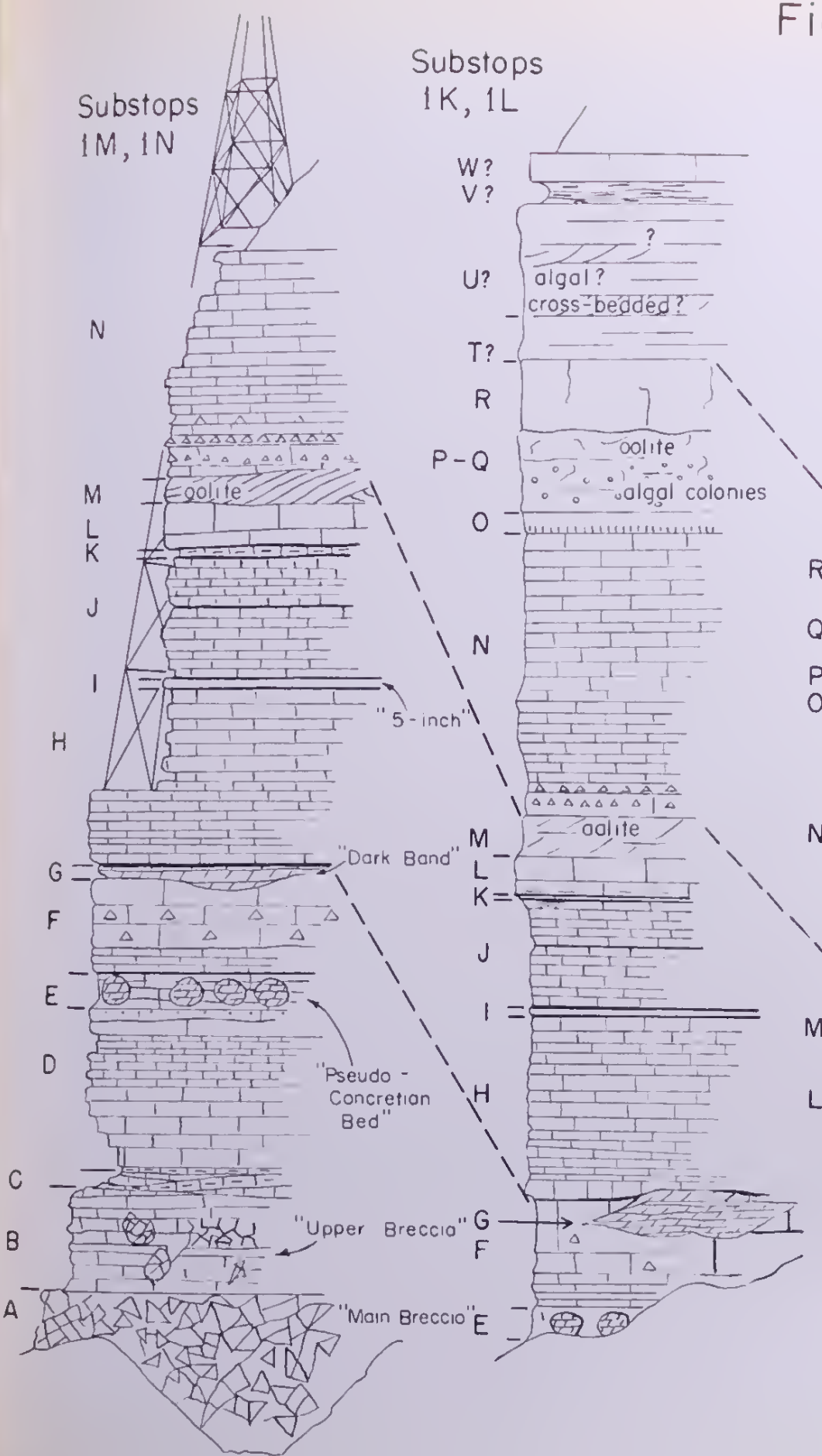
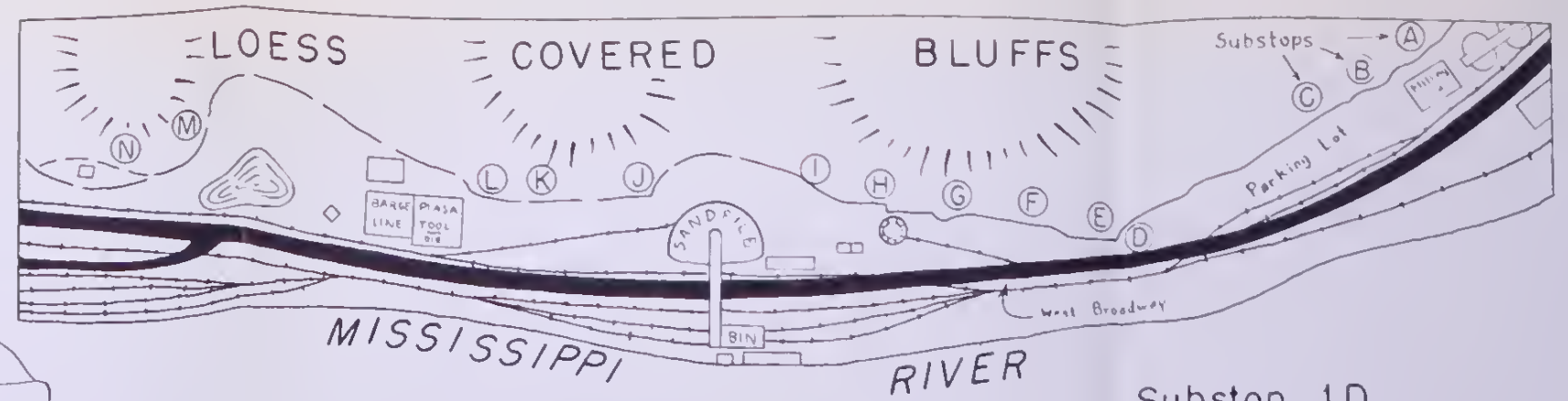
C
B
A

FIGURE 2

Figure 5 - Stop 1. ALTON BLUFF

NW $\frac{1}{4}$ Sec. 14, SE $\frac{1}{4}$ Sec. 10
T. 5 N., R. 10 W.

Alton Quadrangle, Madison Co., Illinois



ft.
20
10
0

or "buttons" of units P and Q, and thus may represent the peaks of algal sedimentation. The character of the units is briefly described in table 4.

Table 4. - Composite section of strata exposed at Stop 1 - Alton bluffs.

	<u>Thickness</u> <u>in feet</u>
Ste. Genevieve formation	
W. Limestone, inaccessible, apparently algal	5
V. Limestone, shaly, or shale, inaccessible, usually making vegetation-covered bench	0-2
U. Limestone, difficult of access, extremely variable, sparingly cross-bedded within one or two one-foot beds, partly algal, with colonies 1/2 inch to several feet in diameter, partly calcarenitic, apparently partly oolitic	5-20
T. Limestone, difficult of access, thin-bedded, shaly to silty, may be slightly sandy	1-15
S. "Sandy oolite." Limestone, coarsely oolitic, sandy (20% insoluble), cross-bedded, scour surface with general relief of 6 inches at base with one-foot cracks filled with sandy oolite	0-18

(Units S through W are highly variable in thickness)

St. Louis formation (see note following discussion of substops)

R. "White bed." Limestone, pure (99% soluble), "curdy" lithographic to pseudo-oolitic, sparingly fossiliferous, weathers very white, basal contact varies from irregular (2 inches relief) with no shale to smooth with 1/2 inch shale	1 1/2-6
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Thickness
in feet

- Q. "Chevron bed." Limestone, oolitic, pure (99% soluble), to extremely sandy (50%) cross-bedded in thin units, algal colonies toward base, locally prominent shale parting at base but elsewhere the contact is gradational 1½-7
- P. "Algal conglomerate." Limestone, partly silty and sandy near bedding planes but pure (98-99% soluble) within beds, fine to oolitic, with algal colonies (curdy, vaguely concentric, lithographic limestone) ranging from pseudo-oolites to 3-inch "biscuits" and a few 1-foot "cabbage heads," divided into 2 to 4 very prominent beds by shale partings which are several hundred feet wide and reach thicknesses of 1-2 inches; where unit O is recognizable the basal contact is a prominent shale parting, elsewhere a scour surface 2-6
- O. "Little White bed." Like Unit R, lenticular, base is scour surface with sandy silty algal conglomerate filling cracks to three feet deep 0-1½
- N. "Bryozoan beds and chert marker." Limestone, pure (98½% soluble) except for basal cherty zone, fine to lithographic with thin bands of fossils, especially bryozoa, thin-bedded, with none to 4 irregular bands of fossiliferous replacement chert in lower 6 feet, the next-lowest band one foot thick in places; base is a scour surface with 6-inch relief and with cracks 3 feet deep where unit M is thick and with a thin shale parting 10-16
- M. "Lower oolite." Limestone, slightly silty, ranges from fine calcarenite to very slightly sandy (96-98% soluble) medium cross-bedded oolite, thin smooth shale parting at base 1½-9
- (Units M through R are moderately variable in thickness.)
- L. "Two beds." Limestone, two well-marked beds, lithographic at top to fine with some coarse fossil debris, slight shale parting at base 3

Thickness
in feet

K. Limestone, very silty, grading downward to prominent shale break	½
J. Limestone, slightly silty (97-98% 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	8½
I. "Five-inch bed," Limestone layer between two well-marked shale partings	½
H. Limestone like unit J, slightly more silty (94-97% soluble)	12½
G. "Dark band." Dolomite, silty (94-95% soluble), very finely crystalline, medium brownish gray, pseudoconcretionary; in some places the dolomite is an irregular 1- to 24-inch bed, its variations almost entirely compensated by variations in thickness of the underlying unit F; in others bodies of dolomite up to 4 feet thick replace the upper part of unit F with slight thickening of the section	0-2
F. Limestone, slightly silty (96% soluble toward base to 98% soluble toward top), similar to unit J but more calcarenitic and thicker beds	6-7
E. "Pseudoconcretion bed." Limestone, shaly and silty (95% soluble), with numerous large oval 6-inch to 3-foot silty dolomite pseudoconcretions	3
D. Limestone, similar to unit J, more fossiliferous, purest toward top and base	10½
C. Limestone, very silty and argillaceous (90% soluble), very fossiliferous	2
(Units C through L vary only little in thickness.)	
B. "Upper breccia." Limestone, much lateral variation, lithographic to detrital, partly fossiliferous, partly cross-bedded, partly evenly bedded, partly brecciated	7

A. "Main breccia," Limestone, average 95-96% soluble, much brecciated, angular pebbles and boulders of lithographic to pseudo-oolitic limestone in somewhat silty calcarenite or clear calcite matrix; up to 22 feet thick in quarries to northwest; exposed above low water level of pond near Substop 111

11

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

DESCRIPTION OF SUBSTOPS

(locations on figure 5)

SUBSTOP 1A.--Behind scale and western elevator cell, In dry weather a few people in climbing shoes can examine a 3-foot crack in unit N which is filled with sandy units O-P where easiest climbing path crosses this contact. This is the only place where sandy cross-bedded oolite unit S can be seen close-up in the time available at this stop. Several slabs may be seen at the foot of the face. Only one cherty zone is present in base of unit N here.

SUBSTOP 1B.--Detail of scour surface at base of unit N, here not cherty. "Basal conglomerate" in N is exposed 100 feet farther northwest.

SUBSTOP 1C.--Weathering of unit Q in upper part of face brings out chevron-bedding (torrential-type cross-bedding in opposite directions in adjacent thin units), football to basketball size algal heads in unit P, "White bed" unit R, and large-scale crossbeds in unit S (top of bluff here). Lower oolite unit M is accessible all along this part of the bluff.

SUBSTOP 1D (fig. 5).--Two more units can be seen above the sandy oolite (unit S). Units M, N, Q, and S are all particularly thick. Chocolate-brown Farmdale loess overlain by buff Peorian loess can be seen at the top of the face.

SUBSTOP 1E.--Piasa Bird. (See note on p. 3.) The present reproduction of the Piasa Bird is on a joint face uncovered by roadwidening within the last decade or so. This joint surface is offset 6 inches by a bedding-plane fault on the shale bed at the base of unit K, about head height above the road, the top moving southwest. Near the northwest end of the face is a small solution-type

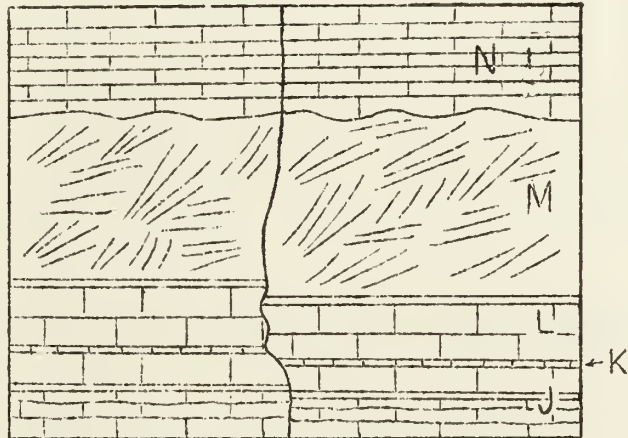


Fig. 6. - Substop 1F
Scale - 1" = 10'

normal fault like that of Substop 1F. Units K and L are offset 1 foot, and the fault dies out near the M-N contact.

SUBSTOP 1F (fig. 6).--A good example of the solution-type normal fault--a small fault dying out upward and accommodating removal of beds by solution. There are perhaps a half-dozen others at this stop. Note that while there is a 14-inch displacement of the contact between L and M, there is no displacement of the M-N contact.

SUBSTOP 1G (fig. 5).--The strongly developed horizontal slickensides, the wide zone of shearing, the slight vertical movement, the curvature of the fault plane, 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 100 feet. Note in particular the variation in the thickness of unit N.

SUBSTOP 1H (fig. 5).--The sandy oolite (unit S) thins to disappearance in a very short distance, letting thin-bedded unit T down on the "White bed" (unit R). The sharp thinning of unit S suggests the edge of a detrital bar of oolite with currents from the south. Note the very large algal growth near base of unit U.

SUBSTOP 1I.--Unit O splits the shale bed at the base of unit P very suddenly at the top of the tree-covered talus cone just east of the sand storage area. The upper part of the bluff can be examined closely here, but there will not be time to study it. The cross-bedding of unit M is very prominent on a low isolated block in front of the main bluff.



Figure 1: Schematic diagram of the experimental setup.

The experimental setup is designed to study the interaction between the fluid flow and the solid structure. The flow is driven by a pump and passes through a nozzle, creating a jet that impinges on the structure. The pressure distribution is measured using a series of sensors.

The results show that the pressure distribution is highly non-uniform, with the highest values occurring at the point of impingement. The flow velocity is also measured, and it is found that the velocity decreases as the distance from the nozzle increases. The data is presented in the following table.

The table shows the pressure and velocity measurements at various points along the flow path. The pressure increases significantly at the impingement point, while the velocity drops to zero. The data is consistent with the theoretical predictions of fluid flow impingement.

The experimental results are compared with the theoretical predictions, and it is found that the agreement is very good. This indicates that the theoretical model is a good representation of the physical process. The data is used to validate the model and to predict the behavior of the system under different conditions.

The study concludes that the interaction between the fluid flow and the solid structure is a complex phenomenon that requires further research. The experimental setup provides a valuable tool for studying this interaction, and the results are used to validate the theoretical model. The data is presented in the following table.

SUBSTOP 1J (fig. 5).--The confused faulting appears to require horizontal movement, probably along stepped surfaces of the type suggested by the block diagrams (fig. 7), as well as vertical movement. Other answers to the problems posed by this faulting, such as interstratal solution in the shortened blocks, or horizontal movement along either bedding planes or essentially vertical planes, appear less reasonable as no supporting evidence has been found. Here, also, the horizontal movement appears to be large, possibly in the order of a hundred feet or so.

A small cave mouth 80 feet west of the substop 1J fault is developed along a high angle normal fault of the solution type.

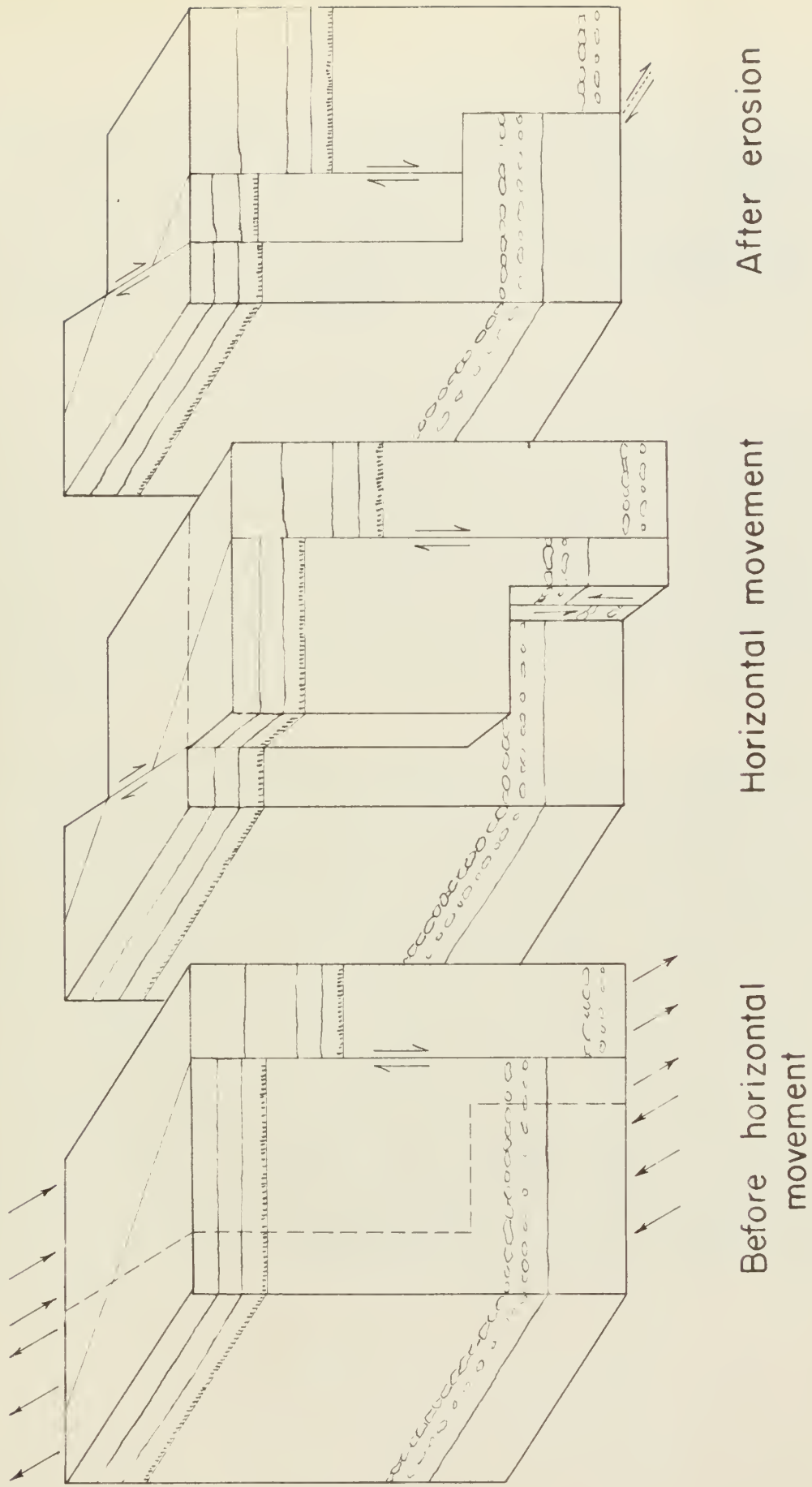
SUBSTOP 1K (fig. 5).--Is the dolomite (unit G) primary or secondary? Note that the shale bed thins over it. Is the thinning a result of squeezing during compaction?

SUBSTOP 1L.--Parking lot of Piasa Tool and Die Company. The main dolomite pseudoconcretion unit is a good marker from here northwest.

SUBSTOP 1M (fig. 5).--Nearly all the beds at this substop can be reached outside the fence at substop 1N. The face is typical St. Louis thin-bedded fine-grained limestone, highly variable vertically but with little horizontal variation. Starting at the base of bed C, about 8 cycles of deposition can be seen. Each cycle starts with relatively shaly limestone at the base, the partings between the limestone beds being prominent and the beds thin. The beds gradually thicken upwards, the shaly partings thin and become obscure, and the beds are a little lighter in color. 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. In several instances a prominent (i.e., a half inch or so) shale bed occurs at the base of the cycle. The basal foot of a cycle is between 90% and 95% soluble, while the top appears to be 96% to 99% soluble. The bases of the successive cycles are at the base of unit C, about $4\frac{1}{2}$ feet below the top of unit D, the base of unit E, near the middle of unit F (quite weak), base of unit H, $5\frac{1}{2}$ feet from top of unit H, base of unit I, 4 feet from top of unit J, and base of unit K.

SUBSTOP 1N.--The breccias, fossiliferous shaly unit C, the pseudoconcretion zone E, "dark band" G, and fossiliferous chert in the lower 6 feet of N are readily examined. The breccia is better exposed at Stop 2 (substop 2G) and the problem of its origin is briefly discussed at that point.

Figure 7 - Formation of offset faults at stop 1 J
by vertical and horizontal faulting



Fossils can be collected from several places at this sub-stop. Crinoids, bryozoans, and brachiopods are common in unit D, which also yields columnals of the crinoid Platycrinites penicillus, which is generally considered to be an index of the Ste. Genevieve (see discussion following). P. penicillus can also be seen in the ledge beneath the high tension tower (unit H) where Fcnestella, Thamnicus, Spirifer, Cleiothyridina, Orthotetes, Streptorhyncus, and Linoproductus are fairly common.

Ste. Genevieve - St. Louis Contact

The difficulties in placing the Ste. Genevieve-St. Louis boundary on the basis of fossils or 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 people at four different points, from the base of unit J to the base of unit S. Rocks as high as units T and U have also been called St. Louis in wells in this vicinity where the sandy coarse oolite (unit S) is insignificant or absent (as it is between substops 1J and 1K), and in outcrops where the sandy oolite, though present, does not contain recognizable Ste. Genevieve fossils.

The situation is further complicated by the lower oolite, unit M. If this unit is examined at its westernmost exposure near substop 1N, where it is a silty very fine-grained calcarenite, little more than a foot thick, with a few oolites scattered through the bottom few inches, 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 predominantly oolitic limestone. If, on the other hand, the unit is examined farther east near substop 1D, where it is an 8-foot cross-bedded oolitic medium-grained calcarenite, the tendency is to place it in the Ste. Genevieve. As the base of unit M appears fairly conformable, even where the unit is quite thick at 1E, the contact may be placed at a lower, more prominent break. However, the scour surfaces, sometimes called "unconformities" or even "major unconformities," both above and below such beds as M tend to be well developed where the bed is thick, the relations fading to apparent conformity within a few hundred feet 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 P and Q, and beneath R, S, and U.

The paleontologic evidence is of little help in placing the boundary. The "guide" fossils are the compact compound coral Lithostrotionella castelnaui [Lithostrotion canadense or L. basaltiforme] and the branching Lithostrotion proliferum, for the St. Louis and the small strongly costate brachiopod Pugnoides ottumwa and a crinoid with oval spiny stem segments, Platycrinites penicillus [huntsvillae], for the Ste. Genevieve, are all strongly facies-confined. Lithostrotionella castelnaui is very sporadic in areal distribution, at least in western Illinois and eastern Missouri. The writers have not seen it in the Alton section, but at Stop 2 it occurs together with Lithostrotion proliferum just above the main breccia, in beds possibly equivalent to unit B here. Lithostrotion proliferum is much more widely distributed, and though it is most abundant in the upper part of the St. Louis, runs far up into the Ste. Genevieve, well above occurrences of Platycrinites penicillus and almost certainly above Pugnoides. Platycrinites penicillus occurs here in units D, H, S, and T. Though the base of the Ste. Genevieve is placed beneath the lowest occurrence of P. penicillus in Indiana, it occurs in beds (such as unit D here) normally recognized as St. Louis in Illinois, Missouri, and Kentucky. It also occurs above the type Ste. Genevieve in the Aux Vases sandstone. Pugnoides ottumwa was reported by Stuart Weller to be present shortly above the algal-bearing beds of unit P here, apparently in unit Q. It occurs above the Ste. Genevieve in the Renault and Beech Creek ("Barlow" or Golconda) limestones of the Chester.

Perhaps the best immediate solution is to recognize St. Louis to about unit J, a St. Louis-Ste. Genevieve transition zone from unit J, or M, through unit R, and Ste. Genevieve in unit S and higher units. As the original St. Louis was restricted by differentiation of the Ste. Genevieve, the contact of the formations in the type section at Ste. Genevieve would be generally accepted as the correct contact. However, individual units within the formations have not been traced in sufficient detail to show the exact position of the type section contact in the section at Alton.

Mileage

22.6 Leave Stop 1. Continue ahead (northwest) on Broadway.

22.7-22.9 Quarries and crusher of Mississippi Lime Company of Illinois.

Most tunnels are in the breccia and immediately overlying beds. The present operations are in a large open quarry, hidden from our road but opposite and beyond the water works.

Mileage

- 23.2 Cliff to right in St. Louis; breccia high in cliff.
- 23.5 Small abandoned high-level quarry in breccia. Divided portion of McAdams Recreational Parkway. The parkway at the foot of the bluff now extends only 6 miles toward Grafton, which is 16 miles above Alton. Its proposed extension to Grafton utilizing the abandoned railroad grade will give easy access to bluffs exposing the entire section down to the Silurian with only a short covered interval in the shaly Warsaw formation.
- 24.3 Abandoned Olin quarry on right (fig. 8).

The section in the Olin quarry was published by Stuart Weller in 1908 when he separated the Salem limestone from the Warsaw in western Illinois. Only 4 feet of Salem is now exposed in the quarry, but all of the St. Louis below the limestone breccia seen at substop 1N can be studied here. The contact between the Salem and St. Louis is not marked by an unconformity or even a definite change in lithology but rather by a gradual change upward from predominance of the calcarenite of the Salem to predominance of the fine-grained and lithographic limestone of the St. Louis. Weller picked the contact at the base of the zone of abundant cherts. This contact is in keeping with faunal evidence, for the large foraminifer Endothyra baileyi has not been found above Weller's Salem, although smaller species of Endothyra are locally abundant in the St. Louis. The prolific macrofauna is that of the type Salem of Indiana. The first study of the well-known Salem or Spergen Hill fauna was published in 1856 by James Hall, who collected some of his material for the study in this and the Hulls Hollow quarry, one mile northwest.

- 24.5 Small abandoned quarry on right.
- 24.9 Larger abandoned quarry on right.
- 25.2 Abandoned Hulls Hollow quarry on the right exposes 116 feet of St. Louis. It formerly exposed 61 feet of Salem (nearly the entire thickness) but the lowermost 30 feet are now covered.
- 26.4 Leave Alton Quadrangle, enter St. Charles Quadrangle.
- 26.5 Enter Clifton Terrace.

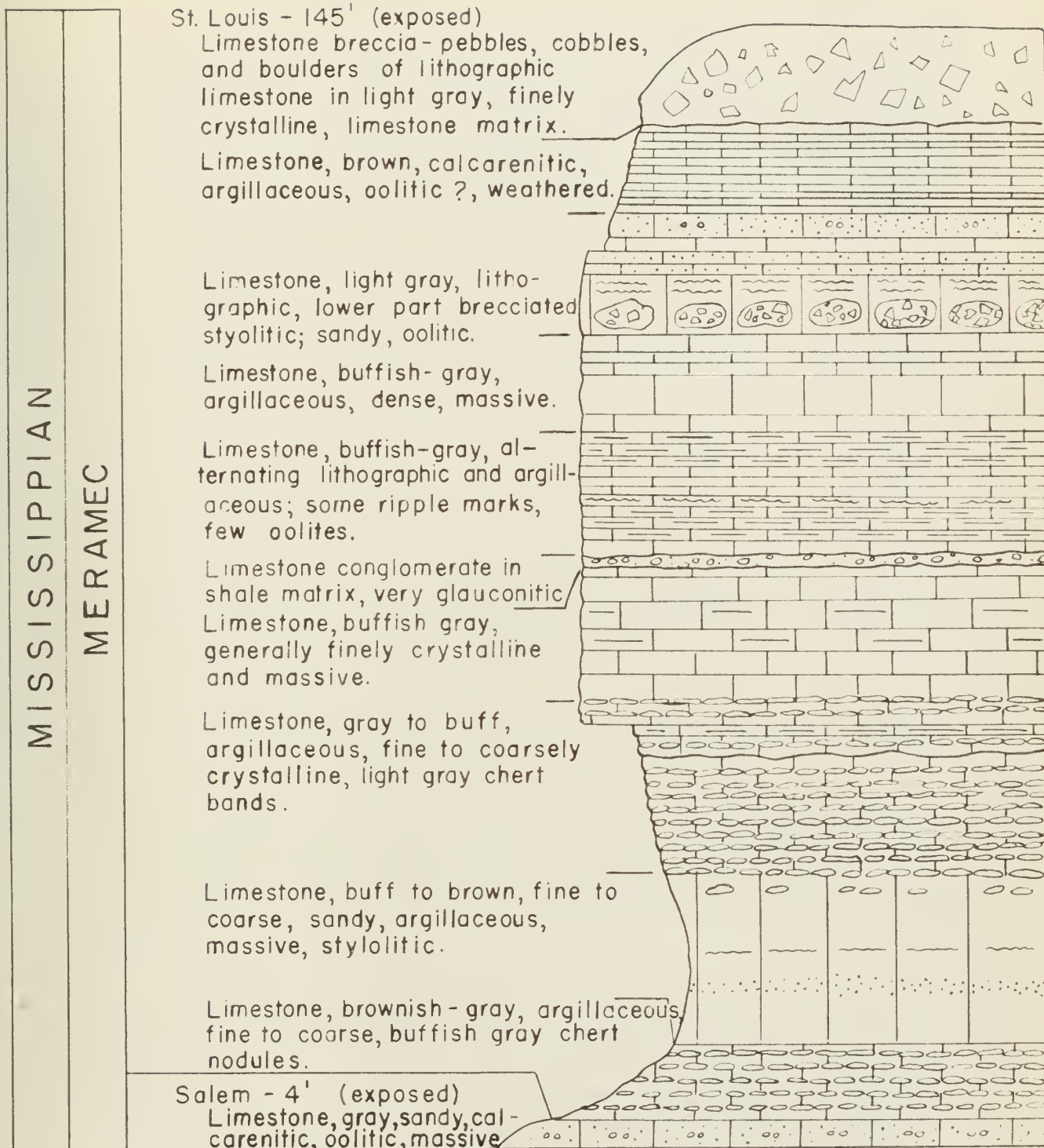


Figure 8— Olin Quarry, Mouth of Hop Hollow
S.E. $\frac{1}{4}$ Sec. 4, T.5 N., R. 10 W., Madison County, Illinois
Vertical scale: 1" = 20'

Mileage

- 26.6 Turn right on Clifton Terrace road, leaving McAdams Recreational Parkway, which now continues only a mile farther. A mile and a half upstream from this intersection, near the northwest end of McAdams Parkway, 50 feet of Salem limestone is exposed in a quarry north of the road. This quarry shows intertonguing of Warsaw-type shale and Salem limestone, which is characteristic of the lower Salem in western Illinois.
- 26.8 Salem outcrop on left.
- 27.2 St. Louis exposed on left.
- 27.5 Stop sign. Junction with Illinois Route 100. Turn left on Route 100.
- 29.2 Cross Piasa Creek.
- 29.3 Salem outcrop on left.
- 30.1 Salem outcrop on right.
- 33.1 Stop sign. Junction of Routes 100 and 109. Bear to left of Standard station in intersection, following Route 100 to Grafton and Pere Marquette State Park.
- 33.4 Salem outcrops in creek bed.
- 34.5 Road-cut through Salem limestone. Warsaw shale outcrops below the road on both sides of the highway.
- 36.3 The side road to the left leads to the two small communities of Elsau and Chautauqua. The former is the home of The Principia, a Christian Science liberal arts college which has a beautiful campus on the Mississippi River bluffs and an active geology department. Chautauqua is a private summer resort.

Excellent exposures of Mississippian strata occur in the mile and a half of river bluffs which separates the two communities. The section at Chautauqua (fig. 9) is of special interest because it shows a good angular unconformity between the Chouteau limestone of Kinderhook age and the Sedalia limestone of Osage age. Also, the Sedalia here attains its maximum thickness in Illinois (20 feet) although only 1/2 mile from the most easterly outcrop of the formation.

Chautauqua is the northernmost outcrop at which the Fern Glen formation is both characteristic and well exposed. Although it has lost its distinctive red color, red mottling

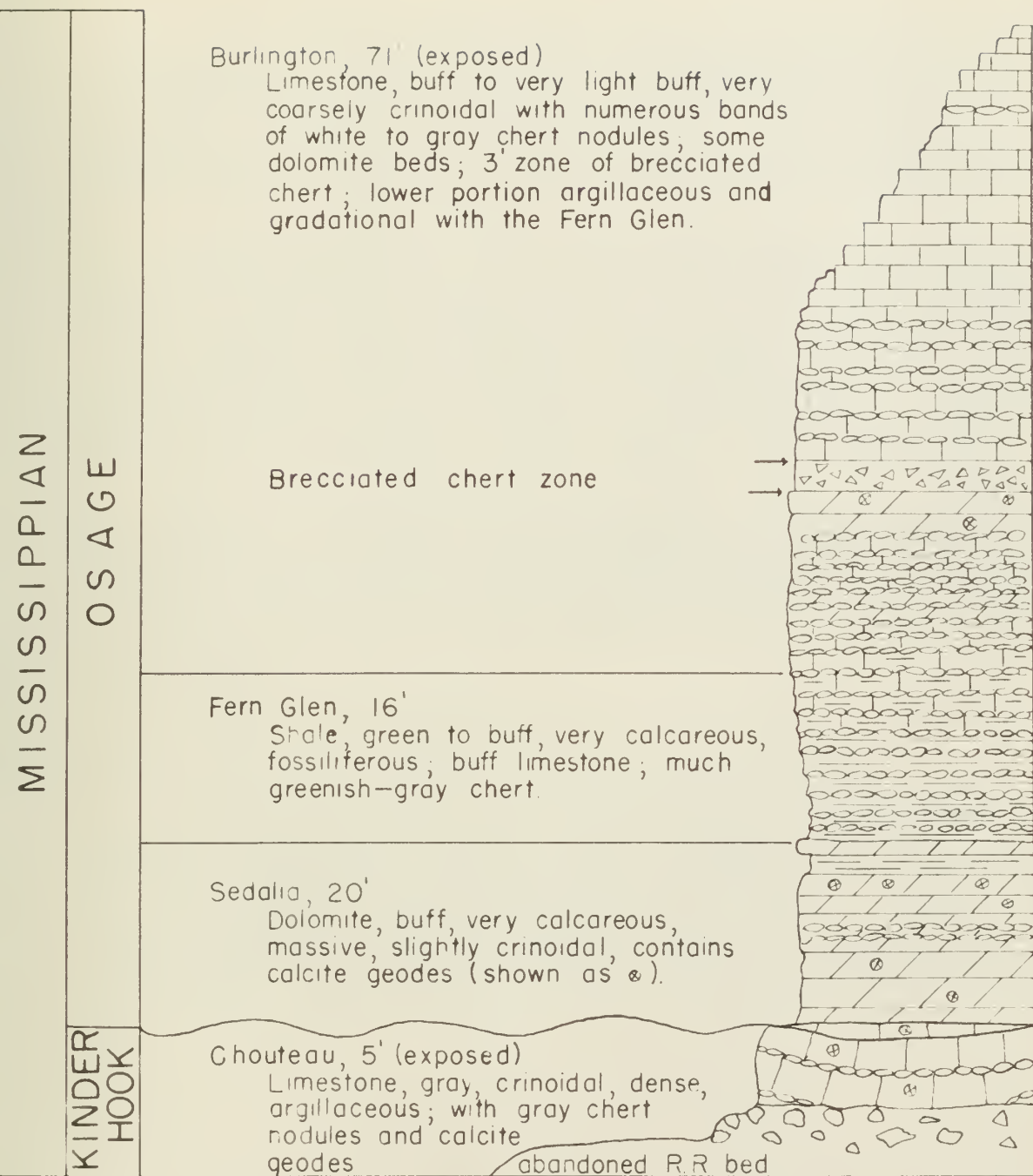


Figure 9 - Chautauqua West

SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ Sec. 13, T.6 N., R. 12 W., Jersey County, Illinois

Vertical Scale: 1" = 20'

Mileage

can be seen in the bluffs only 1/2 mile southeast. In the Chautauqua outcrop 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.

Another outcrop of the Fern Glen occurs less than 3 miles northwest of Chautauqua in Jerseyville Hollow (table 5), where the formation consists of 20 feet of light greenish-gray crinoidal limestone containing greenish-gray chert bands. It is almost indistinguishable from the Burlington. Not far west of Jerseyville Hollow the Fern Glen cannot be differentiated from the lower Burlington, thus indicating that the Fern Glen is actually a shaly facies of the Burlington.

South of Chautauqua the Fern Glen crops out widely in St. Louis, Jefferson, Ste. Genevieve, and Perry counties in Missouri and in Monroe County, Illinois. It is also recognized in the subsurface of western Illinois, but it cannot be differentiated very far eastward into the Eastern Interior Basin.

38.6 Curve left,

39.3 Begin descent of Jerseyville Hollow to Grafton,

One of the longest and finest geologic sections in central western Illinois is exposed along Highway 100 where it descends Jerseyville Hollow to the village of Grafton (table 5). As outcrops are essentially continuous, a complete section from middle Burlington (Mississippian) to Edgewood (lower Silurian) can be studied. Some of the Silurian section is repeated in the lower part of the hollow because of faulting.

Table 5. - Composite section of exposures in Jerseyville Hollow.

	<u>Thickness in feet</u>
Burlington limestone	45+
Fern Glen limestone	20
Sedalia dolomite	7
Chouteau limestone	50
Hannibal shale	25
Glen Park limestone	1
Sylamore sandstone	1/3
Cedar Valley limestone	5
Joliet dolomite	57
Kankakee dolomite	28
Edgewood dolomite	20+
Maquoketa shale (thrown out of shallow dug well)	—
Total	258 1/3

39.6 Burlington limestone, both sides of road for 0.2 mile.

39.8 Burlington (buff) above Chouteau (gray) on left.

40.0 Good Chouteau outcrops on left.

40.1 Cave in Hannibal shale beneath 30 feet of exposed Chouteau across stream to left.

40.3 First Devonian-Silurian outcrops. Silurian outcrops extend down hollow into Grafton.

41.3 Stop sign in Grafton. Turn right (west) on Route 100.

The Illinois River joins the Mississippi River ahead (south) and slightly to the left. Our route west from here is along the Illinois River. The rock garden of Dr. Gideon Dempsey, on the right after turning the corner, consists largely of geodes from the Warsaw formation, collected locally.

41.6 In the 30- to 40-foot bluff on the right (north) at edge of road, Silurian dolomite, with the Kankakee formation at road level, dips very slightly to the south. This outcrop is 300 to 500 feet south of the crest of the Lincoln anti-cline. Our route will be essentially on the crest for two and a half miles before the bluff line swings far enough south to catch the very steeply dipping beds on the south flank of the fold. The crest is typically a thousand feet or so north of the steep dips.

THE HISTORY OF THE UNITED STATES OF AMERICA

CHAPTER I

1776

1776

The first part of the document discusses the early years of the United States, focusing on the period from 1776 to 1789. It covers the Declaration of Independence, the signing of the Constitution, and the early challenges of the new nation. The text is organized into several paragraphs, each detailing a specific event or period. The language is formal and historical, typical of a textbook or reference work. The document is a scan of a page from a book, with some faint markings and a slightly aged appearance.

Mileage

- 41.9 The lower bluff, 400 feet off road to right (north) behind the stone church, is Silurian dolomite, separated from the upper bluff of Chouteau limestone by a slope of Hannibal shale.
- 42.1 Mouth of Mason Hollow on right (north).
- 42.2 Sinclair station on left and Standard on right. Silurian dolomite occurs in the lower cliff 800 feet to right (north). The upper cliff is mainly Chouteau, with Sedalia in the re-entrant near the top, and has a thin cap of Burlington limestone.
- 42.4 Numerous boat docks.
- 42.7 Similar bluff section to last, except about 30 feet of Burlington is present on top.
- 42.9 Entrance to Trail Rangers of America lodge and Pere Marquette State Park carpentry shop.

Pere Marquette State Park is named for Father Jacques Marquette. The site, acquired in 1932, is now Illinois' largest state park, with 5,180 acres. Complete facilities for vacations are provided at the park. These include a lodge-hotel, a restaurant, and guest cottages near the lodge. An important part of the park is the Vacation Area with three organized youth camps. There are many miles of foot trails, 14 miles of bridle paths, the Nature Museum, picnic areas, and campgrounds.

The park area has a colorful historical background. There are about 18 prehistoric Indian village sites in the park and 125 Indian skeletons have been taken from Indian burial mounds on McAdams Peak. In 1680 the area near the lodge was the scene of a savage massacre of Illinois Indian women and children by the Iroquois.

In addition to Marquette and Joliet, many historically famous persons have passed this way. In the spring of 1680 Father Louis Hennepin and his party spent 5 days at or across from Pere Marquette Lodge waiting for the ice to go out up the Mississippi. In December 1680 Robert Cavalier, sieur de La Salle, arrived here and the next year camped here with his lieutenant Henri Tonti.

- 43.1 Pere Marquette Historical Marker on Silurian outcrop on right (north).

Mileage

The large stone cross commemorates the first recorded entrance of white men into Illinois. In the spring of 1673, Louis Joliet and the Jesuit priest Father Jacques Marquette were sent by the French Government over the Wisconsin portage to explore the Mississippi River for a passage to the Pacific Ocean. They traveled as far as the Arkansas River, where they turned back, and in September entered the Illinois River making camp at this spot. Father Marquette noted the event in his journal of the trip, thus making it the first recorded entrance of white men into Illinois.

- 43.3 The Maquoketa shale underlies the slope in front of the Silurian bluffs 800 feet to right (north). The crest of the Lincoln anticline is rising beneath us toward a closure, about 2 miles ahead, where not only the Maquoketa but 60 feet of the underlying Kimmswick (Trenton) is exposed.
- 43.6 The road swings left around a large slump block of Silurian dolomite several hundred feet long and 60 to 80 feet thick, which has pulled away from the joint-faced cliff behind it. The block, lubricated by the Maquoketa shale, has rotated so that it dips back northward at 40 to 55 degrees. Edgewood dolomite is exposed in the slump block beneath the fence, Kankakee in the lower third of the block above the fence, Joliet in the upper two-thirds, and one or two feet of Devonian Cedar Valley limestone at the top.
- 43.8 Graham Hollow, Entrance to Camps Piasa, Ouatoga, and Potawatomi youth camps located in Pere Marquette Park on the upland 2 to 3 miles north of the highway.
- 44.1 Behind the cabins on the right and about 100 feet above the highway is a bluff of flat-lying Silurian dolomite. The cabins are on talus of large Silurian blocks on a Maquoketa shale slope.
- 44.4 Ferry Landing on left.

The easternmost exposure of the steeply dipping beds in the Cap au Gres faulted flexure is a Burlington limestone outcrop 40 feet above the road in the spur just beyond (west of) the taverns across the road from the ferry landing. This outcrop has a strike N. 78° W., and a dip 63° S. Burlington float extends about 75 feet north of the road in the gully between the taverns and the spur. The Burlington is about 100 feet lower topographically than the base of the flat-lying Silurian 500 feet farther north, but is about 300

Mileage

feet higher stratigraphically. Though the intervening section may be buried under the talus, at least part of it may be cut out by faulting.

The Cap au Gres structure was referred to as the Cap au Gres fault for many years. Rubey's detailed study in 1928-1929 showed that the steeply dipping strata are not faulted in some places, and the structure has since been called the Cap au Gres faulted flexure. Rubey (1952, pp. 139-150) discussed the mechanics of deformation and the history of development of the structure. He showed that the major deformations were post-St. Louis pre-Pennsylvanian and post-Pennsylvanian, and that the former was by far the greater. He also cited stratigraphic evidence for movements of the anticline in early Paleozoic, Silurian, Devonian, early Mississippian, and late Tertiary time.

Mississippian beds striking N. 70° W. to N. 85° W. and dipping from 22° S. to 75° S. crop out on the right side of the road for the next 0.7 mile.

- 45.0 Leave St. Charles Quadrangle, enter Brussels Quadrangle. East boundary of area covered by U.S.G.S. Professional Paper 218 (Rubey, 1952).
- 45.2 Deer Lick Hollow. One of Rubey's important cross sections (1952, pl. 21A.) is from this hollow.

We have crossed the Cap au Gres steep belt into the Troy-Brussels syncline. The beds have dropped nearly 900 feet in less than a half mile measured across the strike, though we have been crossing the flexure diagonally for about three-fourths of a mile.

- 45.7 Hartford School on left (south). The Brussels terrace is well developed on the right side of the road for the next mile.
- 45.9 Pennsylvanian (Carbondale) shales and siltstones, flat-lying; in road-cut on right.
- 46.9 Pere Marquette Picnic Area No. 1 on right (north).
- 47.1 Hartford church on right (northeast).
- 47.4 Pere Marquette Park main entrance, and lodge on right (northeast).
- 47.6 Steeply dipping St. Louis on right (east).

Mileage

47.7 Twin Springs. Steeply dipping Silurian on right (east).

48.0 Curve sign opposite Kimmswick outcrop on crest of Lincoln anticline. Buses stop and unload, Buses will return to Lodge parking lot where we will reload after lunch.

STOP 2 - Pere Marquette State Park, Ordovician, Silurian, Devonian, and Mississippian Strata, Cap au Gres Flexure, and Physiography.

NW $\frac{1}{4}$ SE $\frac{1}{4}$ Sec. 9, T. 6 N., R. 13 W., Brussels Quadrangle, Jersey County.

Substops - 12.

Walking distance - three-fourths mile.

Leaving time - for lunch at the lodge at 12 noon sharp.

Buses will unload just beyond the yellow curve sign on Highway 100. DO NOT GO ONTO THE HIGHWAY. LOOK OUT FOR CARS AS THERE ARE CURVES IN BOTH DIRECTIONS.

Turn to figure 10. This diagram shows how Stop 2 has been organized into a series of substops lettered A through L. In addition, detailed diagrams to explain several of the substops are given on following pages. Leaders will be stationed at the major substops.

CAUTION - You will probably not have time to examine every substop in detail so choose what you are most interested in and budget your time accordingly. The trail above the fault blocks at Twin Springs is short but steep and a few may not wish to follow it. If not, follow the trail which goes along the highway beyond Twin Springs. That trail joins the regular Stop 2 route at the St. Louis breccia outcrop (substop 2G).

The last substop (2L) will be for LUNCH in Pere Marquette Lodge. Arrangements with the management require that everyone be present and ready to eat promptly at noon. Accordingly, warning whistles will be blown 10 minutes before noon. The Lodge is little more than 10 minutes walk from any point along the trail.

SPECIAL NOTE - Inasmuch as the lounge in the Lodge will be occupied by another meeting, it will be closed to our party until 11:45.

K

S. 5° W.

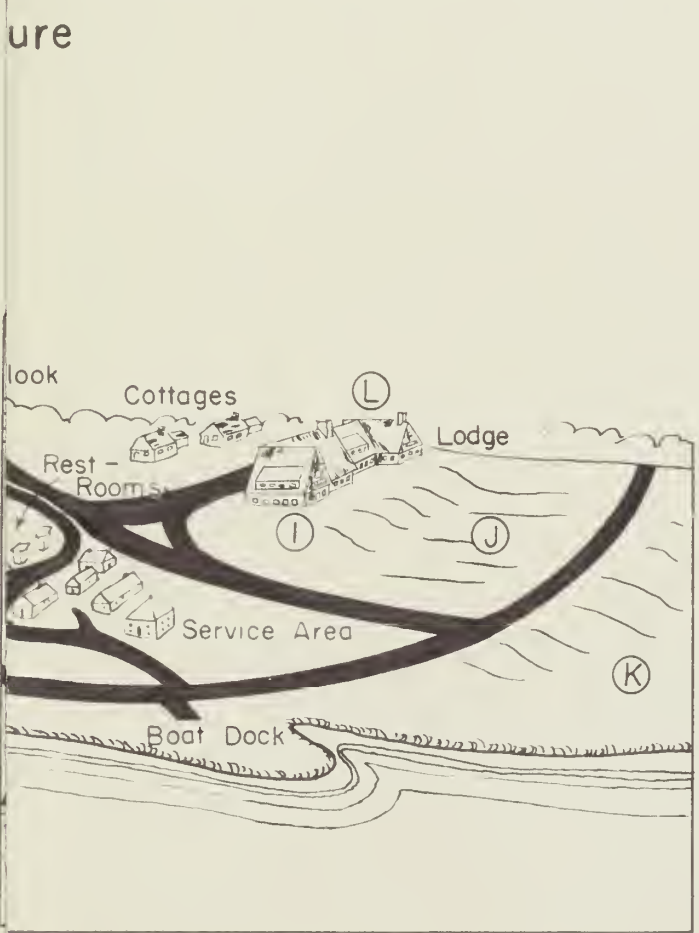
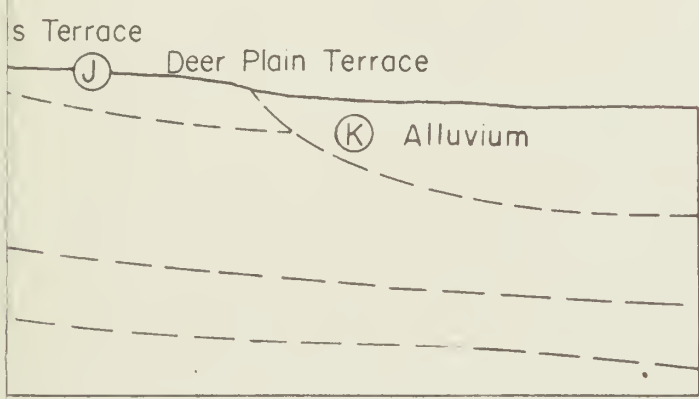
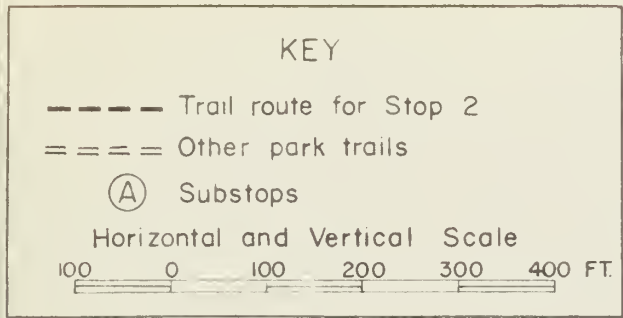


FIGURE 10

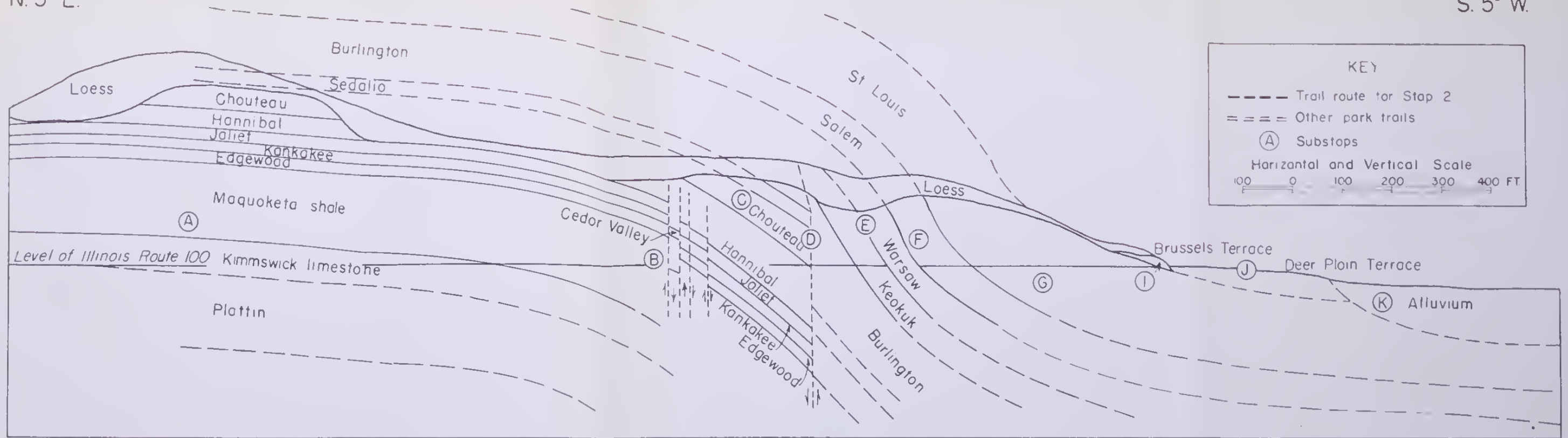
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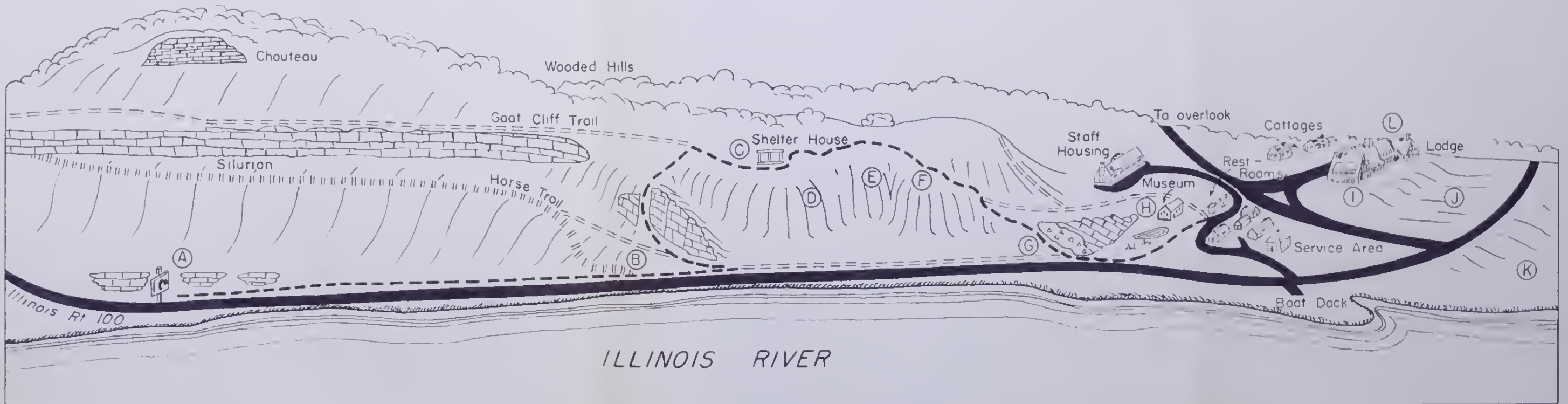
Figure 10 - Stop 2 PERE MARQUETTE STATE PARK

N. 5° E.

S. 5° W.



Cross section through Twin Springs showing Cap au Gres faulted flexure (after Rubey, U.S. Geol. Survey, Prof. Paper 218, pl. 21, 1952)



SUBSTOP 2A.--Kimmswick and Maquoketa (slumped)

The oldest rocks exposed in Pere Marquette Park belong to the middle Ordovician Kimmswick formation which crops out in three small exposures along Highway 100 at the base of the bluff. At Florissant, 18 miles southeast, the formation produces oil at a depth of 1000 feet (page 14). The Waterloo and Dupon production in Illinois just southeast of St. Louis is also from the Kimmswick limestone.

The formation is about 70 feet thick in the park, but only the uppermost 15 to 20 feet of the formation can be seen here. Upon weathering it develops a characteristically rough surface marked by rounded pits which give excellent footing for lichens and moss. It is overlain by the Maquoketa shale which slumps between the outcrops. The Kimmswick is a coarsely crinoidal massively bedded pure limestone. It has a petroliferous odor when freshly broken. The color varies from brown through flesh colors to light gray, and in places its lithology is very similar to that of the Mississippian Burlington limestone. Some layers in the Kimmswick are very fossiliferous, and the index fossil Receptaculites oweni is locally common. One specimen is marked. Please do not destroy it.

Above the Kimmswick outcrops is a 150-foot, tree-covered Maquoketa shale slope. The only exposures of the shale occur in small isolated patches along the bridle trail, but the formation is known to consist of greenish-gray, thin-bedded to platy, calcareous shale which is interbedded with thin layers of argillaceous dolomite. The Maquoketa slope is surmounted by Goat Cliff, a level, fairly continuous cliff half a mile long exposing an 80-foot Silurian section. At the highest points on the cliff the Hannibal (Mississippian) shale can be seen in unconformable contact with Joliet (middle Silurian) dolomite and limestone 15 to 30 feet above the base of the Joliet. At the south end of Goat Cliff, 600-800 feet from Twin Springs, the Silurian starts to dip southward into the Cap au Gres flexure and from there to Twin Springs it is covered by loess and slump.

SUBSTOP 2B (figure 11),--Twin Springs, Silurian, Devonian, and Mississippian formations.

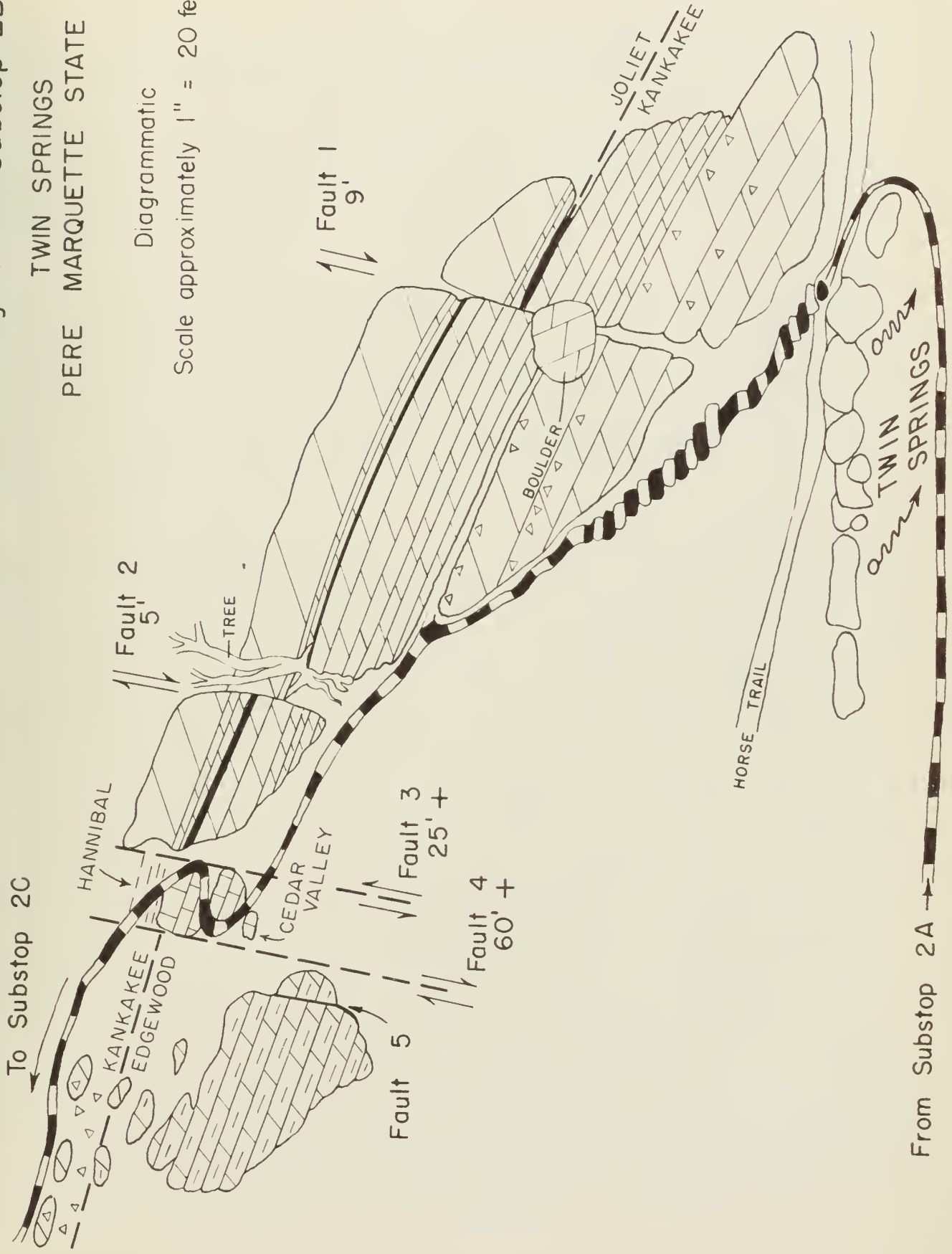
The Silurian reaches road level at Twin Springs, striking approximately east-west and dipping about 28 degrees south. The Twin Springs outcrop is cut by at least 5 faults. The best-exposed fault planes also strike east-west, but dip north at about 65 degrees nearly perpendicular to the beds. The main face, shown diagrammatically in figure 11, is slightly oblique to both bedding and faults. The minor faults--those 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, approached from the left along the ledge nearly

Figure 11 - Substop 2B

TWIN SPRINGS
PERE MARQUETTE STATE PARK

Diagrammatic

Scale approximately 1" = 20 feet



From Substop 2A →

half way up the face, 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.

Five formations--the lower Silurian (Alexandrian) Edgewood and Kankakee dolomites, the middle Silurian (Niagaran) Joliet dolomite, the middle Devonian Cedar Valley limestone, and the lower Mississippian (Kinderhook) Hannibal shale--are seen in the outcrops above Twin Springs.

The oldest of these, the Edgewood dolomite, is exposed only to the left of fault 4. No nearby exposures show the Maquoketa-Edgewood contact, but the Edgewood is more than 30, and probably 40, feet 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 upper part, poorly exposed here but well shown at Stop 3, is purer, approaching the Kankakee, but the Kankakee-Edgewood contact can usually be picked with fair assurance and in some spots is sharp and channeled. The twin springs occur approximately at this contact.

The name Kankakee, derived from northeastern Illinois, is used in this guide rather than Sexton Creek (from southern Illinois) or Brassfield (Kentucky) (Savage, 1926). Five zones are recognizable: (A) a basal zone 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 Platymrella mannensis Foerste, a plicate pentameroid brachiopod an inch to an inch and a half long. It and an overlying cherty glauconitic zone (B) are poorly exposed at the top of the section to the left of fault 5, but are well exposed at Stop 3. The middle zone (C), the purest part of the Kankakee, is well exposed as the bottom two-fifths of the outcrop immediately above the springs. It is pure dolomite (over 98% 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 Niagaran. The overlying zone (D) 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, this unit has a tendency to remain calcareous. About 7 feet above the ledge the thin-bedded unit fades gradually into a purer more massive zone (E), here represented by one four-foot or two two-foot massive beds. This unit in some localities carries the large (1½ to 2 inch) weakly plicate low-beaked pentameroid brachiopod; Stricklandia pyriformis, and a still larger smooth strongly-beaked Pentamerus. It is capped by a prominent smooth surface, difficult to see in the central part of the outcrop because of the overhang of the second unit of the

Joliet, but easily seen on either side of fault 1 approaching from the top of the section at the right.

The two lowest units of the Joliet are seen here, together with a third on Goat Cliff. The basal two or three feet of the Joliet is shaly, silty to very finely sandy, slightly glauconitic, and thinly laminated. The Osgood microfauna of arenaceous forams, including the planispirally coiled Ammodiscus, is abundant. This basal unit grades upward through a cephalopod-bearing bed a foot or two thick to a massive pure bed 10 to 15 feet thick here, 25 feet thick just east of Grafton. 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. Along Goat Cliff 0 to 10 feet of a third Joliet unit occurs between the pure bed and the Hannibal. This unit is dolomite or dolomitic limestone, in regular beds mostly 1 to 2 feet thick. The dolomite is still close to 98% pure but has thin, smooth green shale partings between beds. Red mottling, characteristic of the Niagaran limestones in southern Illinois, is sporadic here and is largely confined to calcitic rather than dolomitized rocks, commoner in the first and third units than the pure bed.

Ten or twelve feet of upper Devonian Cedar Valley limestone occurs between faults 3 and 4, and there is up to a foot of Cedar Valley limestone 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 sublithographic to rather coarsely crystalline. (Please do not collect our guide fossils. The outcrop is very small and structurally important, and there will be ample chance for collecting from extensive surfaces at Stop 3, which is one of a number of good collecting localities in the area.) The big spiriferoid is probably Platyrachella iowensis (Owen). The base of the Cedar Valley is not exposed, but regionally it is unconformable on the entire range of earlier Devonian, Silurian, and upper and middle Ordovician formations. Its thickness ranges to 40 feet on nearby outcrops and 100 feet in the subsurface 50 miles east.

The unconformable contact with the Mississippian Hannibal shale is poorly exposed in the path at the top of the Cedar Valley outcrop. The Sylamore sandstone, sporadically present at the base of the uppermost Devonian and lower Mississippian sequence, is not visible here but it occurs within a few miles in several directions. The Hannibal, which is incompletely exposed here, is a green, rather pure clay-shale. In outcrops both northwest and southeast of here it contains some dark gray to black shale.

If not quite conclusive, the evidence for post-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 right (south) of fault 3. There is no Devonian between Joliet and Hannibal in the first outcrop of the Hannibal to the left of fault 4, but this is a thousand feet or so north. Reconnaissance during the winter of 1953-54 failed to disclose any Devonian rocks along Goat Cliff,

The pre-Mississippian fault hypothesis demands a fault scarp or post-Hannibal movement along fault 3 to account for the 6- to 8-foot difference on the base of the Hannibal. Development of either a vertical-walled valley or sinkhole on the post-Silurian surface filled with Devonian limestone seems unlikely on two accounts. 1) Though the pre-Devonian surface bevels 90 or 100 feet of strata on the Lincoln fold outlier, it is fairly smooth, for example, in the abandoned quarry immediately east of Grafton where it cuts across as much as 10 feet of strata. 2) Where pre-Devonian karst topography is known, and it is common in the subsurface 30 to 100 miles east of here, the sediments filling the irregularities are largely shale and sand (such as the "Hoing" sand, to be seen at Stop 3), rather than limestone.

Post-Devonian pre-Mississippian, or at least pre-Osage, faulting opposed in direction to the later major movement is a characteristic of the Ste. Genevieve-Rattlesnake Ferry faulted flexure belt, roughly parallel in direction but 75 miles south of the Cap au Gres structure. Though the Ste. Genevieve-Rattlesnake Ferry zone is larger and more complicated, the parallelism in time of movement as well as in direction now seems quite striking. The major movement on the Ste. Genevieve structure may well be late Mississippian and early Pennsylvanian, as suggested by evidence at Alto Pass, Fountain Bluff, and the Pennsylvanian "sink-hole" outliers on the Ozarks, and thus be contemporary with that of Cap au Gres and many other Eastern Interior structures, rather than being post-Pennsylvanian as commonly accepted in the literature.

SUBSTOP 2C (figure 12),--Lookout Point. Physiography

From this point you are looking due west across the valley of the Illinois toward peninsular Calhoun County, the crest of which rises about 400 feet above the river. On the far side of the river the Deer Plain terrace of late Wisconsin (Mankato) age makes a low apron, about a mile wide, which slopes gently (15 to 20 feet per mile) away from the base of the bluffs. Above it lies the Brussels terrace of Illinoian age, which can be seen clearly behind the white barn in the middle of the large valley almost directly opposite us. The valley, Greenbay Hollow, is developed in the crest of the Lincoln anticline.

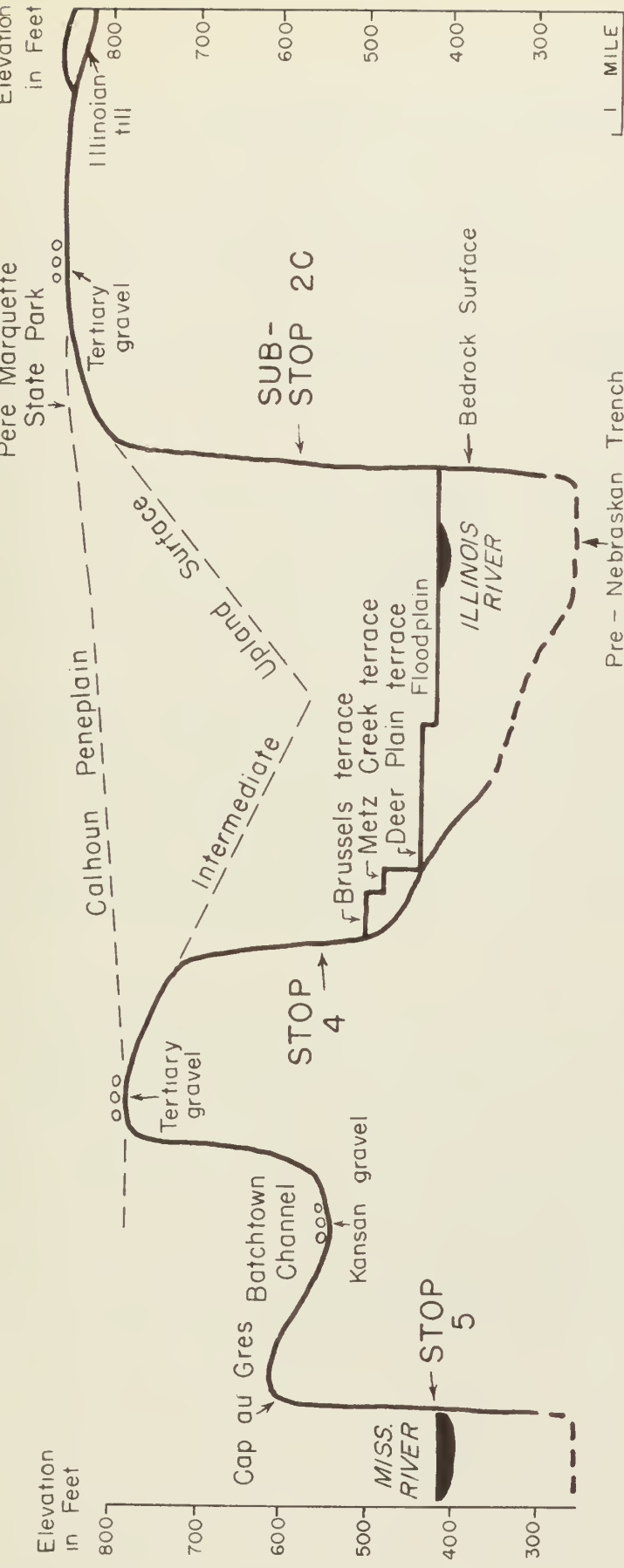


Figure 12 - Diagrammatic profile from Pere Marquette State Park to Cap au Gres. (See also Rubey, 1952, plates 10, 20)

About 1 mile north of Greenbay Hollow, nestled at the base of the first bold cliffs your eyes encounter, is the village of Meppen, near which we will be for Stop 4.

In 1811, as the result of trouble with the Indians a block-house was built at Meppen and another near the mouth of the Illinois River to assure the safety of travelers on the waterway.

To the far left the towers of a high-tension power line cross the Mississippi River at the south end of Calhoun County. At the position of eleven o'clock is the spire of the church in the village of Brussels.

The upland surface on both sides of the Illinois River in this region truncates the Lincoln fold and is interpreted as a peneplain, named the Calhoun peneplain by Rubey (1952, pp. 102-104), and correlated with the Lancaster peneplain of the Driftless area in northwestern Illinois by Horberg (1950, pp. 90, 93). Brown chert gravels (Grover) of Tertiary age occur on the Calhoun peneplain and are overlain by Pleistocene loess deposits.

The steeply dipping beds of the Cap au Gres flexure, on which we are standing, cross the 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 Gres flexure is about 175 feet higher than on the south side. Tertiary gravels occur on both surfaces. Rubey (1952, pp. 64-66) attributes these relations to renewed movement along the Cap au Gres structure in late Tertiary time following erosion of the Calhoun peneplain and deposition of the gravels.

The crests of the spurs sloping from the peneplain, when projected into Illinois Valley, meet about 125 feet above the flood plain 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 150 feet below the present flood plain of the Illinois River before Pleistocene time and the valley carried the combined waters of the preglacial Mississippi River 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 Wisconsin time.

This area was not glaciated (fig. 1); the Kansan ice from the northwest reached the western bluff of Calhoun County and the Illinoian ice came from the northeast to about three miles east of this point. The strongly dissected nonglaciated area which includes most of Calhoun and Pike counties and this corner of Jersey County is the Lincoln Hills section of the Ozark Plateaus (Leighton, Ekblaw, and Horberg, 1948).

SUBSTOP 2D. -- Strike fault in lower Mississippian rocks with displacement of 65 feet plus

This substop is on the slope about 200 feet below the shelter house of Substop 2C. It should be attempted only if the slope is dry and only by those who are accustomed to such climbing--the slope is steep and the footing poor.

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 Sedalia formations and curves down the steep hillside in such a way as to show that the fault surface is either gently concave in horizontal plan to the south or more sharply concave in vertical section to the north or is curved both in plan or section. This fault is downthrown on the south side, the stratigraphic displacement is only about 65 feet and the vertical throw is probably about 150 feet." (See fig. 10.)

A second interpretation may be made if the formation on the downthrown side of the fault is identified as Keokuk. 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 30 feet 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 (Substop 2E) 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 175 feet and the vertical throw 250 feet, approximately the same as a fault on the strike of this one which has been traced for 2 miles beginning a mile and a half east of this place.

SUBSTOP 2E. -- Warsaw geodes

South of the shelter house promontory there is a deep re-entrant in the bluff which marks the position of the Warsaw shale in the flexure. 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 2F.---Salem limestone and lower St. Louis

The Salem limestone is represented in the section along this trail by a single long, narrow, rather steeply dipping outcrop of calcarenitic limestone on the promontory just south of the Warsaw re-entrant. The outcrop 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 St. Louis limestone.

SUBSTOP 2G.---St. Louis limestone breccia, upper St. Louis, possible Ste. Genevieve

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, substop 1N. The breccia, dipping 26 degrees 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 formation only a few miles 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,

Overlying the breccia, about 70 feet of limestone is exposed along the trail which leads to the museum (Substop 2H). 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 10 feet 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.

About 10 feet above the breccia is a zone in which Lithostrotion proliferum and Lithostrotionella castelnaui are common along with bryozoans and brachiopods. Spirifer littoni and Dictyoclostus tenuicostus have been identified from beds immediately above the breccia, and Linoproductus ovatus is common in the uppermost oolitic beds.

SUBSTOP 2H.--Trailside Museum

The park museum, which will be open for your inspection, contains collections of fossils, artifacts, plants, and animals from the park and surrounding area,

SUBSTOPS 2I, 2J, 2K.--Pleistocene and Physiography

From the museum follow the trail to the lodge, noting sub-stops 2I, J, and K, as shown in figure 10.

The lodge is situated on the Brussels terrace (substop 2I) which slopes down in front of the lodge to the surface of the Deer Plain terrace (substop 2J), which the main highway crosses. Beyond it there is a drop of only about 10 feet to the flood-plain level (substop 2K), 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 deposited in a lake formed by Illinoian ice blocking the river at St. Louis, as previously noted. The water-laid deposits are overlain by 20 feet or more of Wisconsin 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 late Wisconsin (Mankato) glacial outwash heading in the upper reaches of Mississippi Valley. It consists of gravel, sand, and silt. It was the latest valley train in Mississippi Valley and is not loess covered. Deer Plain aggradation in Mississippi Valley greatly exceeded that in 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 Illinois Valley from sand to silt, and the terrace surface declines gradually until it passes beneath the Recent flood plain about 15 miles above the mouth of the valley.

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, 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 its gradient so much (28 feet in 236 miles) that high-water stages at Grafton are as high as low-water stages at Starved Rock State Park near LaSalle, Illinois.

In contrast, the Mississippi River channel has been constantly changing by the formation of new bars and the lateral erosion of its flood plain. In this region Pleistocene terraces have been almost entirely cut from the floor of 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).

SUBSTOP 2L.--<u>Pere Marquette Lodge Hotel</u>

Lunch will be served promptly at noon in the main dining room, which is on the right as you enter the main lounge.

Rest rooms are along the hall which is on the far left just as you enter the lounge.

TALK AFTER LUNCH.--After lunch Mr. W. W. Rubey will discuss the development of the Lincoln anticline on the terrace in front of the lodge.

After the talk the buses will reload in the parking area southeast of the lodge.

Mileage

- 47.4 Mileage on first passing lodge repeated. Leaving the lodge, turn right (west) onto highway 100 at entrance.
- 49.0 Williams Hollow. Floor and lower slopes underlain by Maquoketa shale. Note the well-developed Brussels terrace, 30 to 40 feet above road level running nearly a mile back up the hollow to right (east).
- 49.4 Edgewood high in valley wall at edge of Williams Hollow.
- 49.5 Maquoketa shale exposed behind small white house on right. Silurian bluff nearly continuous.
- 49.7 Leave Brussels Quadrangle, enter Hardin Quadrangle.

Mileage

- 50.0 High bluff of Mississippian visible above Silurian-Devonian bluff for short distance.
- 50.5 Small quarry in Edgewood dolomite in bluff to right (east).
- 50.7 Maquoketa in ditch on right. Edgewood bluff continuing.
- 51.4 Another Maquoketa exposure at south edge of large metal barn.
- 51.5 The Edgewood (Silurian) bluff is dropping closer to the road as we approach the axis of the Otter Creek syncline (fig. 3).
- 52.1 Edgewood at road level.
- 52.7 Village of Rosedale in Coon Creek Hollow at right (east).
- 52.8 Devonian-Silurian at right (east).
- 53.6 Near the S-curve sign, the Silurian is largely mantled by talus of tan fossiliferous Cedar Valley (Devonian) limestone, the top of which is almost continuously exposed on the wooded slope about 50 feet above the highway. Two to four feet above the top of the Cedar Valley are scattered outcrops of very light gray lithographic Louisiana (early Kinderhook) limestone, with outcrops of thin-bedded platy silty dark gray Glen Park limestone for another 6 feet. The Louisiana weathers into chips and rectangular blocks up to the size of paving bricks. It weathers white, in contrast to the dull gray to tan weathered surfaces of the Cedar Valley and the even duller dark gray Glen Park shingles. Higher on the slope a little slumped Hannibal shale shows, and Chouteau limestone forms a ledge 68 feet above the Louisiana.
- 54.1 Devonian close to road at right, Mississippian bluff set back from highway.
- 54.3 The thin-bedded Cedar Valley (Devonian) in the cut on the secondary road at right is the start of the Teneriffe School section (fig. 13), which is exposed for the next half mile. This section is included to show the relations of the basal Kinderhook formations, although time does not permit us to make a stop.

The section from the Cedar Valley through the Glen Park was measured in a fresh excavation about 500 feet north of the secondary road and 20 feet above the highway. From there to Teneriffe school, where the remainder of the section was measured, the Chouteau and Burlington limestones form a high-

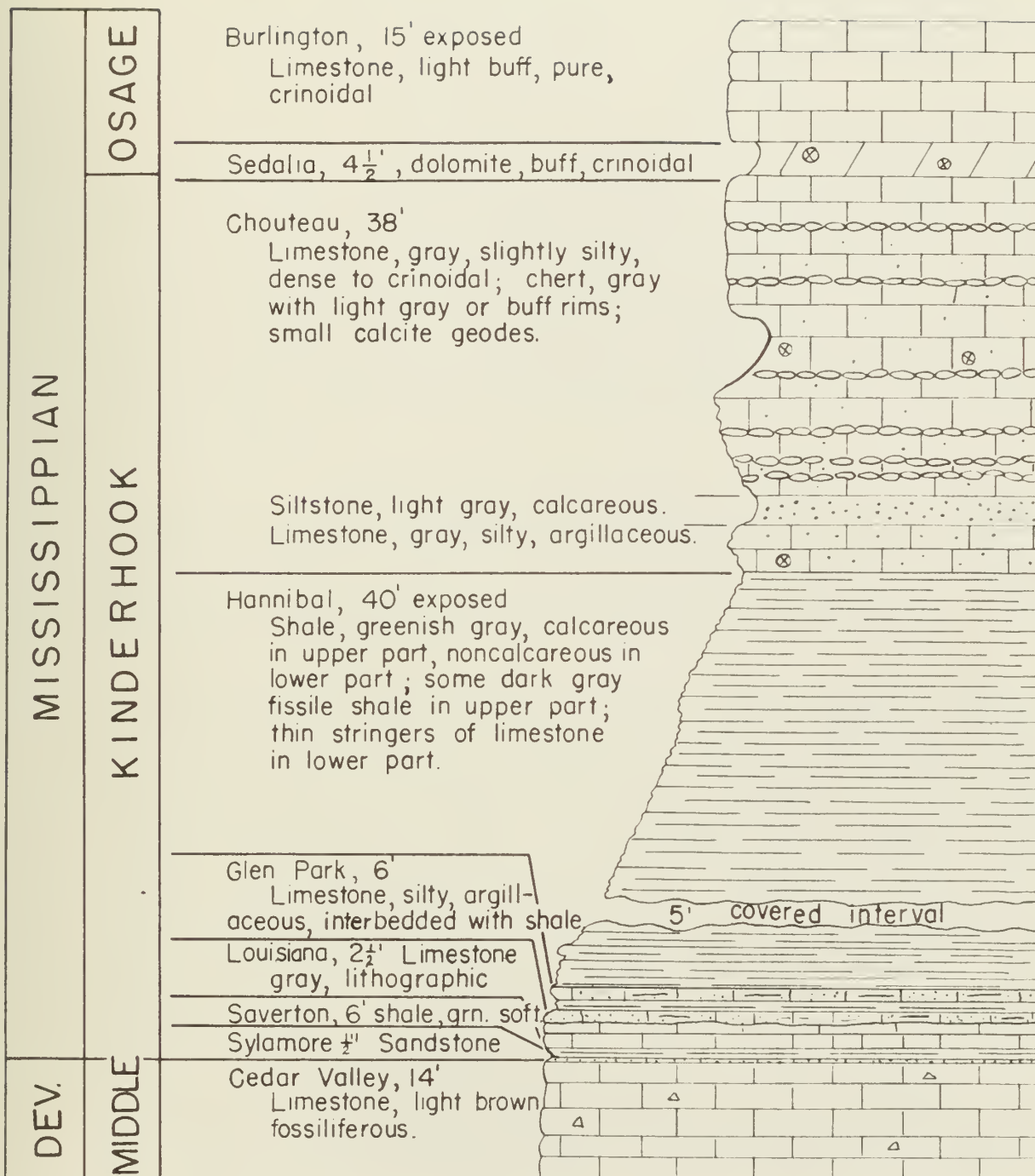


Figure 13 - Teneriffe School

NW. Corner Sec. 9, T. 7 N., R. 13 W., Jersey County, Illinois

Vertical Scale: 1" = 20'

level bluff. The base of the Hannibal does not show at the school, but a 4-foot outcrop of Glen Park at road level 500 feet north of the school establishes the position of the contact. In the half mile across the section the beds dip about 25 feet north into the Otter Creek syncline.

At Stop 2 the Hannibal shale rests directly on Silurian or Devonian strata, and at Stop 3 only a few inches of Sylamore sandstone separates the Hannibal from the Cedar Valley. North and east of these stops, older Kinderhook units are intercalated beneath the Hannibal but above sandstones similar to the Sylamore, and in the Illinois Basin farther east and south, units of the New Albany (Chattanooga) black shale come in at this position. Three of the post-Sylamore pre-Hannibal units (Saverton, below, Louisiana, and Glen Park) occur here, and we shall pass over the buried feather edges of a lower unit (Grassy Creek) on our return trip through Jerseyville to St. Louis.

The age of these beds has long been in doubt. Some follow the classification of the Sylamore as basal Mississippian, as used in this guidebook. Others consider the Grassy Creek, and still others the Louisiana, as the top of the Devonian. Recently many have listed the Sylamore to Louisiana sequence as "Mississippian or Devonian."

Although the Hannibal is largely greenish-gray shale, it contains lenses of dark gray to black shale in many places. Rubey (1952, pp. 37-38) describes minutely laminated very dark gray shale in the Hannibal near Hamburg, 14 miles northwest of here, and we shall see similar shale in the Hannibal at Meppen (Stop 4). East and southeast more laminated spore-bearing black shale comes into the Hannibal, and the formation thins. The black shale crops out in Mason and Jerseyville hollows at the north edge of Grafton, and perhaps most clearly along a branch of Otter Creek, 1.0 to 1.4 miles northeast of Nutwood and about 2 miles north of Teneriffe school. In the Nutwood section the Hannibal is black fissile shale in the interval from 7 to 22 feet above the Glen Park. Black spore-bearing shale outcropping above the Glen Park is also described in Ste. Genevieve County, Missouri, 75 miles south of here. Within the New Albany, beds believed to be equivalent to the Hannibal do not change entirely to black shale, but include some gray or greenish-gray shale all the way east across the Illinois Basin.

The Glen Park is sandy argillaceous occasionally oolitic limestone and calcareous shale. Its contact with the Hannibal shale is transitional, with thin limestone or calcareous siltstone lentils appearing in the lower part of the Hannibal,

at first sporadically but becoming thicker and more numerous downward. The Glen Park is fossiliferous, and its fauna, sometimes called the Hamburg fauna, occurs also in the Underwood shale in the upper New Albany of Indiana. The pinch-outs of the Glen Park and the Louisiana limestones coincide about 2 miles south of here, but generally the Glen Park is much more widespread.

The Louisiana limestone is a hard, dense, light gray lithographic limestone with buff dolomitic mottling. It is overlain by the Glen Park formation or the Hannibal shale, and underlain by Cedar Valley limestone, Sylamore sandstone, or Saverton shale. It occurs as a lens up to 50 feet thick, perhaps 20 miles wide, and 200 miles long, extending from Iowa down the Mississippi Valley to Calhoun County and then eastward in subsurface. At Louisiana, Missouri, and other places north of Calhoun County where the Louisiana crops out, the Chouteau limestone above the Hannibal has been removed by pre-Osage erosion. However, the two somewhat similar limestones, separated by the Hannibal and usually the Glen Park, both crop out here and in many other localities in Calhoun and Jersey counties. The Chouteau is present above all Louisiana outcrops mentioned by Rubey (1952, pp. 33 and 34) in the northeastern half of the Hardin and Brussels quadrangles. Both limestones are present and are separated by 30 to 100 feet of Glen Park-Hannibal in wells in Jersey County, except for the southwestern corner, and eastward for another 50 miles or so. The Louisiana does not occur south of the latitude of Alton, and the fine-grained limestone overlying the New Albany almost throughout the Illinois Basin and correlating with the Indiana Rockford is the Chouteau rather than the Louisiana (Buschbach, 1953).

The bluish-green Saverton shale is very thin and soft in this area, and Rubey (1952, p. 33) treats it as part of the Louisiana. The outcrop here is the only one seen by the writers in the field trip area, though a covered interval between the Louisiana and the Cedar Valley suggests its occurrence at many other places.

Creek

The black Grassy/shale is overlapped by the Louisiana limestone in northern Calhoun County. The southernmost outcrop is in the section at Hamburg (table 6). The lower part of the section is in Irish Hollow, a few hundred feet east of the center of sec. 35, T. 9 S., R. 3 W., Calhoun County, Hardin Quadrangle. The part above the Glen Park is measured at the north edge of Hamburg, in the NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 35.

Table 6. - Composite section at Hamburg

	<u>Thickness</u> <u>in feet</u>
Burlington, crinoidal buff limestone	10*
Chouteau, argillaceous gray limestone	25
Hannibal, greenish-gray siltstone and shale with some dark gray mottling	75
Glen Park, gray to brown sandy limestone and oolite	13*
Louisiana, buffish-gray lithographic limestone	5
Saverton, greenish-gray shale	1/2
Grassy Creek, black fissile shale	1/3
Sylamore sandstone	0-1"
Cedar Valley limestone	4-5
Joliet limestone	15*

In subsurface the Saverton-Grassy Creek shale thickens rapidly eastward. At Alton the Louisiana and the Glen Park still overlap the Saverton and Grassy Creek; a well shows (above the Devonian) a trace of Sylamore, five feet of Louisiana, 15 feet of Glen Park, 40 feet of Hannibal, including much black as well as greenish-gray shale, 15 feet of Chouteau, and 45 feet of Fern Glen. A few miles east of Alton, the Saverton-Grassy Creek shales extend southward beneath the Louisiana to lie directly beneath Glen Park or undifferentiated Hannibal-Glen Park. Both shale sequences are similar and the entire sequence is then called New Albany. However, they can be separated in electric logs by an abrupt downward increase in resistivity, the upper part of the black Grassy Creek being more resistive than the black shales or any other units in the Hannibal. This electric criterion may classify the Saverton, which is only a few inches thick in the basin, with low-resistivity upper New Albany (Glen Park-Hannibal equivalents) rather than with the high-resistivity middle New Albany.

The Indiana correlative of the Grassy Creek is believed to be the middle New Albany or Blackiston, now considered upper Devonian in age by many workers. Sylamore-type sand occurs almost universally at the base of the Grassy Creek-Blackiston in the southwestern Illinois subsurface. It is widely present at that position in southern Indiana and also in central Tennessee, where it is called the Hardin sandstone. About 120 miles southeast of here, in Clay and Jefferson counties, is the feather edge of the lower New Albany Blocher formation, generally recognized as Devonian, probably as low as Tully. No Sylamore-type sand is known at the base of the Blocher in Illinois, and it is definitely lacking in at least three places where the section has been cored, but Sylamore-type sand occurs locally at the base of even this early black shale unit in Indiana and central Tennessee.

Milcare

- 55.1 Bridge over Otter Creek, on axis of the gentle Otter Creek syncline, here 200 feet structurally beneath the crest of the Lincoln anticline at Stop 2, 7 miles behind us, and 100 feet below the crest of the Nutwood anticline, a little over a mile ahead. The Devonian is here at, or slightly beneath, the road level.
- 55.7 Nutwood. Devonian-Silurian at right (east) in road cut and bluff. Basal Devonian "Hoing" sand is exposed in lower part of re-entrant 14 feet above the road at the arrow pointing to Nutwood.
- 56.0 Crest of Nutwood anticline. Devonian-Silurian bluffs on right continue for about a mile.
- 57.3 Bridge and stop sign. Junction with Illinois 16. Continue ahead (north) on Illinois 100.
- 57.5 Extensive Devonian outcrops with cap of fossiliferous Cedar Valley sandstone. Occasional Silurian outcrops.
- 57.8 Nose with good Devonian section. The Devonian is dropping rapidly.
- 58.3 Small rise brings road over Devonian.
- 58.9 A slope on Hannibal shale, on the right, leads up to a bluff of Chouteau limestone capped with loess.
- 59.4 Chouteau and Burlington exposed at right as road curves left.
- 61.1 Fieldon quarry in bluffs on right exposes Chouteau, Sedalia, and lower Burlington limestones.
- 62.4 The Calhoun County bluff across the Illinois River is nearly everywhere capped by the middle Burlington. However, in and immediately south of Hardin the Hardin syncline (fig. 3), with 250 feet of negative closure, pulls the Burlington down to the road level at the water tower. The start of dip south into the syncline can be seen just above and to left of the bridge. Silurian dolomite crops out at the base of the bluff from the bridge abutment for about a mile north, and again from a mile and a half south of the bridge on south for 8 miles.
- 63.0 Joe Page Memorial Bridge over Illinois River. Until 1931, when this bridge was constructed, Calhoun County could be reached only by ferry or by gravel roads coming down both sides of the peninsula from the north.

Mileage

- 63.4 End of bridge. Stop sign. Turn left (south) into Hardin, leaving Route 100. Hardin is the county seat of Calhoun County, which is famous for its apples.
- 63.8 Main street junction in Hardin. Continue ahead on newly constructed road. (If construction is still in progress, we will take the old road a few hundred feet farther west against the base of the bluff, adding about 0.2 mile to the mileage.)
- 65.0 Cedar Valley limestone crops out at road level, dipping 3 degrees north on south flank of Hardin syncline.
- 65.5 Maquoketa in road ditch at right. Over 100 feet^{of} structure in the last half mile.
- 66.4 Leave new construction, onto old blacktop road.
- 67.0 Far right (west) behind the white house, Louisiana and Glen Park limestones are well exposed above the ledge of Devonian limestone and beneath a slope of Hannibal shale which extends up to Chouteau-Sedalia-Burlington in the high bluff.
- 67.9 High bluffs on right. The Sedalia forms a bluff, five-foot re-entrant just above tree-top level. Above the Sedalia is a fifteen-foot band of basal Burlington. Cherty middle Burlington caps the bluff, and there are good exposures of gray Chouteau beneath the Sedalia.
- 68.2 Devonian-Silurian strata are exposed 10 to 15 feet above the valley floor. Cherty middle Burlington is well exposed high in the bluff.
- 68.8 Apple orchard on right is on a small alluvial fan with a small intermittent stream entrenched on top of the fan. All along the road from Hardin to Meppen the small bridges are on rises in the road as we travel near the top of an apron formed by the coalescence of numerous small alluvial fans.
- 69.0 Good view of the Chouteau-Sedalia-Burlington bluff above the talus. The lower 15 to 20 feet of the bluff is Chouteau.
- 69.3 Behind the trees at right is a Devonian-Silurian bench 20 feet high with 15 feet of Hannibal shale exposed above.
- 70.2 Middle Burlington limestone is well exposed at the top of the bluff.
- 70.7 Maquoketa shale with Silurian dolomite above is exposed at road level 200 feet right (west) of the road.

Mileage

- 71.1 Union school on right.
- 71.3 Devonian-Silurian strata at road level on the right.
- 71.8 Devonian-Silurian blocks along the old road 100 to 200 feet on right,
- 71.9 The cliff at right is the front of a truncated spur sloping away from the Illinois River, as we will see looking back north from the next stop, a mile south of here.
- 72.6 The cedar-dotted slope is developed on the Maquoketa shale. The base of the Silurian is lifted about 40 feet above road level by a small unnamed anticlinal nose.
- 72.9 Junction with Batchtown road. Turn right (west) on Batchtown road.
- 73.0 Turn right (north) on road to Monterey school.
- 73.1 Park in yard near school.

STOP 3. - Monterey school. Ordovician, Silurian, Devonian, and Mississippian Strata

NE $\frac{1}{4}$ SW $\frac{1}{4}$, Sec. 11, T. 12 S., R. 2 W., Hardin Quadrangle, Calhoun County.

Walking distance - 100 yards.
Leaving time - 2:30 p.m.
See figure 14.

Except for the covered Maquoketa-Edgewood contact, the section from the Ordovician Maquoketa shale to the Mississippian Hannibal shale is continuously exposed at the end of a ridge immediately north of the abandoned Monterey school.

Structurally this stop is on the crest of a very low unnamed subsidiary anticlinal nose plunging gently eastward parallel to, and three miles north of, the crest of the Lincoln fold (fig. 3). It is separated from the major anticlinal axis by the Meppen syncline, which brings the Mississippian down to road level at the next stop, a mile and a half south. Consequently, the section at the next stop is essentially the upward continuation of the section here.

The Maquoketa shale is about 125 feet thick in this vicinity. The upper part of the shale, exposed on both sides of the east-west fence shortly south of the nose of the bluff, is greenish-gray nonfossiliferous clay-shale. The lower part of the

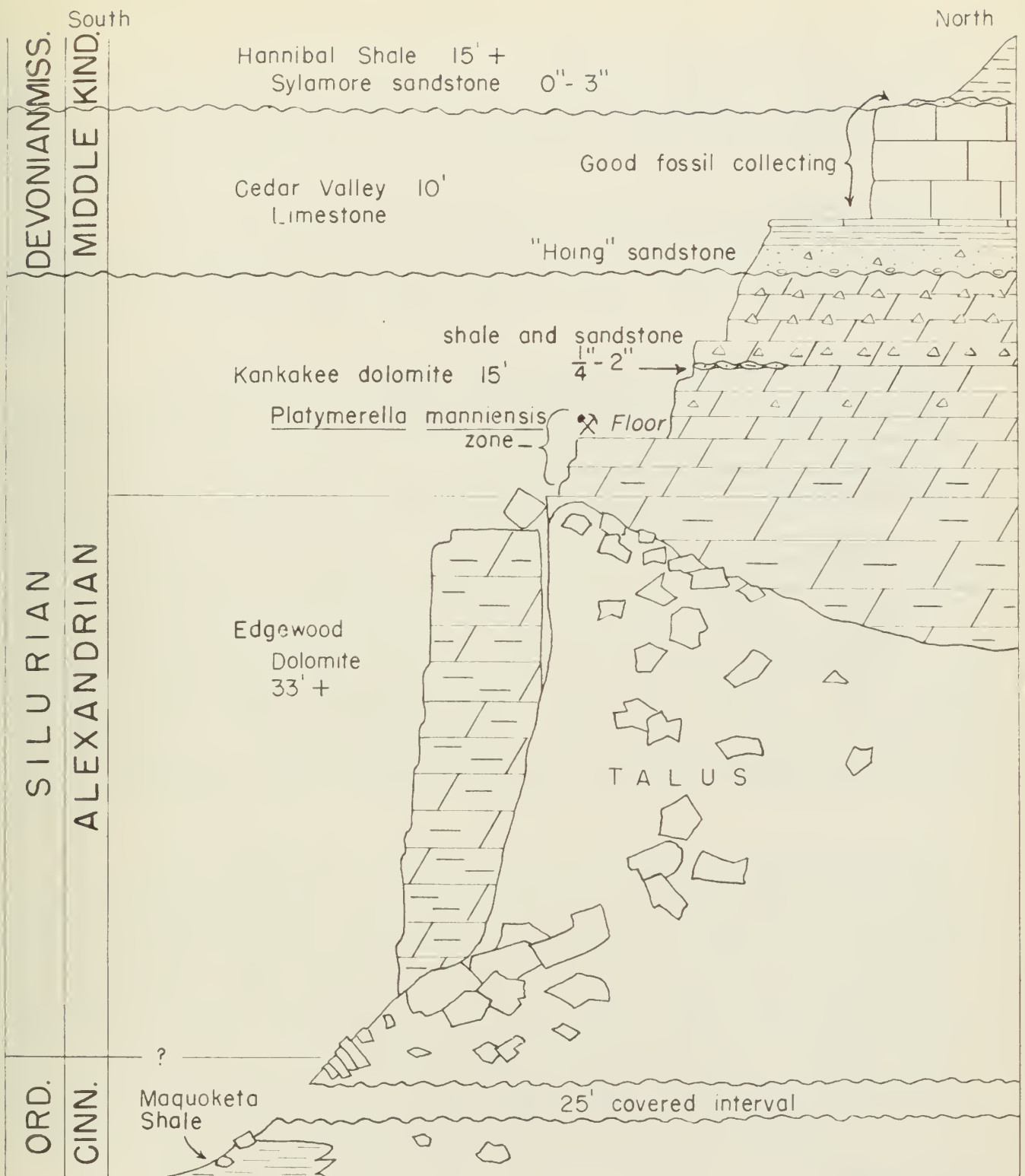


Figure 14 - Stop 3 Monterey School
 NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ Sec. 11, T. 12 S., R. 2 W., Calhoun County, Illinois
 Vertical Scale: 1" = 10'

shale includes darker, more calcareous beds, even grading to shaly dolomite. It contains thin sideritic layers and thin layers of granular fossiliferous phosphate carrying a miniature "depauperate" fauna at or near the base, and a sporadic basal conglomerate of fossiliferous chert.

In some seasons the level of the Maquoketa-Silurian contact beneath the talus cover is marked by water seeps; after the dry 1953 fall, this seep line could not be recognized, but the contact is probably near the top of the 25-foot covered interval (fig. 14).

The 48 feet of buff Silurian dolomite exposed here is referred to two Lower Silurian (Alexandrian) formations, the Edgewood and Kankakee. The Edgewood is divided into 3 members northwest of here in Missouri: the Cyrene limestone (at the base), the Noix oolite, and the Bowling Green magnesian limestone, but only the latter is represented in our 33-foot section; the Noix is overlapped 6 miles north and the Cyrene 20 miles or so northwest. The Edgewood through wide areas averages only 10 to 20 feet thick. Where it reaches a thickness of 50 feet, as it does a couple of miles south, it typically thickens at the expense of the Maquoketa, filling depressions on the post-Maquoketa erosion surface. Therefore, it is not surprising that here at the edge of a thick area, the lower half of the exposure should show low-angle cross-bedding. The dominant lithology is yellowish-buff smooth-weathering fine-grained silty dolomite (80-85% soluble) with high true porosity, low naked-eye porosity, and low permeability. The top few feet are relatively pure. Fossils in the dolomite facies are few--occasional small brachiopod molds, and a few silicified stromatoporoids in the upper part.

Only the lower 15 feet (about half) of the Kankakee is present here; the upper part was removed by pre-Devonian erosion. At this outcrop there is no well-defined unconformable surface between the Edgewood and Kankakee formations, and the exact position of the contact within two or three feet of transitional beds can be questioned. The beds three to six feet above the base of the Kankakee are pure (up to 98% soluble), hard, permeable dolomite, which grades upward to cherty, very slightly sandy dolomite which extends from 6 to 8 feet above the base to the top. Though both Silurian formations are buff dolomite, there is a good contrast between the smooth-surfaced, smooth-bedded yellow-weathering Edgewood and the rough-surfaced, wavy-bedded, grayer Kankakee.

Eight and a half feet above the base of the Kankakee and 5 to 7 feet below the top is a two-inch sandstone. Rubey (1952, p. 28) notes another locality with a similar thin sandstone 18 feet above the base and 5 feet below the top. The adjacent dolomite beds carry a few scattered sand grains covering the same size range, very

fine to medium, as the grains in the sandstone. However, the sand is also similar to that in the Devonian "Hoing" sand above, and there is some possibility that it is a basal Devonian cavity filling.

The guide fossil of the lower part of the Kankakee, the oval plicate pentameroid brachiopod, Platymerella manniensis, about an inch to an inch and a half long, can be found, together with a few other fossils, on the floor of the small quarry and on loose blocks, and cross sections can be found on quarry faces, both above and below the floor. It cannot be called common in this exposure.

The upper part, perhaps 15 feet, of the Kankakee is removed by pre-Devonian erosion. Beveling of the Silurian is fairly sharp beneath the unconformity. Above the Kankakee there is 15 to 30 feet of Niagaran at Pere Marquette Park, just across the Illinois valley, 57 feet in Jerseyville Hollow at Grafton, about 70 just beyond Grafton, about 150 feet at Alton, and 500 feet 30 miles east of Alton.

The Devonian of Calhoun and Jersey counties is referred to the Cedar Valley formation, which is late Middle Devonian. Older beds, though still Middle Devonian, are overlapped within a very few miles both east and north, and it is possible that some poorly fossiliferous beds at the base of this and other sections may be outliers of the earlier Wapsipinicon formation.

On this outcrop the basal few inches of Devonian are extremely varied; dolomite, shale, sandstone, and chert conglomerate immediately overlie the unconformity within a few feet laterally. However, fairly clean sand is abundant enough in the basal two feet to justify the use of the term "Hoing," which is the productive basal Cedar Valley sandstone in the Colmar-Plymouth oil field 90 miles north. About a foot of shale overlies the "Hoing" sandstone, followed by 7 to 8 feet 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 miles north of here (Cooper and Cloud, 1938). The Monterey fauna includes the following:

SPONGE

Astrospongia hamiltonensis, saucer-shaped, indistinguishable from A. meniscus, the "Niagaran" guide

CORALS

Hexagonaria [Acervularia or Prismatophyllum], compound tetracoral

Favosites alpenensis, honeycomb tabulate, 1 mm. cells

Alveolites, fine-tubed, slanting honeycomb tabulate

Striatopora, twig-like tabulate

Cystiphyllum, solitary tetracoral, vesicular structure

Tabulophyllum, small, solitary tetracoral, strong horizontal
tabulae

"Cvathophyllum," unidentified solitary tetracorals

CRINOIDS

Numerous stems and isolated plates. Complete heads have not yet
been found within a mile or so.

BRYOZOANS

Fenestella, the lace-like cryptostome

Sulcoretopora, a strap-like branching cryptostome

BRACHIOPODS

Athyris fultonensis, subcircular, biconvex, low fold, weak concentric
lamellae

Atrypa reticularis, flat ventral overlapping strongly convex dorsal,
numerous costellae and lamellae reticulate

A. (Hystericina) hystrix, few strong costae

Chonetes, semielliptical, concavo-convex, spines on straight hinge

Cranaena, smooth ovoid, curved beak, small to medium

Cyrtina, small narrow spiriferoid, high triangular cardinal area

Elytha subundifera, large narrow spiriferoid, few low costae,
extremities rounded

Megastrophia, large, deeply concave stropheodontid

Pentamerella, small subcircular costate pentameroid, ventral sulcus

Pholidostrophia, small, smooth, very white glistening, semiellipti-
cal

Platyrachella iowensis, very large, wide, acute spirifer

P. curyteines, large, acute, sharper costae than P. iowensis

Schizophoria iowensis, transversely elliptical, very low broad sinus, finely striate

Schuchertella, semielliptical, often unsymmetrical, finely costellate, prominent rounded deltidium

Stropheodonta, semicircular to subrectangular, concavo-convex, costate, with denticulate hinge, several species

Strophonelloides, reversed convexi-concave stropheodontid

Syringospira, medium spiriferoid, very high triangular cardinal area

Tylothyris, medium spiriferoid, strong plication on sinus and groove on fold

TRILOBITES

Phacops, compound eye, swollen nose

Proetus, smooth eye, large rims on head and tail

FISH

Helodus, small corrugated crushing teeth

Dinichthys and Ptyctodus, large worn plate fragments, commonly black

The Cedar Valley is here overlain unconformably by the Sylamore sandstone, an oxidized brown sandstone, up to 3 inches thick lying in pockets on and infiltrating 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 Cedar Valley sandstone. Here, however, the upper limestone beds are quite pure and the break to the Sylamore is sharp, though silicified Cedar Valley brachiopods are mixed in the lower part of sand. This sandstone, whose brown color is due to the oxidation of pyrite (some subsurface occurrences are floating sand grains in a pyrite matrix), is very similar to those distributed widely, though sporadically, at the base of the Devonian-Mississippian black shale sequence, the New Albany or Chattanooga, regardless of what particular unit overlies the sandstone. Known in the Midcontinent subsurface as Misener, these sandstones are generally called Hardin in the Illinois Basin subsurface, after the western Tennessee outcrop area where the sandstone underlies Chattanooga shale. The outcropping Sylamore of Arkansas and Missouri underlies Grassy Creek or "Chattanooga," and we are using

the name Sylamore on this field trip because the sandstone here is more directly traceable to the sandstone beneath the Grassy Creek.

The Hannibal shale, the only representative of the New Albany (Chattanooga) shale sequence exposed at our stops, is here almost entirely noncalcareous gray to greenish-gray siltstone and shale. The basal 10 to 12 feet can be seen here, the top at the next stop, a mile and a half south. The relations of the Sylamore and Hannibal to the New Albany-Chattanooga black shale sequence were described at the Teneriffe School section, mileage 54.3.

Mileage

73.2 Return to Batchtown road and turn left (east).

73.3 Turn right (south) on Hardin-Brussels road.

73.6-74.5 Silurian and Devonian come down to road level on the north flank of the Meppen syncline, with about 80 feet of reversal. At 74.5 the Cedar Valley is at road level, overlain by Sylamore sandstone and Hannibal shale.

75.2 Pass the black-top road to Meppen, which branches off to the right, and park along the road.

STOP 4. - Meppen North Quarry, Lower Mississippian Strata

Abandoned quarry north of Meppen, SW $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 23,
T.12 S., R. 2 W., Hardin Quadrangle, Calhoun County.

Walking distance - 100 yards.

Leaving time - 3 P.M.

See figure 15.

Buses will unload along the highway. LOOK OUT FOR CARS
WHILE CROSSING THE ROAD.

Only a brief stop will be made here as much of the face is not accessible and climbing would be dangerous, particularly for those below. The lithology of all the formations can be seen in fallen blocks.

This exposure presents a close-up view of the Mississippian formations which we have observed along the bluffs south from Hardin. The quarry is near the center of the east-west trending Meppen syncline (fig. 3), which accounts for the fact that the Silurian and Devonian strata are not exposed, although they crop out within a half mile north or south.

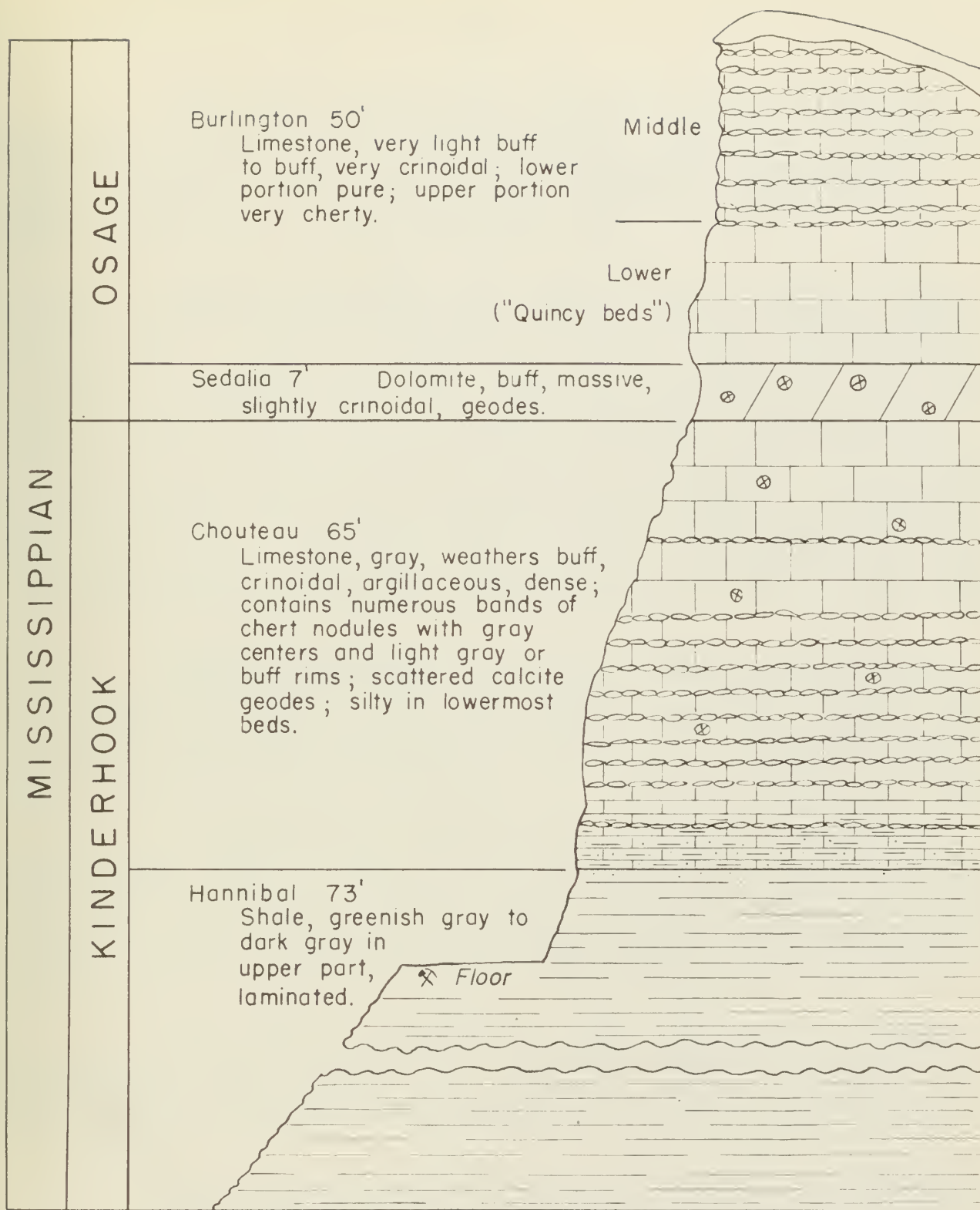


Figure 15 - Stop 4 Meppen North Quarry
SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ Sec. 23, T. 7 N., R. 2 W., Calhoun County, Illinois

Vertical Scale : 1" = 20'

From this vantage point the bluffs of Pere Marquette Park across the valley can be seen clearly. Most of the flat surface of the valley floor to the southeast, between here and the river, consists of Deer Plain terrace deposits. The Brussels terrace can be seen across the valley in Williams Hollow (first large valley north of Pere Marquette Park).

Hannibal formation.---The incline to the quarry floor traverses some 60 feet of Hannibal shale. Above the quarry floor about 13 feet of shale is exposed, varying in color from greenish gray to black. X-ray and differential thermal analyses have shown the shale to consist mainly of chlorite and illite clays with small amounts of quartz and carbonate. Siltstone beds which are prominent in the type locality at Hannibal, Missouri, feather out at the top of the formation 10 to 15 miles north of here. The contact of the shale with the overlying Chouteau is distinct, but the lowest few feet of the limestone are argillaceous and silty, as at Teneriffe School (fig. 13). Except south of here, where both thin and disappear, the two formations have compensating thicknesses so that the lower Chouteau silty beds exposed here are considered equivalent to the upper Hannibal siltstone farther north.

Chouteau formation.---In this outcrop the Chouteau approaches its maximum thickness in Illinois. It is 75 feet thick in southernmost Calhoun County but thins rapidly north, east, and south and disappears 15 miles to the north. It is present, however, throughout most of the subsurface of the Eastern Interior Basin, where it averages only 10 to 15 feet in thickness (Buschbach, 1953).

In outcrop the formation is distinguished from other Mississippian rocks of this area by its gray argillaceous character and its chert nodules, which have gray centers and light gray or buff rims. The Chouteau as well as the overlying Sedalia contains scattered small calcite goodes. Where weathered the Chouteau has a characteristic hackly thin-bedded appearance, which is well exhibited in the south bluff adjacent to the quarry.

The contact of the Chouteau with the Sedalia is sharp and apparently conformable. At Chautauqua (fig. 9) a good angular unconformity exists between the formations, and in Jerseyville Hollow a basal conglomerate constitutes the lowest few inches of the Sedalia.

The Chouteau formation of Illinois probably correlates with the Compton formation in the Chouteau group of north-central Missouri, and it is equivalent to the Rockford of Indiana.

Sedalia formation.---This unit forms the buff band across the quarry face a little above half way to the top. It is readily distinguishable because it forms a characteristic buff re-entrant in the river cliffs. The Sedalia has only limited distribution in

Illinois, being restricted to the west-central portion of the State. It reaches its known maximum thickness in Illinois at Chautauqua (fig. 9). West of the Illinois River it never exceeds 10 feet, and it thins gradually northward from here and disappears within 20 miles.

Although the name Sedalia, from Sedalia, Pettis County, Missouri, has long been used for this unit in Illinois, following Moore (1929), it does not correspond to the present usage in central Missouri. The Illinois Sedalia belongs in the Osage group while the Sedalia of central Missouri is Kinderhook in age. On the basis of stratigraphic position and lithology, the Illinois Sedalia correlates best with the basal Osage Pierson formation of Missouri.

Burlington formation.--The coarse crinoidal Burlington limestone is the most prominent formation in the bluffs of this area; it forms the brow of the cliffs for some 80 miles along the Mississippi between Alton and Quincy and for more than 50 miles up the Illinois River. In Calhoun County it also forms the divide between the Illinois and Mississippi rivers. Its prominence is partially attributable to the fact that the middle Burlington is very cherty and, as weathering proceeds, residual chert accumulates, forming a resistant cap. The chert which is so conspicuous in the Burlington generally occurs as white to buff nodules or bands. From Calhoun County northward the Burlington consists of three members: an upper, rather thin, chert-free glauconitic member; a thick, very cherty middle member; and a chert-free, pure lower member, which is well exposed in this outcrop. These members probably correspond respectively to Laudon's Pentremites, Physetocrinus, and Cactocrinus zones. The lower member, commonly referred to as the "Quincy beds," is the basis for a high-purity limestone industry which is centered at Quincy, Illinois. The "Quincy beds" are present in Pere Marquette Park but eastward, between the park and Chautauqua, they grade laterally to the cherty argillaceous Fern Glen.

The thickness of the Burlington is rather uniform in this area; it thickens gradually southward, attaining a maximum thickness of about 200 feet in southern Calhoun County. Along the Cap au Gres flexure, where it is near its thickest, the Burlington is overlain conformably by the Keokuk limestone. On the upland north of the flexure the Burlington is overlain unconformably by small outliers of Pennsylvanian strata and by patches of Tertiary gravel.

Mileage

- 75.7 The village of Meppen lies beneath the bluff to the right (west). The south limb of the Meppen syncline has brought the Silurian to the surface in the main Meppen quarry.
- 76.5 Maquoketa overlain by Silurian is exposed in the re-entrant to the far right (west).
- 76.6 The long, low terrace behind the white barn on the far right is the Brussels terrace.
- 76.9 The mouth of Greenbay Hollow, which we saw from Pere Marquette Park, is on the right. Here, we cross the crest of the Lincoln fold at a saddle which is 100 feet lower structurally than the crest at Twin Springs (Stop 2) and 400 feet lower than near West Point (Stop 5).
- 77.3 We are now passing over the steeply tilted but poorly exposed beds of the Cap au Gres flexure. Two tilted blocks of Salem limestone can be seen on the right of the highway. There is some minor faulting at this place. One half mile west of here Burlington beds can be seen dipping 20 to 25 degrees south.
- 77.5 Small remnant of Brussels terrace on left.
- 77.7 Cuts in Peorian loess on both sides of the highway.
- 78.0 Turn right (west) on the Beechville road. We will now drive parallel to the Cap au Gres flexure over flat-lying St. Louis limestone and Pennsylvanian shale, largely loess covered.
- 78.4 Meppen road on right. Continue straight ahead.
- 79.0 Road to left. Numerous sink holes on all sides of road corner are in loess-mantled St. Louis.
- 80.0 Road to left. Note absence of sink holes for next half mile as we cross Pennsylvanian bedrock in hill above St. Louis level. Tertiary (Grover) gravel overlies the Pennsylvanian beds along crest of the ridge south of here. A detailed study of these gravels was made by Rubey (1952, pp. 62-74).
- 80.6 Turn right (north) into Beechville. More sinkholes, down on St. Louis again.
- 80.9 The road to left leads by devious turns to the mouth of Dogtown Hollow.

Mileage

- 81.1 Descend hill into upper part of Dogtown Hollow. We cross the Cap au Gres flexure in the next quarter mile, but unfortunately no outcrops are visible from the road. There is about 750 feet of structure here. At the mouth of Dogtown Hollow $1\frac{1}{2}$ miles west there is about 1100 feet of structural relief with 700 feet of strata exposed.
- 82.5 Nicholas school. Maquoketa slopes to right. This strongly dissected bench is largely on the Kimmswick limestone. It is bounded on the right (east) by the sharp rise to the escarpment of Silurian, Devonian, and Mississippian limestones and on the left (west) by a sharp drop through Ordovician formations to the Mississippi River bottomlands. This surface, called the Batchtown channel (Rubey, pp. 75, 117), is about $1\frac{1}{2}$ miles wide and extends 7 miles north from the Cap au Gres flexure (fig. 12). Much-weathered gravel deposits locally underlie the mantle of loess and are believed to have been deposited when the Kansan ice sheet, advancing from the west, crossed Mississippi Valley to the Cap au Gres bluffs and temporarily diverted the river onto the bench (Rubey, fig. 5, p. 79). The river is believed to have passed around the south end of the escarpment and into Illinois Valley, but its course is uncertain.
- 82.9 Kimmswick (Trenton-Viola) in creek bed in pasture to left.
- 83.5 Turn left (west) off Beechville-Batchtown road onto West Point ferry road. Good exposure of loess in road-cut on right just before turn.
- 83.6 Decorah formation on road on right. Intermittent outcrops of Decorah-Plattin in next half mile.
- 84.1 Bridge.
- 84.2 Path on right leads to suspension footbridge over West Point Creek and past red house to West Point quarry. This is the wet-season route.
- 84.3 Abandoned road to right is dry-season route to West Point quarry.
- 84.4 Buses park, turn around in yard to left, 0.1 mile from West Point ferry landing.

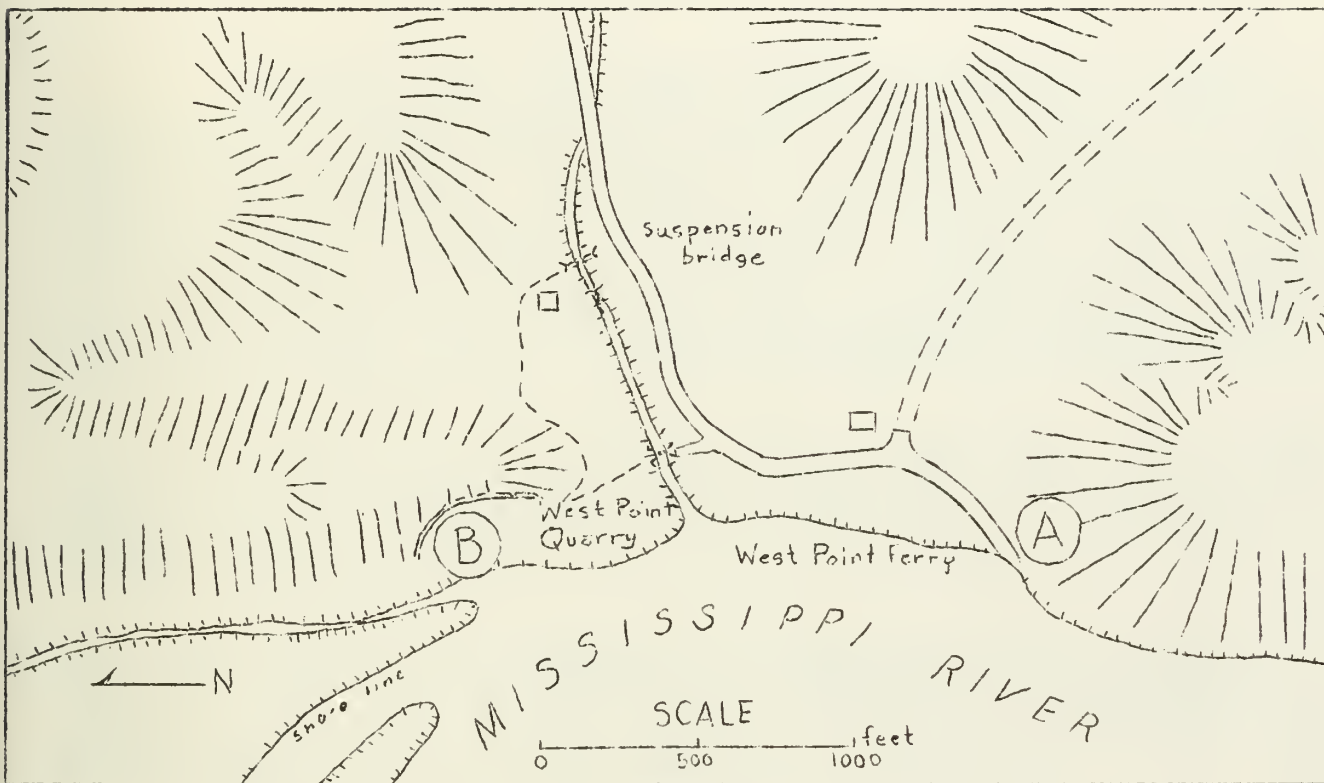


Fig. 16 - Stop 5. West Point Ferry Landing

STOP 5. - West Point Ferry. Middle Ordovician Formations.

SE $\frac{1}{4}$ Sec. 19, T. 12 S., R. 2 W., Hardin Quadrangle,
Calhoun County.

Walking distance - three-fourths mile.

Leaving time - 4:30 P.M.

See figure 16.

Two exposures will be examined at this stop. First, the exposure of St. Peter sandstone at the landing (substop 5A), and second, the exposure of Joachim and Platin strata in the quarry one-third mile north in Mississippi River bluff north of West Point Creek (substop 5B). If the bridge over West Point Creek, on the line between substops 5A and 5B, is not rebuilt by the time of our visit, it will be necessary to walk along the main road 100 yards east, cross the creek on the swinging bridge and follow the trail shown in figure 16.

SUBSTOP 5A - West Point Landing. St. Peter Sandstone,
Joachim Dolomite

The St. Peter (see Rubey, 1952, pp. 14-16) is a well-sorted, well-rounded, fine-grained quartz sandstone with very uniform texture and remarkably low content of silt, clay, mica, heavy minerals, and feldspar. It is white where fresh but in most outcrops it is weathered yellow, brown, or locally red. It has no calcareous beds or cement. It is generally incoherent where fresh, but it case-hardens on exposure because of secondary quartz enlargement of the sand grains. The sandstone is generally massive with faint thin bedding, and it has minor development of cross-bedding in some beds, which usually are not over 1 to 2 feet thick.

The St. Peter is about 150 feet thick here. The entire thickness is exposed in the bluffs between this locality, where the upper 75 feet is exposed, and a small exposure of the underlying limestone which is visible only at low-water stages about three-fourths of a mile south,

Subsurface tracing by the Missouri Geological Survey has shown that the St. Peter sandstone is underlain by the Everton limestone in the area of the Lincoln fold, and the outcrop here beneath the St. Peter, for many years correlated with the much older Cotter limestone, is now correlated with the Everton.

The St. Peter is overlain by the Joachim dolomite, the lower 50 feet of which is well exposed at the top of the bluffs above the ferry landing. The exposure is not accessible for study by a large group, but blocks may be seen at the foot of the bluff. Similar rock types will be seen in the upper 35 feet of the formation, which is more accessible in the quarry to the north (substop 5B).

At this locality we are approximately three-fourths of a mile north of the axis of the Lincoln fold and one and one-fourth miles north of the Cap au Gres faulted flexure (see Rubey, fig. 14, plates 20, 21). The flexure is named for the bluff, Cap au Gres (cape of sandstone), which extends from this point southward to the mouth of Dogtown Hollow. The steeply dipping beds of the flexure are exposed on the south side of Dogtown Hollow, which is not accessible by bus and the best exposures may be under water at this time of year. Only the Mississippian part of the sequence is well exposed, and it is complicated by several strike faults.

In the Cap au Gres bluff the St. Peter sandstone is flat-lying except for several small, gentle rolls which can be seen when crossing the river on the ferry. Here at the ferry landing the north dip increases sharply to about 5 degrees, and the Joachim limestone declines from the top to the base of the bluffs in the distance across West Point valley.

North of West Point Ferry a northward dip of 75 to 100 feet per mile brings the Joachim, Plattin, Decorah, and Kinmswick formations successively to the floodplain level in about 5 miles, but farther north the dip is much more gentle, with minor reversals, and the top of the Silurian reaches the flood plain near Rockport, about 35 miles northwest.

SUBSTOP 5B (fig. 17). - West Point Quarry. Joachim and Plattin Formations.

The quarry face is accessible nearly up to the prominent white bed (member H) by ascending ledges reached from the talus slope on the left (north). Because the ledges are too small to accommodate the entire party, and are dangerous to climb if they are wet, blocks have been assembled and identified on the quarry floor. Samples may be chipped from these blocks if desired.

Many lithologic units of the Middle Ordovician strata have been traced recently in outcrops and subsurface throughout Illinois and adjacent states, and in much less detail to more distant areas. Names of the new units have not been published, and for convenience here the units are given letters as shown in figure 17.

These regional studies have shown that within the thick carbonate formations many distinctive units, differentiated primarily on the basis of relative argillaceousness, have a great continuity. Although there is frequent repetition of units of similar gross lithology, units are recognized by key beds, by matching sequences, and by minor variations in lithology. Many characteristics have been used in identifying the units, such as the presence of bentonites, colites, calcarenites, massive and thin-bedded zones, distinctive colors on fresh or weathered faces, red or green shale zones, chert zones, scour and corrosion surfaces, and distinctive types of bedding surfaces. Although the identifications are based largely on lithology, the top or bottom range of a few fossils and zones with an abundance of a particular fossil have been useful. Most of the units can be identified in well samples, and in some localities the long sequences of the wells make identification of units easier than in outcrops. Very fresh quarry faces and deeply weathered outcrops are the most difficult to work. Moderately weathered road cuts and old quarry faces, such as this, give about the maximum differentiation of the units. Slight differences in argillaceous content can be recognized by close examination of the insoluble residue on the weathered faces.

In this locality and along a belt extending northeastward from the Ozarks to the Chicago region, most of the units are greatly thinned and some are absent, including several lower Plattin

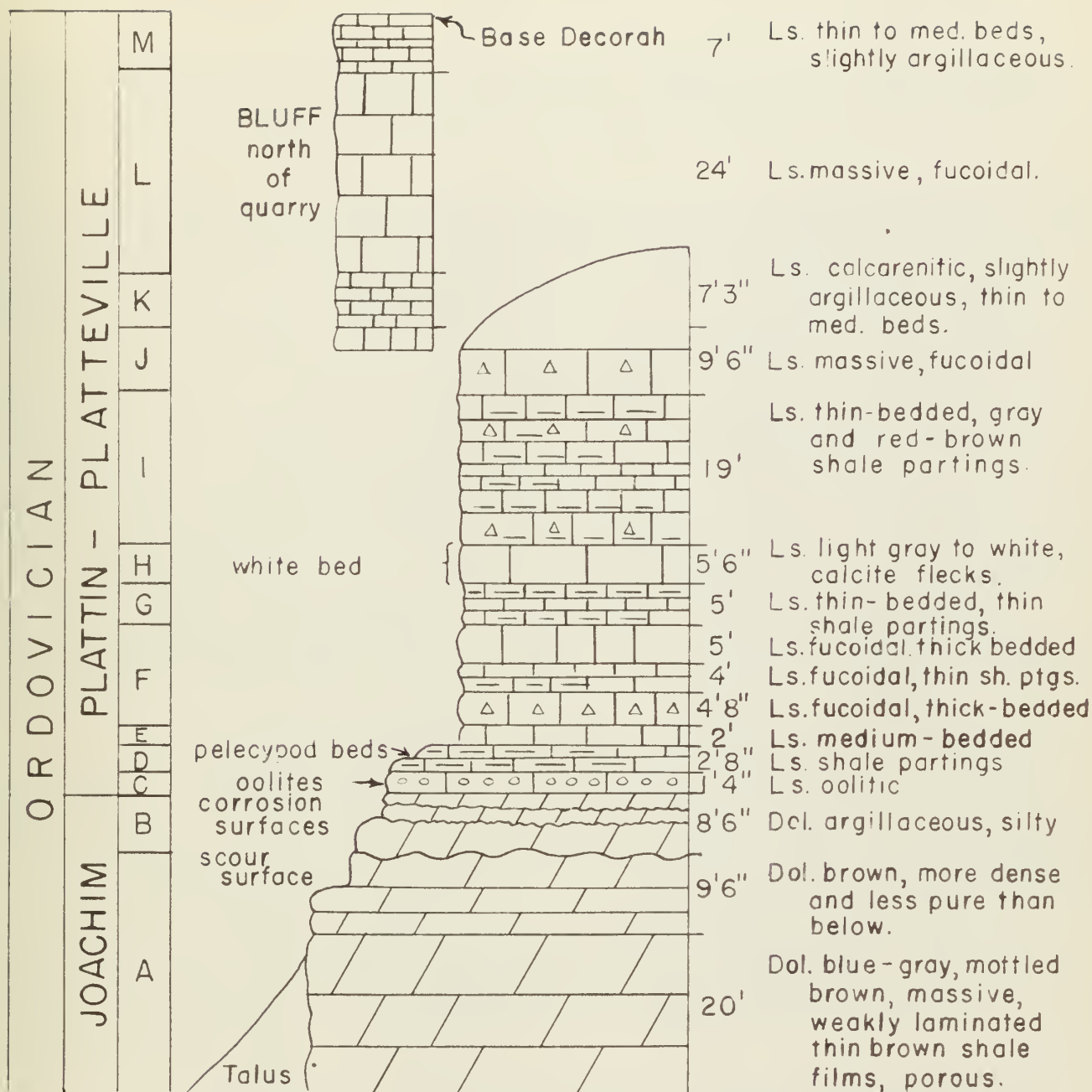


Figure 17 — Substop 5B - West Point Quarry
 N. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ Sec. 19, T. 12 S., R. 2 W. - Calhoun County, Illinois

Vertical scale: 1" = 20'

units. The entire Peconica formation, which is the basal Plattin (Platteville) in both northern and southern Illinois, is absent here.

The uniformity of sedimentation in the middle part of the continent during the Middle Ordovician is shown by the identification of many of the units of the sequence in exposures from New York to Colorado and from Manitoba to Tennessee. For example, the prominent white bed (unit M) in the upper part of the face, for which this is the type section, has been traced in numerous exposures throughout the outcrop belt of northern Illinois, Iowa, Minnesota, Wisconsin, and Ontario to the type New York Black River sequence. Southward from here it is a prominent member of the sequence through Missouri, Kentucky, and Tennessee and into the greatly thickened sequence in the margin of the folded Appalachians of western Virginia, where it occurs in the Moccasin formation. It is generally a foot or less thick in the upper Mississippi Valley region, about 2 feet thick in Ontario and New York, 5 to 7 feet thick from here to central Tennessee, and it thickens to 16 feet in western Virginia. The prominent red shales and argillaceous limestones of the Moccasin formation are represented in this region by thin red shale partings which occur in the thin-bedded unit above the white bed. These partings are relatively weak here but are strong in northern Illinois.

The Joachim formation is distinguished by its silty, argillaceous character, but 8 to 10 feet below the top it contains a massive, relatively pure, strongly laminated bed, 20 to 30 feet thick (unit A). Above it the thick-bedded very light gray (nearly white) silty dolomite with gray or red mottling, called "cotton rock" in some reports, is more typical of the major part of the formation. The Joachim formation is about 80 feet thick in this locality, but it thins out a short distance north and it thickens southward to about 300 feet in southern Illinois. In this region the Joachim is differentiated from the overlying Plattin limestone by its dolomitic character, but in some areas the basal Plattin beds are strongly mottled with dolomite.

The overlying Plattin limestone is characteristically a lithographic to fine-grained limestone with much vertical variation in argillaceousness, shaliness, bedding, and texture. The vertical character changes for the most part are sharp, so that the sequence consists of well defined units of fairly uniform character. The differences between the units are not great compositionally but they are important stratigraphically because of their lateral persistence, as previously noted.

The basal unit of the Plattin in this locality is an oolite, which is a distinctive marker bed along the east side of the Ozarks (Grohskopf, 1948, p. 357). This oolite and the thin-

bedded shaly limestone above it (unit D), which contains an abundance of small pelecypods and ostracodes, are all that here represent the widespread shaly Mifflin limestone of northern Illinois and Wisconsin.

The limestone above the Mifflin is differentiated into three major units: (1) a basal medium-bedded zone (units E-I), less shaly than the Mifflin below but more impure than the unit above, (2) a massive pure fucoidal limestone (units J-L), only the basal part of which, weathered and somewhat thin-bedded, is present at the top of the quarry, and (3) a thin-bedded argillaceous limestone (unit M) exposed in the bluffs north of the quarry.

The overlying Decorah and Kimmswick formations are present in the upper part of the bluffs about one-fourth mile north of the quarry, but there will not be enough time to visit them.

Mileage

- 84.4 Leaving Stop 5 retrace route to Beechville-Batchtown road.
- 85.3 Road junction. Turn left (north) toward Batchtown.
- 85.6 Loess on right.
- 86.3 Crossroad, continue ahead. Kimmswick in stream bed on left.
- 86.4 Loess bank on left.
- 86.7 Kimmswick in stream on left just before bridge.
- 87.5 Turn right (east) into Batchtown.
- 87.7 Batchtown business district.
- 88.0 Maquoketa in stream cuts on right (south).
- 88.3 Maquoketa-Silurian contact exposed 1/8 mile up creek to right.
- 88.7 Loess cut on right. Crest of "Dividing Ridge." The Calhoun peneplain.
- 89.0 Loess cut on left as we start down Illinois River side of Dividing Ridge.
- 89.1 Poor outcrop of Burlington on left.
- 89.2 Chouteau limestone with dark gray chert bands.

Mileage

- 90.1 Maucketa in gully to right as we turn left.
- 90.6 Monterey school, our Stop 3, on left.
- 90.7 Turn left (north) on main Hardin-Brussels road and return to Hardin.
- 100.2 Junction with Illinois 100. Turn right (east) on route 100 and cross bridge over Illinois River.
- 106.3 Turn left (east) on Highway 16, leaving Highway 100. It is 56 miles to downtown St. Louis, via Jerseyville and Alton.
- 162.3 Jefferson Hotel, St. Louis.

