ROCKS ASSOCIATED WITH THE MISSISSIPPIAN-PENNSYLVANIAN UNCONFORMITY IN SOUTHWESTERN INDIANA

Indiana Department of Conservation

GEOLOGICAL SURVEY

Field Conference Guidebook No. 9

1957

STATE OF INDIANA
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GEOLOGICAL SURVEY
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Bloomington

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CONFERENCE SPONSORED BY

Geological Survey, Indiana Department of Conservation,
and
Department of Geology, Indiana University,

October 4, 5, and 6, 1957

CONFERENCE COMMITTEE

Henry H. Gray, Chairman; T. A. Dawson;
Duncan J. McGregor; T. G. Perry; and William J. Wayne

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CONTENTS

ILLUSTRATIONS

ROCKS ASSOCIATED WITH THE MISSISSIPPIAN-PENNSYLVANIAN UNCONFORMITY IN SOUTHWESTERN INDIANA

INTRODUCTION

By Duncan J. McGregor, T. G. Perry, and William J. Wayne

The purpose of this field conference is to acquaint participants with strata that are associated with the Mississippian-Pennsylvanian unconformity in southwestern Indiana. Criteria which aid in distinguishing between Mansfield strata of Pottsville (early Pennsylvanian) age and clastic formations of Chester (late Mississippian) age will receive considerable attention in discussions at evening meetings and on the outcrop. Inspection of limestone and sandstone quarries will afford an insight into the economic products of Chester and Mansfield rocks. Participants may collect fossils at many of the stops.

PHYSIOGRAPHY

The area that will be traversed during this field conference lies outside the glaciated part of Indiana, within the physiographic province called the Interior Low Plateau by Fenneman (1938, p. 411-448).

The eastern part of the conference area belongs to the Highland Rim section of the Interior Low Plateau (Fenneman, 1938, p. 425-427). The western part of the Highland Rim section in Indiana is underlain by limestones of middle Mississippian age and is characterized by a topography of sinkholes and relatively low relief. This subdivision was named the Mitchell plain by Beede (1911, p. 95) and later defined more completely by Malott (1922, p. 94-98). Underground drainage is one of the typifying features of the Mitchell plain, and few streams that rise on or east of it cross it without disappearing into cavernous routes. Only deeply entrenched water courses, such as the East Fork of White River, cross the sinkhole plain as surface streams.

The ragged, dissected Chester escarpment (pl. 1), upheld by sandstones and shales of the Chester series, forms the eastern boundary of the Shawnee section of the Interior Low Plateau (Fenneman, 1938, p. 434-440). The eastern part of the Shawnee section in Indiana is called the Crawford upland (Malott, 1922, p. 98-102). The Crawford upland is a high-land area that has been maturely dissected so that local relief is fairly great. Steep bluffs and local structural plains result from erosion of an alternating series of massive sandstones, shales, and limestones. Karst valleys are common along the east edge of the upland, where tributary creeks disappear into swallow holes in inliers of Ste. Genevieve limestone. Most of the spectacular caverns of Indiana and Kentucky are found along the east edge of this physiographic unit.

PALEOZOIC STRATIGRAPHY

Chester rocks in Indiana crop out in a northwestward-trending belt that extends from the Ohio River to the vicinity of Greencastle in central Putnam County, a distance of approximately 125 miles. The width of the Chester outcrop belt in southern Indiana approximates 40 miles, extending from west-central Harrison County to just east of Cannelton in Perry County. The Chester outcrop area narrows gradually northward and is less than 10 miles wide near its northern extremity in south-central Putnam County. Perry and Smith (in press) have delineated the areal distribution of lower, middle, and upper Chester rocks in Indiana. As Chester rocks have a low regional westerly and southwesterly dip of approximately 25 to 30 feet per mile and underlie the highly dissected topography of the Crawford upland, outcrop patterns of rocks of Chester age are sinuous and are controlled by the topography of their outcrop area.

Chester rocks have a unique location in the stratigraphic column because of their position between dominantly calcareous strata of Meramec (middle Mississippian) age and rocks of the Pennsylvanian system which consist largely of clastic materials (pl. 2). In contrast with the underlying limestones of Meramec age and the overlying dominantly clastic rocks of Pennsylvanian age, the most striking feature of the Chester series is the repeated alternation of fossiliferous marine limestones and generally unfossiliferous clastic formations. Chester limestones characteristically maintain their lithologic individuality throughout their outcrop area; Chester clastic formations, which include shale, siltstone, and fine-grained sandstone, commonly display abrupt lateral and vertical var-

iations in lithology. Because of lithologic variability of Chester clastic rocks, they are identified in the field mainly by their stratigraphic position with respect to Chester limestones.

Stratigraphic names in the Chester series used in this guidebook (pl. 3) are essentially those evolved through the work of Malott (1919, 1925, 1952, and Esarey, Malott, and Bieberman, 1948). Specific lithologic terms have been dropped from some names and replaced with the term formation, in line with a suggestion by Gray and Perry (1956), because many of these formations are heterogeneous and the single term sandstone is not descriptive of, for example, the Sample formation.

The name Bethel formation is here used in place of Mooretown sandstone (pl. 3). Correlation of the Mooretown with the Bethel has been generally accepted for some time, and Bethel has the advantage of priority and wider usage. Furthermore, the name Mooretown is incorrectly spelled and refers to a village that no longer exists, and the formation is not dominantly sandstone and is not completely exposed at the type section designated by Malott (1952, p. 101).

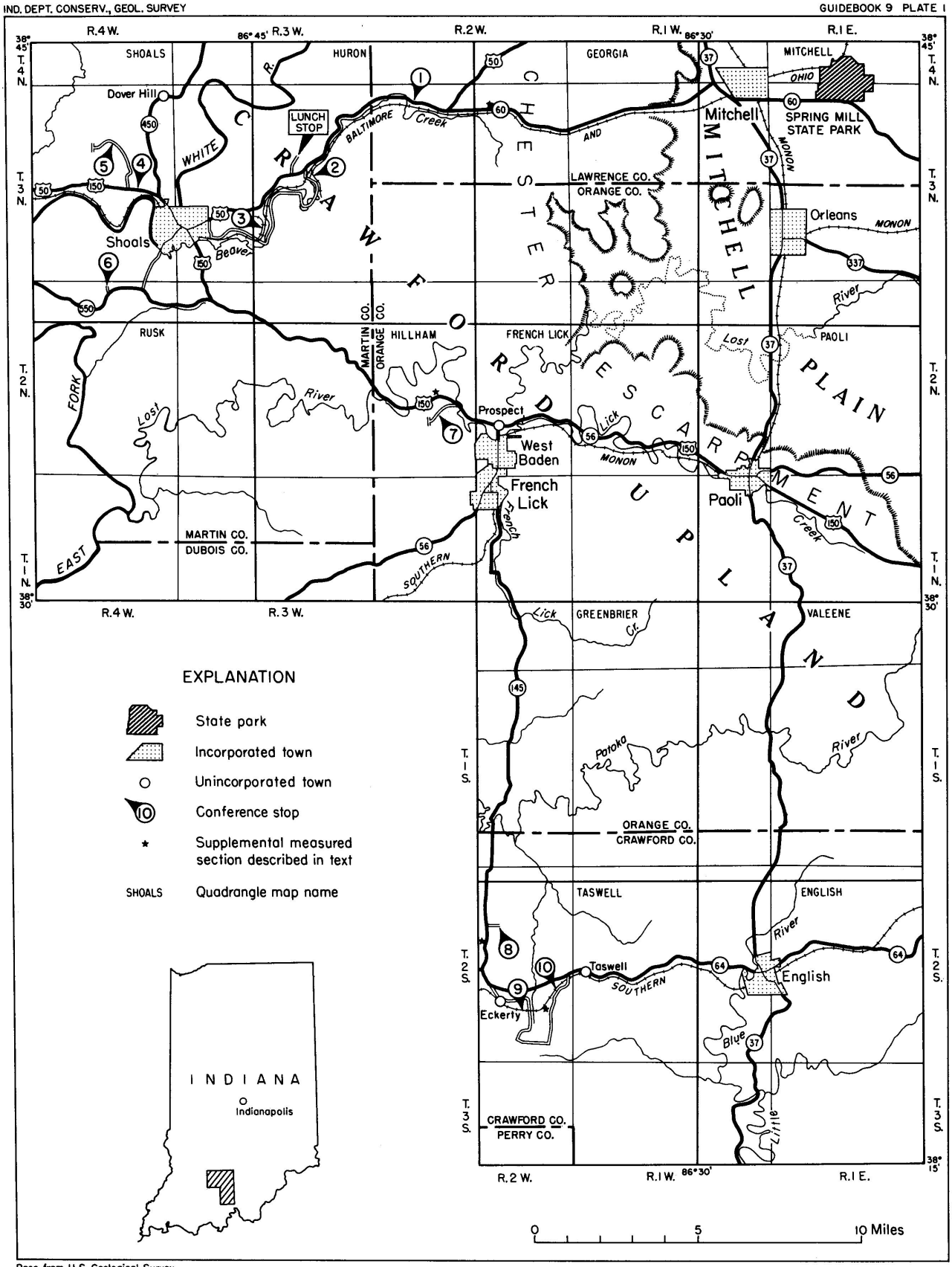
The name Big Clifty formation is here used in place of Cypress sandstone. It now appears practically certain that the name Cypress has been incorrectly used in Indiana and that the Kentucky name Big Clifty would be preferable. (See Swann and Atherton, 1948, fig. 1.) The true correlative of the Cypress sandstone of southern Illinois is the Elwren formation; the name Elwren is here retained because only confusion would result from adoption of the term Cypress in this sense.

The outcrop belt of the Mansfield formation extends in a northwesterly direction from the Ohio River to northern Warren County, a distance of approximately 185 miles. Chester and Mansfield strata have a regional westerly and southwesterly dip of approximately 25 to 30 feet per mile, and the main part of the Mansfield outcrop area lies immediately west of the Chester outcrop belt. Because of the rugged topography of the Crawford upland, however, outliers of Mansfield rocks are encountered commonly in the higher areas of the Chester terrane, particularly in its western part. As a result of stream erosion, numerous inliers of Chester rocks are found within the Mansfield outcrop belt.

The Mansfield formation, which ranges from 250 to 300 feet in thickness in the conference area, includes many rock types. Crossbedded fine-grained light yellow-brown sandstones, wavy-bedded very fine-grained gray sandstones thinly interbedded with gray shales, and gray shales that locally are slightly carbonaceous and micaceous are the dominant rock types. In addition, the Mansfield contains thin local coal beds, thin discontinuous clay beds, and local deposits of pebble conglomerate and conglomeratic sandstone. Various types of ironstone occur in many places throughout the formation, and near the top some thin limestone beds are encountered. Mansfield rocks show striking lateral and vertical lithologic variations of both regional and local nature.

The most conspicuous regional unconformity in the bedrock of Indiana separates the Mississippian system from the Pennsylvanian. Malott (1951, p. 239-246) has discussed the regional aspects of this unconformity. Pre-Pennsylvanian erosion has removed progressively older Chester formations at increasing distances north of the Ohio River. For this reason, upper Chester strata are absent north of the town of Shoals in Martin County, and rocks of middle Chester age are not found north of the town of Spencer in Owen County. North of central Putnam County pre-Mansfield erosion removed all strata of early Chester age. As the Mansfield directly overlies rocks of late Chester age near the Ohio River in southern Perry County and rests directly on Ste. Genevieve limestone of late Meramec age in central Putnam County, the base of the Mansfield has descended through a stratigraphic interval of approximately 600 feet in a distance of 125 miles.

In the southern part of the field conference area, the Mansfield formation generally rests on the Tar Springs formation; in the northern part of the area, in western Lawrence County and eastern Martin County, the base of the Mansfield typically is on the Golconda formation. Because of the undulatory nature of the pre-Pennsylvanian erosional surface and its entrenched stream channels, the pre-Pennsylvanian unconformity may locally be above or below its expectable stratigraphic position. Where the stratigraphic position of the pre-Pennsylvanian unconformity is such that the Mansfield rests on a clastic formation in the Chester series, it is difficult to distinguish between rocks of early Pennsylvanian and Chester age.



Base from U.S. Geological Survey topographic quadrangle maps.

MAP OF FIELD CONFERENCE AREA SHOWING PHYSIOGRAPHIC UNITS

GEOMORPHIC HISTORY

A good record of the erosion cycle that preceded the present one can be found in southern Indiana, but little evidence of earlier cycles can be found. The former surface produced by this cycle of erosion, which has been correlated with the Lexington and Highland Rim peneplains (Malott, 1922, p. 130), probably was characterized by gentle slopes and moderate relief. Many hilltops in the driftless part of the State have a mantle of weathered quartzose gravel, generally referred to as Lafayette? gravel. This weathered gravel is thought to represent scattered deposits of streams that flowed over the surface just before the last major uplift took place. The age of these gravels is generally stated as Pliocene? .

During late Tertiary or early Pleistocene time the streams were rejuvenated and began a period of down-cutting, during which valleys were entrenched about 300 feet below the former erosion surface. This cycle of erosion continues in regions that were not directly affected by glaciation, but in Indiana the advent of early Pleistocene glaciers brought about cessation of entrenchment.

The glacial boundary lies nearly parallel to and about 1 mile west of the west edge of the map shown on plate 1. Till is not present in the area of the field conference. Pleistocene sediments include outwash, lacustrine silts and clays, loess, alluvium, and colluvial or solifluction debris.

During the Illinoian glacial age and probably during the earlier Kansan age as well, the ice margin was only a few miles west of the area in which this field conference is being held. Glacial ice blocked all westward-flowing streams, and fine-grained sediments filled the lakes that were formed by the ice dam. As much as 60 feet of sandy, clayey silt has been recorded in some of the valleys that were dammed.

Wisconsin glaciers did not come as far south as had the Illinoian and Kansan, but White River Valley, which served as a sluiceway during both earlier glaciations, again was filled with outwash gravel and sand. Large and frequent fluctuations in the amount of melt water in the valley permitted the wind to pick up silt and clay from the valley-train outwash and carry it to be deposited as a loess mantle over the adjacent upland.

Terracelike masses of colluvium and alluvium occur on the lower parts of most slopes in the area of the conference. Some of these deposits probably represent material moved by solifluction during times of more severe climate, when either the Wisconsin or the earlier glaciers lay only a few miles away. Higher-level alluvium deposited on Wisconsin or pre-Wisconsin flood plains is present on a few of these benches.

Deposits in the area during the Recent stage are almost entirely confined to the flood-plain sediments along the rivers and creeks.

ECONOMIC GEOLOGY

Industrial minerals in the area covered by this field conference include crushed stone, dimension sandstone, whetstone, quartz pebble, and gypsum.

The Mulzer Brothers quarry near Eckerty, Crawford County, produces from the Glen Dean limestone of late Mississippian age. Products include crushed stone for general purposes, agricultural limestone, and riprap. This quarry operation employs 18 persons and has a rated daily capacity of 2,000 tons. Quarryable rock is 23.5 feet thick; extracting the rock requires the removal of 27 feet of overburden.

Several other limestone quarries in the field conference area produce crushed stone and agricultural stone from the Paoli and Ste. Genevieve limestones. These include the Calcar Quarries at Paoli, the Cave Stone Co. of French Lick, the Mitchell Crushed Stone Co., Inc. of Mitchell, and two quarries operated by Radcliff and Berry of Orleans. The total capacity of these 5 quarries is 3,400 tons per day (McGregor, 1956).

Dimension sandstone is produced by the Indiana Sandstone Co. and the Leonard Sandstone Co. near Huron, Lawrence County, and the French Lick Sandstone Co. at French Lick, Orange County (McGregor, Patton, and Smith, 1956). The quarries are in rocks of late Mississippian and early Pennsylvanian age. Sandstone used for dimension stone generally consists of quartz grains which are bound together by iron oxides, clay, calcite, and quartz. Color is one of the primary prerequisites for a building sandstone.

Whetstones are produced by the Indiana Sandstone Co. about 6 miles west of Orleans, Orange County. The whetstones are very fine-grained sandstones of early Pennsylvanian age. Most of the whetstone now quarried is used as flagstone.

Gypsum is mined by the National Gypsum Co., 2 miles east of Shoals, Martin County, and U. S. Gypsum Co., 5 miles east of Shoals. The gypsum is found in the lower part of the St. Louis limestone of middle Mississippian age (McGregor, 1954; Bundy, 1956b). It is encountered approximately 500 feet beneath the surface and ranges from 14 to 17 feet in thickness. Exploration for gypsum began in 1951 and the 2 plants began production late in 1955. The gypsum is used principally in manufacturing wallboard and as an additive in manufacturing portland cement.

The General Refractories Co. quarries quartz pebbles from the lower part of the Mansfield formation of early Pennsylvanian age. The quarry is about 3 miles southwest of Shoals. Raw material is trucked to the washing plant about 1 mile south of Shoals, and washed quartz pebbles are shipped to Joliet, Ill., to be used in manufacturing refractory bricks.

Formerly important economic mineral deposits of this area include a clay composed of varying quantities of hydrated halloysite (endellite), allophane, and iron oxides, which was taken from many surface pits and small drift mines near Huron and shipped in moderate quantities to ceramic plants as far away as Philadelphia, and sandy iron ores, which were once widely quarried on a small scale and shipped to a furnace near Shoals for refining. A ferruginous clayey sandstone of early Pennsylvanian age near Huron, Lawrence County, is being investigated as a possible source of raw material for cement manufacture (Bundy, 1956a).

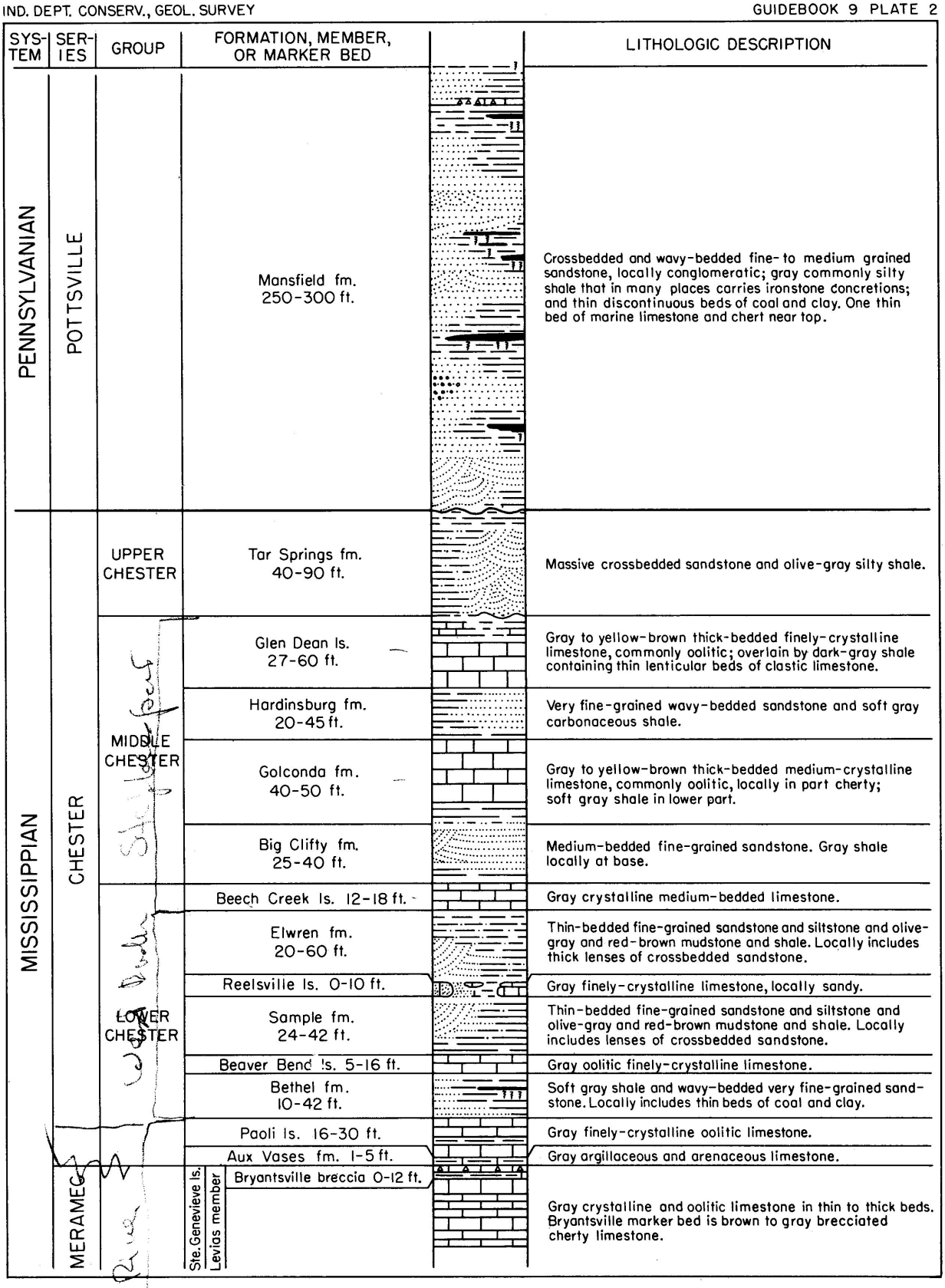
Coal has been mined on a small scale at many places in this region, but it has never been economically important and has been used only locally. A few small mines remain in operation; the entire production from most of them is consumed by the owner-operator.

ITINERARY

By Henry H. Gray, T. G. Perry, and William J. Wayne

SATURDAY, OCTOBER 5, 1957; STOPS 1-7

Mileage between stops	
0.0	Load cars in parking lot in front of Inn, 8 a. m. Proceed up hill, bearing right to gatehouse. Mitchell quadrangle.
1.0	Stop. Park entrance. TURN RIGHT (west) on State Route 60. Route traverses the sinkhole-pitted surface of the Mitchell plain, here developed on St. Louis limestone, at an altitude of 650 to 700 feet. Cherty limestone exposed in road cuts is St. Louis. Red clay with chert fragments is a residue characteristic of the St. Louis.
3.7	Cross Monon Railroad.
4.3	Stop. Junction with State Route 37. TURN RIGHT (north) and follow State Route 60. Smooth western part of Mitchell plain here is underlain by silty dolomites of upper St. Louis limestone.
5.1	TURN LEFT (west) and follow State Route 60. Cuts along State Route 37 ahead (north) are in Levias member of Ste. Genevieve limestone.
5.8	Enter Georgia quadrangle. Low escarpment ahead and to the right (north) marks edge of Crawford upland.
6.5	Road cut exposes Paoli limestone and overlying Bethel formation. A measured section here (SE1/4NW1/4SW1/4 sec. 3, T. 4 N., R. 1 W.) shows:



GENERALIZED COLUMNAR SECTION OF UPPER MISSISSIPPIAN AND LOWER PENNSYLVANIAN ROCKS EXPOSED IN FIELD CONFERENCE AREA

Mississippian system: *Feet*

Bethel formation: 13 feet exposed

6. Sandstone (orthoquartzite), yellow-brown, fine-grained; contains *Stigmaria* ---------- 13.0

(Altitude 760 feet)

Paoli limestone: 15.5 feet exposed

5. Limestone, gray, medium-bedded, fossiliferous; contains stylolite seams ---------- 3.8

4. Limestone, shaly, gray ---------- 0.2

3. Limestone, clastic, gray, fossiliferous ---------- 3.0

2. Shale and siltstone; gray, calcareous; contains a few poorly preserved fossils ---------- 3.5

1. Limestone, slightly brecciated at top, gray, finely crystalline ---------- 5.0

Base of exposures in ditch along road.

Refer to the Glossary, p. 32, for definitions of rock-type terms.

7.0 Road cut exposes Paoli limestone.

7.1 Route enters headwaters area of large karst valley of Beaver Creek. For approximately 7 miles valley floor is underlain by cavernous upper Ste. Genevieve and Paoli limestones. Tributary streams disappear into swallow holes in valley floor.

9.8 Abandoned village of Georgia. Large quarries to left (south) are in Paoli and Ste. Genevieve limestones. Road cuts on right (north) expose yellow-brown sandstone and gray shale of the Bethel formation.

12.4 Abandoned village of Moorestown. Type locality of Malott's Mooretown (sic) sandstone. A measured section here (SE1/4NW1/4SE1/4 sec. 3, T. 3 N., R. 2 W.), modified slightly from Malott (1952, p. 101), shows:

Mississippian system: *Feet*

Bethel formation: 22 feet exposed

9. Sandstone, yellow-brown, hard, platy ---------- 0.5

8. Shale, gray ---------- 8.0

7. Sandstone, shaly, yellow-brown ---------- 3.0

6. Shale, black, carbonaceous, hard ---------- 0.2

5. Coal, firm ---------- 0.1

Mississippian system--Continued *Feet*

Bethel formation--Continued

4. Clay, black, soft ---------- 0.2

3. Sandstone, soft; bedding absent; *Stigmaria* at top ------ 3.0

2. Shale, gray, sandy at top ---------- 7.0

(Altitude 600 feet)

Paoli limestone: 2 feet exposed

1. Limestone, white, finely granular ---------- 2.0

Base of exposures in ditch on north side of road.

The top of the Bethel is not exposed at this place, but Malott considered it to be present here in essentially its full thickness.

12.9 Enter Huron quadrangle.

13.8 Stop. Junction with U. S. 50. End of State Route 60. BEAR LEFT (west) on U. S. 50. Mansfield formation caps hills to right (north).

14.3 On left (south), mill of Leonard Sandstone Co. Tributary valley from right is karsted, and trunk drainage is subterranean for approximately 2 miles.

14.7 STOP 1. HURON CUT. Park and walk through woods at left (south) to cut on Baltimore and Ohio Railroad. Descend carefully to bottom of cut and KEEP TRACK CLEAR. FORTY-FIVE MINUTES are allowed for this stop.

Malott (1919) named the Beaver Bend limestone for this locality. A section measured at this place (NE1/4SW1/4 sec. 5, T. 3 N., R. 2 W.), in part after Malott (1952, p. 103), shows:

Mississippian system: *Feet*

Big Clifty formation: 10 feet exposed

23. Sandstone (orthoquartzite), yellow-brown, very fine-grained ---------- 6.0

22. Covered; probably sandstone similar to above (Malott, 1952, p. 103) ---------- 4.0

(Altitude 670 feet)

Beech Creek limestone: 16.1 feet

21. Limestone, light-gray, very thick-bedded; contains large crinoid columnals ---------- 9.0

20. Limestone, medium-gray, thick-bedded, sparsely fossiliferous ---------- 5.5

Malott (1919)	Cumings (1922)	Malott (1925)	Malott (1952 and Esarey, Malott, and Bieberman, 1948)	This guidebook	Wabash Valley subsurface
NOT CONSIDERED		Negli Creek limestone	Kinkaid limestone	NOT CONSIDERED	Kinkaid limestone
	----?----	(Shale interval)			Degonia formation
	Buffalo Wallow formation	Mt. Pleasant sandstone	Degonia sandstone		
		(Shale interval)	Clore limestone		Clore limestone
		Bristow sandstone	Palestine sandstone		Palestine formation
		(Shale interval)	Menard limestone		
	Siberia limestone	Siberia limestone			Menard limestone
	Tar Springs (sandstone)	(Shale interval)			Waltersburg formation
		Wickcliff sandstone	Waltersburg sandstone		
		(Shale interval)	Vienna limestone		Vienna limestone
			Tar Springs sandstone	Tar Springs formation	Tar Springs formation
	Glen Dean (limestone)	Glen Dean limestone	Glen Dean limestone	Glen Dean limestone	Glen Dean limestone
	Hardinsburg (sandstone)	Hardinsburg sandstone	Hardinsburg sandstone	Hardinsburg formation	Hardinsburg formation
Golconda limestone and shale	Golconda (limestone)	NOT CONSIDERED	Golconda limestone	Golconda formation	Golconda limestone
	Indian Springs shale				Jackson formation
Cypress sandstone	Cypress (sandstone)		Cypress sandstone	Big Clifty formation	
Beech Creek limestone	Beech Creek limestone		Beech Creek limestone	Beech Creek limestone	Barlow lime
Elwren sandstone and shale	Elwren (sandstone)		Elwren sandstone	Elwren formation	Cypress formation
Reelsville limestone	Reelsville limestone		Reelsville limestone	Reelsville limestone	Paint Creek formation: Upper Paint Creek limestone
Brandy Run sandstone horizon	Sample sandstone		Sample sandstone	Sample formation	Paint Creek formation
Beaver Bend limestone	Beaver Bend limestone		Beaver Bend limestone	Beaver Bend limestone	Paint Creek formation: Lower Paint Creek limestone
Sample sandstone and its horizon	Mooretown (sandstone)		Mooretown sandstone	Bethel formation	Bethel formation
Mitchell limestone	Paoli limestone		Paoli limestone	Paoli limestone	Renault formation
	Ste. Genevieve limestone		Aux Vases sandstone	Aux Vases formation	
			Ste. Genevieve limestone	Ste. Genevieve limestone	Ste. Genevieve limestone

EVOLUTION OF STRATIGRAPHIC NOMENCLATURE IN THE CHESTER SERIES IN INDIANA

Rock names in parentheses under Cumings (1922) were implied but not specifically stated. Names in parentheses under Malott (1925) were stated but were considered informal. Wabash Valley subsurface in part after Swann and Atherton (1948).

Mississippian system--Continued	*Feet*
Beech Creek limestone--Continued	
19. Clay, dark-brown; probably weathered residuum of limestone similar to unit above (See Malott, 1952, p. 103.)	1.6
Elwren formation: 43.2 feet	
18. Mudstone, medium green-gray, light gray at top	4.3
17. Siltstone, olive-gray; in one bed	1.0
16. Mudstone, medium green-gray and red-brown; abundant limy nodules near top	6.3
15. Covered; probably varicolored mudstone and shale similar to that of units above and below. Line of section crosses U. S. 50	6.3
14. Shale, medium green-gray and red-brown	11.0
13. Shale, light green-gray; contains a few thin silty layers; fresh rock has irregular fracture and resembles mudstone	14.3
Reelsville limestone: 7 feet	
12. Limestone, light-gray; in one bed; oolitic; contains abundant crinoid columnals; other fossil forms sparse; gives way laterally eastward to green-gray laminated shaly siltstone containing calcareous concretions	7.0
Sample formation: 22.1 feet	
11. Mudstone, medium green-gray, irregularly mottled with brown-red; shaly in upper 4 feet	8.9
10. Covered; probably shale similar to that of unit below (Malott, 1952, p. 104)	6.0
9. Shale, medium-gray, poorly exposed	4.0
8. Siltstone, medium green-gray; fucoids on bedding surfaces; contains minor interbedded gray-green shale	3.2
Beaver Bend limestone: 15.1 feet	
7. Limestone, light-gray; in one bed; composed largely of oolites and small fossil fragments	3.4
6. Limestone, light-gray, thick-bedded, very finely crystalline, locally abundantly fossiliferous	5.7

	Feet
Mississippian system--Continued	
Beaver Bend limestone--Continued	
5. Limestone, light-gray, thick-bedded; lower 2.5 feet oolitic; remainder is finely crystalline and contains abundant crinoid columnals	6.0
Bethel formation: 2.9 feet exposed	
4. Shale, medium-gray, carbonaceous	1.9
3. Coal, shaly, black; clay parting near middle	0.1
2. Clay, light-gray, plastic; contains abundant carbonized root impressions	0.9
1. Siltstone, yellow-brown; top only seen	---
Base of exposures in ditch along track.	

The abrupt termination of the Reelsville limestone in the east end of the cut may be the result of unconformity, but a sharp facies gradient is here considered a more likely explanation because (1) the green-gray shaly siltstone that is laterally equivalent to the limestone is similar to shales above and below the limestone, (2) there is no evidence of a significant break in deposition within the clastic rocks, and (3) the siltstone equivalent to the limestone contains calcareous, sparsely fossiliferous concretions that indicate a close relationship to the limestone (Gray and Perry, 1956).

The sandstone at the top of this section is identified with the Big Clifty formation on the basis of its continuity with similar rocks to the north which are overlain by limestone of the Golconda formation. The Mansfield formation is not exposed in the hill north of the highway. On the hill about half a mile southeast of this cut the Mansfield rests on the Elwren formation at an altitude of approximately 650 feet.

Mileage between stops	
0.0	Return to cars and continue westward on U. S. 50.
0.7	Village of Huron to left (south) of highway.
1.2	Indiana Sandstone Co. mill to right (north) of road. Sandstone comes from quarries in the Big Clifty formation, approximately 4 miles north of here.
1.4	Enter Martin County. Road cut on left (south) exposes sandy, clayey silt of late Pleistocene? age beneath old flood plain of Beaver Creek. Patches of similar material are locally present along most of the major streams in this area. The upper surface of the alluvium once stood 30 to 40 feet above the present valley floors, but only small areas remain and most of these are reduced and intricately dissected by gullies.
1.7	Reelsville limestone in cut on right (north) side of highway.
2.4	Mansfield formation caps hills to right (north). Basal Mansfield here consists partly of heavily iron-impregnated sandstone. Many years ago iron ore was shipped from open pits on these hills to a furnace at Shoals, approximately 8 miles southwest along the

Baltimore and Ohio Railroad.

3.9 Cuts on both sides of highway expose sandstone of the Elwren formation.

4.5 BEAR LEFT ON COUNTY ROAD into settlement of Willow Valley. Continue on across railroad and bridge over Beaver Creek.

4.9 STOP 2. Park and walk into cut on spur of Baltimore and Ohio Railroad just left (east) of county road. KEEP TRACK CLEAR. HALF AN HOUR is allowed for this stop. This cut was made in 1955 to provide access to the new U. S. Gypsum Co. mine and plant half a mile southeast of this point.

A measured section here (SW 1/4 NW 1/4 SW 1/4 sec. 14, T. 3 N., R. 3 W.) shows:

Mississippian system:	*Feet*
Elwren formation: 42 feet exposed	
7. Mudstone, shaly, green-gray and red-brown, somewhat slumped	8.0
6. Sandstone (graywacke), yellow-brown, crossbedded, fine-grained; locally contains abundant clay chips; basal contact disconformable	31.5
5. Siltstone, shaly, olive-gray; thickness variable	2.5
(Altitude 500 feet)	
Reelsville limestone: 2.6 feet	
4. Clay, red-brown; apparently the residuum of gray clastic limestone that is locally present at this position where the overlying siltstone is 4 feet or more thick	0.5
3. Siltstone, olive-gray to red-brown, locally abundantly fossiliferous	2.1
Sample formation: 5.8 feet exposed	
2. Siltstone, olive-gray, thin-bedded, lenticular	1.8
1. Mudstone, silty, green-gray to red-brown; bottom not seen	4.0

Base of exposures in ditch along track.

This section was measured east of the track approximately 250 feet south of the bridge over Beaver Creek at the north end of the cut. Sections measured elsewhere show some differences both in thickness and lithology.

Weathered slabs of Beech Creek limestone may be seen at the very top of the exposure described. The limestone is seen in place higher on the hill, where the top of the limestone is at an altitude of 570 feet. Capping the hill is an 8-foot ledge of sandy ironstone that probably lies at or near the base of the Mansfield formation. The base of this ledge is at 605 feet altitude, and the Mansfield probably rests on the Big Clifty formation at this place.

The disconformity at the base of the prominent sandstone in the Elwren formation has no regional significance; it does not appear in other exposures of Elwren in this vicinity. Similar unconformities are common at the base of sandstones of this type in clastic formations of the Chester series in Indiana.

Mileage between stops

0.0 Return to cars and continue southward on county road.

0.2 Elwren, Reelsville, and Sample formations exposed in railroad cut to left (north).

0.6 Continue straight ahead. U. S. Gypsum Co. plant and mill on left (east). Gypsum is mined from lower part of St. Louis limestone. Head frame marks position of shaft. Side road to right (west) exposes Big Clifty formation, Beech Creek limestone, and Elwren formation.

1.0 Road here follows abandoned railroad grade. Deep cut at this point exposes 55 feet of even-bedded to crossbedded sandstone of Elwren formation.

1.1 Side road to left (east). Continue straight ahead.

2.6 Side road to right (north). Continue straight ahead. Large sandstone blocks along valley walls have tumbled or crept from ledges of Mansfield formation near top of hills.

4.1 Side road to left (east). BEAR RIGHT. Continue across Beaver Creek and railroad.

4.5 STOP 3. Park and walk northward up railroad spur, which was constructed in 1955 to serve the new National Gypsum Co. plant and mine on top of the hill to the northwest. KEEP TRACK CLEAR. ONE HOUR is allowed for this stop.

A profile of the west wall of this cut (W1/2NE1/4 sec. 28, T. 3 N., R. 3 W.) and a description of the rocks follow. Three sections were measured in this cut (pl. 4), as shown on the profile (fig. 1):

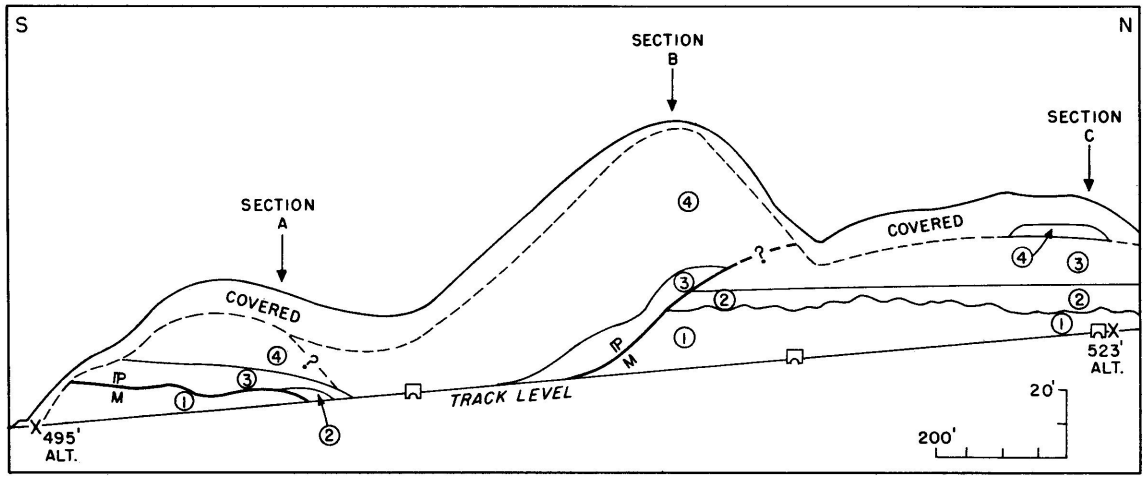


Figure 1.--Profile of west side of railroad cut at National Gypsum Co. plant near Shoals (Stop 3). Approximately to scale; vertical exaggeration 5 times.

RAILROAD CUT AT NATIONAL GYPSUM CO. PLANT NEAR SHOALS (STOP 3)

Section A: 400 feet from south end of cut

	Feet
Pennsylvanian system:	
Mansfield formation: 18 feet exposed	
4. Sandstone (graywacke), yellow-brown, interbedded with minor amounts of gray shale; fucoidal markings common	13.
3. Sandstone (graywacke), gray and yellow-brown, interbedded with approximately equal amounts of gray shale; fucoidal markings common	4.
2. Sandstone (graywacke), yellow-brown; indistinct and contorted bedding; base transitional into sandstone below but showing considerable relief; lenticular	1.
(Altitude 505 feet)	
Mississippian system:	
Big Clifty formation: 6 feet exposed	
1. Sandstone (orthoquartzite), yellow-brown, medium-bedded; in part crossbedded; base slightly below track level	6.

Section B: 1,000 feet from south end of cut (pl. 4)

	Feet
Pennsylvanian system:	
Mansfield formation: 49 feet exposed	
4. Sandstone (graywacke), yellow-brown; uneven medium bedding, locally contorted; in part crossbedded	42.
3. Ironstone, sandy, red-brown; indistinct bedding; lenticular	7.
(Altitude 535 feet)	
Mississippian system:	
Golconda formation: 3 feet	
2. Siltstone and mudstone, olive-gray; basal contact undulatory	3.
Big Clifty formation: 20 feet exposed	
1. Sandstone (orthoquartzite), yellow-brown, medium-bedded; in part crossbedded; upper 3 feet locally carbonate cemented, base slightly below track level	20.

Section C: 1,600 feet from south end of cut

	Feet
Mississippian system:	
Golconda formation: 24.6 feet exposed	
4. Limestone, clastic, yellow-brown; abundant fossils and fossil fragments	2.5
3. Shale and mudstone, olive-gray and red-brown in lower third, gray in upper two-thirds; fossils abundant near top	17.0
2. Siltstone and mudstone, olive-gray; yellow-brown marly zone at top; basal contact undulatory	5.1
(Altitude 530 feet)	
Big Clifty formation: 13 feet exposed	
1. Sandstone (orthoquartzite), yellow-brown, medium-bedded; in part crossbedded; upper 3 feet locally carbonate cemented; base 6 feet below track level	13.0

This cut exposes the cross section of a pre-Mansfield valley. Although in this area the Mansfield formation commonly rests on the Golconda, the pre-Mansfield valley bottom here cuts almost through the Big Clifty formation. This valley can be traced from a point approximately 3 miles northeast of Huron southwestward to Shoals, a distance of 12 miles. In some places, as here, deposits of sandy ironstone are associated with this valley; in others, as above Huron, clay deposits, formerly of some economic importance, are found where the valley bottom cuts just below the Beech Creek limestone.

Mileage between stops

0.0 Return to cars and continue westward along county road. Exposures for next 4 miles are of Mansfield formation.

0.1 Enter Shoals quadrangle.

1.7 Ironton. Site of old Shoals furnace. TURN RIGHT (north). Terrace here is probably underlain by late Pleistocene? alluvium and may represent a pre-Wisconsin alluvial flat or a lake terrace of Wisconsin age formed when valley-train deposits along the East Fork of White River dammed local tributaries.

2.2 Stop. Junction with U. S. 50. TURN RIGHT (east) on U. S. 50.

3.6 On right (south) is mine and mill of National Gypsum Co.; the mine produces from lower part of St. Louis limestone.

3.8 Reenter Huron quadrangle.

4.0 On right (east) side of highway, sandstone of Mansfield formation overlies sandstone of Big Clifty formation, which in turn overlies Beech Creek limestone. The base of the

Mansfield is at an altitude of approximately 540 feet; the top of the Beech Creek lies at 505 feet.

4.7 In road cut on left (west) of highway, basal Mansfield rests unconformably on upper part of Elwren formation at an altitude of 515 feet. Less than a quarter of a mile farther west Mansfield rests on Big Clifty formation and full thickness of Beech Creek limestone is shown.

4.9 Sandstones of Mansfield formation show in road cuts on both sides of highway.

5.5 Entrance to Martin State Forest. TURN LEFT AND THEN BEAR RIGHT to picnic ground.

5.9 LUNCH STOP. ONE HOUR. Lunches will be brought to the picnic ground.

Mileage between stops

0.0 Cars will load at the picnic ground and retrace route to entrance of State Forest.

0.4 Forest entrance. Stop. Junction with U. S. 50. TURN RIGHT (west).

1.4 Broad open valley to right (west) is recently abandoned strath of Beaver Creek. Beech Creek limestone and a few feet of sandstone of the overlying Big Clifty formation are exposed in the small meander core hill.

2.2 Reenter Shoals quadrangle.

4.1 Shoals Community School stands on terrace of late Pleistocene? age.

4.5 Junction with U. S. 150. TURN RIGHT (north) into town of Shoals. Water supply for National Gypsum Co. plant comes from sand and gravel underlying this terrace level about half a mile south of this point.

4.8 Cross East Fork of White River. Shoals in river, about 100 yards downstream (to left, west) are caused by an outcrop of sandstone of the basal Mansfield formation. This marks the position of a pre-Mansfield valley, as Chester rocks are exposed at higher levels both north and south of this point.

5.4 Deep cut through crossbedded sandstone of the Mansfield formation.

6.8 STOP 4. PEEK CUT. Park and walk into deep cut along highway. KEEP HIGHWAY CLEAR. HALF AN HOUR is allowed for this stop.

A stratigraphic section measured here (E1/2NW1/4NE1/4 sec. 23, T. 3 N., R. 4 W.) shows:

Pennsylvanian system:	*Feet*
Mansfield formation: 84 feet exposed	
5. Sandstone (graywacke), yellow-brown; in thick sets of thin crossbeds; very fine-grained	30.
4. Sandstone (graywacke), green-gray to yellow-brown; wavy thin bedding; very fine-grained; shaly partings; lenticular	11.

Pennsylvanian system--Continued *Feet*

Mansfield formation--Continued

3. Sandstone (graywacke), yellow-brown; thick sets of thin tangential crossbeds; medium-grained ---------- 25.

2. Sandstone (graywacke), light-gray; uneven thin bedding; abundant clay chips; fine-grained; few very thin interbeds of carbonaceous shale ------- 11.

1. Sandstone (graywacke), yellow-brown; uneven medium bedding; fine-grained ---------- 7.

(Altitude 565 feet)

Base of exposures in ditch on north side of road.

The base of this section is approximately 70 feet above the base of the Mansfield formation.

Mileage between stops

0.0 Return to cars and continue westward on U. S. 50 and 150.

0.3 TURN RIGHT (north) on county road near foot of hill. Small quarry on right at road corner exposes 35 feet of yellow-brown sandstone near base of Mansfield. A covered interval of 33 feet intervenes between the top of this exposure and the bottom of exposures at Stop 4.

0.7 Cross creek. Quarry across valley to left (west) is in Glen Dean limestone.

1.5 TURN LEFT (west) on county road. Smooth slopes and subdued topographic benches are characteristic of the western part of the Crawford upland, which is underlain by the Mansfield formation.

2.1 STOP 5. Leave cars and cross stream into quarry to left (south) of road. Cars will please proceed to road junction 0.7 mile ahead (west), turn around, and return to this spot. FORTY-FIVE MINUTES are allowed for this stop.

A profile (fig. 2) and a measured section at this point (NW 1/ 4SW 1/ 4SW 1/ 4 sec. 11, T. 3 N., R. 4 W.) show:

Pennsylvanian system: *Feet*

Mansfield formation: 56.8 feet exposed

17. Sandstone (graywacke), yellow-brown; thick sets of thin tangential crossbeds; medium-grained. Base is disconformable and cuts down 11 feet into next 7 units below ---------- 18.0

16. Shale, silty, olive-gray; thin bedding ---------- 1.5

	Feet
Pennsylvanian system--Continued	
Mansfield formation--Continued	
15. Coal, shaly, black	1.2
14. Clay, shaly, gray; indistinct bedding; contains root impressions	0.8
13. Coal, dull-banded attrital	1.0
12. Siltstone, clayey, gray; bedding absent; contains *Stigmaria*	1.5
11. Siltstone, quartzitic, yellow-brown	2.0
10. Siltstone, light-gray; thin bedding; many worm? trails on bedding surfaces	7.5
9. Shale, silty, gray; very thin bedding	0.9
8. Clay, carbonaceous, gray; bedding absent	0.9
7. Siltstone, quartzitic, yellow-brown; bedding absent; abundant plant impressions	1.5
6. Mudstone, olive-gray; indistinct bedding; thickens eastward	11.0
5. Coal, shaly, black, lenticular	0.5
4. Sandstone (graywacke), gray; indistinct bedding; fine-grained, lenticular	0.5
3. Sandstone (graywacke), yellow-brown; bedding absent; medium-grained, lenticular	2.0
2. Shale, gray; thin bedding; contains siderite concretions; thins eastward; bottom contact sharp	6.0
(Altitude 525 feet)	
Mississippian system:	
Glen Dean limestone: 34 feet exposed	
1. Limestone, brown-gray; uneven medium bedding; abundant coarsely crystalline fossil fragments in a very finely crystalline matrix; upper 0.5 foot is soft, porous, red-brown	34.0
Floor of quarry.	

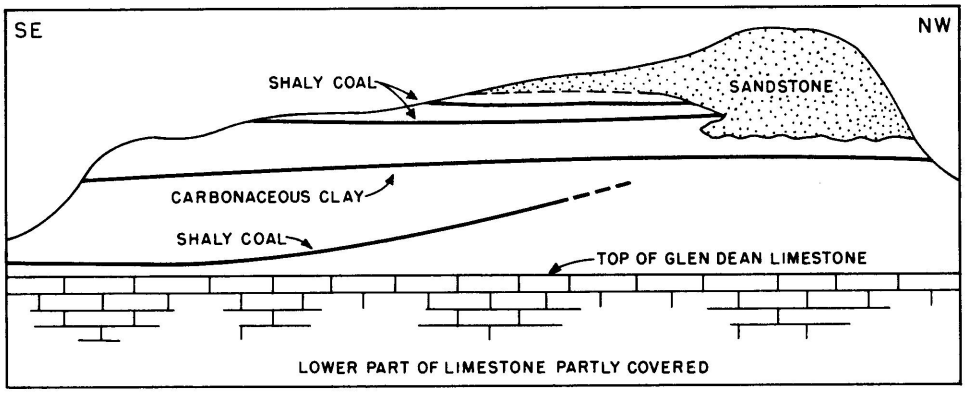


Figure 2.--Profile of quarry wall at abandoned Martin County Highway Department quarry (Stop 5). Not to scale.

The lowest rock unit in this quarry is certainly Mississippian in age, and probably few would question the assignment of the uppermost unit to the Mansfield. The age of units between, however, may be in doubt; they are here considered Pennsylvanian because (1) they constitute an essentially indivisible series, in which the most profound depositional change is at the bottom, (2) the basal unit of the sequence, gray shale with ironstone concretions, is a rock type commonly found in the Mansfield but unknown in Indiana in exposures for which a Chester age can be demonstrated, and (3) the coal and even-bedded siltstone are lithologic types more characteristic of rocks of Pennsylvanian rather than Mississippian age.

Mileage between stops	
0.0	Return to cars and proceed eastward on county road.
0.6	TURN RIGHT (south) on county road.
1.8	Stop. Junction with U. S. 50 and 150. TURN LEFT (east) on highway.
3.4	In woods to left (east), Jug Rock is peculiar weathered remnant of sandstone (Mansfield). See Malott (1922, p. 230-232).
4.1	East Fork of White River and town of Shoals. TURN RIGHT (west) on first street beyond bridge.
5.1	Bridge over Beaver Creek. Beech Creek limestone is exposed in river bank a quarter of a mile to right (north). TURN LEFT on county road.
5.2	Spout Spring on right (west) issues from base of sandstone unit near bottom of Mansfield.
5.4	General Refractories, Inc. preparation plant on left (east).
6.0	On left (east) is meander core hill and abandoned course of Beaver Creek. Probable date of abandonment: late Pleistocene.
6.5	Stop. TURN RIGHT (west) on State Route 550.

7.6 STOP 6. GENERAL REFRACTORIES, INC. QUARRY. TURN RIGHT (north). Park and walk into quarry. Keep clear of heavy equipment that may be operating. HALF AN HOUR is allowed for this stop.

This quarry and preparation plant of General Refractories, Inc. was opened in 1955 to develop the quartz-pebble conglomerate phase of the Mansfield as a source of high-silica materials for refractory purposes. Production is 240 tons per day.

Quartz-pebble conglomerate such as exposed here is a well-known, though rare, constituent of the Mansfield formation. Exposures of this lithologic type are known at Buddha, Mitchell, and Williams, in Lawrence County, and in several places in Martin County along a line from Indian Springs southwestward through Shoals to this point (NE 1/ 4NE 1/ 4 sec. 3, T. 2 N., R. 4 W.). No true conglomerate of any extent is known elsewhere in the Mansfield in Indiana, although scattered quartz pebbles are rather common. Malott (1931) has shown that some of the conglomerate deposits are related to pre-Mansfield valleys; it is presumed that others are also, but this is difficult to prove in some cases. Most appear to be related to the same valley system. The conglomerate does not necessarily lie along the axis of the valley; in fact, this appears to be the exception rather than the rule. It does not commonly comprise the basal unit of the Mansfield; here the base of the Mansfield is probably 50 feet below the base of the quarry.

The origin of the conglomerate is not certainly known. Wagner (1956, p. 40) states the rock has close affinities to what Pettijohn (1949, p. 207) referred to as an oligomictic conglomerate in which the pebbles are commonly of one rock type. Wagner believes this deposit was laid down at the shoreline by streams. Considerable reworking at the strand line by wave action removed most of the unstable minerals and left the rounded quartz. The source of the quartz pebbles is not known but probably lies to the north or northeast, as indicated by crossbedding directions. Correlation of this conglomerate with the somewhat similar Sharon conglomerate in Pennsylvania and Ohio has not been demonstrated.

Return to cars and retrace route to State Route 550.

Mileage between stops	
0.0	Quarry entrance. TURN LEFT (north) on State Route 550. Exposures for next 5 miles are of Mansfield formation.
3.7	Stop. Junction with U. S. 150. TURN RIGHT (south) on U. S. 150. Several small mines in this vicinity operated in coal bed approximately 125 feet above base of Mansfield.
5.1	Enter Huron quadrangle.
5.4	Enter Hillham quadrangle.
6.9	Masses of colluvium on lower parts of slopes to left (north).
8.6	In road cuts near top of hill and to right (west) of road, approximately 50 feet of very fine-grained yellow-brown sandstone of the basal Mansfield formation is exposed. Base of Mansfield is 15 feet below the best exposures at an altitude of 670 feet. Mansfield rests on Glen Dean at this point.
9.1	In road cuts to right (south) of highway, 30 feet of fine-grained sandstone (Big Clifty), 15 feet of gray crystalline fossiliferous limestone (Beech Creek), and 15 feet of red-brown and green-gray mudstone (Elwren) may be seen. Top of Beech Creek limestone is at an altitude of 580 feet.

9.6 In road cut to right (south) of highway, 4 feet of silty red-brown and green-gray mudstone overlying 20 feet of yellow-brown fine-grained sandstone (Sample) may be seen.

10.2 Enter Orange County.

11.2 Road cut to left (north) of highway exposes Beaver Bend limestone. Top of limestone is at an altitude of 490 feet.

11.4 Bridge over Lost River.

11.8 Exposures in road bank to left (north) show 6 feet of abundantly fossiliferous clastic limestone (Reelsville), overlain and underlain by fine-grained sandstone. Top of Reelsville is at an altitude of 550 feet.

12.0 Exposures in road cut at right (south) show 16 feet of medium-bedded very finely crystalline abundantly fossiliferous gray limestone (Beech Creek) overlain by 12 feet of yellow-brown thin-bedded fine-grained sandstone (Big Clifty). Top of Beech Creek is at an altitude of 625 feet.

12.3 Exposures on both sides of road at this place (NW1/4NE1/4SE1/4 sec. 20, T. 2 N., R. 2 W.) show:

Mississippian system:	*Feet*
Big Clifty formation: 24 feet exposed	
5. Sandstone (orthoquartzite), yellow-brown; thin crossbedding; fine-grained, locally ferruginous	17.0
4. Sandstone (graywacke), yellow-brown; thin wavy bedding; interbedded with equal amounts of silty gray shale	7.0
(Altitude 635 feet)	
Beech Creek limestone: 15 feet	
3. Limestone, gray; thick bedding; abundant coarsely crystalline fossil fragments in finely crystalline matrix	15.0
Elwren formation: 7.5 feet exposed	
2. Shale, red-brown; grades upward into olive-gray mudstone	6.0
1. Sandstone (orthoquartzite), calcareous, green-gray	1.5

The Big Clifty formation at this point strongly resembles some aspects of the Mansfield, but it is known to be Big Clifty because at several nearby localities stratigraphically equivalent rocks of similar lithology are overlain by limestone of the Golconda formation.

12.5 In road bank to left (north), just east of side road, 6 feet of thin wavy-bedded fine-grained fossiliferous calcareous sandstone at an altitude of 585 feet occupies the ex-

pectable stratigraphic position of the Reelsville. This abruptly gives way westward to a very fine-grained even-bedded yellow-brown siltstone in much the same way as the Reelsville limestone at Stop 1

12.9 Exposures in ditch and bank to left (north) show gray finely crystalline limestone (Paoli).

13.1 Cross bridge over creek and TURN RIGHT (west) on county road.

13.7 STOP 7. FRENCH LICK SANDSTONE CO. QUARRY. Leave cars and walk to abandoned sandstone quarry on left (south) of road. Cars will please proceed to intersection 0.5 mile ahead (west), turn around, and return to this point. HALF AN HOUR is allowed for this stop.

A section measured at this point (E1/2NE1/4NE1/4 sec. 29, T. 2 N., R. 2 W.) shows:

	Feet
Mississippian? or Pennsylvanian? system:	
3. Sandstone (orthoquartzite), gray and yellow-brown, crossbedded, fine-grained, cliff-forming; weathered surface is pitted	37.7
2. Sandstone (orthoquartzite), gray mottled with yellow-brown; irregular medium bedding; fine-grained	8.6
(Altitude 520 feet)	
Mississippian system:	
Beaver Bend limestone: 17.1 feet exposed	
1. Limestone, gray, medium- to thick-bedded, fine- to medium-crystalline, oolitic in upper beds and locally stylolitic. Fossils include *Linoproductus ovatus*, *Spirifer leidyi*, *Orthonychia* sp., compositoid brachiopods, and small crinoid stems	17.1
Base of exposures at spring.	

The Beech Creek limestone, 17 feet thick and at an altitude of 630 feet, is exposed higher on the hill and 100 yards to the east of the sandstone cliff.

Proper identification of the cliff-forming sandstone is difficult. Brookley and Perry (1955, p. 202-206) interpreted the sandstone as a lower Pennsylvanian channel fill deposited in a steep-sided pre-Pennsylvanian valley. Their reasons included (1) the similarity of the crossbedded cliff-forming honeycomb-weathered sandstone to rocks elsewhere considered to belong in the Mansfield formation and (2) the absence here of the Reelsville limestone from its expectable stratigraphic position (it should be near the top of the cliff face, if present).

It is, however, also reasonable to consider this rock to be of Chester age, for the following reasons: (1) in this area the Mansfield formation commonly rests on the Golconda and nowhere south of the valley of Beaver Creek is the base of the Mansfield known to cut down to or through the Beech Creek limestone and (2) three-quarters of a mile northwest of this point sandstones similar to these cliff-forming sandstones overlie and underlie Reelsville limestone in road cuts along U. S. 150.

Mileage between stops	
0.0	Return to cars and continue ahead (east) on county road.
0.6	Stop. Junction with U. S. 150. TURN RIGHT (south) on U. S. 150.
1.5	Enter French Lick quadrangle.
2.0	Village of Prospect. Road cut to left (north) exposes 15 feet of brownish-red clayey sand overlying 3 feet of siliceous gravel. These fluviatile sediments underlie a former strath of Lost River that now stands approximately 50 feet above the present flood plain. The hill just north of Prospect is an old meander core. Probable age of these deposits is mid-Pleistocene or older.
2.1	BEAR LEFT (east) on U. S. 150.
2.2	Stop. Junction with State Route 56. STRAIGHT AHEAD on U. S. 150.
3.0	Cross Lost River.
4.6	Route follows valley of Lick Creek. Valley floor is underlain by Ste. Genevieve limestone. Quarries along valley between here and Paoli are in Paoli and upper Ste. Genevieve limestones.
9.1	Enter Paoli quadrangle.
10.1	Enter town of Paoli. Type locality of Paoli limestone (Malott and Esarey, 1940, p. 5) is on north side of Monon Railroad near west city limits, where limestone is 27 feet thick and includes 3 feet of limy shale near middle.
11.0	Square in town of Paoli. TURN RIGHT, FOLLOW THREE-FOURTHS WAY AROUND SQUARE, AND THEN TURN RIGHT ON STATE ROUTE 37, NORTH.
11.8	Leave town of Paoli.
12.3	Highway cut exposes sandstone of Sample formation near top of hill.
15.1	Cross dry bed of Lost River, which here flows underground through caverns in St. Louis and Ste. Genevieve limestones.
16.1	Enter Mitchell quadrangle. Low hills on right (east) are capped by Ste. Genevieve limestone; most of sinkhole-pitted plain is underlain by St. Louis limestone.
18.3	Orleans city limits. Slow down.
19.7	Leave town of Orleans. Resume speed. Exposures along road for next 7 miles are of St. Louis limestone. Chester rocks cap isolated hills to left (west).
20.5	Enter Lawrence County.
23.5	Junction with State Route 60. TURN RIGHT (east).
24.1	Cross Monon Railroad.
26.8	Park entrance. TURN LEFT (north). Follow signs to Spring Mill Inn.

27.8 Parking area, Spring Mill Inn. End of first day's trip.

SUNDAY, OCTOBER 6, 1957; STOPS 8-10

Mileage between stops	
0.0	Load cars in parking lot in front of Inn, 8 a. m. Caravan will retrace last night's route as far as Prospect; only road directions will be given for this part of itinerary. Proceed up hill, bearing right to gatehouse. Mitchell quadrangle.
1.0	Park entrance. TURN RIGHT (west) on State Route 60.
3.7	Cross Monon Railroad.
4.3	Stop. Junction with State Route 37. TURN LEFT (south) on 37.
7.3	Enter Lawrence County.
8.1	Orleans city limits. Slow down.
9.5	Leave town of Orleans. Resume speed.
11.7	Enter Paoli quadrangle.
16.0	Paoli city limits. Slow down.
16.6	Paoli square. TURN RIGHT, FOLLOW ONE-QUARTER WAY AROUND SQUARE, AND TURN RIGHT (west) on U. S. 150.
17.6	Leave town of Paoli. Cross Monon Railroad. Resume speed.
18.6	Enter French Lick quadrangle.
25.5	Town of Prospect. TURN LEFT (south) on State Route 56.
25.7	Stop. CONTINUE LEFT on State Route 56.
25.8	Cross bridge over Lost River. Cross Monon Railroad. Enter town of West Baden.
26.8	Leave West Baden; enter French Lick. Formerly extensive resort industry in these towns was based on mineral waters, most of which issued from springs in the Paoli limestone. Valley floor here is somewhat below level of Paoli limestone.
27.2	Cross French Lick Creek and Southern Railroad.
27.3	TURN LEFT (south) on Monon Street.
27.6	TURN LEFT (east) on State Route 145.
28.2	Cross Southern Railroad.
28.4	Leave town of French Lick. Continue ahead (south) on State Route 145.

30.6 Slow down. Sharp turns, rough road, and narrow bridges ahead. Valley floor of French Lick Creek is just below level of Beaver Bend limestone here. Beaver Bend is exposed in road cuts and quarries low on valley side for next mile. Note the distinctive topographic benching of valley walls. This is characteristic of the Crawford upland, particularly that part underlain by Chester rocks.

31.8 Enter Greenbrier quadrangle.

33.1 Beech Creek limestone and overlying sandstone of Big Clifty formation are exposed just above valley floor.

34.2 Hills are capped by Tar Springs formation and Glen Dean limestone.

36.6 Cross bridge over creek. In road cut on left and stream bed on right (west), sandstone of Big Clifty formation is well exposed.

37.3 Hill is capped by Mansfield formation, underlain by Glen Dean limestone. Hills to right (west) are capped by Mansfield; those to left are capped by sandstone of Tar Springs formation and by Glen Dean limestone.

39.2 Sharp turns and steep grades ahead. Outcrop on left (east) is probably limestone of Golconda formation.

39.3 Cross Patoka River. The present course of the Patoka has resulted from integration of three former separate tributaries of the East Fork of White River into a single stream that now enters the Wabash near the mouth of the White. The upper Patoka, of which this is the valley, formerly entered the East Fork just north of Jasper (Malott, 1922, p. 145-146; Leverett, 1899, p. 98-102). This drainage derangement probably took place during the Illinoian age, but part of it may date from the Kansan age.

39.8 Enter Crawford County.

41.0 Cross Fleming Creek.

41.1 On right (west) outcrop and small limestone quarry are probably in Golconda, overlain by wavy-bedded sandstone of Hardinsburg formation.

41.2 Enter Taswell quadrangle.

41.5 Junction with State Route 164 west. Continue ahead (south) on State Route 145.

42.4 STOP 8. MULZER BROTHERS QUARRY. TURN LEFT (east). Proceed to quarry office. Stop, park, and walk into quarry. Be careful of heavy equipment that may be working. HALF AN HOUR is allowed for this stop.

Most of the stone from this quarry goes westward into the limestone-deficient lower Pennsylvanian outcrop area around Jasper and Huntingburg; west of this point easily accessible limestone reserves are small.

A section measured on the south face of this quarry (NW 1/4 SE 1/4 sec. 10, T. 2 S., R. 2 W.) shows:

Mississippian system:	*Feet*
Glen Dean limestone: 50.7 feet exposed	
10. Siltstone and shale, gray, thin and irregularly bedded; top is soil-covered	6.0

Mississippian system--Continued	Feet
Glen Dean limestone--Continued	
9. Limestone, argillaceous, gray, medium to coarsely crystalline, irregularly medium-bedded; contains many coarsely crystalline organic fragments; interbedded with thin beds of soft dark-gray shale	4.5
8. Shale, gray, arenaceous, somewhat calcareous, thick-bedded; vertical jointing common	6.9
7. Shale, gray to black, soft, thin-bedded, fissile	3.5
6. Limestone, gray, fine-grained, argillaceous and arenaceous; in one bed	0.9
5. Shale, gray to black, soft, thin-bedded	0.4
4. Limestone, argillaceous, gray, coarse-grained; indistinct bedding; contains abundant coarsely crystalline organic material, principally crinoid stems	2.3
3. Shale, gray to black, soft, fissile, thin-bedded	2.7
2. Limestone, gray, coarsely crystalline, irregularly medium-bedded; locally contains much coarsely crystalline organic debris	1.5
1. Limestone, gray, finely to coarsely crystalline, thick-bedded; thin partings of gray calcareous shale commonly between beds	22.0

Floor of quarry. (Altitude 570 feet)

The Glen Dean limestone is undoubtedly the most fossiliferous formation in the Chester series. Fossils are collected most readily from interbedded limestones and clastic rocks in the upper part of the formation, especially after these rocks have undergone a moderate amount of weathering following their discard during quarrying operations. Horowitz and Perry (1956) have shown that distinctive faunas are found in the lower and upper parts of the formation. Thick-bedded and massive limestones in the lower Glen Dean contain a fauna that is characterized by the brachiopods *Linoproductus pileiformis, Productus cestriensis, Stenoscisma explanatum, Torynifer setiger, Martinia contracta,* and *Spirifer leidyi*. In contrast, beds in the upper part of the formation bear a fauna that is characterized by *Cleiothyridina sublamellosa, Composita subquadrata, Punctospirifer transversus, Reticulariina spinosa,* and *Spirifer increbescens*. Argillaceous beds in the upper part of the Glen Dean yield many specimens of the bryozoan *Tabulipora ramosa* and fistuliporoids; fenestellids appear equally abundant in limestone and calcareous shale. Plates of *Pterotocrinus* are most abundant in limestones, and species that may be regarded as Glen Dean guide fossils in In-Indiana are *Pterotocrinus spatulatus, P. bifurcatus, P. depressus, P. acutus,* and *P. vannus*. Pentremites are equally common in limestone and shale; *Pentremites spicatus,* a species characterized by prominently protruding deltoid plates and deeply concave ambulacra, is a Glen Dean index fossil (Galloway and Kaska, 1957,

p. 73). This formation contains more than 100 species, many of which may be collected at this locality.

The upper boundary of most limestones in the lower part of the Chester series (Paoli, Beaver Bend, and Beech Creek) presents no particular obstacles to mapping in most of the Indiana outcrop area, but both limestones in the middle Chester (Golconda and Glen Dean) have indeterminate upper contacts. If the interbedded lenticular limestones and shales at the top of this section are placed in the Glen Dean, the top of the Glen Dean in many places will be vague and equivocal; if, on the other hand, the name Glen Dean is restricted to the massive limestone, it may be difficult to determine whether a particular poorly exposed limestone bed belongs within the Glen Dean or to the overlying limestone-shale sequence. For surface mapping it would seem most satisfactory to designate the top of the massive limestone as the top of the Glen Dean.

Return to cars and retrace route to highway.

Mileage between stops

0.0 Quarry entrance. TURN LEFT (south) on State Route 145.

0.2 Abandoned quarry to right (west) shows interbedded limestone and shale above the massive limestone (Glen Dean) of the lower quarry wall.

0.6 Road bank to right (west) shows Mansfield formation overlying Glen Dean limestone. A measured section at this place (SW1/4NW1/4NW1/4 sec. 15, T. 2 S., R. 2 W.) shows:

	Feet
Pennsylvanian system:	
Mansfield formation: 44 feet exposed	
6. Sandstone (graywacke), yellow-brown; thin-bedded at bottom; thick-bedded and resistant to weathering at top; very fine-grained	26.0
5. Sandstone (graywacke), gray; wavy thin bedding; very fine-grained; contains many chips, laminae, and lenses of gray carbonaceous very thin-bedded shale as thick as 1 foot	11.0
4. Shale, carbonaceous, gray, very thin-bedded; contains several zones of small ironstone concretions	7.0
(Altitude 585 feet)	
Mississippian system:	
Glen Dean limestone: 4.8 feet exposed	
3. Shale, olive-gray, very thin-bedded	1.0
2. Sandstone (orthoquartzite), yellow-brown; indistinct bedding; contains brachiopod molds	0.8

Mississippian system--Continued *Feet*

Glen Dean limestone--Continued

1. Limestone, silty, gray; indistinct bedding; finely crystalline; contains abundant fossils ---------- 3.0

Here the contact between the Mississippian and the Pennsylvanian systems is picked on the basis of (1) probable Mississippian age of the olive-gray shale and fossiliferous sandstone, both of which are lithologic types unknown in the Mansfield in this area and (2) probable Pennsylvanian age of the carbonaceous gray shale with ironstone concretions, a lithologic type never conclusively shown to be present in the Chester series in this area.

1.7 Eckerty junction. TURN LEFT (east) on State Route 64.

2.2 BEAR RIGHT (south) on paved road, old Route 64.

2.9 Village of Eckerty. Do not cross railroad. TURN LEFT (north) at railroad bridge and THEN RIGHT (east) following paved road, old Route 64.

3.6 At left curve in pavement CONTINUE STRAIGHT AHEAD (east) on unimproved county side road that is hard to see. Sandstone in creek at right is probably in the Tar Springs formation.

3.8 TURN RIGHT (south) following county road.

3.9 Olive-gray shale in bank to right (west) is probably in the Tar Springs formation.

4.2 STOP 9. Cross Southern Railroad track and park. Walk into cuts to right (west) of road. KEEP TRACK CLEAR. HALF AN HOUR is allowed for this stop.

A section measured in the western and deeper of these cuts (N1/2SE1/4NW1/4 sec. 26, T. 2 S., R. 2 W.) shows:

Pennsylvanian system: *Feet*

Mansfield formation: 75 feet exposed

3. Sandstone (graywacke), yellow-brown, crossbedded, fine-grained ---------- 28.

2. Shale, gray, very thin-bedded; thickens westward ---------- 29.

1. Sandstone (graywacke), yellow-brown, medium-bedded, very fine-grained; contains several zones of ironstone concretions ---------- 18.

(Altitude 695 feet)

These cuts are representative of the Mansfield formation in this area, both as to type and proportion of rocks. The direction of sediment transport in this area was southwesterly, and the dominance of coarse clastic materials here indicates that this was probably a principal route of sediment supply.

Locally some evidence of penecontemporaneous deformation may be seen along the lower contact of the upper sandstone unit. This feature is more prominently displayed at the next stop.

Mileage between stops

0.0 Return to cars and proceed ahead (south) on county road. If damp weather has made road impassable, an alternate route will be followed.

1.1 TURN LEFT (east) on gravel road.

2.1 TURN LEFT (north) on gravel road.

3.9 STOP 10. Park and walk into Southern Railroad cut on left (west) of road. KEEP TRACK CLEAR. HALF AN HOUR is allowed for this stop.

The general relations and description of the rocks exposed at this place (SW 1/ 4NW 1/ 4SE 1/ 4 sec. 24, T. 2 S., R. 2 W.) are shown in the diagram (fig. 3) and measured section below:

Pennsylvanian system:	*Feet*
Mansfield formation: 70 feet exposed	
3. Sandstone (graywacke), gray to yellow-brown, thin-bedded, very fine-grained; scattered ironstone concretions in lower part	30.
2. Sandstone (graywacke), gray to yellow-brown; irregular and locally contorted thin bedding; very fine-grained; contains several lenses as much as 15 feet thick of yellow-brown and green-gray fine- to coarse-grained crossbedded sandstone that locally contains pyrite nodules and coal streaks	20.
1. Shale, gray, thin-bedded	20.
(Altitude 760 feet)	

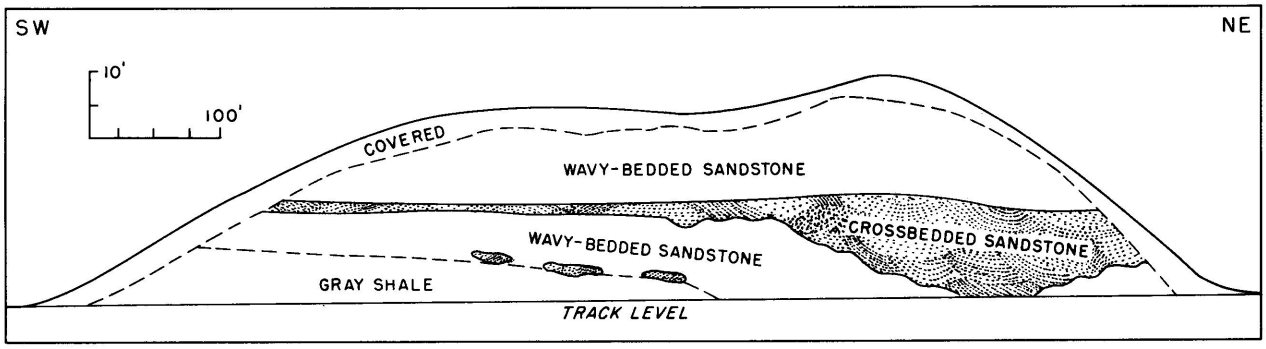


Figure 3.--Profile of northwest side of cut along Southern Railroad 1 mile west of Taswell (Stop 10). Approximately to scale; vertical exaggeration 5 times.

The entire section described above shows evidence of deformation that is interpreted as having taken place shortly following deposition while the sediments were as yet unconsolidated. The disturbance is not confined to this cut but also can be seen in cuts to the southwest. A section measured in the cut 0.7 mile southwest of Stop 10 (NE1/4SW1/4NW1/4 sec. 25, T. 2 S., R. 2 W.) shows:

	Feet
Pennsylvanian system:	
Mansfield formation: 70.5 feet exposed	
7. Siltstone, gray; contorted and very thin bedding	6.0
6. Sandstone (graywacke), yellow-brown; indistinct bedding; very fine-grained	5.0
5. Shale, silty, gray; indistinct bedding; contorted in upper part	9.5
4. Sandstone (graywacke), yellow-brown; uneven thin bedding; fine-grained	12.0
3. Sandstone (graywacke), yellow-brown, crossbedded, medium-grained, friable; abundant contorted ironstone nodules and inclusions of coal at base	30.0
2. Sandstone (graywacke), red-brown; indistinct somewhat contorted bedding; very coarse-grained; contains some contorted coalified logs; lenticular	4.0
1. Shale, silty, gray; indistinct bedding, locally much contorted. Appears to be cut out locally by unit above	4.0
(Altitude 730 feet)	

Deformation of individual units here indicates a relative southwesterly slip of the upper beds over the lower. The disturbance decreases in intensity westward and is scarcely noticeable in the cuts 0.5 mile and 0.7 mile farther west that constituted Stop 9. These rocks are probably of deltaic origin. Penecontemporaneous deformation observed here may be the result of either (1) sliding on initial dip or (2) flowage due to differential loading of unconsolidated water-saturated sediments.

This is the last formal stop of the field conference. Brief remarks by Dr. Charles F. Deiss, State Geologist, will conclude the conference.

Your attention is called to the postconference road logs at the back of the guidebook. These are intended to give returning conferees a brief summary of the salient geologic features of their route home.

To return to State Route 64, continue ahead (north) 0.5 mile, bearing left across bridge over Southern Railroad. Route 64 eastbound traffic turn right; English; beginning of road logs 1, 2, and 3 to points north, east, and south, is 6.6 miles. Westbound traffic turn left; Eckerty junction, beginning of road log 4 westbound, is 3.1 miles.

GLOSSARY OF ROCK-TYPE TERMS

Some of the terms used in this guidebook for the description of rock types are controversial or have neither a widely nor an officially accepted definition. The definitions given here are intended only to inform the reader of the usage in this guidebook. They are derived in part from Ingram (1953), Krynine (1948), and Pettijohn (1949). Other definitions may be equally valid and useful.

MUDROCKS (silt- and/or clay-rocks or lutites; modal grain size less than 1/16 mm)

CLAY: consists essentially of clay-sized grains (less than 1/256 mm), is poorly consolidated, and has irregular fracture.

MUDSTONE: consists essentially of approximately equal proportions of silt- and clay-sized grains, is moderately to well consolidated, lacking fissility, and has irregular (hackly or "starchy") fracture.

SHALE: consists essentially of clay-sized grains or of approximately equal amounts of clay- and silt-sized grains, is well consolidated, and has well-defined platy or splintery fracture.

SILTSTONE: consists essentially of silt-sized grains (from 1/256 to 1/16 mm), is moderately to well consolidated, and has either irregular or platy fracture.

SANDSTONES (sand-rocks or arenites; modal grain size from 1/16 to 2 mm)

GRAYWACKE: consists essentially of quartz grains and a significant amount of clay minerals, both as grains (clay aggregates or argillaceous rock fragments of sand size) and as matrix (dispersed argillaceous materials). Clay minerals generally serve as bonding agent; chemically precipitated cements may be present but are commonly insignificant.

ORTHOQUARTZITE: consists essentially of quartz grains; may have quartz or carbonate or other cement. A small amount of clayey or silty matrix may be present but in quantity insufficient to form an effective bond.

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POSTCONFERENCE ROAD LOGS

NO. 1. STATE ROUTE 37 NORTH TO PAOLI

By Henry H. Gray and T. G. Perry

Miles	
0.0	Junction State Routes 37 and 64 in English. Proceed north on 37.
0.6	Leave town of English. Overpass is for relocation of State Route 64. Beaver Bend limestone lies just above valley floor at this point and is exposed in several quarries and road cuts for next 2 miles.
4.6	Enter Orange County.
4.9	Route follows topographic bench developed on Tar Springs formation.
5.5	Route follows topographic bench developed on Hardinsburg formation.
6.8	Route follows topographic bench developed on Big Clifty formation.
8.0	Cross Patoka River.
8.8	In bank on right (east) of road, Teaford Spring issues from base of a 13-foot exposure of oolitic limestone (Beaver Bend). Top of Paoli limestone is exposed in creek bed to right (west) of road.
12.0	Route follows topographic bench developed on Hardinsburg formation.
13.3	Beech Creek limestone is exposed on left (west) side of highway, overlain by sandstone of Big Clifty formation.
16.2	In bank on left (west) side of highway are slabs of Beech Creek limestone containing large crinoid stems.
16.9	Enter town of Paoli.
17.5	Paoli square. End of postconference road log no. 1.

NO. 2. STATE ROUTE 64 AND U. S. 460 EAST TO NEW ALBANY

By Duncan J. McGregor and Ned M. Smith

Miles	
0.0	Junction State Routes 37 and 64 in English. Proceed east on 64. Exposures on left (north) side of road for next 3.6 miles are Beaver Bend limestone, overlain by Sample formation.
3.6	Cross Southern Railroad.
3.8	Beaver Bend limestone exposed in bank on right (south).
4.2	Beech Creek limestone exposed in bank on right (south).
6.8	Beaver Bend limestone on right side of road.
7.1	Bethel formation on right side of road.

7.2 Paoli limestone in creek bank to right (south) of highway.

7.8 Junction with State Route 66 just west of town of Marengo. Turn right (south) on 66. Because of road construction between Marengo and Milltown, a short detour must be taken.

The Hy-Rock Products Company produces Ste. Genevieve limestone from an underground mine in the southeastern part of Marengo; the face of the now-abandoned open quarry displays a stratigraphic section from the Ste. Genevieve (probably Rosiclare member) up to and including the Sample formation.

8.2 Ste. Genevieve limestone is exposed in the hill on the left (east). The Bryantsville breccia bed, a significant marker, identifies the Meramec-Chester contact. Paoli and Beaver Bend limestones are also exposed higher on the hill.

8.8 Beaver Bend limestone overlain by Sample formation; the spring house on the left (east) is in the Sample.

9.2 On the right (west), in ascending order, Sample formation, Reelsville limestone, and Elwren formation.

9.3 Beech Creek limestone overlain by shaly sandstone of Big Clifty formation exposed in cut on right side of road.

9.5 Limestone of Golconda formation overlies sandstone of Big Clifty on right (west) side of road.

9.6 Junction with county gravel road. Turn left (east). Continue on this road to Milltown.

11.7 Beech Creek limestone exposed in hillside to left (north) of road.

12.0 Top of Paoli limestone exposed in ditch on left (north) side of road.

12.1 Ste. Genevieve limestone. The Bryantsville breccia bed crops out here in ditch on left side of road.

12.9 Sinkholes on both sides of road here are in Ste. Genevieve limestone.

13.7 Enter town of Milltown; public school on right.

14.1 Bear right on paved road.

14.2 Turn right (south) where main travelled road bears left and then turn sharp left down hill, along which Ste. Genevieve limestone is exposed.

14.5 Turn right (south) on State Route 64.

14.6 Cross Blue River; enter Harrison County.

14.7 Cross Southern Railroad. Continue on State Route 64. To left, entrance to abandoned quarry of Louisville Cement Co. Ste. Genevieve limestone in railroad cut to right (south).

The entire stratigraphic section present in this area extends from the St. Louis limestone up through the Ste. Genevieve limestone, Aux Vases formation, Paoli limestone, Bethel formation, Beaver Bend limestone, and Sample formation. In the Milltown quarry, limestone was taken from the upper part of the St. Louis and the lower Ste. Genevieve and used in manufacturing lime.

14.9 Ste. Genevieve limestone exposed on left (north) side of road.

16.3 Ste. Genevieve limestone exposed in hillside to left (north) of road.

16.5 To left (north), abandoned Depauw quarry of Louisville Cement Co., which produced stone from Paoli limestone and possibly from the upper Ste. Genevieve. Note sinkholes for next few miles.

17.7 Enter town of Depauw.

17.9 Junction with State Route 337; continue ahead on State Route 64.

18.5 Paoli limestone overlain by Bethel formation in cut to left (north).

19.3 Bethel formation exposed in bank along right (south) side of road.

19.5 Ste. Genevieve limestone in bank to right of road.

20.6 Davis Brothers Crushed Stone Co. half a mile to the left (north). This quarry is in the Paoli limestone and the upper part of the Ste. Genevieve.

21.3 Enter town of Ramsey.

23.8 St. Louis limestone exposed along highway.

24.9 Junction with State Route 135; continue ahead on State Route 64.

27.2 Junction with State Route 335; continue ahead on State Route 64.

27.3 Salem limestone exposed in bank to right (south) of highway.

27.7 Harrodsburg limestone exposed in road cut to left (north).

28.0 Shaly fossiliferous beds in Harrodsburg limestone in road cut to right (south).

29.0 Interbedded sandstone and siltstone of Borden group exposed in cut along right (south) side of road.

29.4 Contact between Harrodsburg limestone and Borden group exposed to left (north) of road.

30.7 Enter Floyd County.

31.6 Enter town of Georgetown.

35.1 Rocks of Borden group exposed in cut along Southern Railroad at west tunnel entrance, just to right (south) of highway.

35.8 Enter town of Edwardsville.

36.0 Junction with U. S. 460 and State Route 62. Continue ahead (east) on 460.

36.1 Quarry in Harrodsburg limestone left (west) of highway. Begin to descend Knobstone escarpment. Road cuts for next 0.3 mile are in Borden group.

36.4 Lowest exposure of rocks of the Borden group, along left (north) side of highway.

37.0 Cross Southern Railroad.

38.2 Cross Southern Railroad.

39.1 Enter town of New Albany.

40.4 Junction with State Route 111. Bear left on U. S. 460.

41.4 Junction with U. S. 150. Continue ahead on U. S. 460.

42.5 Junction with U. S. 31W. End of postconference road log no. 2. Turn right for bridge to Louisville, Ky.

NO. 3. STATE ROUTES 37 AND 66 SOUTH TO CANNELTON

By Henry H. Gray and T. G. Perry

Miles

0.0 Junction State Routes 37 and 64 in English. Proceed south on 37.

2.0 Hilands Overlook Roadside Park. Upland surface here is developed on sandstones of Tar Springs formation.

4.5 Town of Grantsburg.

4.7 Beech Creek limestone to right (west) of road.

5.5 Elwren formation and Beech Creek limestone exposed in bank to left (south) of highway. Higher up hill are good exposures of sandstone in Big Clifty formation.

6.3 Abandoned roadside quarry on right (west) is in limestone of Golconda formation.

7.4 Sample formation, Reelsville limestone, and Elwren formation are exposed in cut to right (north) of road. Elwren here includes, 12 feet above the base, a limestone bed as much as 4 feet thick that is lithologically similar to the Reelsville. Above these, upper Elwren formation and Beech Creek limestone are exposed on wooded slope. Capping the hill is sandstone of Big Clifty formation, which makes prominent cliffs that locally are called Salt Shake Rock.

9.2 Beech Creek limestone is exposed in road cut on right (west). Roadside limestone quarries higher on hill are in Golconda formation and Glen Dean limestone.

10.2 Sulphur. Junction with U. S. 460 and State Route 66. Go straight ahead (south) on State Route 66. The famous Sulphur section, in which formations of the Chester series from the Beaver Bend limestone to the Waltersburg formation are exposed, is 0.4 mile to 1.4 miles to left (east) along routes 460 and 66.

10.5 Sandstone of Tar Springs formation exposed in cuts on both sides of highway.

10.8 In bank to right (west) of highway, limestone of Golconda formation is exposed.

11.1 In bank to right (west) of highway, Beech Creek limestone is exposed.

12.0 Cross Stinking Fork. Enter Perry County.

12.5 In abandoned quarry to left (east) side of road, limestone of Golconda formation overlain by Hardinsburg formation is exposed. Higher on hill exposures of Glen Dean limestone may be seen in ditches on both sides of road.

13.6 Near crest of hill exposure in road bank to left (east) is crossbedded sandstone in lower part of Mansfield formation. Scattered roadside exposures for next 7 miles are of Mansfield.

15.3 Village of Oriole to right (west).

21.3 Leave outcrop area of Mansfield formation. Descend long steep hill to valley of Little Oil Creek. The following sequence of formations is visible (nomenclature modified from Esarey, Malott, and Bieberman, 1948; in part following Wabash Valley subsurface usage shown on plate 3):

Mississippian system:

Palestine? formation: 60 feet exposed

Gray shale containing thin nodular yellow-brown argillaceous limestones, thin wavy-bedded sandstones, and green-brown shales.

21.4 Menard limestone: 23 feet

Red-brown crystalline limestone, gray shale, slabby yellow-brown limestone, green-gray shale, and yellow-brown argillaceous limestone.

Waltersburg formation: 88 feet

Green-brown shale and mudstone, yellow-brown argillaceous limestone, gray shale, and wavy-bedded sandstone.

21.6 Vienna? limestone: 1 foot

Loose weathered gray crystalline limestone boulders.

Tar Springs formation: 65 feet

Irregularly bedded sandstone, red and green mudstone, and wavy-bedded sandstone. Lower part mostly covered.

21.8 Glen Dean limestone: 21 feet

Thick-bedded gray crystalline limestone.

Hardinsburg formation: 34 feet

Red mudstone, wavy-bedded sandstone, and green mudstone.

21.9 Golconda formation: 36 feet

Yellow-brown argillaceous limestone and gray crystalline limestone.

Big Clifty formation: 35 feet exposed

Wavy-bedded sandstone; upper part mostly covered.

22.1 Sharp right turn at bottom of hill.

22.5 Limestone ledge on right (west) side of road is in Golconda formation.

25.1 Village of Dexter. Turn right, following State Route 66.

29.1 Abandoned limestone quarry on right (west) is in Golconda formation, overlain by sandstone of Hardinsburg formation. Half a mile west, in a quarry operated by Mulzer Brothers, the Hardinsburg formation consists largely of dark-gray shale.

29.6 Village of Derby. Continue ahead on State Route 66.

31.3 Golconda formation, Hardinsburg formation, and Glen Dean limestone are exposed in long cliffs and steep slopes to right (west).

34.3 In bank on right (west) side of road, limestone of Golconda formation is overlain by wavy-bedded sandstone of Hardinsburg formation. Higher on hill Glen Dean limestone may be seen.

36.3 Follow State Route 66 to right (west); village of Rome to left.

36.7 Cross Bear Creek. Sandstone exposed in banks of creek is in Big Clifty formation.

38.0 In road bank to right (north), Glen Dean limestone is exposed. Farther up hill, at bend in road, green-brown shale containing thin yellow-brown argillaceous limestones may represent the Vienna. Shortly above bend, ditch on right (east) exposes yellow-brown argillaceous limestone, gray shale, green-brown shale, and gray laminated limestone (Menard), closely overlain by hard quartzitic blocky-weathering sandstone (Palestine) near top of hill.

39.1 In road bank to right (north), crossbedded friable sandstone of basal Mansfield formation is exposed.

44.4 Sharp right turn over Deer Creek. In high bluff on left (east), thick sandstone of the Mansfield formation is exposed; best viewed from a little distance.

46.0 Junction with State Route 166. Turn right, following State Route 66. Cross Deer Creek.

47.2 Lafayette Springs. On right (north) high bluffs held up by resistant beds in the Mansfield formation rise over 200 feet to top of hill. Besides the prominent cliff-forming sandstones the Mansfield here contains thick shales, thin underclays, and at least two thin coals.

50.8 Traffic light in center of Cannelton. End of postconference road log no. 3. Turn left (south) 0.4 mile to ferry to Hawesville, Ky., and U. S. 60.

NO. 4. STATE ROUTE 64 WEST TO MT. CARMEL, ILL.

By Henry H. Gray and Charles E. Wier

Miles

0.0 Junction of State Routes 64 and 145 at Eckerty Junction. Proceed west on State Route 64. Roadside exposures for next 18 miles are of Mansfield formation.

3.3 Enter Dubois County.

11.7 Village of St. Marks.

14.0 Lenticular limonitic cap on sandstone exposed on both sides of highway is lowest known extensive key bed in the Mansfield, lying approximately 70 feet below the Ferdinand limestone. It is widely represented in the southern part of the outcrop area of the Mansfield formation. In most exposures the limonite is identified by a characteristic "scoriaceous" appearance.

17.4 The Ferdinand limestone, an important key bed near the top of the Mansfield formation, does not crop out along the highway but can be seen in the county road cut at the north end of the hill 0.3 mile south of State Route 64 at this point. The limestone here is represented by 0.8 foot of fossiliferous chert. A coal tentatively identified as Lower Block? crops out 11 feet above the chert.

Outcrops along highway from this point westward for the next 3 1/2 miles are of the Brazil formation.

18.7 Huntingburg city limits.

19.4 Junction with U. S. 231 and State Route 45. Continue straight ahead on State Route 64.

19.5 Beeler's Hill. Minshall? limestone is poorly exposed in road cut. Limestone is well exposed in abandoned shale pit on the right (north) side of road. In highway cut near top of hill 2 thin coals 25 to 30 feet above the Minshall? limestone may represent Coal II or coals in the lower part of the Staunton formation.

19.8 Abandoned shale pit on left (south) side of road is in the same stratigraphic position as the pit previously described.

20.9 Lake on left (south) furnishes water for the city of Huntingburg. Scattered outcrops of coal smut, shale, and sandstone for next 5 miles are in Staunton formation.

25.9 Enter Pike County.

26.5 Coal III exposed in road cut. The coal here is underlain by 12 feet of clay and overlain by 8 feet of sandstone. The 0.8-foot upper bench is separated from the 1.2-foot lower bench by 1.2 feet of clay shale. Coal III has a similar parting throughout eastern Pike County. Coal IIIa, which is not exposed along the highway, is less than a foot thick and in most places lies approximately 20 feet above Coal III.

30.0 Highway built through abandoned Coal IV strip pits. Coal IV is 65 feet above Coal III and is 2.0 to 2.5 feet thick in this area.

30.5 Coal IVa, which lies approximately 40 feet above Coal IV, is exposed on both sides of highway. For the next several miles the highway is constructed through abandoned Coal V strip pits. Coal V is approximately 100 feet above Coal IV and is 4.0 to 5.0 feet thick.

33.4 Lower Millersburg coal, 3.5 feet thick and badly weathered, crops out on both sides of road. This coal is 80 feet above Coal V. The Lower Millersburg coal and the underlying Universal limestone can be seen in some of the abandoned Coal V pits south of highway. All pits adjacent to highway for the next several miles are in Coal V.

36.2 Junction with State Route 61.

39.8 Enter Gibson County.

43.0 Junction with State Route 57.

43.2 Abandoned strip mine on left (south) side of road is in Lower Millersburg coal.

46.2 Cross glacial boundary. The road has come thus far through an unglaciated area. For the next several miles cuts of Illinoian drift may be seen.

55.0 Junction with U. S. 41.

58.0 Windblown sand and loess of Wisconsin age exposed on small bluff just above Wabash River bottom. The valley is filled with as much as 180 feet of outwash gravel, sand, silt, and clay of Illinoian and Wisconsin ages.

65.9 Cross Wabash River; enter Illinois. End of postconference road log no. 4.