SEDIMENTATION AND STRATIGRAPHY OF THE DEVONIAN ROCKS OF SOUTHEASTERN INDIANA

Compiled by

HAYDN H. MURRAY

Indiana Department of Conservation

GEOLOGICAL SURVEY

Field Conference Guidebook No. 8

1955

STATE OF INDIANA
George N. Craig, Governor

DEPARTMENT OF CONSERVATION
Harley G. Hook, Director

GEOLOGICAL SURVEY
Charles F. Deiss, State Geologist
Bloomington

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Contributions by

T. A. Dawson
R. K. Leininger
Duncan J. McGregor
Haydn H. Murray
John B. Patton
William J. Wayne

CONFERENCE SPONSORED BY

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

September 30 to October 2, 1955

CONFERENCE COMMITTEE

Haydn H. Murray, Chairman; T. A. Dawson;
Duncan J. McGregor; William H. Moran;
John B. Patton; William J. Wayne;
and Gerald S. Woodard

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ILLUSTRATIONS

SEDIMENTATION AND STRATIGRAPHY OF THE DEVONIAN ROCKS OF SOUTHEASTERN INDIANA

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INTRODUCTION

This is the eighth in a series of field conferences sponsored jointly by the Indiana Geological Survey and the Department of Geology at Indiana University. During past conferences exposures of Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Pleistocene deposits have been visited and discussed. This conference is concerned primarily with the sedimentation and stratigraphy of the Devonian rocks that are exposed in southeastern Indiana (pl. 1). In addition, the conference participants will visit excellent localities for collecting fossils and minerals and will see exposures of particular interest to geologists studying the Pleistocene series.

Devonian rocks in southern Indiana have presented many problems of correlation; their stratigraphy has been studied during recent years by T. A. Dawson and John B. Patton (p. 37-43). General conditions of sedimentation of the Devonian rocks are reviewed in this guidebook by Haydn H. Murray (p. 43-46). Other aspects of the Devonian rocks and the general area of the conference also are discussed; these reports include geochemistry (R. K. Leininger, p. 53-67), economic geology (Duncan J. McGregor, p. 48-53), and the physiography and Pleistocene history (William J. Wayne, p. 46-48). Staff members of the Indiana Geological Survey and the Department of Geology, Indiana University, will talk briefly at each of the scheduled stops; they will review such aspects of the chemical composition, petrology, mineralogy, and stratigraphic nomenclature as are most applicable to the locality and exposure.

The stratigraphic sections included in this guidebook were measured by one or more of the following: T. A. Dawson, Dallas Fiandt, Duncan J. McGregor, John B. Patton, Thomas G. Perry, Arthur P. Pinsak, Ned M. Smith, and William J. Wayne. Photographs were taken by George R. Ringer, of the Indiana Geological Survey.

The Chairman wishes to express his sincere thanks to the members of the Field Conference Committee and to those members of the Indiana Geological Survey and of the Department of Geology, Indiana University, who contributed information and work to this conference. Thanks also are due to the officials of the various companies who have so generously allowed us to visit their facilities.

SUMMARY OF PROGRAM

A preconference tour through the Clifty Creek Power Plant, now under construction by the Indiana-Kentucky Electric Corporation, west of Madison on Indiana Highway 62, has been arranged for 2:30 p. m., Friday, September 30. Persons interested in this tour will assemble in the visitors' parking lot at the entrance to the power plant. The Clifty Creek Power Station will be the largest that has ever been built by private enterprise; it is expected to cost $175,000,000. The turbo-generators are the largest high-pressure units in operation anywhere. The three stacks are 682 feet above ground level; they are the tallest in the world.

Registration will begin at the conference headquarters in Clifty Inn at 4:30 p. m., Friday, September 30.

The conference will be opened at 8:00 p. m., Friday, September 30, with a welcoming address by Dr. Charles F. Deiss, State Geologist of Indiana and Chairman, Department of Geology, Indiana University. Brief talks on geologic features applicable to the thesis of the field conference will be presented. Mr. Donald Baird, of the Ohio Oil Company, will review broad aspects of the stratigraphy of Devonian rocks in the Eastern Interior Basin; Mr. T. A. Dawson, Head of the Petroleum

Section, Indiana Geological Survey, will discuss the stratigraphy of Devonian rocks of southeastern Indiana; Dr. Allan M. Gutstadt, Petroleum Section, Indiana Geological Survey, will present information on Devonian subsurface conditions in Indiana; Dr. Haydn H. Murray, Department of Geology, Indiana University, and the Indiana Geological Survey, will discuss sedimentation conditions in Indiana during Devonian time; and Dr. Erwin C. Stumm, University of Michigan, will present some regional aspects of Devonian paleontology. A brief discussion period will follow each talk. The remainder of the evening will be available for informal discussion among the conference participants.

Private transportation has been used during previous field conferences. Because of the large number of cars used during these conferences the exposures that were visited were determined by the availability of parking space. In order to permit conference participants to visit more inaccessible exposures, buses will be used for the field trip on Saturday. Private transportation will be used on Sunday.

Buses will be loaded for departure at 8:00 a. m. on Saturday, October 1. The buses will proceed to the first stop on Fourteen Mile Creek (pl. 2), where Ordovician, Silurian, and Devonian rocks can be seen. The buses then will proceed to the Falls of the Ohio River at Jeffersonville (pl. 2), where excellent exposures of Middle Devonian rocks can be observed. This classic area for paleontologic collecting will be covered with water in the near future when a new dam below the falls is completed.

After examining the section at the Falls of the Ohio River, the participants will travel to an abandoned quarry formerly operated by the Sellersburg Stone Company east of the town of Sellersburg (pl. 2). At this stop we shall see the Louisville limestone (Silurian) and the entire Devonian limestone section of extreme southern Indiana.

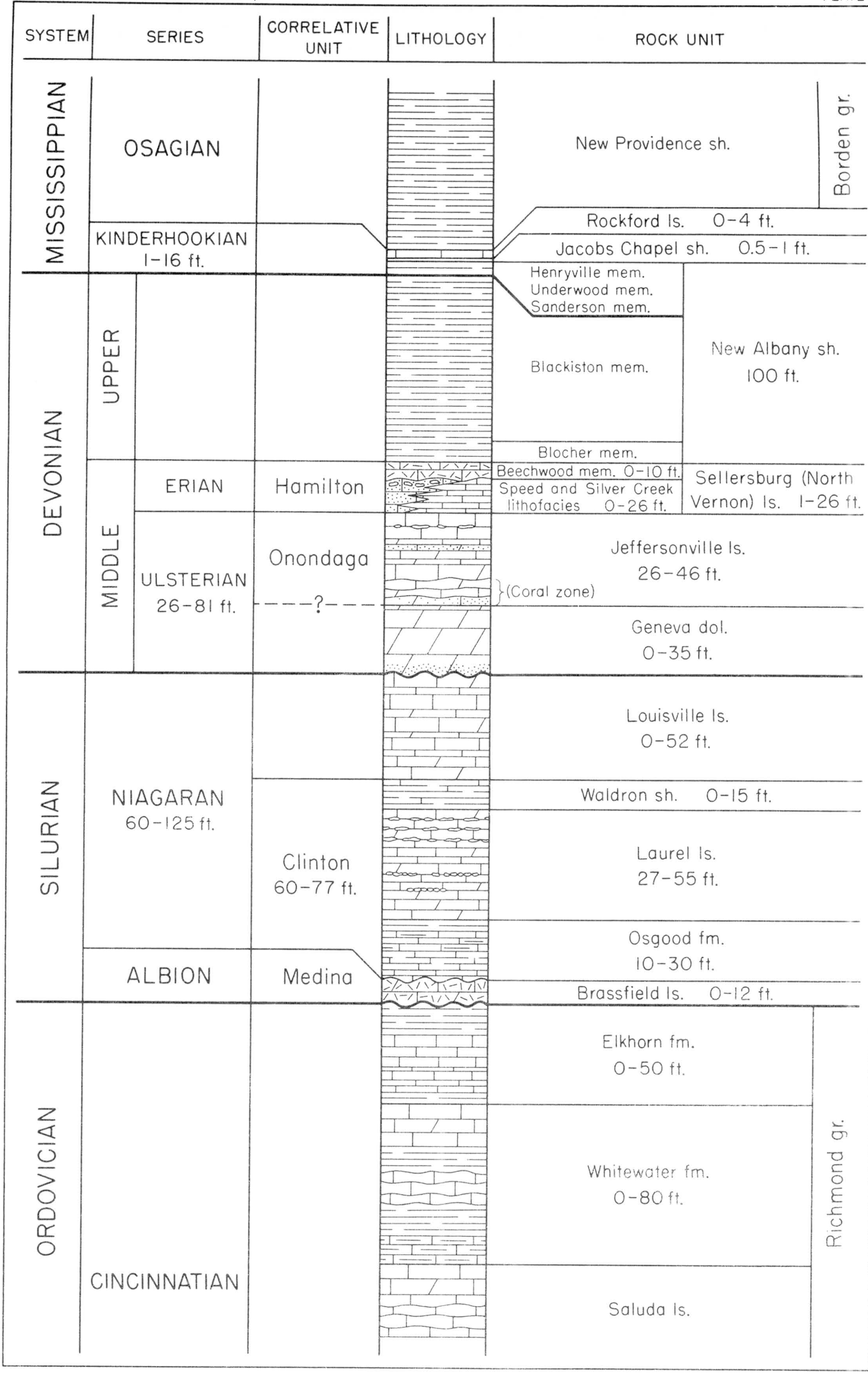
From this abandoned quarry the group will go to the Louisville Cement Company quarry (pl. 2). The group will enter this quarry through the entrance used by the Sellersburg Stone Company, which is quarrying in the floor of the large Louisville Cement Company quarry. This quarry will be the lunch stop. Picnic lunches will be brought to the conference participants. After lunch the group will examine some of the rocks in the quarry.

From the Louisville Cement Company quarry the participants will travel to Henryville, where weathered Rockford limestone (Mississippian) is exposed in a highway cut (pl. 2). The buses will proceed from this stop to the Scott County Stone Company quarry south of Blocher, where an excellent section of Devonian limestone is exposed (pl. 2). Here the participants can study the relationship between Devonian formations and also can see large colonial and horn corals in the coralline zone of the Jeffersonville limestone.

From this quarry the group will proceed to the Paul Frank quarry in North Vernon (pl. 2), which is the last stop of the day. An excellent exposure of New Albany shale is accessible in the quarry. The group then will return to Clifty Inn for dinner.

On Saturday night a program of short talks will be given. Mr. R. K. Leininger will discuss some geochemical aspects of Devonian rocks; Dr. John B. Patton will present information on the petrography of Devonian limestones and dolomites; Dr. Duncan J. McGregor will discuss some problems of economic geology in southeastern Indiana; Dr. William J. Wayne will present a brief discussion of problems concerning physiography and Pleistocene geology in southeastern Indiana; and Dr. J. J. Galloway will discuss Devonian stromatoporoids, which he has actively studied for the past decade.

On Sunday morning, October 2, the caravan (personal cars) will depart from the parking lot at Clifty Inn at 8:00 a. m. The first stop will be the Meshberger Stone Company quarry, southeast of Columbus, Ind., in Bartholomew County (pl. 2). Here the group will see the entire Devonian limestone section present in this area. The Geophysics Section of the Indiana Geological Survey will demonstrate making an electric log at this stop.



COMPOSITE STRATIGRAPHIC COLUMN OF SILURIAN, DEVONIAN, AND ADJACENT ROCKS IN SOUTHEASTERN INDIANA

Compiled by John B. Patton and Haydn H. Murray, 1955

An alternative first stop for those interested in seeing an unusual Pleistocene section will be the reservoir at Muscatatuck State School (pl. 2). This group will stay at this stop for 40 minutes and then will join the remainder of the conference participants at the Meshberger quarry.

The last stop will be the Cave Stone Company quarry in southern Shelby County (pl. 2). In the section at this quarry the laminated zone of the Jeffersonville is particularly striking, and the contact between the Geneva and Jeffersonville is indistinct.

After this exposure has been examined, the group will assemble at the cars. Brief remarks by Dr. Charles F. Deiss will formally conclude the conference.

ITINERARY

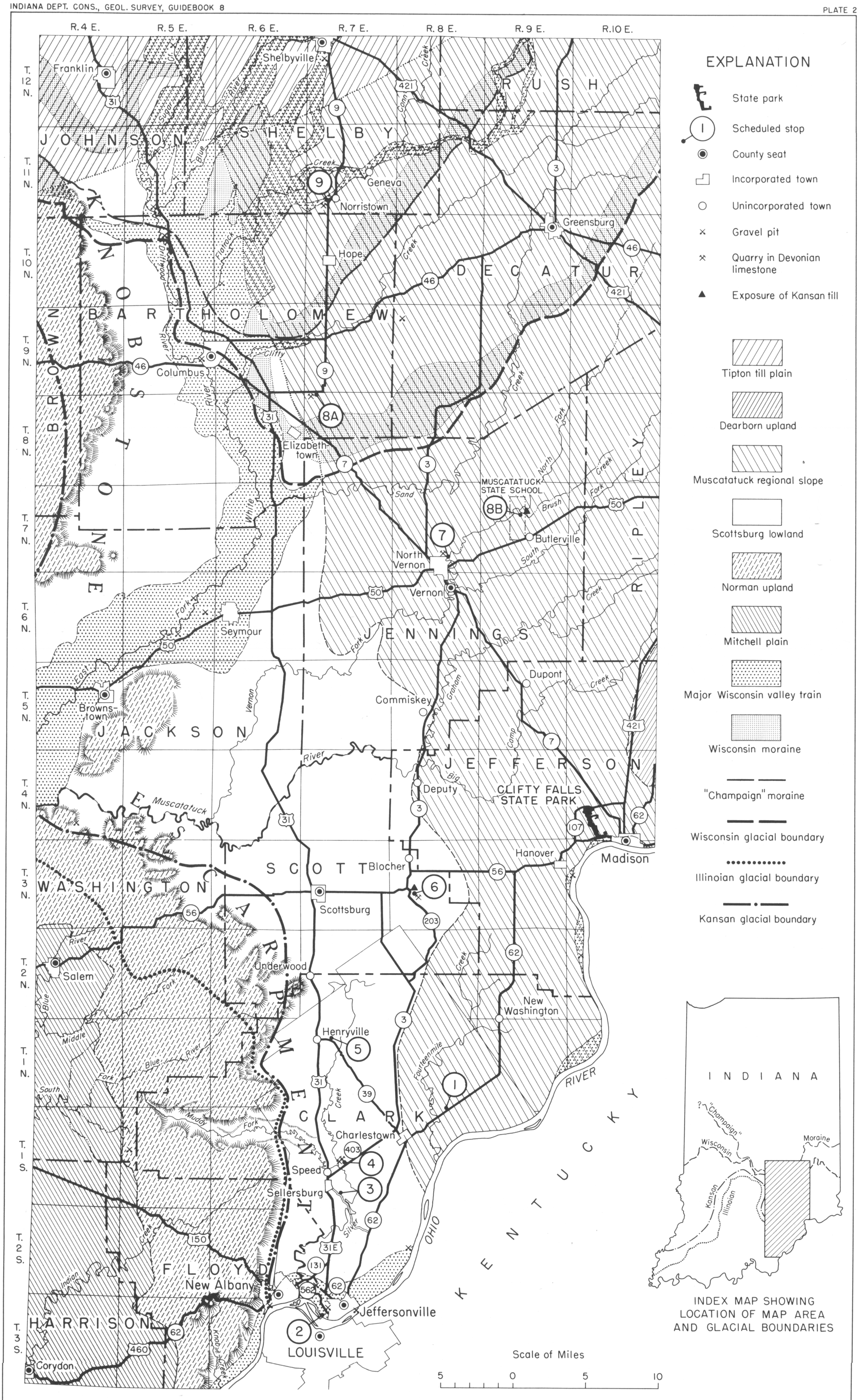
Saturday, October 1, 1955

Mileage between stops	
0.0	The group will load on buses which will be parked near Clifty Inn. Departure will be at 8:00 a. m.
0.2	The road descends through a stratigraphic section that includes the Laurel, Osgood, Brassfield, Saluda, Liberty, and Waynesville formations.
0.9	Road junction with Indiana Highways 56 and 62 at the south entrance to Clifty Falls State Park. Turn right (west).
1.4	Entrance to new power plant of Indiana-Kentucky Electric Corporation on left.
1. 5	Cross Clifty Creek.
1.7	Pass through a low cut in the Waynesville formation.
1.9	Another cut in the Waynesville.
2.0	View to left of the “Hog Trough,” an abandoned valley separated from the Ohio Valley by a ridge called “Devil’s Backbone.”
2. 1	A cut on the right in the Waynesville.
2.4	Long road cut in which the exposures range from Liberty to Laurel.
2.9	Junction with Indiana Highway 256. Bear left at Y intersection on Highways 56 and 62.
3. 1	Junction with Indiana Highway 107. Continue on 56 and 62. The buses now have ascended from the Ohio Valley and are on the Muscatatuck regional slope.
4.0	Entrance to Hanover College on left.
4.7	Pass road to left that goes into town of Hanover. Leave Madison West quadrangle.

Mileage between stops	
7.9	Exposure of Devonian limestone (Sellersburg, Speed facies) in barn lot and low road cut on right.
8.1	Exposure of Speed facies and Beechwood member of Sellersburg over lain by basal New Albany shale in low road cut on left.
8.2	Junction of Highways 56 and 62. Turn left and continue on 62.
8.5	Junction with Highway 356; continue on 62.
8.7	Abandoned quarry on left. Section includes Speed and Silver Creek facies and Beechwood member of the Sellersburg formation and New Albany shale.
11.6	The very flat, poorly drained topography in this area, called "slash--land," is the upper surface of a thin Illinoian till.
12.2	North limits of Chelsea.
15.4	Junction with Highway 362; continue on 62.
17.6	New Washington Rest Park.
18.2	North limits of New Washington.
25.3	Exposure of Louisville limestone in stream bank on right.
26.4	Pass through a low cut in the Jeffersonville limestone. The exposure is mostly the basal coralline zone but also includes about 3 feet of over lying beds. Weathered lllinoian till is exposed on the south side of road.
27.2	Passengers will disembark at the upper end of a lengthy exposure which may be seen by walking 0. 4 mile down a gentle grade.

STOP 1. Fourteen Mile Creek.--Time: 30 minutes. Location: Road cut on Indiana Highway 62, southeast side of Grant 121, T. 1 S., R. 8 E., Clark County, 3 miles northeast of Charlestown (Owen quadrangle). The measured section is listed below. (Seep. 57 for chemical and spectrographic analyses of samples from this stop.)

SILURIAN		Feet
Louisville limestone		
10.	Limestone: Gray-tan, finely crystalline, dolomitic; contains calcite masses. Weathers to honeycomb surface	18.0
9.	Dolomite: Gray to buff, finely crystalline, massive, porous	20.0
8.	Limestone: Gray (buff where weathered), finely crystalline, bedded, dolomitic; contains calcite masses	14.0
	Total exposed thickness of Louisville limestone	52.0



Base modified from Indiana Transportation Map (1947), U.S. Department of Commerce, Bureau of Public Roads.

MAP OF FIELD CONFERENCE AREA SHOWING ROUTE, GEOMORPHOLOGY, AND PITS AND QUARRIES

Compiled by William J. Wayne and Duncan J. McGregor from original sources and published works by Leverett and Taylor (1915), Malott (1922), Thornbury (1937), and Thornbury (in preparation).

		Feet
	Waldron shale	
7.	Shale: Light-gray; consists mostly of clay	12.5
	Laurel limestone	
6.	Limestone: Gray to buff (reddish where weathered), finely crystalline, dolomitic, cherty, vuggy	27.0
	Osgood formation	
5.	Shale: Gray, weathered to yellow	2.3
4.	Limestone: Gray to buff, finely crystalline, dolomitic, argillaceous	5.8
3.	Shale and limestone: Gray dolomitic shale and argillaceous limestone	10.3
	Total thickness of Osgood formation	18.4
	ORDOVICIAN	
	Saluda limestone	
2.	Dolomite: Gray to buff, mottled, finely crystalline; weathers to reddish surface; argillaceous	1.3
1.	Dolomite: Gray to buff, mottled, finely crystalline, argillaceous, thick-bedded	10.8
	Total exposed thickness of Saluda limestone	12.1
	Total thickness of measured section	122.0

This is the only exposure where the participants will be able to see a complete Silurian section. The Osgood at this locality is very argillaceous, but to the north and east it is more calcareous. An interesting feature of the Louisville limestone, which is the top of the Silurian in this area, is that it somewhat resembles the Geneva dolomite, which will be discussed at later stops.

Mileage between stops	
0.0	Check mileage at Fourteen Mile Creek. On north side of road are exposures of stratified lacustrine silts and clays of Wisconsin age that underlie the terraces of Fourteen Mile Creek.
0.6	Enter Charlestown quadrangle.
0.8	Pass through exposure of Saluda.
1.2	Pass through a long exposure which ranges from Upper Ordovician to Louisville limestone.
2.2	Pass through exposure of basal Jeffersonville and Louisville.
2.5	East limits of Charlestown.

Mileage between stops	
3.0	Junction with Indiana Highway 3. Continue on Highway 62, which here becomes a four-lane road. This point is part of the crest of the divide between Fourteen Mile Creek and Silver Creek and is the place designated by Malott (1922, p. 86) as the boundary between the physiographic units called the Muscatatuck regional slope and the Scottsburg lowland.
3.1	Administration building of Indiana Ordnance Works on left.
5.5	Indiana State Police Post on right.
11.3	Low cut on left exposes soil developed on Illinoian till. Note the zone of siliceous pebbles about 4 feet below the surface.
13.5	East limits of Jeffersonville.
15.6	Junction with U. S. Highway 31E. Angle left on 31E and follow as far as the approach to the Municipal Bridge.
15.8	Turn right at overhead railroad trestle.
16.0	Turn left.
16.3	Highways 31E and 460 veer left at the approach to the Municipal Bridge. Keep right on Missouri Avenue to West Market Street at river. Enter New Albany quadrangle.
16.5	Turn right on West Market Street and immediately pass through floodwall; then angle to right on Riverside Drive.
17.0	Buses will park on left side of road just east of the railroad bridge.

STOP 2. Falls of the Ohio River. --Time: 45 minutes. Location: Along north shore of the Ohio River near Dam No. 41. The exposure is along the southwest edge of Jeffersonville (New Albany quadrangle).

The following section measured at the Falls of the Ohio River is a composite of exposures that extend from 1 mile downstream up to the bridge.

	DEVONIAN	Feet
	Sellersburg limestone	
4.	Limestone: Light-gray, crystalline, fossiliferous; contains phosphate pebbles (Beechwood member)	4.5
3.	Limestone: Gray, argillaceous; has conchoidal fracture (Silver Creek facies)	15.0
	Total exposed thickness of Sellersburg limestone	19.5
	Jeffersonville limestone	
2.	Limestone: Gray, fossiliferous, cherty	15.0

		Feet
1.	Limestone: Brown, crystalline; contains small amount of chert (coralline zone)	12.0
	Total exposed thickness of Jeffersonville limestone	27.0
	Total thickness of measured section	46.5

Prior to the last glaciation, the Ohio River flowed through a somewhat different course at this place. The bottom of the bedrock valley of the Ohio River passes directly beneath Louisville, Ky. As a result of aggradation, probably by valley train deposits of Wisconsin age, the river overlay a bedrock spur when post-Wisconsin entrenchment began (Rorabaugh, Schrader, and Laird, 1953, p. 2 and pl. 1).

An excellent Devonian section is exposed at low water in the river bed and along the north bank. Note the many potholes caused by differential solution in the limestone and dolomite. Many of these potholes contain rounded mudballs. This stop affords the paleontologist an excellent opportunity to see specimens in the Jeffersonville formation. Fossils which have been found at this locality (Campbell, 1942, p. 1058-1060) include:

CORALLINE ZONE

Brachiopoda

Meristella nasuta
Spirifer divaricatus
Stropheodonta demissa
Strophonella ampla

Gastropoda

Platyceras compressum
Platyceras conic um

Pelecypoda

Conocaridum cuneus

Trilobites

Dalmanites anchiops
Proetus crassimarginatus

Corals

Acrophyllum oneidaense
Blothrophyllum descorticum
Cyathophyllum rugosum
Favosites emmonsi
Favosites hemisphericus
Favosites limitarus
Favosites tuberosus
Heliophyllum halli
Heliophyllum exiguum
Synaptophyllum stramineum
Syringopora perelegans
Zaphrentis compressum
Zaphrentis ungula

SPIRIFER GREGARIUS ZONE

Brachiopoda

Spirifer gregarius

Gastropoda

Bellerophon pelops
Euomphalus decewi
Turbo shumardi

Corals

Blothrophyllum promissum
Heliophyllum conniculum

Pelecypoda

Paracyclas elliptica

SPIRIFER ACUMINATUS ZONE

Brachiopoda

Athyris spiriferoides
Atrypa reticularis
Atrypa spinosa
Chonetes mucronatus
Leptostrophia perplana
Nucleospira conciana
Pentamerella paviliomensis
Philhedra cremistra
Pholidestrophia iowaensis
Productella spinulicosta
Rhipidomella vanuxemi
Schizophoria striatula
Spirifer acuminatus
Spirifer duodenarius
Spirifer grieri
Spirifer concava

Corals

Aulacophyllum sulcatum
Prismatophyllum davidsoni
Striatopora alba

Gastropoda

Platyceras dumosum
Platyceras thetis
Ptomatis patulus

Pelecypoda

Aviculopecten princeps

Trilobites

Phacops rana

Bryozoa, ostracodes, and stromatoporoids also have been described from this locality.

Mileage between stops	
0.0	Parking area just east of railroad bridge.
0.1	Immediately after passing under railroad bridge, turn right and go over the floodwall on Sherwood Avenue.
0.4	Turn right on Montgomery Avenue.
0.5	Junction with Indiana Highway 562. Turn left on 562 (Clark Boulevard).
1.2	Turn right.
1.3	Turn left (Randolph Avenue).
1.5	Turn left (Francis Avenue).
1.7	Turn right (Clark Boulevard).
2.9	Junction with Highway 62; turn right on 62.
3.5	Junction with Highway 131; go straight ahead on 131.
4.7	Junction with Highway 31E; turn left on 31E.
5.5	Enter Jeffersonville quadrangle.

Mileage between stops	
6.7	South limits of Cementville.
6.9	Junction with Indiana Highway 60. Continue on 31E.
7.6	Cross Silver Creek.
9.4	Enter Speed quadrangle.
9.8	South limits of Sellersburg.
10.2	Junction with Highway 31W. Continue on 31 into Sellersburg.
10.5	Stop light. Turn right (east) on East Utica Street and go through Sellersburg.
10.6	Stop light at New Albany Street in Sellersburg.
11.0	Cross double railroad tracks; enter Charlestown quadrangle.
11.1	Cross single railroad track.
11.7	Entrance to abandoned quarry formerly operated by Sellersburg Stone Company. Depart from buses.

STOP 3. Abandoned quarry, Sellersburg Stone Company. --Time: 40 minutes. Location: SE½W¼ Grant 90, Clark Military Survey, near east edge of Sellersburg in Clark County (Charlestown quadrangle).

	QUATERNARY	Feet
20.	Clay: Medium-grayish-brown, slightly mottled, "ghost-pebbles"; contains minor amount of silty sand	6.0
19.	Silt: Orange-brown, clayey; contains minor amount of sand and some highly weathered pebbles of chert, shale, and quartzite; MnO_2 coatings present on aggregates of clayey silt	3.0
18.	Clay: Dark-brown, blocky; contains chert and well preserved silicified brachiopods and corals	3.0
	Total thickness of Quaternary	12.0
	DEVONIAN	
	New Albany shale	
17.	Shale: Black, fissile, carbonaceous	5.0
	Sellersburg limestone	
16.	Limestone: Gray, crystalline, fossiliferous (Beechwood member)	3.8

		Feet
15.	Limestone: Gray, crystalline, fossiliferous; contains abundant phosphate nodules (Silver Creek facies?)	0.2
14.	Limestone: Gray, argillaceous, dolomitic, fossiliferous; fractures conchoidally (Silver Creek facies)	5.5
13.	Limestone: Gray, crystalline, argillaceous, dolomitic, fossiliferous. Weathers to thin chips and plates (Speed facies?)[1]	1.0
12.	Limestone: Gray, argillaceous, dolomitic, fossiliferous; fractures conchoidally (Silver Creek facies)	9.1
I1.	Limestone: Gray, crystalline, argillaceous, fossiliferous, laminated. Weathers to thin chips and plates (Speed facies)	<u>1.8</u>
	Total thickness of Sellersburg limestone	21.4
	<u>Jeffersonville limestone</u>	
10.	Limestone: Tan, crystalline, massive, fossiliferous	5.6
9.	Limestone: Same description as above unit	5.6
8.	Limestone: Gray to tan, dense, fossiliferous	2.3
7.	Limestone: Brown, coarsely crystalline, fossiliferous	0.6
6.	Limestone: Blue-gray to tan, dense	2.8
5.	Limestone: Brown and gray, dense to crystalline	4.7
4.	Limestone: Brown, dark, coralline (coralline zone)	<u>10.0</u>
	Total thickness of Jeffersonville limestone	31.6
	SILURIAN	
	<u>Louisville limestone</u>	
3.	Limestone: Gray to tan, dolomitic, thin-bedded, rubbly; contains <u>Halysites</u>	6.2
2.	Limestone: Gray, dense, argillaceous	<u>5.1</u>
	Total exposed thickness of Louisville limestone	<u>11.3</u>
	Total thickness of measured section	81.3
1.	Limestone: Gray to tan, dense, dolomitic, argillaceous. (Now under water; sampled in 1947 when quarry was active.)	11.1

[1] Lithology resembles Speed facies, but chemical composition (p. 58) is intermediate between Speed and Silver Creek.

Sellersburg is in the western part of the Scottsburg lowland, a physiographic region named by Malott. (See p. 46 of this guidebook.) The Knobstone escarpment which forms the western boundary of the province can be seen 4 miles to the west.

Unconsolidated materials at the top of the quarry have been derived from weathering of till and Devonian limestone. The degree of weathering on the till is considerably greater than that ordinarily observed on Illinoian tills in southeastern Indiana. (See p. 58 for chemical and spectrographic analyses of the limestone section.)

Four tunnels were driven into the Silver Creek in the hanging wall of the quarry, and the rocks that had been removed were used for natural cement. (See p. 52.) This stop affords the group an excellent opportunity to see the entire Devonian limestone section (pl. 3) in its southernmost outcrop area of Indiana. The Silver Creek and Speed lithologies which are discussed by John B. Patton and T. A. Dawson (p. 40-41) are both exposed in this quarry. At the base of the Beechwood member is a zone of phosphate nodules (p. 45), which are composed of carbonate-apatite as established by X-ray diffraction by Haydn H. Murray. The quarry was abandoned in January 1951.

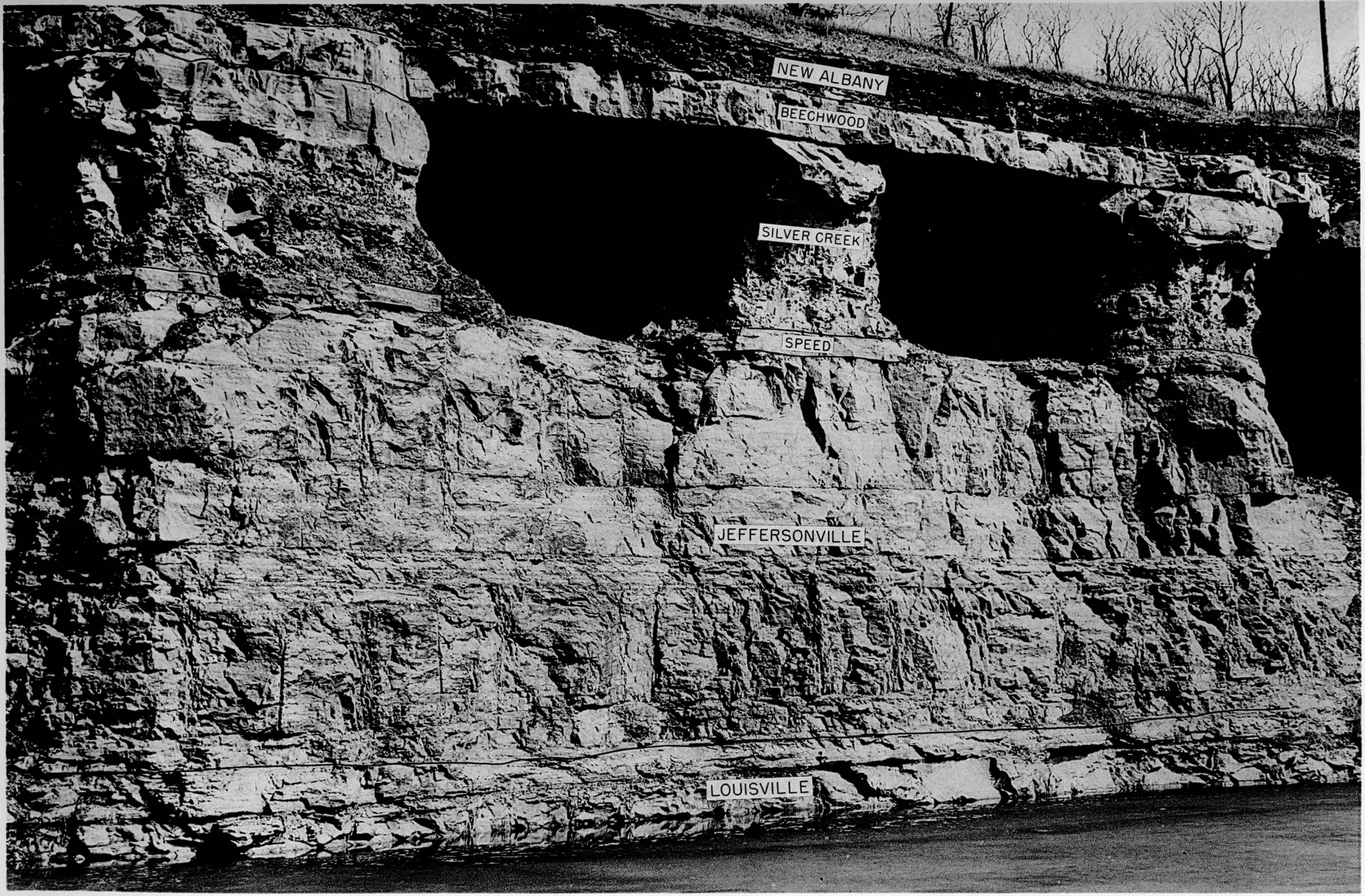
Mileage between stops	
0.0	Entry gate of abandoned quarry formerly operated by Sellersburg Stone Company. Turn right toward Highway 31 in Sellersburg.
0.7	Cross double-track railroad; enter Speed quadrangle.
1.2	Second stop light and junction with Highway 31. Turn right (north).
1.6	Junction with Highway 403. Turn right on 403 and cross double railroad track.
1.9	Enter Charlestown quadrangle; Louisville Cement Company plant on left.
2.6	Cross Silver Creek.
3.2	Entrance to the Sellersburg Stone Company operation in floor of the Louisville Cement Company quarry. Turn left into quarry.
3.8	Park in floor of quarry. LUNCH.

STOP 4. Louisville Cement Company quarry. --Time: 45 minutes. Location: Grant 132 and the southwestern part of Grant 131, Clark Military Survey, 1.0 mile northeast of Speed, in Clark County (Charlestown quadrangle).

		Feet
	DEVONIAN	
	New Albany shale	
14.	Shale: Black, fissile	5.0
	Sellersburg limestone	
13.	Limestone: Gray, crystalline, fossiliferous (Beechwood member)	3.1

		Feet
12.	Limestone: Blue-gray, drab, argillaceous, dolomitic, fossiliferous; has conchoidal fracture (Silver Creek facies)	7.8
11.	Limestone: Lithology same as unit 12 (Silver Creek facies)	6.1
10.	Limestone: Blue-gray, crystalline, fossiliferous. A brown, shaly, highly weathered zone, 0.3 foot thick, lies 0.6 foot above the base (Speed facies)	4.4
	Total thickness of Sellersburg limestone	21.4
	Jeffersonville limestone	
9.	Limestone: Brown, mostly dense, crystalline in upper 0.2 foot	1.1
8.	Limestone: Tan, crystalline, fossiliferous	11.2
7.	Limestone: Gray, crystalline, fossiliferous; bounded by stylolite at the top and a pronounced bedding plane at the bottom. Contains scattered horn corals	1.8
6.	Limestone: Gray, dense, fossiliferous	6.8
5.	Limestone: Brown, dense; contains scattered large horn corals	5.8
4.	Limestone: Brown, shelly, thin-bedded; contains abundant corals	1.2
3.	Limestone: Brown, dense; contains scattered corals	4.1
2.	Limestone: Light-brown, crystalline, thin-bedded; contains abundant horn corals	3.7
	Total thickness of Jeffersonville limestone	35.7
	SILURIAN	
	Louisville limestone	
1.	Limestone: Light-gray, crystalline, slightly argillaceous. Contains Halysites	3.5
	Total exposed thickness of Louisville limestone	3.5
	Total thickness of measured section	65.6

The Silver Creekfacies of the Sellersburg formation is used for making Brixment, a natural cement, and is quarried separately from the underlying limestone, which is used for portland cement, aggregate, and agricultural limestone. (See p. 52.) The Louisville Cement Company quarries the entire Devonian limestone section except the lower 3.4 to 4.0 feet of Jeffersonville. This 3.5 feet and an additional 3.5 feet of Louisville limestone (Silurian) are quarried by the Sellersburg Stone Company. (See p. 59 for chemical and spectrographic analyses of the limestone section.)



NORTH WALL OF ABANDONED SELLERSBURG QUARRY

Mileage between stops	
0.0	Entrance to Louisville Cement Company plant along Highway 31. Turn right (north).
1.7	Pass exposure of New Albany shale.
5.0	South limits of Memphis.
6.4	Cross Blue Lick Creek; enter Henryville quadrangle.
8.9	Exposure of New Albany shale on left.
9.0	South limits of Henryville.
9.2	Junction with Indiana Highway 160.
9.3	Junction with Indiana Highway 39; turn right on 39.
9.4	Cross Pennsylvania Railroad tracks.
9.6	Road cut on Highway 39.

STOP 5. Exposure of Rockford limestone.--Time: 10 minutes. Location: NE¼W¼ Grant 255, Clark Military Survey, 0.2 mile southeast of Henryville, Clark County (Henryville quadrangle).

MISSISSIPPIAN	Feet
New Providence shale	
4. Shale: Gray, soft	covered
Rockford limestone	
3. Limestone: Gray, mottled (weathered reddish brown), dense, crystalline, ferruginous, argillaceous; contains few fossils	2.5
Jacobs Chapel shale	
2. Shale: Grayish-green, soft	0.5
New Albany shale	
1. Shale: Black, fissile	16.0
Total thickness of measured section	19.0

Although the Rockford is not Devonian, the conference committee thought that this was a worthwhile stop because most participants of the conference have never seen a Rockford exposure.

The Rockford limestone is a good subsurface marker because it is thin and persistent although not universally present.

The Knobstone escarpment can be seen about 2.5 miles to the west. It forms the boundary between the Norman upland and the Scottsburg lowland and was an effective barrier to the glacier that covered the lowland.

The results of chemical and spectrographic analysis of the Rockford limestone are shown on page 60. The sample analyzed was taken from a site 2.5 miles southeast of this exposure on Indiana Highway 39, where the Rockford is less weathered than at Stop 5.

The name Rockford, taken from a village on the East Fork of White River, in northeastern Jackson County, Ind., was apparently in common use for a number of years before it found its way into print. It was never formally proposed. Wilmarth (1938, p. 1828) credited the name to Meek and Worthen (1861, p. 167-177), but Comings (1922, p. 486) said that Owen and Norwood (1847) were apparently the first to publish it. The formation rests upon the New Albany shale and underlies the New Providence shale. For many years the Rockford limestone was regarded as the sole representative of the Kinderhookian series of Lower Mississippian rocks in Indiana. However, the underlying New Albany shale came to be regarded as transitional between Devonian and Mississippian, and ample paleontologic evidence to show that at least the upper 11 feet are Kinderhookian has been presented by Campbell (1946, p. 847-855), who also (1946, p. 855-856) gave the name Jacobs Chapel shale to a bed of bluish-green clay shale less than 1 foot thick that underlies the Rockford limestone and overlies the New Albany shale.

Mileage between stops	
0.0	Exposure of Rockford limestone. Retrace route to Henryville.
0.3	Junction with Highway 31; turn right (north).
0.6	North limits of Henryville.
1.1	Entrance to Clark State Forest and nursery.
3.4	Cut exposes glacial drift.
4.0	Note the impressive view to the left of the Knobstone escarpment, which stands 1 mile to the west.
4.5	South limits of Underwood.
5.0	Leave Clark County and enter Scott County.
5.1	Exposure of weathered glacial gravel in ditch 300 feet west of highway.
5.7	Pigeon Roost Memorial.
6.3	Cross Pigeon Roost Creek.
8.0	Junction with Indiana Highway 356. Continue on 31.
10.0	South limits of Scottsburg.
10.6	Stop light; junction with Indiana Highway 56. Turn right (east).
11.4	East limits of Scottsburg.
11.8	This locality is the type area for the Scottsburg lowland.

Mileage between stops

13.4 Till exposed in road cut.

14.3 Junction with Indiana Highway 203; continue on 56.

15.3 Junction with Indiana Highway 3; continue on 56.

17.2 Junction with Highway 203; turn right on 203.

17.3 Entrance to Scott County Stone Company quarry.

STOP 6. Scott County Stone Company quarry. --Time: 50 minutes. Location: NE¼NW¼ sec. 20, T. 3 N., R. 8 E., 2 miles south of Blocher, in Scott County.

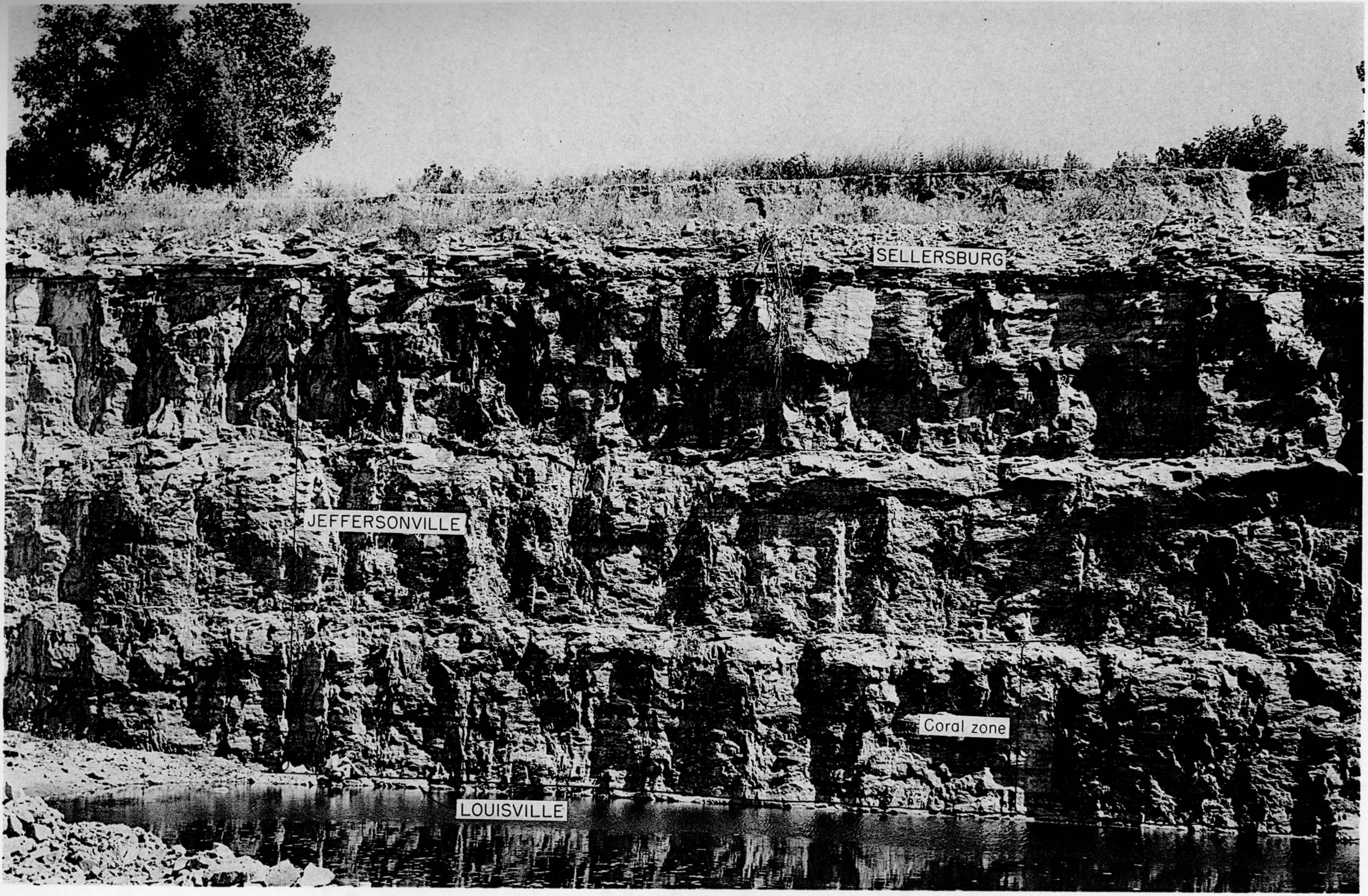
		Feet
QUATERNARY		
	Illinoian	
20.	Silt: Brownish-yellow, sandy	3.0
19.	Gravel: Brownish-yellow, clay-rich, noncalcareous	6.0
18.	Till: Brown, clayey, noncalcareous	5.0
17.	Till: Brown, clayey, calcareous; contains a few thin gravel lenses and scattered wood fragments	3.0
16.	Gravel: Brown, muddy, calcareous	1.0
15.	Till: Medium-greenish-gray to dark-gray, brown along joints, calcareous; wood fragments abundant	5.6
	Total Illinoian	23.6
	Kansan	
14.	Till: Dark-greenish-gray, reddish-brown along joints, stony, sandy, silty, very compact, noncalcareous; siliceous pebbles abundant	7.0
13.	Till: Covered	7.0
	Total Kansan	14.0
	Total Quaternary	37.6
DEVONIAN		
	Sellersburg limestone	
12.	Limestone: Light-gray, crystalline, dolomitic, fossiliferous (Beechwood member)	4.9
11.	Limestone: Gray, drab, argillaceous, dolomitic; has conchoidal fracture (Silver Creek facies)	0.8

		Feet
10.	Limestone: Gray, finely crystalline, massive, dolomitic, fossiliferous (Speed facies)	3.8
9.	Limestone: Gray-blue, dense to crystalline, very fossiliferous, laminated (Speed facies)	9.2
	Total thickness of Sellersburg limestone	18.7
	Jeffersonville limestone	
8.	Limestone: White to light-tan, massive, dolomitic, fossiliferous, hard	8.0
7.	Limestone: Brown, crystalline, dolomitic, porous, fossiliferous, hard; contains chert nodules in lower 1.4 feet	11.1
6.	Limestone: Brown, granular; contains chert nodules	1.5
5.	Chert: White and brown	0.4
4.	Limestone: Brown, dense, banded, hard	9.2
3.	Limestone: Tan, hard, dolomitic; contains lenticular masses of dense brown limestone	2.8
2.	Limestone: Brown, dense, dolomitic; contains abundant horn corals. Becomes more dolomitic toward the base	7.0
	Total thickness of Jeffersonville limestone	40.0
	SILURIAN	
	Louisville limestone	
1.	Limestone: Gray, granular, dolomitic, stylolitic, fossiliferous. Exhibits sharp color contrast with overlying Jeffersonville	2.8
	Total exposed thickness of Louisville limestone	2.8
	Total thickness of measured section	99.1

Of special interest at this stop are the large horn corals and colonial corals that are found in the coralline zone of the Jeffersonville formation (pl. 4). Also note the numerous stylolites parallel to the bedding planes. The upper part of the Jeffersonville contains many chert masses. The Speed facies is 13 feet thick at this quarry, and the Silver Creek facies is 0.9 foot thick; this is roughly the reverse of the thickness ratio at the abandoned Sellersburg Stone Company quarry.

At the top of the quarry beneath a thick section of Illinoian drift is probably the most convincing exposure of weathered till of Kansan age that has yet been discovered in southeastern Indiana. This Illinoian till contains abundant wood fragments. The upper surface is a valley-train terrace and is underlain by a few feet of weathered gravel.

(See p. 61 for chemical and spectrographic analyses of samples of the limestone section.)



SOUTH WALL OF SCOTT COUNTY STONE COMPANY QUARRY

Mileage between stops	
0.0	Entrance to Scott County Stone Company quarry. Turn right.
0.1	Junction of Highway 203 with Highways 3 and 56. Turn right on 3 and 56.
0.8	Morgan Trail Rest Park.
1.3	Junction with Highway 56. Stay straight ahead on 3.
1.9	South limits of Blocher.
3.0	Leave Scott County and enter Jefferson County.
3.5	Junction with Highway 256. Stay on 3.
5.6	Pass exposure of New Albany shale in low road cut. Note the change of color where it is weathered. (It is known as the "cinnamon shale" in some areas.)
7.2	Road cuts expose weathered till.
7.5	South limits of Deputy. This is the approximate position of the transitional boundary between the Scottsburg lowland and the Muscatatuck regional slope (pl. 2). (Seep. 68 for Graham section.)
8.8	Cross Graham Creek. Note terraces which are underlain by outwash.
9.0	Pass through a cut that exposes the Spirifer acuminatus beds, the Speed lithology, a few thin beds of Silver Creek lithology, and the Beechwood (may be top of Beechwood but New Albany shale not exposed).
9.8	Leave Jefferson County and enter Jennings County.
9.9	Cross Graham Creek; note terraces.
11.7	Exposure of New Albany shale in cut.
12.0	Note soil profile developed on till in road cuts.
12.5	County road that leads west to Commiskey. Abandoned quarry 100 feet on right of highway. (See Addenda, p. 69, for Commiskeyquarry section.)
18.1	New Albany exposed in cut.
18.6	New Albany exposed in cut.
19.5	New Albany exposed in cut.
19.8	New Albany exposed in cut.
19.9	Spirifer acuminatus zone exposed on right in cut.

Mileage between stops	
20.6	Exposure of Speed and Jeffersonville.
20.7	Exposure of upper Jeffersonville on right.
21.0	Exposure of New Albany underlain by Beechwood on right.
21.05	Exposure of Speed lithology underlain in turn by Spirifer acuminatus beds, laminated beds, and coralline zone of Jeffersonville on right in cut.
21.1	Junction of Highways 3 and 7. Turn left on 7.
21.4	Cross Muscatatuck River.
21.5	East limits of Vernon.
22.3	Entrance to Muscatatuck State Game Farm.
22.7	East limits of North Vernon.
23.4	Junction with U. S. Highway 50. Turn right (Walnut Street).
23.6	Cross railroad tracks and angle left off Walnut Street on 5th Street.
23.7	Cross Baltimore and Ohio Railroad tracks.
24.0	Entrance to Paul Frank quarry.

STOP 7. Paul Frank quarry. --Time: 50 minutes. Location: NE¼ sec. 34, T. 7 N., R. 8 E., on the northeast edge of North Vernon, Jennings County.

The Devonian limestone is overlain by as much as 45.0 feet of New Albany shale at this quarry (pl. 5). (See p. 62 for chemical analysis of New Albany shale and chemical and spectrographic analyses of limestone section.)

	QUATERNARY	Feet
24.	Silt: Pale-grayish-brown, mottled with gray, browner in upper part, clayey, sandy	2.5
23.	Clay: Light-yellow-brown, pebbly, noncalcareous	1.5
22.	Till: Pale-gray, mottled with orange-brown, clayey, sandy, noncalcareous	2.0
21.	Till: Yellow-brown, clayey, sandy, noncalcareous	2.0
20.	Clay: Light-yellowish-gray, sandy, noncalcareous; only locally present	0.5
19.	Till: Reddish-brown, silty, sandy, noncalcareous	0.5

NORTHEAST WALL OF PAUL FRANK QUARRY

		Feet
18.	Till: Reddish-brown, silty, sandy, calcareous; this unit and the one above constitute a lenticular bed that is locally absent in the section	1.0
17.	Till: Yellow-brown, sandy, silty, and bouldery, very calcareous, hard and compact; locally lower part of unit is covered with slump	7.5
16.	Gravel: Yellow-brown, clayey, compact, noncalcareous; local	0.5
	Total thickness of Quaternary	18.0

DEVONIAN

New Albany shale

15.	Shale: Dark-gray to black, tough, platy; has bituminous odor	7.4
14.	Shale: Gray and greenish-gray, soft, platy	20.4
13.	Shale: Black, platy, brittle	11.2
	Total thickness of New Albany shale	39.0

North Vernon limestone

12.	Limestone: Gray, coarsely crystalline, massive, crinoidal, hard (Beechwood member)	3.4
11.	Limestone: Gray, argillaceous, dolomitic, platy; contains thin partings of dark-gray shale (Silver Creek facies?)	0.2
10.	Limestone: Blue-gray, crystalline, dolomitic, fossiliferous, hard (Speed facies)	3.0
	Total thickness of North Vernon limestone	6.6

Jeffersonville limestone

9.	Limestone: Tan, crystalline, massive, dolomitic, fossiliferous; contains chert nodules and lenticular seams of chert as much as 0. 4 foot thick (Spirifer acuminatus zone)	5.9
8.	Limestone: Brown, massive, dolomitic, obscurely laminated	4.45
7.	Limestone: White to tan, chalky, dolomitic; contains scattered calcite crystals	6.3
6.	Limestone: Tan and brown, massive, dolomitic, laminated	5.4

		Feet
5.	Limestone: Tan to brown, granular, massive, dolomitic; contains small white calcite masses and scattered cup corals (coralline zone)	5.6
	Total thickness of Jeffersonville limestone	27.65
	Geneva dolomite	
4.	Dolomite: Medium-brown, granular; vugs and cavities generally elongate parallel to bedding and contain masses of calcite	3.1
3.	Dolomite: Light-tan-brown, saccharoidal, massive; concentrically zoned chert nodules as much as 1 foot in diameter scattered irregularly along base of unit	6.3
2.	Dolomite: Chocolate-brown, dense to finely granular, massive; contains scattered small cavities; breaks with hackly fracture	1.7
1.	Dolomite: Light-tan-brown, finely granular, hard; irregularly bedded; has minor small cavities	0.8
	Total exposed thickness of Geneva dolomite	11.9
	Total thickness of measured section	103.15

Mileage between stops	
0.0	Entrance to Paul Frank quarry. Retrace route to Highway 7 and begin return trip to Clifty Inn.
0.5	Angle right on Walnut Street (Highway 50) from 5th Street.
0.7	Junction with Highway 7. Turn left on 7 and stay on 7 to Madison.
2.1	West limits of Vernon.
2.8	Junction of Highways 3 and 7. Bear left on 7.
7.3	Cross Graham Creek.
10.6	North limits of Dupont.
17.4	North limits of Midway.
18.1	North limits of Wirt.
21.4	North limits of Madison.
21.6	Junction with Highway 107. Turn right on 107.
22.8	North entrance to Clifty Falls State Park. Turn left into Park.
26.9	Parking area, Clifty Inn.

Sunday, October 2, 1955

Mileage between stops	
0.0	The caravan will assemble on the parking lot at Clifty Inn. Departure will be at 8:00 a. m. Please check mileage before leaving and at each scheduled stop during the morning so that you may determine your location at anytime. Cars will follow the road that leads toward the north entrance to Clifty Falls State Park.
0.6	Leave Madison West quadrangle.
1.2	A small waterfall to the left of the road descends over the Brassfield limestone.
1.6	Look to the left to see the V-shaped gorge of Clifty Creek as it enters the Ohio River Valley.
3.4	Clifty Falls may be seen across the valley from the lookout point on the left side of the road.
4.1	North entrance of Clifty Falls State Park. Turn right on Highway 107.
4.5	Note the lack of dissection on this upland. The Ohio River, intrenched 400 feet, is only l.5 miles to the south. (See Madison West quadrangle.)
5.3	Junction with Highway 7. Turn left.
8.3	South limits of Wirt.
9.1	South limits of Midway.
11.6	Abandoned quarry on left. Section includes Laurel limestone, Geneva dolomite, and Jeffersonville. Laurel-Geneva contact shows undulatory disconformity.
13.8	Cross Big Creek.
15.7	South limits of Dupont.
17.3	Leave Jefferson County and enter Jennings County.
18.6	Pass exposure of New Albany shale on right.
19.6	Cross Graham Creek.
19.7	Pass exposure of Geneva and coralline and middle zones of Jeffersonville in creek on left and middle Jeffersonville exposure on right.
20.6	New Albany exposure on right in cut.
20.7	New Albany exposure on right in cut.
21.0	New Albany exposure on right in cut.
21.4	New Albany exposure on right in cut.

Mileage
between
stops

21.6	New Albany exposure on right in cut.
21.9	New Albany exposure on right in cut.
22.6	New Albany exposure on right in cut.
23.9	Pass exposure of laminated beds and coralline zone of Jeffersonville in cut on left.
24.0	Junction with Highway 3. Continue on 3 and 7. Note till at cut.
24.2	Cross Muscatatuck River.
24.3	East limits of Vernon.
25.5	East limits of North Vernon.
26.2	Junction with U. S. Highway 50. Cars going to Stop 8B, the dam at Muscatatuck State School, turn right on 50. (See p. 31 for road log. Cars going directly to Stop 8A, Meshberger Stone Company quarry, continue straight ahead on Indiana 7.
27.2	Junction with Highway 3. Continue straight ahead on 7.
33.2	South limits of Scipio.
34.1	Cross Sand Creek.
35.0	Approximate position of the southern limit of Wisconsin glaciation.
37.6	Exposure of Hamilton bone bed on right in creek bed.
38.2	Leave Jennings County and enter Bartholomew County.
39.6	Railroad crossing.
39.9	Turn right on blacktop road toward Grammar and then left in 100 feet on crushed stone road.
40.9	T intersection. Turn right on crushed stone road.
41.4	Left turn.
41.8	Cross iron bridge over Little Sand Creek.
42.1	Entrance to Meshberger Stone Company quarry.

STOP 8A. Meshberger Stone Company quarry. --Time: 2 hours. Location: NE¼ sec. 6, T. 8 N., R. 7 E., 2.0 miles northeast of Elizabethtown in Bartholomew County.

		Feet
QUATERNARY		
	Wisconsin	
24.	Till: Brown, noncalcareous, sandy and clayey; completely weathered to soil in upper part	5.0
23.	Till: Yellowish-brown, calcareous, very sandy, silty; in some places contains wood fragments	15.0
	Total Wisconsin	20.0
	Illinoian	
22.	Till: Brown, clayey, noncalcareous, upper part of soil profile missing	3.0
21.	Till: Medium-gray, clayey, calcareous	7.0
	Total Illinoian	10.0
	Total thickness of Quaternary	30.0
	DEVONIAN	
	New Albany shale	
20.	Shale: Dark-brownish-gray, mottled, weathered	2.7
19.	Shale: Gray, platy, finely micaceous, hard	0.3
	Total thickness of New Albany shale	3.0
	North Vernon limestone	
18.	Limestone: Upper 1. 1 feet dark-gray, dense, fossiliferous; lower 1. 5 feet gray to tan, coarsely crystalline, fossiliferous (Beechwood member)	2.6
	Jeffersonville limestone	
17.	Limestone: Upper 3. 0 feet tan, crystalline, medium bedded, fossiliferous; lower 4.4 feet tan, fine-grained, mottled; contains fossil detritus. A zone of lenticular and nodular chert, 0. 4 foot in average thickness, occurs 1.0 foot from base (*Spirifer acuminatus* zone)	7.4
16.	Limestone: Tan, fine-grained, dolomitic; black shale partings occur at base and top	1.3
15.	Limestone: Gray, dense, dolomitic	3.6
14.	Limestone: Tan, dense, chalky, dolomitic	1.0
13.	Limestone: Brown, dense, crystalline; laminated in upper part	1.8

		Feet
12.	Limestone: Tan, granular, porous, dolomitic; shows scattered calcite faces; contains breccia in upper part	1.1
11.	Limestone: Tan, dense, dolomitic; laminated in upper part	3.5
10.	Dolomite: Light-tan, nearly white when dry, chalky, soft, slightly banded; contains scattered faces of crystalline calcite	6.4
9.	Dolomite: Brown, chalky, banded	1.3
8.	Limestone: Tan, dense, laminated, dolomitic; contains fractures cemented with calcite	2.2
7.	Dolomite: Gray, chalky, argillaceous, banded	1.3
6.	Limestone: Upper 1.0 foot gray, finely granular, chalky; contains scattered calcite crystals. Lower 1.7 foot gray to dark-gray-brown, massive, dolomitic, granular to dense; contains dark bands, stylolitic partings, and scattered calcite crystals; pyrite occurs in vuggy spaces	2.7
5.	Limestone: Light-gray, granular, clastic, dolomitic, soft; contains fossils and fossil fragments (stromatoporoids, trilobites, brachiopods, and cup corals)	8.9
4.	Limestone: Light-gray to light-brown, dense to fine grained, dolomitic, fossiliferous (stromatoporoids, trilobites, brachiopods, and cup corals); contains vugs and solution cavities	3.3
	Total thickness of Jeffersonville limestone	45.8
	Geneva dolomite	
3.	Dolomite: Brownish-gray to chocolate-brown, finely granular to saccharoidal, massive; contains small pockets of calcite. Upper 0. 8 foot finely granular	3.8
2.	Dolomite: Medium-brown to chocolate-brown (when wet), granular to saccharoidal, massive; contains large masses of white to yellow, coarsely crystalline calcite; black carbonaceous bedding planes occur rarely. Dolomitized coral molds and casts occur in 2- to 3-foot zone 2. 6 feet below top of unit. Pyrite locally abundant	26.1
	Total exposed thickness of Geneva dolomite	29.9

VIEW LOOKING EAST ACROSS MESHBERGER QUARRY

Louisville limestone	Feet
1. Limestone: Dark-medium-gray, fine-grained, crystalline, massive, dolomitic; weathered surface drab-medium-gray. Stylolites are common. Measured to water level --	4.2
Total exposed thickness of Louisville limestone ----------------	4.2
Total thickness of measured section -----------------------------	115.5

The section that is exposed in this quarry extends from the Louisville limestone into the basal New Albany shale and includes Geneva dolomite, a full Jeffersonville section, and a thin North Vernon section (pls. 6 and 7A). The quarry lies along the boundary between the two physiographic regions named the Scottsburg lowland and the Muscatatuck regional slope. Wisconsin glaciation reached its southern limit in this area, and Wisconsin till overlies a soil on Illinoian till in the upper part of the quarry. The Geneva contains large masses of white calcite. Vugs in the middle part of the Jeffersonville formation contain well-formed calcite crystals, sphalerite, and fluorite, and some of the vugs contain many small pyrite crystals. Interesting mineral specimens can be collected at this stop. The Geneva-Jeffersonville contact is clearly defined by color and lithology at this locality. The Jeffersonville immediately above the contact contains abundant corals, whereas the Geneva is unfossiliferous.

The Geophysics Section of the Indiana Geological Survey will demonstrate making an electric log at this stop.

Chemical and spectrographic analyses of the section are on page 64.

Itinerary to Stop 8B

Mileage between stops	
26.2	Junction of Indiana Highway 7 with U. S. Highway 50.
26.4	Turn right (east) on U. S. Highway 50.
27.5	Cross Muscatatuck River.
27.6	New Albany shale exposed in road cut.
31.7	Turn left (north) at entrance to Muscatatuck State School; cross double tracks of Baltimore and Ohio Railroad.
32.4	Turn right (east).
32.8	Turn left (north) on blacktopped road.
34.0	Turn right (north) on lane at bend in road.
34.1	Park in area south of dam.

STOP 8B. Spillway section, Brush Creek reservoir, Muscatatuck State School. --Time: 40 minutes. Location: NE¼ sec. 16, T. 7 N., R. 9 E., 2 miles northwest of Butlerville in Jennings County.

QUATERNARY		Feet
	Illinoian	
16.	Clay: Light-yellowish-gray, mottled, silty, sandy, noncalcareous	5.0
15.	Till: Brown, sandy and clayey, noncalcareous	2.0
14.	Till: Gray, brown along joints, sandy, noncalcareous	5.0
13.	Till: Gray, sandy, calcareous throughout, but less calcareous at base; oxidized brown along joints; contains large, randomly oriented chunks of dark-yellowish-brown noncalcareous till	15.0
	Total Illinoian	27.0
	Kansan	
12.	Till: Dark-yellowish-brown, noncalcareous, clayey and somewhat sandy; contains abundant chert pebbles and scattered quartzite pebbles	1.0
	Total Quaternary	8
	DEVONIAN	
11.	Sand: Yellowish-white, fine-grained, composed largely of authigenic quartz; loosely consolidated; contains a few fossils, including silicified remains of a stromatoporoid which appears to be Stromataporella selwyni, and a rugose coral	1.0
10.	Sand: Yellowish-gray, thick-bedded; composed largely of authigenic quartz and interstitial calcite; basal contact smooth	1.8
	Total thickness of Devonian rock	2.8
	SILURIAN	
	Laurel limestone	
9.	Limestone: Medium-bluish-gray, brownish-yellow in upper few beds, thick-bedded, dolomitic, moderately stylolitic; contains beds of light-gray chert that range from 0. 1 to 0. 3 foot thick	9.2
8.	Limestone: Light-bluish-gray, thick-bedded; contains a few zones of dark-bluish-gray siliceous nodules that weather to pitted dark-gray chert	12.0
7.	Limestone: Light-bluish-gray, medium-grained, medium-bedded, moderately fossiliferous, glauconitic; weathering shows partings about 0.1 foot thick; contains enlarged joints and potholes on exposed surfaces. The upper part is the spillway floor	5.2

		Feet
6.	Limestone: Pale -yellowish-gray, fossiliferous with fine-grained matrix; thick-bedded but shows thin partings on weathered face; cherty	5.6
5.	Limestone: Gray to orange-brown; thin- to thick-bedded; partings 0.1 foot thick are visible on weathered surface; lower part fossiliferous; contains brachiopods, cephalopods, crinoidal fragments; upper part only slightly fossiliferous; cliff-forming	5.3
4.	Limestone: Brownish-gray, thin-bedded, argillaceous	1.4
3.	Limestone: Pale -yellowish-gray, mottled with yellowish-brown, medium-bedded, moderately fossiliferous	1.4
2.	Siltstone: Medium-bluish-gray, thin-bedded, calcareous, clayey; contains a few limestone nodules an scattered fossils	1.6
1.	Limestone: Yellowish-brown to gray, mottled, medium-bedded; bedding surface irregular; locally fossiliferous; base not exposed	2.5
	Total exposed thickness of Laurel limestone	44.2
	Total thickness of measured section	75.0

Units 10 and 11 are float from the basal part of the Jeffersonville ("silicified bed" of Dawson, 1941, p. 19-20) and are not in their normal stratigraphic position, as the entire Geneva section is absent, probably because of solution.

When the spillway for this reservoir was being constructed, a filled bedrock gorge was encountered at the exact place where plans had been made to locate the spillway. Because plans required the use of a rock floor, the position of the spillway was shifted slightly to allow it to be cut through the former spur. Lacustrine sediments and till fill the former valley. As much as 1.0 foot of noncalcareous greenish-gray sandy clay which contains rooted stumps and is capped locally by a peaty zone is exposed along the shore line. This clay and peat undoubtedly represent late-Yarmouth-early-Illinoian flood-plain deposits over which Illinoian ice moved. The basal 5 to 15 feet of the overlying dark-gray clayey till contains abundant wood fragments and masses of soil that were incorporated into the debris carried by the ice, moved a short distance, and redeposited.

Mileage between stops	
0.0	Return to blacktopped road; turn left (south).
1.2	Turn right (west).
1.6	Turn left (south).
2.3	Cross railroad at junction with U. S. Highway 50. Turn right (west).
7.7	Junction of Highways U. S. 50 and Indiana 7; turn right on 7.
8.7	Junction with Highway 3; continue on 7.

Mileage between stops	
14.6	South limits of Scipio.
15.6	Cross Sand Creek.
16.5	Approximate position of southern limit of Wisconsin glaciation.
19.1	Exposure of Hamilton bone bed on right in creek bed.
19.7	Leave Jennings County and enter Bartholomew County.
21.1	Railroad crossing.
21.4	Turn right on blacktop road toward Grammar, and then turn left in 100 feet on crushed stone road.
22.4	T intersection. Turn right on crushed stone road.
22.9	Left turn.
23.3	Cross iron bridge over Little Sand Creek.
23.6	Entrance to Meshberger quarry (Stop 8A; seep. 29).
0.0	Entrance to Meshberger quarry. Turn right (north).
0.4	Junction with Indiana Highway 9. Turn right. The caravan will follow Highway 9 to the next stop.
1.3	Left turn. (An abandoned quarry in the Jeffersonville limestone, not visible from Highway 9, lies southeast of a farmhouse 150 yards east of this turn. The laminated beds and the upper zone of the Jeffersonville are exposed.)
1.5	The small knolls visible on both sides of the highway are part of the moraine that marks the southernmost extent of Wisconsin glaciation. Glacial drift is generally less than 30 feet thick in the area, but it is greater than 100 feet thick in a few places along buried valleys.
1.8	Right turn.
5.1	Junction with Indiana Highway 46.
5.7	Cross Clifty Creek.
6.6	Enter Hope quadrangle.
7.4	Morainic topography. This area was mapped by Leverett (Leverett and Taylor, 1915, p. 6) as “undulatory drift inpart morainic.” Malott (1922, pl. 3) called it one of the moraines of the “Champaign glacial substage.”
10.1	Cross “Big Four” Railroad.
10.2	South limits of Hope.

Mileage between stops	
10.4	Street to left leads to small abandoned quarry in which the laminated beds of the middle Jeffersonville are exposed above water.
10.9	Cross Little Haw Creek.
11.4	Cross Haw Creek.
13.8	Leave Bartholomew County and enter Shelby County.
14.7	Sharp curve to right on Highway 9; continue straight (north) on crushed stone road.
14.8	Entrance to Cave Stone Company quarry.

STOP 9. Cave Stone Company quarry. --Time: 45 minutes. Location: NE¼NW¼ sec. 32, T. 11 N., R. 7 E., near the west edge of the village of Norristown, in Shelby County (Hope quadrangle).

	QUATERNARY	Feet
14.	Silt: Medium-grayish-brown, sandy, noncalcareous	0.6
13.	Clay: Reddish-brown to brown, sandy and stony, non calcareous; contains lenses of brown sand locally	2.0
12.	Silt: Yellowish-brown, somewhat mottled, non calcareous, obscurely stratified	1.5
11.	Silt: Pale-yellowish-gray mottled with yellowish brown, calcareous, obscurely stratified	3.0
10.	Till: Medium-yellowish-gray to gray-brown, iron stained along fractures and laminae, calcareous; thickness variable but in thickest part of exposure is as much as 3. 0 feet	3.0
9.	Sand and silt: Yellowish-brown, calcareous, some what stratified; sand fine	0.1
8.	Silt: Grayish-brown in upper 0. 2 foot; remainder medium-yellowish-gray; contains humus and small wood fragments at top; calcareous throughout but less so in humic zone; gastropod shells scattered throughout but more abundant at top in some places; base pebbly	0.8
7.	Gravel: Yellowish-brown, sandy and silty, compact, calcareous	1.0
6.	Till: Medium-gray, clayey, silty, sandy, stony, calcareous; upper part contains secondary limonite concentration	1.0
	Total thickness of Quaternary	13.0

DEVONIAN	Feet
Jeffersonville limestone	
5. Dolomite: Light-tan and iron-stained and weathered in upper 3 feet; somewhat banded in lower part; thin-bedded, granular. Sandstone layer 0.1 foot thick approximately 6.0 feet from top of this unit ---------------------	8.9
4. Dolomite: Light-tan, banded, finely granular, porous --	4.2
3. Dolomite: Tan, thin-bedded (0.1-0.5 foot), chalky. Obscure lamination in bed 2.2 to 2.6 feet from base. Lower bed (0.7 foot thick) contains tubular calcite masses 6 to 12 millimeters in diameter --------------------------	7.4
Total exposed thickness of Jeffersonville limestone -------	20.5
Geneva dolomite?	
2. Dolomite: Brown, dense, massive, tough. Contains calcite masses as much as 0.5 foot across. Bedding planes, especially upper surface of unit, marked by thin dark-brown or black layer (less than 1 millimeter thick) of carbonaceous material that is green in places --------	11.1
1. Dolomite: Chocolate -brown, fine-grained, crystalline. Unit contains many calcite masses -------------------------------	6.9
Total exposed thickness of Geneva dolomite?---------------	18.0
Total thickness of measured section --------------------------	51.5

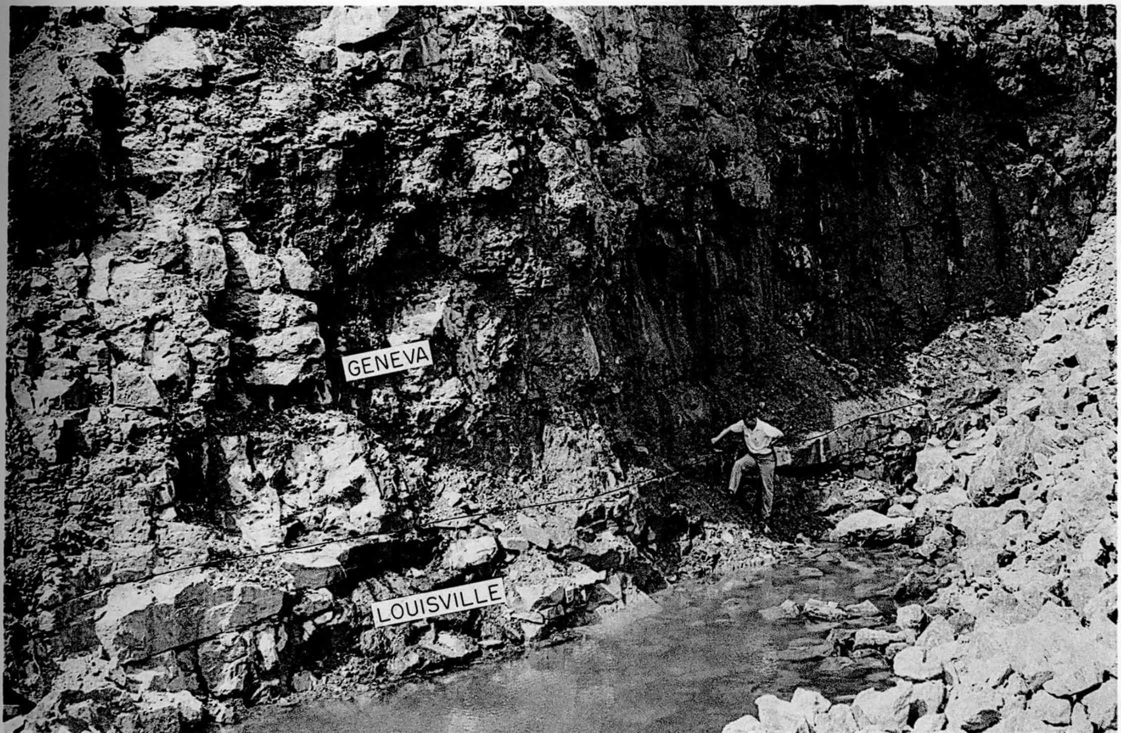
This stop exhibits a section composed of Geneva dolomite and Jeffersonville limestone (pl. 7B). The laminated zone of the Jeffersonville is well exposed. The boundary between the Geneva and the Jeffersonville is questionable at this location.

Within the overburden, which at the thickest place is only 13 feet thick, is a fossiliferous unit that records two distinct advances of the ice during the Wisconsin glaciation. (See p. 48.) The deglaciation probably represents a relatively short time, and the ice front may not have retreated far. The following gastropods have been identified from a 2-pound sample of the interstadial silt:

Columella alticola (7)
Deroceras laeve (5)
Discus cronkhitei (17, and 2 eggs)
Econulus pulvus (1)
Lymnaea parva (10)
Pupilla muscorum (8)
Succinea avara (46)
Vallonia albula (30)
Vertigo elatior (90)
Vertigo modesta (12)

All of these 10 species live today, but the range of only five reaches as far south as Indiana. All of the species are reported from northern Ontario (Oughton, 1948), where they are found on margins of upland bogs.

CONCLUDING ASSEMBLY. The group will assemble at the cars, and members will be given an opportunity to discuss the geology that has been seen during the conference. Brief remarks by Dr. Charles F. Deiss will formally conclude the Eighth Indiana Geologic Field Conference.



A. CONTACT OF LOUISVILLE LIMESTONE AND GENEVA DOLOMITE

B. VIEW LOOKING SOUTH ACROSS CAVE QUARRY

By John B. Patton and T. A. Dawson

When David Dale Owen made a reconnaissance traverse across southern Indiana in 1837, he recorded (1839, p. 15-16) extensive commercial use of the strata beneath the "black bituminous aluminous slate" that was later named the New Albany shale. A "water lime" was being utilized for mortar at the Louisville canal. Near Vernon a burrstone "almost entirely made up of a collection of fossil polyparies or corallines, often encased in a sheath of drussic crystals of quartz" was manufactured into millstones "but very little inferior to the French burr"; and many of the beds were quarried for building stone along the line of the Madison and Indianapolis Railroad.

Owen did not propose formation names for the Devonian strata, and if local names were in use, he did not use them in his report. Most of the Devonian rocks of southern Indiana are fossiliferous, and some of them are so rich in fossils that many paleontologists and stratigraphers were attracted to them during the latter half of the nineteenth century. The interest shown by stratigraphers in the Devonian limestone section is well documented by the impressive number of names that have been proposed for this relatively thin (50 to 80 feet) representation of Middle Devonian time in southern Indiana and northern Kentucky. In the following pages the formations are considered in ascending order.

Geneva dolomite

The oldest rocks of probable Devonian age in the southern Indiana outcrop consist of dolomite and were named "Geneva limestone" by Collett (1882, p. 63, 81, 82) for the village of Geneva, on the Flat Rock River in Shelby County, Ind. The Indiana Geological Survey uses the name Geneva dolomite.

Between 1900 and 1920 various writers commented on the probable age and correlation of the formation, and most of them concluded that it was a northerly facies of the Jeffersonville limestone or of both the Jeffersonville and "Sellersburg" limestones. Cumings (1922, p. 466) summarized previous views and the evidence for them and concluded correctly that the Geneva was probably a distinct formation, older than the Jeffersonville. Sutton and Sutton (1937, p. 331) termed the Geneva "a northward lithologic facies of the Jeffersonville formation of Onondaga age as shown by the Onondaga faunules of the Jeffersonville, which continue into the Geneva at the same horizons..." and stated that the name Geneva had priority and should replace the name Jeffersonville. The zones from which the "Onondaga faunules" were identified are shown in measured sections in their report, and field checking has shown that they are from the Jeffersonville, as only two of the sections reached the Geneva, and in them the rock is barren. Detailed evidence regarding the stratigraphic relationships of the Geneva dolomite was furnished by Dawson (1941), who concluded (p. 27) that "the Geneva is a distinct formation older than the Jeffersonville."

The relationship of the Geneva to the lower part of the Jeffersonville is not clear from central Jennings County northward, but data acquired in the last 15 years prove that the middle and upper Jeffersonville maintain their distinctive characteristics throughout this area and overlie the Geneva.

Although the Geneva is known to be overlain by Onondagan rocks and underlain by Niagaran rocks, its precise age has not been established, as identifiable fossils are virtually absent. Kindle (1901, p. 551, 553, 555-557) mentioned localities at which he had found fossils in the Geneva and concluded (p. 536) that the formation was Devonian in age. He later (1913, p. 314) stated that the Geneva was possibly Onondagan but probably Schoharie in age. His descriptions of the rock and the localities from which the fossils were obtained leave no doubt that some of his collections were made from Jeffersonville rather than Geneva. A fossiliferous bed that is locally composed of authigenic quartz crystals occurs at the base of the

Jeffersonville limestone. Dawson (1941, p. 19-20) called this unit the "silicified bed" and considered it part of the Jeffersonville. Some of the fossils that Kindle attributed to the Geneva came from this bed, which he correlated with the lower Jeffersonville elsewhere in the same paper. Much of his evidence for the age of the Geneva is thus questionable.

Throughout the southern Indiana outcrop, the Geneva is overlain by the Jeffersonville limestone. Inmost places the Geneva rests upon the Louisville limestone, but locally it rests upon Waldron shale or Laurel limestone.

From Shelby, Rush, and Bartholomew Counties, where it reaches a maximum thickness of 35 feet, the Geneva thins fairly regularly southward to its pinchout in northern Clark County. Thin sections of dolomite that resembles the Geneva are present locally between Charlestown and the northern boundary of Clark County. North of central Decatur County the Geneva is largely obscured by Wisconsin glacial drift except along the valleys of Clifty Creek and Flat Rock River, and it is not exposed north of Milroy, in southern Rush County.

The Geneva consists of buff to chocolate-brown, granular, thin-bedded to massive dolomite and contains white crystalline calcite masses that range from a fraction of an inch to more than 1 foot in cross section. Carbonaceous material is present in bands and partings, and much of the dark color is apparently due to organic content (p. 54), as the beds just beneath soil cover commonly are oxidized to pale tan, cream, or nearly white.

Dolomitization has destroyed virtually all organic remains in the Geneva. However, vestigial fossil outlines and replacements of fossil fragments by calcite, chert, and quartz indicate that the Geneva was at least partially biofragmental in origin.

Porosity is high in much of the dolomite and might better be termed micro-vugularity, as the openings are, in many specimens, several times the size of the surrounding dolomite crystals. Porosity of this type is presumably caused by the volume-shrinkage that accompanies the change from calcite to dolomite.

Jeffersonville limestone

Kindle (1899, p. 8, 23, 110) named the Jeffersonville limestone for the town of Jeffersonville, in Clark County, Ind., where the formation was well exposed in the Falls of the Ohio. The formation is the only proven representative of the Onondaga group in southern Indiana. At the type locality and northward through most of Clark County the Jeffersonville rests upon the Louisville limestone, the uppermost Niagaran formation. From northern Clark County northward the Jeffersonville is underlain by the Geneva dolomite. Throughout southern Indiana the Jeffersonville is overlain by rocks of Hamilton age (Middle Devonian).

Outcrops of the Jeffersonville are found from the Falls of the Ohio northward through Clark County, eastern Scott County, western Jefferson County, and Jennings County. In Bartholomew and Decatur Counties and southwestern Shelby County, exposures are rare because thick glacial drift blankets the formation. The Jeffersonville is not exposed north of Flat Rock Valley, in southeastern Shelby County. Measured sections and the locations of many exposures are given in papers by Kindle (1901), Whitlatch and Huddle (1932), Dawson (1941), and Campbell (1942).

In its type section the Jeffersonville maybe divided into three zones. The lower Jeffersonville contains a prolific coral fauna and is generally known as the "coralline zone." It is brown to gray, dense to crystalline, and dolomitic. Bedding is thin and undulating, and the beds are commonly separated by carbonaceous partings that range from paper-thin films to bands several millimeters in thickness. The top surface of the coralline zone and most bedding planes within it yield undulatory surfaces because of large colonial coral masses.

At the Falls of the Ohio the middle zone is lighter gray or brown than the coralline zone, is dense to crystalline, and is fossiliferous. It includes the Spirifer gregarius beds of Kindle (1901, p. 539). In Jennings, Bartholomew and Shelby Counties the middle Jeffersonville is unfossiliferous and is composed of light-gray and tan, conspicuously and thinly laminated dolomitic limestone and massive dolomitic limestone that is ashy or chalky in appearance and contains numerous small calcite crystals. In central Jennings County 1 foot to 3 feet of dense, tan limestone lie at the base of the middle zone. In places the laminated beds are crumpled and brecciated and are recemented with calcite and pyrite. Rounded, frosted sand grains occur fairly abundantly in bands, but are not distributed throughout the laminated beds.

The upper Jeffersonville consists of tan or light-gray, crystalline, thick-bedded, and extremely fossiliferous limestone (includes restricted Spirifer acuminatus zone of Kindle, 1901, p. 538-539). Fenestelloid bryozoa, trilobite fragments, and brachiopods are abundant in the uppermost part of the zone.

At many places in eastern and northern Jennings County a bed composed mainly of stromatoporoids and corals has been partially or largely replaced by silica ("burrstone" of Owen, 1839, p. 16; "buhrstone bed" of Kindle, 1901, p. 553). Dawson (1941, p. 19-20) referred to this unit as the "silicified bed" and placed it in the base of the Jeffersonville. Internal structure of the organisms has been destroyed, but the shapes are well preserved. Silicification has been complete in some localities, and the rock consists of terminated quartz crystals that range in size from .02 to 0.5 millimeter. Kindle (1901, p. 545, 548) described float of similar aspect in the vicinity of Wirt and Smyrna Church, in Jefferson County. Both Kindle and Dawson (1941, p. 20) believed that this float correlated with the burrstone in Jennings County.

The Jeffersonville ranges in thickness from 26 to 46 feet at the outcrop. The basal coralline zone is commonly 10 to 12 feet thick in Clark and Scott Counties and southern Jennings County, but from central Jennings County northward it is thinner or is absent or unrecognizable. The middle zone is about 10 feet thick in southern Clark County and thickens to 26 feet in Bartholomew County. The upper zone is about 13 feet thick in southern Clark County and thins slightly northward to 7 to 9 feet in Bartholomew County.

Sellersburg (North Vernon) limestone

The limestones of Hamilton age in Indiana have been designated by eight geographic names in addition to a host of names based on composition, lithology, color, and fauna.

Borden (1876, p. 160-161), after discussing the "Corniferous limestone" (Jeffersonville), said: "The next deposit in the ascending series is the North Vernon limestone, so designated from being first extensively quarried at that place, and shipped to various points by rail," as forthright a proposal of a stratigraphic name from a geographic locality as maybe found in the geological literature of the 1870's. The author proceeded to define the formation as follows:

> It lies at the horizon of the hydraulic limestone of Clarke county on the south, and is here a continuation of the same bed, but is a differently constituted rock. In Clarke county the entire beds, which are from 12 to 14 feet in thickness, are used for hydraulic cement, and known to the trade as Louisville cement. The capping in the Vernon beds is in many places a gray crystalline limestone, resembling the cap stone of the cement. The strata of gray stone in many places overlying the blue, often contains a great number of crinoid stems; some plates of Cariocrinus ornatus, and some Corniferous corals.

At the same time that Borden made his study of Jennings County and wrote the report from which the quotations above are taken, he had previously made a report on Clark and Floyd Counties (1874), Scott County (1875a), and Jefferson County (1875b). His background for an understanding of the regional relationships of the Devonian rocks had thus been good. Even before he published the name North Vernon limestone, he recognized the age equivalence of the cement rock and the purer crystalline limestone in Jefferson County (1875b, p. 148).

Anew formational name for a large part of the Hamilton section was proposed by Kindle (1899, p. 8, 20) when he introduced the name "Sellersburg beds" to "include the beds from the New Albany shale down to the lowest beds worked at the cement quarries.... These beds consist of a fine-grained calcareous sandstone from six to twenty feet thick and a thin bed of limestone, which when present lies immediately under the New Albany Black Shale." Kindle gave no explanation for proposing a new name for the North Vernon limestone, although he could hardly have been unaware of Borden's name for the formation, as it had been accepted and used by other writers (Cox, 1879, p. 88; Elrod, 1882, p. 174; Elrod, 1883, p. 106) since its proposal. Few of the cement quarries of that period are still available for inspection, but in most of the area in which they were situated the "lowest beds worked at the cement quarries" do not rest upon the Jeffersonville limestone and thus do not extend to the base of the Hamilton. Kindle did not understand the relationship of the Hamilton rocks in Jennings County to the subdivision that he made in Clark County, as shown by the following opinion, expressed in a later and expanded paper (1901, p. 534-535): "About 35 miles north of the Falls of the Ohio the Sellersburg beds lose their characteristic lithological features and cannot be distinguished from the Jeffersonville limestone. This blending of the physical features of the two formations is accompanied by a mingling of their two faunas...."

The new term "Sellersburg beds" was scarcely in print before its meaning was changed. Siebenthal (1901, p. 341) used the name "Sellersburg limestone" and restricted it to "that bed of white to gray crystalline limestone which overlies the cement rock, which underlies the New Albany Black shale, and which by various writers has been alluded to as the Crinoidal limestone...." He was thus restricting Kindle's name Sellersburg to a small part of the section that Kindle had wished to designate and to one which Kindle (1901, p. 534), in a paper that appeared in the same volume with Siebenthal's paper, apparently considered unimportant because "it shows considerable variation in lithological characters, and in some localities is absent or cannot be distinguished from the 'cement'."

In the same paper (1901, p. 345) Siebenthal gave the name "Silver Creek Hydraulic Limestone" to a unit that lies "beneath the Sellersburg limestone, and between it and the Jeffersonville limestone and is thus the lower part of the Sellersburg beds of Kindle." Siebenthal's paper made no statement about the disposition of the several feet of Hamilton rocks that lie between the cement rock and the Jeffersonville limestone in most Clark County exposures. However, as his proposed name contains the words "hydraulic limestone," it must be assumed that he intended the Silver Creek to terminate at the base of the natural cement rock.

Butts (1915, p. 118, 120) proposed that the name Sellersburg limestone be restored to the original usage intended by Kindle, that the name "Beechwood limestone member" be used for the "Sellersburg lime stone" of Siebenthal, and that the formation that Siebenthal had called "Silver Creek Hydraulic Limestone" be reduced to member rank and called the "Silver Creek limestone member" of the Sellersburg formation. These suggestions were generally accepted and are the terms in current use by the United States Geological Survey (Wilmarth, 1938, p. 145, 1952, 1998).

Whitlatch and Huddle (1932, p. 369-370) called attention to a "gray, shaly, very fossiliferous limestone, characterized by an abundance of <u>Athyris fultonensis</u>, <u>Stropheodonta demissa</u>, and several species of <u>Fenestella</u> and other bryozoa," that occurs directly beneath the natural cement rock. The authors were "inclined to agree with Kindle and Siebenthal that this zone belongs to the Jeffersonville limestone, but wish to suggest that it may represent the base of the overlying Silver Creek formation." Actually Kindle has made no reference to the zone, as it was not present at his type section of the Jeffersonville. The zone appears a short distance to the north of the type section and was thus not accounted for in a classification that recognized only the Jeffersonville limestone and Kindle's "Sellersburg beds," which extended "to the lowest beds worked at the cement quarries."

The existence of rocks of Hamilton age beneath the natural cement rock and above the Jeffersonville limestone was finally established by Sutton and Sutton (1937, p. 326), when they proposed the name "Speeds" to designate a basal member of the Sellersburg formation. The new name was applied to "shaly limestone 18 inches thick below the typical Silver Creek cement rock...."

Dawson (1941) published the most complete assemblage of field information to date on the Devonian rocks of southern Indiana; he gave 59 measured sections distributed between the Falls of the Ohio and southern Rush and Shelby Counties, 22 of which contain beds classified as Beechwood or Silver Creek. Dawson mentioned (p. 13) the disposition that had been made of the "Stropheodonta demissa zone" by Whitlatch and Huddle (1932, p. 369-370) and included the beds in the Jeffersonville in his measured sections. He did not mention the name "Speeds" member, but stated (1941, inside cover) that he believed the zone was of Hamilton age.

The extent and correlation of Sutton and Sutton's "Speeds member" was first explained in print by Campbell (1942, p. 1060), who stated "The Speeds is equivalent in part to the 'North Vernon blue limestone' of Borden...." Campbell used the names "Speeds" (p. 1060), Silver Creek (p. 1061), and Beechwood (p. 1064) as formations rather than as members of the Sellersburg limestone.

Campbell also named two new formations within the Hamilton group. The "Deputy formation" was assigned to a unit above the "Speeds" and below the Silver Creek. The formation was shown to be 6 feet thick at its type section in a small abandoned quarry three-quarters of a mile south of the village of Deputy, in Jefferson County.

In addition, Campbell (p. 1063) gave the name "Swanville formation" to "a thick-bedded hard bluish to gray crystalline limestone difficult to distinguish from the Beechwood on lithology alone." Like the Beechwood, it lies beneath the New Albany shale and above the Silver Creek. The Beechwood and Swanville were not found together in a single section by the author of the new name, but they were found in close lateral proximity.

The term North Vernon limestone includes the entire Hamilton sequence that has been reviewed in the paragraphs above. The name Sellersburg in its original sense was nearly in synonymy with North Vernon limestone, although its author inadvertently failed to account for the lowest rocks of Hamilton age. The names North Vernon and Sellersburg can both be used to advantage in describing and understanding the Hamilton rocks of southeastern Indiana. The Sellersburg formation as defined by Kindle and modified by later workers is present in Clark County and southern Scott County--that is, throughout the area where Hamilton rocks are readily divisible into Beechwood, Silver Creek, and Speed lithologies. The name Sellersburg is not applicable in Bartholomew and Jennings Counties or in most of Jefferson County, where the Hamilton rocks are not readily divisible on lithologic criteria, and a name other than Sellersburg is useful when reference is made to the undifferentiated Hamilton limestones of this area. The name North Vernon limestone, as set forth by Borden (1876, p. 160-161), is especially meaningful when applied to the relatively homogeneous Hamilton limestones of Bartholomew, Jennings, and Jefferson Counties. If only one of the names North Vernon and Sellersburg were to be retained, it should be North Vernon, on grounds of both priority and inclusiveness.

In most localities the uppermost bed or beds of Sellersburg (North Vernon) limestone are medium to dark gray, coarsely crystalline, and abundantly crinoidal. These beds are generally thick-bedded to massive and contain small black phosphatic pebbles, especially in the basal few inches. The latest and most generally accepted name for these beds is "Beechwood limestone member" (Butts, 1915, p. 118, 120). Two divergent types of lithology are present in the part of the Sellersburg that lies beneath the Beechwood in Clark County, southern Scott County, and southwestern

Jefferson County. One of these lithologies consists of drab-gray, fine-grained, homogeneous argillaceous limestone that fractures conchoidally. This is the “Silver Creek Hydraulic Limestone” of Siebenthal (1901, p. 345). The other lithology consists of blue-gray crystalline limestone that weathers to a platy, thin-bedded appearance because of flat-lying brachiopod shells and other fossil debris that give a layered character to the individual beds. This is the “Speeds” member of Sutton and Sutton (1937, p. 331).

These two lithologies exist as wedges that complement each other. They are contemporaneous facies, their time equivalency being indicated by stratigraphic position and by the inclusion of lentils or tongues of one lithology in the other. The wedge of Speed lithology thickens northward at the expense of the Silver Creek, and north of southern Scott County it makes up nearly all of the Hamilton section below the Beechwood.

Where the Silver Creek lies between the Beechwood and Speed members, the Speed is a very distinct lithologic unit. Separation of the Beechwood and Speed is commonly difficult where the Silver Creek is absent and the Speed lithology occupies all of the Hamilton section below the Beechwood--that is, in the area north of southern Scott County. This difficulty is increased in Jennings County by the fact that the Speed is harder and less layered and, thus, more closely resembles the Beechwood than in the counties to the south. Where separation of the Beechwood from the under - lying beds of Hamilton limestone is difficult, questionable, or impossible, the term North Vernon limestone should be used.

An abandoned quarry near Commiskey (Addenda, p. 69) displays the northernmost representative of the Silver Creek lithology. Here and in the vicinity of Deputy (Jefferson County) the Silver Creek lithology exists only as thin lenses or tongues within a thick section of Speed lithology. The Silver Creek is less than 1 foot thick and lies just beneath the Beechwood near Blocher, in southern Scott County (Stop 6). In most of Clark County the Silver Creek is a massive unit, as the intervening crystalline layers are absent. At Sellersburg the Silver Greek makes up most of the Hamilton below the Beechwood, and less than 2 feet of the Speed is present at the base. At both Claysburg, in the north bluff of the Ohio Valley, and at the Falls of the Ohio, the natural cement rock rests directly upon the Jeffersonville limestone.

It can thus be seen that Silver Creek and Speed are lithofacies. A lithofacies may be a mappable unit, and thus qualify for member rank, but at many places these lithofacies are either interbedded with each other or one contains lenses of the other. An attempt to map them as members will result in an inverted relationship at some localities unless the geologist maps only the gross aspect of the lithology and ignores the thin beds or lentils of different lithologies.

The Beechwood is not necessarily younger than all the other Hamilton beds of southeastern Indiana. It is present nearly everywhere that the Silver Greek is identifiable, but its thickness varies markedly within small areas, and at places itis absent. At such places Silver Creek lithology extends to the top of the Hamilton section. The absence of the Beechwood apparently does not decrease the total thickness of the Hamilton; this fact suggests that the same time of deposition is represented, where the Beechwood is not found, by beds that have Silver Creek lithology.

The exhaustive collecting and useful paleontologic identifications by Campbell (1942) will undoubtedly lead to a much more detailed understanding of the Hamilton rocks and their distribution, but the Deputy and Swanville “formations” appear to be only faunal facies of units previously recognized and named, or combinations of such units. They might better be called “zones” or “faunal facies” of the Sellersburg (North Vernon) limestone.

At present the Indiana Geological Survey uses both of the terms North Vernon and Sellersburg as formation names that include all of the limestones of Hamilton age of the southeastern Indiana outcrop. The term Beechwood is used for a member at the top of the Hamilton sequence. The names Silver Creek and Speed are applied to lithofacies of the Hamilton rocks; these lithofacies may be used as members in the southern part of the outcrop belt. Middle Devonian stratigraphy in southeastern Indiana appears to be understandable without the use of additional names.

Total thickness of the Sellersburg (North Vernon) limestone ranges from 1 foot to 26 feet. The Beechwood member is absent locally, ranges from a few inches to 10 feet in thickness where present and identifiable, and is typically about 3.5 feet thick. North of central Jennings County the part of the North Vernon beneath the Beechwood member is apparently absent. Within southern Indiana, the top of the Devonian limestone section is not exposed north of southern Bartholomew County, and thus the presence or absence of the North Vernon limestone in Shelby County and northern Bartholomew County has not been determined.

New Albany shale

The name “New Albany black slate” was proposed by Borden (1874, p. 158) for a unit that is about 100 feet thick in and near the southern Indiana outcrop and that consists mainly of black shale. Cumings (1922, p. 472-474) reviewed the opinions of many workers concerning the age of the formation and noted, after 1910, “a tendency to regard at least the upper portion as belonging to the Mississippian.” Campbell's detailed study of the problem (1946) assigned about 12 feet at the top of the New Albany to the Kinderhookian. The Devonian part of the formation was divided into (ascending) the Blocher and Blackiston “formations,” and the Mississippian part was divided into the Sanderson, Underwood, and Henryville “formations.” The Indiana Geological Survey uses these terms with the rank of member.

The New Albany is “evenly laminated, conspicuously and regularly jointed, deep brown to black... shale” (Cumings, 1922, p. 475). Gray-green shale is present, at least locally, in the lower part of the formation. (See unit 14 of measured section at Paul Frank quarry, p. 25.)

In southern Indiana, exposures of the New Albany are found from the Ohio Valley, in the region of New Albany and Jeffersonville, northward through eastern Floyd County, Clark and Scott Counties, western Jefferson County, Jennings County, and southern Bartholomew County.

CONDITIONS OF SEDIMENTATION DURING DEPOSITION OF DEVONIAN ROCKS IN SOUTHEASTERN INDIANA

By Haydn H. Murray

The Middle Devonian rocks of southeastern Indiana are predominantly normal marine limestones and dolomites that were deposited on a stable platform. These rocks vary from high-calcium limestones to dolomite of almost theoretical composition. Carbonate rocks, especially limestone and dolomite, have been studied for many years, but conditions of sedimentation of these rocks have never been fully understood. Correlation of minor lithologic variations of carbonate rocks with their environment and water depth has seldom been very successful.

Since this brief discussion is based on the study of outcrops in southeastern Indiana, it must be general in nature and subject to revision after information on the subsurface Devonian rocks in other areas of Indiana becomes available. Some fundamental problems which must be understood before conditions of sedimentation can be interpreted are: the relationship of texture, lithology, and composition of rocks to water depth at the time of deposition; the ratio between chemically precipitated and detrital carbonate rocks; the effect of marine organisms on the deposition of carbonate; whether the magnesium in dolomite was introduced after deposition and lithification of the dolomite or whether it was in the original carbonate mud; and the amount of alteration of carbonates during diagenesis. Because these problems still have not been answered satisfactorily, the conditions and environments of sedimentation cannot be fully understood.

The Eastern Interior Basin did not exist as we now know it during Devonian sedimentation. An extensive Middle Devonian sea covered the entire midwestern part of the United States (Schuchert and Dunbar, 1941, p. 198). Since Silurian reefs influenced the deposition of Devonian rocks to a great extent, the position of the Silurian reef front must be discussed in order to understand Devonian deposition.

This reef front crossed south-central Illinois from southwest to northeast as far north as Vermilion County, Ill. (Lowenstam, 1949, p. 8). From Vermilion County, Ill., the reef front swings southeastward and enters Indiana in Vigo County. It continues through Sullivan, Knox, Pike, and Warrick Counties into Kentucky. All Devonian rocks which will be seen during this conference were deposited north and east of this Silurian reef front.

Lower Devonian sediments were not deposited in southeastern Indiana because, in the writer's opinion, the reef platform was too high to permit deposition during Helderbergian and Oriskanian time. As Lower Devonian rocks are present in Illinois south of the reef front (Workman, 1944, p. 194), these rocks probably can be found south and west of the reef front in Indiana, that is, in Posey, Vanderburgh, and Gibson Counties.

Deposition of Geneva dolomite

The Geneva dolomite is the oldest Devonian formation that will be observed on the field conference. Mr. Howard R. Schwalb, of the Illinois Geological Survey, recently has studied the Geneva and correlated it with the lower part of the Grand Tower limestone, which is Onondagan in age (oral communication, 1955). The southern limit of the Geneva dolomite lies in the same general area as the Silurian reef front; therefore, deposition of this dolomite probably was controlled by the reef front. The Geneva has a distinctive brown color and contains organic material (p. 54), which could have been deposited along with the shallow basin muds.

The Geneva contains more magnesium than the formations above and below it. This magnesium probably was in the original lime mud instead of being introduced after the deposition of the dolomite. Groundwater that carried dissolved magnesium salts could have percolated through the Geneva and not through the other formations, but this explanation does not seem as plausible as the belief that the magnesium was in the original lime mud. The Geneva is not present in the southern part of the Devonian outcrop areas in southeastern Indiana. Evidently the basin in which this dolomite accumulated was shallow and was controlled by the reef front. The present extent of the formation (Howard R. Schwalb, oral communication, 1955) indicates that this basin was a few hundred miles in length but only a few tens of miles in width.

Deposition of Jeffersonville limestone

The Jeffersonville limestone is divided into three zones (p. 38). The lower zone (the coralline zone) was deposited as a biostrom in the extreme southern area of Devonian outcrop in Indiana and as both biostroms and bioherms in Bartholomew County and northward. The middle zone consists of the laminated zone in the northern outcrop area and was deposited in a restricted tidal flat or lagoon environment in which fine-grained organic material was abundant. Sedimentary structures characteristic of very shallow water are prevalent in this laminated zone. In the southern outcrop area the Spirifer gregarius beds of Kindle (1901, p. 539) occur in this middle zone (p. 38), which is a normal marine platform limestone. The upper zone of the Jeffersonville, a normal marine platform limestone, contains the Spirifer acuminatus bed of Kindle (1901, p. 538).

The lowermost zone of the Jeffersonville limestone, which conference participants will see at Stops 2, 3, 4, 6, 7, and 8A, is the coralline zone. This zone is extremely striking because of the many corals. In the southern part of the Devonian outcrop belt the zone appears to be a biostrom which was deposited in warm, clear, shallow water on the reef platform. North of this southern outcrop belt at Stop 8A, a well-developed coralline zone is represented by both bioherms and bio strom. Still farther north at Stop 9, the coralline zone is not present. The absence of this zone suggests that conditions for coral growth over the platform were not as suitable as they were farther south and that bioherms may have been formed north of Stop 8A in Bartholomew County. Subsurface information will have to be evaluated before this belief can be substantiated, but the writer thinks that bioherms will be found to be more extensive than biostrom in this zone to the north of Stop 8A.

The laminated zone of the Jeffersonville is well developed in southern Shelby County and overlies the coralline zone in Bartholomew and Jennings Counties, but this laminated zone is not present south of these counties. Conference partic ipants will see this laminated zone at Stops 7, 8A, and 9. This zone is characterized by laminae caused by organic material concentrated in layers and is slightly more argillaceous than the coralline zone. It probably was deposited in a relatively restric ted small basin in which organic debris and lime muds accumulated. This basin probably was similar to a broad tidal flat, as mudcracks and ripple marks have been observed on the bedding planes at many localities.

The middle zone in the southern outcrop area and the upper zone of the Jeffersonville limestone are normal marine limestones deposited on a flat stable platform where organisms were abundant. These two zones are called Spirifer gregarius (lower) and Spirifer acuminatus (upper) because of the abundance of these fossils. One or both of these zones will be seen at Stops 2, 3, 4, 6, 7, and 8A.

Deposition of Sellersburg limestone

The Sellersburg (North Vernon) limestone is the uppermost Middle Devonian formation in Indiana. It is characterized by two distinct lithofacies, Speed and Silver Creek, and by the Beechwood member, which overlies the two facies at most places.

The Speed facies is biofragmental and may be termed “shell hash” by some geologists. Broken fossil fragments are the predominant component of this facies. The Speed facies will be observed at Stops 3, 4, 6, and 7. The Silver Creek facies is characterized by its argillaceous content. It is fossiliferous, but its fossils are not as broken as the fossils of the Speed facies. This fact indicates that the Silver Creek facies probably was deposited in quiet and deep water. The Silver Creek facies will be seen at Stops 3, 4, and 6. The Speed facies is best developed in the central part of the Devonian outcrop belt, and the Silver Creek facies is best developed in the southern part of this belt. The Silver Creek probably would look like the Speed if the fine-grained argillaceous material were removed. At Stop 3, Speed and Silver Creek lithologies are interbedded. The Speed at this stop probably was deposited inactive water in which the fossils were broken and the fine-grained muds were winnowed out, whereas the Silver Creek was deposited in quiet water.

The Beechwood member, the uppermost unit of the Sellersburg, is a normal marine limestone that is extremely fossiliferous. As the fossils are broken, the Beechwood must have been deposited in an environment in which wave action was intense. At some localities the basal part of this member is characterized by a zone of phosphate pebbles ranging from a few millimeters up to 2 inches in diameter. These phosphate nodules probably are a lag concentrate similar to that described by Dietz, Emery, and Shepard (1942, p. 815-847). The Beechwood apparently is a shallow-water deposit which accumulated on a stable shelf.

Deposition of New Albany shale

The New Albany shale was deposited after the Beechwood. Rich (1951, p. 2017-2040) believes that the New Albany was deposited in deep water, but Stockdale (1939, p. 38) believes that the New Albany is a near-shore facies. Twenhofel (1939, p. 307) says that "so far as the writer is acquainted with the black shales of North America, none has been seen that justifies assumption of deep-water deposition."

Black shale is deposited as a result of the rapid accumulation of mud and organic matter which prevents elimination of the organic material or a limited circulation that prevents oxidation from taking place. Whether or not the basin was deep or shallow is controversial and, therefore, will not be discussed here.

GEOMORPHOLOGY OF FIELD CONFERENCE AREA

By William J. Wayne

Physiographic units

The entire area covered by this field trip lies within the Till Plains section of the Central Lowland province as defined by Fenneman (1938, p. 449). Although the area has been glaciated, the drift is thin and bedrock control of topography is conspicuous, and thus the area might well have been considered a part of the Interior Low Plateaus province. Portions of four of the nine physiographic units recognized by Malott (1922, p. 83-124) in Indiana will be seen (pl. 2).

Dearborn upland. --The Dearborn upland in Indiana lies entirely within the area that has been glaciated. It is characterized by smooth, steep slopes and long, flat-topped upland ridges between deeply intrenched valleys. Most of the valley bottoms are narrow. The upland ranges from 950 to 1,000 feet in altitude and is considered to be a remnant of a Tertiary peneplain covered by a thin mantle of glacial drift. The western margin of the unit is formed by the Laughery escarpment, a feature produced by erosion of Cincinnatian shales beneath a resistant cap of Niagaran lime stone.

Muscatatuck regional slope. --The back slope of the Laughery escarpment, essentially a gently westward-dipping structural plain, is called the Muscatatuck regional slope. It is mantled with a thin layer of glacial drift as far south as the Ohio River. At its eastern margin altitudes range from about 875 to more than 1,000 feet. The western margin is about 500 feet above sea level near the Ohio River and 700 feet at the north where the unit disappears beneath Wisconsin drift. Streams trenching the regional slope flow in steep-walled valleys, but interstream areas are relatively flat.

Scottsburg lowland. --Malott selected the nearly flat divide between Fourteen Mile Creek and Silver Creek as a somewhat arbitrary boundary between the Muscatatuck regional slope and the Scottsburg lowland in Clark County. The two units merge through a zone a few miles wide and become obscured beneath glacial drift in Johnson County. The lowland is underlain by Devonian and Lower Mississippian shales (pl. 1), which have little resistance to erosion. Glacial drift a few tens of feet thick mantles the surface. Most of the valleys in the Scottsburg lowland are broad and lack steep bluffs, and local relief is everywhere less than 75 feet. North of the Wisconsin glacial boundary the lowland is buried beneath glacial drift 200 to more than 400 feet thick (Wayne, 1952).

Norman upland. --The Knobstone escarpment forms the boundary between the Scottsburg lowland and the Norman upland to the west (pl. 2). This escarpment, the most prominent physiographic feature of southern Indiana, stands 300 to 600 feet above the lowland and valleys to the east and was a rather effective barrier to the westward movement of the ice lobes which moved down the Scottsburg lowland. The Norman upland is the back slope of a cuesta produced by erosion of the resistant sandstones and siltstones of the Borden series. It is characterized by great local relief and is maturely dissected by streams so that it consists of sharp ridges, steeply sloping valley sides, and narrow valley bottoms. Ridge-top altitudes range 900 to more than 1,000 feet.

Tertiary erosion and deposits

Erosion surfaces. --Between the end of deposition of Paleozoic sediments and Pleistocene glaciation, southern Indiana undoubtedly was subjected to several cycles of uplift and erosion. Earlier erosion surfaces were destroyed during succeeding cycles. The oldest cycle now recognizable in Indiana is one which ended with Tertiary (possibly Pliocene) rejuvenation of streams. The gently rolling surface developed during this erosional cycle has been called the Lexington peneplain in Kentucky and the Highland Rim peneplain in Tennessee (Fenneman, 1938, p. 432).

The Lexington peneplain was an early old-age landscape on which some relief remained. Stream gravels on this peneplain indicate that local relief was great enough to provide coarse debris to streams. Remnants of this peneplain stand between 900 and 1,000 feet above sea level in southeastern Indiana.

Rejuvenation of streams in late Tertiary time began a new cycle of erosion during which streams became intrenched 200 to 300 feet beneath the Lexington peneplain. An erosional surface along abandoned valley segments of streams disrupted by glaciation has been called the Parker strath (Fenneman, 1938, p. 301-302). Probably most of the deep valleys now buried beneath thick glacial drift had been excavated by the end of Pliocene time (Horberg, 1950, p. 97; Wayne, 1952).

Tertiary deposits. --Fluviatile deposits cap the upland rock surface in many places in southern Indiana. Deeply weathered siliceous gravels ("Lafayette" formation) have been described (Malott, 1922, p. 132-134), although other lithofacies are also represented. Thick sand beds of the Ohio River formation (Ashley, 1903, p. 68-70) probably are Tertiary in age, and stratified silts that resemble floodplain deposits have been observed. These fine-grained deposits probably are much more common than is indicated in the literature. One reason why these fine-grained deposits are not mentioned oftener in the literature may be that high-level, rounded gravels are more readily recognized than interbedded silt and sand and thus are less likely to be disregarded or called "residual soil."

Pleistocene geomorphic history and deposits

Kansan glaciation and Yarmouth interglacial age. --At least one glacier reached southern Indiana prior to the Illinoian ice advance. Leverett (1929, p. 33-49) described pre-Illinoian erratics in Kentucky, and Wayne (1954, p. 1320) recorded the presence of Kansan till beneath Illinoian till in southwestern Indiana. Exposures in Scott, Jennings, Brown, and Monroe Counties (pl. 2) indicate that the Kansan ice margin across Indiana must have closely approximated that of the Illinoian ice. Because of their very deep weathering, some drift deposits along the glacial boundary in southern Indiana are suspected of being older than Illinoian.

Kansan till throughout Indiana is generally a sandy, silty, and stony till. Where a full soil profile is present on Kansan till beneath fresh Illinoian drift, primary carbonates are found at depths of 9 to 13 feet.

During Yarmouth interglacial time the Kansan till surface was subjected to weathering and erosion. Yarmouth flood-plain deposits beneath Illinoian drift have been observed in Indiana, in Monroe, Clay, and Montgomery Counties, but none have been recognized yet in the area covered in this field conference.

Illinoian glaciation and Sangamon interglacial age. --The most extensive glaciation in Indiana was the Illinoian, which blanketed approximately five-sixths of the state with ice-laid drift. Malott (1926, p. 93-104) reviewed the revisions made in mapping the position of the glacial boundary across Indiana from 1876 to 1926; the boundary shown on plate 2 is essentially that drawn by Thornbury (1937, fig. 3).

Large amounts of wood beneath and in the Illinoian till in many places indicate that Illinoian ice advanced over standing forests. Lithologically, Illinoian till differs from the underlying Kansan till and most of the Wisconsin till in that it is more clayey and seems to contain less sand and boulders. Where a full soil profile on Illinoian till lies buried beneath Wisconsin drift, the depth to primary carbonates in the lllinoian till generally ranges from 5 to 7 feet (Thornbury, 1937, p. 100-121). Where it is the surface material, Illinoian till is leached of carbonates to an average depth of about 12 feet.

Wisconsin glaciation. --Wisconsin glaciers reached their maximum extent in central Indiana approximately 20,000 radiocarbon years ago (Rubin and Suess, 1955, p. 483). Although the ice margin oscillated in Illinois to produce the sequence of moraines mapped in that state, a slightly different situation seems to have existed in the Indiana lobe during the same time. A larger retreat and readvance of the ice took place in Indiana and are marked by a soil and topographic discontinuity that crosses the state from near Attica in western Indiana southeastward past Danville and then follows the "Champaign" moraine in a general way to eastern Indiana (Wayne, 1954, p. 199). The distal margin of this readvance is marked by outwash plains, kames, and other end moraine features. Five places have been found north of this line where a thin fossiliferous silt that has a humus zone at the top separates till of this readvance from the till beneath. (See Stop 9, p. 35.) The time involved in deposition of these interstadial materials must have been brief, however, as no leaching of carbonates took place. Most of the mollusk species recovered from the silt are now living generally in the latitude of northern Ontario, but a few have more widespread distribution (Oughton, 1948, p. 80-83).

INDUSTRIAL MINERALS IN THE FIELD CONFERENCE AREA

By Duncan J. McGregor

The economic well-being of Indiana is linked to the mineral raw materials that are found below the surface of the state. Various minerals are abundant in Indiana; some of these are not being exploited to the fullest extent at the present time; others have potential commercial value but are awaiting future utilization.

The mineral raw materials produced in the area of the field conference consist of sand, gravel, shale, and crushed stone. About 72 pits have been located from which sand or gravel or both have been removed; 16 of these pits are now active or active on demand. Crushed stone is produced from eight quarries, and shale used in manufacturing cement is extracted from one pit.

The mineral aggregates industry

Production. --Sand and gravel produced in Indiana during 1953 amounted to 11,203,059 short tons valued at $9,500,914. Sand and gravel sold or used by producers in Indiana during 1953 are shown according to use in table 1. About 0.3 percent of the state's sand and gravel value comes from the five counties visited during this field conference.

Crushed limestone produced in Indiana during 1953 amounted to 8,200,831 short tons valued at $10,616,484. Crushed limestone sold or used by producers in Indiana during 1953 is shown according to use in table 2. About 16 percent of the state's crushed stone value comes from the area of Devonian outcrop in southeastern Indiana.

Uses. --Most sand and gravel is used commercially in building and paving construction, as railroad ballast and fill, and for filtration purposes. The construction

Table 1. --Sand and gravel sold or used by producers in Indiana during 1953 according to use[1]

Product	Short tons	Value
Sand:		
Molding -	499,290	$ 672,166
Structural -	1,745,960	1,476,207
Paving (commercial)- - - - - - - - - - - - -	2,096,126	1,628,489
Paving (government and contractor operations) - - - - - - - - - - - - - -	131, 322	78, 803
Engine -	72,087	43,019
Other -	34,283	10,320
Undistributed - - - - - - - - - - - - - - - - -	293,478	254,455
Total sand - - - - - - - - - - - - - - - -	4,872,546	4,163,459
Gravel:		
Structural -	1,735,956	1,667,002
Paving (commercial) - - - - - - - - - - - - -	3,583,081	2,974,015
Paving (government and contractor operations) - - - - - - - - - - - - - -	412,430	203,008
Railroad ballast - - - - - - - - - - - - - - - - -	523,815	438,916
Other -	75,231	54,514
Total gravel - - - - - - - - - - - - - - -	330,513	5,337,455
Total sand and gravel - - - - - - - -	11,203,059	$9,500,914

[1]Data from U. S. Bureau of Mines.

Table 2. --Crushed stone sold or used by producers in Indiana during 1953 according to use[1]

Product	Short tons	Value
Riprap -	147,456	$ 268,975
Flux -	86,683	105,385
Concrete, road metal, and screenings - - - -	5,598,649	6,847,528
Railroad ballast - - - - - - - - - - - - - - - - - - -	336,577	398,641
Agriculture -	1,890,843	2,410,352
Miscellaneous - - - - - - - - - - - - - - - - - - -	140,623	585,605
Total -	8,200,831	$10,616,486

[1]Data from U. S. Bureau of Mines.

of highways and buildings provides the principal market for gravel. Crushed limestone is used mainly for concrete aggregate, road construction, railroad ballast, riprap, sewer filter beds, and fine aggregate in concrete products. It also is used as fluxstone in smelting; in making cement, lime, agricultural limestone, and rock wool; in manufacturing sugar and glass; by the chemical industries; as filters; and for rock dusting. Principal uses for crushed limestone in Indiana are for concrete aggregate, road construction, and agricultural limestone.

Economics. --Sand, gravel, and crushed limestone are low-priced commodities and cannot absorb high transportation costs. Plant prices for sand, gravel, and crushed stone may be as much as 40 or 50 percent less than freight rates charged to haul them. Thus, the sale of sand, gravel, and crushed stone is restricted to relatively local markets.

Like other mineral industries, the nonmetals industries have shown a trend toward concentrating business in larger operations. In crushed stone the trend toward larger units with increased production capacity is outstanding. An exception to this general trend is the use of portable crushed stone or sand and gravel equipment, which can be shifted from one location to another. Operations using this portable equipment, by saving in freight, may compete successfully with the larger centralized plant tied to a fixed location.

Further economies in production costs can be expected through technological changes and improvements. In addition, more attention is being centered on raising the quality of the product and on recovering by-products from materials formerly wasted.

Distribution and stratigraphy of mineral raw materials

Sand and gravel. --Sand and gravel are intimately related to glaciation. Three stages of glaciation have been recognized in Indiana; these are, from oldest to youngest, Kansan, Illinoian, and Wisconsin. Kansan drift has not been found at the surface in Indiana, but both it and the younger Illinoian drift covered about five-sixths of the state. Wisconsin drift is at the surface in the northern two-thirds of Indiana. (Seep. 48.)

Glacial gravels occur as valley-train deposits, outwash plains, kames, and eskers. Although the glacial gravels contain pre-Cambrian granites, gneisses, and schists, the coarser materials are composed mostly of carbonates and shale that the ice had overridden within 100 miles or so of its margin.

Gravel deposits of commercial value are relatively scarce in Illinoian glacial materials. The Illinoian drift has been subjected to weathering for a long period of time, and as a result a thick mantle of soil overlies the recoverable gravel. Many Illinoian valley-train deposits have been dissected or removed almost entirely by post-Illinoian stream erosion; others have been covered by Wisconsin outwash materials and cannot be distinguished from the overlying younger gravel and sand.

In contrast to the gravel deposits of older glaciations, Wisconsin drift has a much thinner soil, and streams have had less time to remove the Wisconsin deposits. Because of these facts and because of the fact that Wisconsin drift covers all older materials in the northern two-thirds of Indiana, this drift is the principal source of sand and gravel in the state.

Most sand and gravel in Indiana are produced from valley-train materials that lie along all major and many minor glacial drainage channels in Indiana. The valley occupied by the East Fork of White River is an example of such a former glacial sluiceway. Active or active-on-demand gravel pits in southeastern Indiana are shown on plate 2.

Crushed stone. --Crushed stone in southeastern Indiana consists of limestone and dolomite and is produced from Ordovician, Silurian, and Devonian rocks.

Most of southeastern Indiana is covered by Illinoian glacial drift (pl. 2). In many areas, however, bedrock is close enough to the surface to permit profitable stripping and quarrying. In the area between the south edge of the Wisconsin drift border and the Champaign morainic system (Malott, 1922, pl. 2), drift is fairly thin and most of the major streams and their tributaries have cut into bedrock; thus a quarry can be opened there without excessive stripping. Quarries in Bartholomew, Shelby, Rush, and Decatur Counties lie within this area of early Wisconsin drift.

Quarries that produce crushed stone from Devonian rocks in southeastern Indiana are shown on plate 2.

Specifications for mineral aggregates

Specifications now in effect for sand, gravel, and crushed stone are the outgrowth of study by the users of these aggregates in constructing highways and buildings. Specifications are determined largely by performance of the mineral raw materials and by differences in their physical characteristics. Specifications usually are set forth for each construction project.

Characteristics of mineral raw materials that are included in specifications are size gradation, soundness, durability, deleterious particles, hardness, and strength of aggregates. Other characteristics that may be included are particle shape, surface texture, mineral composition, absorption, specific gravity, weight, voids, volume, change characteristics, and reactivity with portland cement. Test methods of the American Society for Testing Materials are accepted as standard for most mineral raw materials.

The State Highway Commission of Indiana in its manual, Standard specifications for road and bridge construction and maintenance (1952), lists the general requirements for coarse aggregate and the tabulated sizes of coarse and fine aggregate.

Some of these specifications are not realistic in terms of Indiana's geology. Patton (1953a, p. 116) in discussing Indiana gravels illustrates this lack of realism by saying that:

> the materials from which producers must meet a single set of specifications are extremely diverse in composition. Recognition of this diversity is shown by the special clause in the Indiana specifications which provides that the limits of the amount of chert may be waived for those sources of aggregates that lie in counties south of U. S. Highway 50 or through which the highway passes, provided that gravels from such sources have a satisfactory service record under similar conditions of service and exposure. Highway engineers think in terms of highways and undoubtedly feel that a numbered highway makes an ideal boundary for any purpose, but the realistic boundary for any such deviation from specifications is a geologic one. Some of the lowest chert contents in the state may be found in areas south of U. S. 50. Nevertheless, this special clause was a realistic move to use aggregates in regions where none would have passed the usual specifications. However, the terms of the clause do not accurately delimit the area of shortage. Additional special clauses may become necessary in Indiana and other states if the increased demand for aggregates is to be met.

Importance of mineral raw materials in the conference area

Uses of mineral raw materials. --The Geneva dolomite, Jeffersonville limestone, Speed and Silver Creek facies, the Beechwood member of the Sellersburg limestone, and New Albany shale constitute a source of mineral raw materials in southeastern Indiana.

The Geneva dolomite is quarried for the general uses of crushed stone. The composition of this dolomite suggests that it would be ideal as a refractory material and for other uses in which high-magnesium content is essential. However, it is not quarried for these uses.

The Jeffersonville limestone is principally a calcium limestone in deposits near the Ohio River but becomes increasingly more dolomitic, particularly in its lower part, in deposits to the north. The Jeffersonville is quarried for the general uses of crushed stone and as a raw material for portland cement. As the magnesium content of limestone used in manufacturing cement must below, the Jeffersonville is used for this purpose only in the region near the Ohio River. The laminated zone of the Jeffersonville satisfies the State Highway specifications for coarse aggregate but does not have a good performance record as concrete aggregate. Thus rock from the laminated zone is not acceptable for use in concrete pavement but is acceptable as aggregate in other types of road surface and in volume concrete.

The Speed facies, although relatively thin, is used for the general purposes of crushed stone, and in places where it is associated with low-magnesium Jeffersonville limestone, it is used as a raw material in manufacturing portland cement.

The Silver Creekfacies is used principally as a raw material in manufacturing natural cement. The rock is soft and argillaceous and is not acceptable for concrete aggregate or grade A stone; also its low carbonate content makes it unsuitable for agricultural limestone. It probably would be suitable, however, in manufacturing rock wool.

The Beechwood member of the Sellersburg limestone is a high-calcium limestone in some places, but it is too thin to be quarried alone commercially. It can be used for the general purposes of crushed stone.

Laboratory tests show that some of the New Albany shale has bloating characteristics that would make it suitable as a raw material for lightweight aggregate. The New Albany shale presents interesting possibilities of being combined with limestone to form special products. In Sweden the International Ytong combines shale with limestone to produce a product known as Ytong Lightweight Building Units. The shale, limestone, and other additives are mixed, emptied into a deep mold 4 feet by 8 feet by 18 inches, and subjected to steam under pressure. After this molded block has cured, it can be cut into various shapes and sizes. This process recently was introduced into North America (Ortengren, 1955, p. 222-224). The New Albany shale may constitute a source of raw material for this type of product. It is a low-grade oil shale from which oil has been recovered experimentally. As the maximum yield reported is 6 to 114 gallons per ton (Reeves, 1922, p. 1692), the shale is not likely to be developed for this purpose alone.

Radioactivity is higher in the New Albany shale than in any other bedrock in Indiana tested to date, and recent interest in sources of radioactive materials has stimulated new interest in the black shale on the part of prospectors. The radioactivity probably is due to uraniferous minerals, the mineralogy of which is not yet known (McKelver, 1955). The radioactivity of the New Albany shale is much lower, however, than the radioactivity of known commercial ores.

Some economic considerations.--Sand and gravel operators in some areas are now employing special beneficiation methods to produce sand and gravel that will meet the required specifications. These beneficiation methods are concerned with eliminating deleterious constituents in sand and gravel. An example of new techniques in use at the present time is the removal of deleterious materials by heavy-media separations. Torgerson (1955, p. 68) described a beneficiation method used in Michigan in which the heavy medium is a mixture of 60 percent magnetite and 40percent ferrosilicon. Magnetite and ferrosilicon cost about $50 and $150 per ton respectively. Media loss in processing seems to be about 1 pound per ton of finished product; the cost of this media loss is about 4. 5 cents per ton. The specific gravity of the medium is kept as close to 2. 5 as possible. Most of the chert, shale, and other deleterious particles are floated off and discarded when this method of beneficiation is used.

Lewis and Venters (1954) also used heavy-media separation on some Indiana gravels. They concluded that heavy-media separation can be used to separate deleterious particles and thus improve the durability of concrete made with these gravels. They pointed out that the cost of this treatment would have to be evaluated carefully in relation to the benefits derived in order to determine the economic feasibility of heavy-media separation.

Some of the rock formations in Indiana, notably the carbonate rocks, are not being used for the purposes for which they are best suited. For example, in some quarries the entire wall of limestone is blasted at the same time, even though the mixture that is obtained is not suitable for many purposes. However, products of high quality can be produced if ledging and separating the rocks into various types are used. The Louisville limestone in places where it is overlain by the calcitic Jeffersonville limestone in a quarry wall illustrates the benefits that can result from proper quarrying. The Louisville may have many uses, but its high-magnesium content makes it unsuitable for manufacturing portland cement. The Louisville limestone maybe separated from the usable Jeffersonville by the ledge method of quarrying. Thus some useful products are obtained instead of an unsuitable rock mixture. Ledge separation also can be used in producing good concrete aggregate from some beds and good road metal, bituminous aggregate, and agricultural lime - stone from others.

Producing each mineral raw commodity so as to realize its fullest value not only benefits business but also helps in conserving mineral resources. Producers seeking maximum returns on their investments may profitably turn to the manufacture of special products and high-specification materials.

CHEMICAL COMPOSITION OF DEVONIAN ROCKS OF SOUTHEASTERN INDIANA

By R. K. Leininger

A knowledge of the chemical composition of rocks has become useful to stratigraphy; chemical data, along with mineralogic analyses, replace geologic field terms such as “dolomitic,” “argillaceous.” “phosphatic,” and “arenaceous” with quantitative measures. Two or more facies differing in composition can be dealt with more certainly if analyses are available than if only descriptions are available.

Chemical analyses have been made of chip samples from many of the lithologic units described in the stratigraphic sections in this guidebook. The chip samples which have been analyzed were taken from fresh rock; they were collected by breaking uniformly sized chips from the outcrop in such a way as to include material in a continuous sequence from bottom to top of the rock unit. Where two or more units grade into each other lithologically, a single sample was taken. Most samples, however, represent single lithologies.

The determinations of carbon dioxide (CO_2), total sulfur (S), and phosphorus pentoxide (P_2O_5) for the limestones, and all determinations for the New Albany shale were obtained by chemical methods in the laboratories of the Indiana Geological Survey by or under the direction of Maynard E. Coller. Determinations of the content of calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$), silica (SiO_2), alumina ($A1_2O_3$), total iron expressed as ferric oxide (Fe_2O_3), titanic (TiO_2), and manganese oxide (MnO) were obtained by spectrographic methods.

The discussion of composition of the formations is based on all pertinent analyses on file in the offices of the Indiana Geological Survey. These analyses include those of cores and chip samples from other localities in addition to the various stops of the field conference.

In the tables of analyses the units correspond to those of the stratigraphic sections. All results are expressed as percentage by weight. An asterisk (*) signifies that the constituent was detected and is present in the sample in an unmeasured amount but not necessarily in an amount less than for other samples. Similarly, a hyphen (-) signifies that the constituent was not detected, but that the constituent is not necessarily absent nor is less than the least quantity listed.

Chemical composition of Geneva dolomite

Except for local occurrences of siliceous material at the base and the occurrence of chert at one locality in Rush County, the Geneva is predominantly dolomite. In 45 analyses of samples from 21 localities, however, the maximum percentage of dolomite is 95 (calculated from the result for magnesium carbonate). Because impurities do not account for the total difference between the maximum dolomite content and 100 percent, some calcite must be present. Large crystals of calcite are found locally in the Geneva, but even where these crystals are absent, some calcite must still be present. North of Jefferson County the Geneva is more dolomitic than the underlying Louisville. In Jefferson County and to the south differentiation of Louisville and Geneva on the basis of chemical composition is not reliable. For example, at Stop 1, unit 10 resembles Geneva more than Louisville in composition, but this unit is included in the Louisville because of paleontologic evidence.

Silica ranges from 0.3 to 7.0 percent except for the basal portion which is locally sandy. In contrast with the underlying Louisville limestone, which is locally argillaceous, the Geneva contains little clay as shown by a range for $A1_2O_3$ from 0.02 to 0.5 percent. One exception to this range for $A1_2O_3$ is a thin (0. 1 foot) siliceous sample of Geneva (72 percent SiO_2) for which $A1_2O_3$ is 2 percent.

The iron content of Geneva is consistent and surprisingly low. The range, expressed as percentage of Fe_2O_3, is from 0. 1 to 0. 8. In 31 of 45 analyses of Geneva, Fe_2O_3 exceeds $A1_2O_3$, whereas for 22 of 27 analyses of Louisville, A12O3 exceeds Fe_2O_3. The TiO_2 content in most samples of the Geneva is low. MnO is a common constituent, averaging approximately 0.04 percent. Sulfur is variable; pyrite is present in some samples but is not common, as can be concluded from the range of 0.01 to 0.2 percent for sulfur (29 samples). P_2O_5 is extremely low and lies in the range of 0.002 to 0.014 percent.

An important constituent of the Geneva is organic matter. Most of the characteristic dark-brown color of the formation is due to heavy hydrocarbons. This organic matter resembles crude petroleum in composition. Two samples of Geneva were found to contain an average of 1 percent volatile organic matter.

Differentiation of Geneva and basal Jeffersonville is difficult, and little assistance in differentiating them can be obtained from the present chemical analyses. In general, the Geneva is more dolomitic than the basal Jeffersonville. At Stops 3, 4, and 6, Geneva must be absent, as dolomite does not occur at the base of the Jeffersonville. At Stops 7 and 8A and at the Graham (Big Camp Creek) section, the Geneva is more dolomitic than the Jeffersonville; at Stop 9 no chemical distinction is known.

Chemical composition of Jeffersonville limestone

In contrast with the relatively uniform composition of the Geneva dolomite, the chemical composition of the Jeffersonville limestone is varied. This variation does not involve argillaceous components, however; in its argillaceous components the Jeffersonville resembles the Geneva. For 86 analyses of Jeffersonville the range of $A1_2O_3$ is from 0.03 to 0.9 percent except for a 1.9-foot unit which contains 1.2 percent $A1_2O_3$. Of course, thin shale partings contain alumina as a major constituent. Except for local concentrations of secondary pyrite, the iron content also is low and is similar to that of the Geneva. The range for Fe_2O_3 in the Jeffersonville is 0.07 to 3.0 percent, but only in five samples does Fe_2O_3 exceed 0.6 percent. Silica in most samples of Jeffersonville ranges from 0.2 to 12 percent and averages about 3 percent; one bed of the Jeffersonville limestone is exceptional in that silicification is almost complete. Secondary pyrite gives rise to a variable sulfur content; results show that sulfur ranges from 0.002 to more than 4 percent. MnO averages about 0.3 percent. The TiO_2 content is variable but does not exceed 0.07 percent.

The constituents of primary interest in the Jeffersonville are phosphorus, calcium, and magnesium. At many localities this limestone may be divided into distinct lower, middle, and upper zones. (See p. 38.) Differentiation of the three zones has been made on the basis of phosphorus content. For all localities along the outcrop where samples have been obtained, the phosphorus content increases from bottom to top in the limestone. Whether this increase is stepwise or continuous has not been determined. The range of P_2O_5 for the three zones is as follows: lower, 0.001 to 0.016 percent; middle, 0.004 to 0.042 percent; upper, 0.076 to 0.20 percent. The increase of phosphorus continues into the Sellersburg (North Vernon) limestone and reaches a maximum in a thin bed of Silver Creek lithology. This bed contains black phosphatic pebbles and/or nodules which Haydn H. Murray (oral communication, 1955) has found to contain carbonate-apatite. The bed at Stop 7 was found to contain 2.25 percent P_2O_5. Brachiopods of the Lingula type identified by Patton (1953b, p. 51) indicate an organic origin for phosphorus in at least some of the Devonian rocks.

Though the middle zone of the Jeffersonville generally contains more magnesium than the other zones, the important trend for magnesium in the limestone is lateral rather than vertical. Constituents other than calcite and dolomite are minor except for quartz in the silicified bed of the coralline zone and chert in one known locality. Thus strata of low calcium content are high in dolomite and vice versa. The percentage of dolomite may be assumed to be the percentage of $MgCO_3$ times 2.19. In southern Clark County, as at Stops 3 and 4, the average dolomite content for the entire limestone is low (about 5 and 6 percent respectively); northward the dolomite content increases as follows: northern Clark County, 15 percent; Scott County, at Stop 6, 21 percent; Jennings County, at Stop 7, about 60 percent; and Bartholomew County, at Stop 8A, about 50 percent. The last-mentioned location differs from the others, however, because a calcitic bioherm lowers the average for the whole limestone. Farther north, in Shelby County, the exposed Jeffersonville contains about 80 percent dolomite. Field and analytical data indicate that the increase in dolomite occurs both as an increase in the relative thickness of the limestone that is dolomitic and, what is probably more important, as an increase in the proportion of dolomite in the rock throughout the thickness.

Chemical composition of Sellersburg (North Vernon) limestone

Speed facies. --Fourteen samples of the Speed facies from 12 localities have been analyzed. Calcium carbonate ranges from 77 to 94 percent, and magnesium carbonate ranges from 3 to 17 percent (equivalent to 7 to 37 percent dolomite). The amount of silica is between 2 and 9 percent, and $A1_2O_3$ ranges from 0.5 to 2 percent. Except in two samples, Fe_2O_3 is less than $A1_2O_3$ and ranges from 0.4 to 1.2 percent; in the two samples in which Fe_2O_3 is greater than 0.7 percent, a higher than average sulfur content indicates pyrite. Thus the iron content is remarkably uniform. The TiO_2 content is as much as 0.09 percent and correlates with the $A1_2O_3$ content. MnO averages about 0.07 percent, which is higher than in the Jeffersonville. Sulfur ranges from 0.05 to 0.9 percent. The P_2O_5 content is high, ranging from about 1.5 to 1.8 percent. Though the Speed facies in most samples is impure, the degree of impurity is sufficiently different from that of the Silver Creek facies to permit differentiation of the two facies by analysis.

Silver Creek facies. –Eighteen samples of the Silver Creek facies from 10 localities have been analyzed. Based on a magnesium carbonate range of 13 to 31 percent, the dolomite content of the Silver Creek facies ranges from about 30 to 70 percent. This is but one of the distinguishing features of the Silver Creek. Calcium carbonate content is low, from 48 to 73 percent; silica is high, from 7 to 17 percent; alumina is high, from about 2 to about 5 percent. Fe_2O_3 is not as uniform as it is for the Speed facies, and its variations are not all correlative with sulfur; the Fe_2O_3 range is from 0.9 to 2.2, with one exception of 4.7 percent. The sample with 2.2 percent Fe_2O_3 contains next to the least sulfur for all samples, but the sample with 4.7 percent Fe_2O_3 contains 1.4 percent sulfur. The sulfur content is variable but in most samples is high, ranging from 0.3 to 1.4 percent, with one exception of 0.04 percent. In some samples of the Silver Creek the phosphorus content is the highest found in the analysis of any limestone from Indiana. Most samples of the

Silver Creek facies, however, contain less phosphorus than the Speed facies. The range for P_2O_5 is 0.04 to 9.2 percent.

Beechwood limestone member. --Fifteen samples of Beechwood limestone from 11 localities have been analyzed. The Beechwood limestone is one of few strata in the northern part of southeastern Indiana which may contain more than 90 percent $CaCO_3$. In Clark County, however, high-calcium limestone (more than 95 percent $CaCO_3$) is available from the Jeffersonville. At Stop 8A, in Bartholomew County, a bioherm in the Jeffersonville yields limestone containing 93 percent $CaCO_3$; at the same location the Beechwood is about 94 percent $CaCO_3$. The Beechwood, however, is not consistently calcitic limestone. The percentage of $CaCO_3$ ranges from 70 to about 98; the percentage of $MgCO_3$ ranges accordingly from 0.5 to 18. The impurity content is fairly consistent and is predominantly silica, for which the range is 0.8 to about4percent. $A1_2O_3$ is less than 1 percent (one exception of 1.04 percent) and is as low as 0.12 percent. Fe_2O_3 is high in samples in which pyrite is common, but in other samples it is low. The range for Fe_2O_3 is 0.2 to 4 percent. TiO_2 is fairly low, because the limestone is not argillaceous. MnO is above average, ranging from 0.03 to nearly 0.2 percent. Sulfur is high, ranging from 0.05 to 3 percent. P_2O_5 ranges from 0.01 to 0.6 percent. Differentiation of the Beechwood from underlying Silver Creek and Speed facies on the basis of composition is difficult only where the Speed is relatively pure and the Beechwood is relatively impure.

Chemical composition of New Albany shale

Four chemical analyses of the New Albany shale at Stop 7 appear on page 62. Because no extensive analytical work has been done on the samples of this formation, little can be said about the chemical composition of the New Albany. Many problems are involved in the accurate determination of results in analyzing samples of black shale, and the problems for some samples are difficult. Because of the interest in black shale as a source of oil, raw material for lightweight aggregate, and uranium, future analytical work is anticipated. Analyses of the New Albany will be of interest to geologists in studying such problems as the environment of deposition, the reason for the great quantity of black shale vertically and laterally, and the mineralogy.

Table 3. --Chemical and spectrographic analyses of samples from measured section at Stop 1, Fourteen Mile Creek[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
9	20.0	Louisville	55.4	40.8	2.06	.44	70	-	.025	.040	.015	45.6
8	14.0	Louisville	56.0	32.6	7.38	1.94	1.01	.069	-	.080	.012	42.1
7	12.5	Waldron	no analysis									
6	27.0	Laurel	55.2	36.4	5.04	1.30	1.44	.058	.027	.077	.016	43.6
5	2.3	Osgood	no analysis									
4	5.8	Osgood	52.3	33.4	8.86	2.64	1.68	.094	.032	.16	.063	40.4
3	10.3	Osgood	47.4	28.7	16. 3	4.56	1.72	.20	.029	.029	.061	35.3
2	1.3	Saluda	52.4	31. 2	10..6	3.13	1.59	.14	.036	.059	.040	39.2
1	10.8	Saluda	52.8	31.3	10.8	2.52	1.40	.14	.029	.049	.16	39.3

[1]All analytical results are exp ressed in percent.

Table 4. --Chemical and spectrographic analyses of samples from measured section at Stop 3, abandoned quarry, Sellersburg Stone Company[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
16	3.8	Beechwood	90.9	4.15	3.82	.20	.38	*	.064	.073	.15	42.0
15	0.2	Silver Creek?	55.7[2]	17.4	13.4	2.73	4.65	. 13	.20	1.41	9.2	25.9
14	5.5	Silver Creek	53.7	29.0	11.5	2.33	2.26	.13	.075	.29	.042	38.8
13	1.0	Speed?	66.9	15.4	11.4	2.92	1.23	.16	.056	.33	.042	37.5
12	upper 3.0	Silver Creek	60.5	19.0	13.5	3.19	1.58	.23	.066	.51	.047	36.7
12	lower 6. 1	Silver Creek	61.6	17.4	14.1	3.26	1.39	.21	.060	.51	.064	35.8
11	1.8	Speed	82.9	5.08	7.21	1.61	.61	.065	.041	.33	1.81	38.0
10	5.6	Jeffersonville	88.4	5.81	2.97	.19	.53	-	.045	.36	.48	41.5
9	5.6	Jeffersonville	92.2	3.58	3.41	.092	.18	-	.033	.034	.11	42.0
8-5	10.4	Jeffersonville	92.4	3.82	2.40	.68	.45	.034	.022	.31	.009	42.1
4	10.0	Jeffersonville	95.4	.98	3.24	.083	.14	-	*	.078	.004	42.1
3-2	11.3	Louisville	65.4	15.0	14.5	3.22	.81	.12	.024	.42	.010	36.5
1	11.1	Louisville	66.6	13.9	14.5	3.22	.70	.12	.025	.25	.008	36.5

[1]All analytical results are expressed in percent.

[2]Includes $Ca_3(PO_4)_2$ expressed as $CaCO_3$

Table 5. --Chemical and spectrographic analyses of samples from measured section at Stop 4, Louisville Cement Company quarry[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
13	3.1	Beechwood	91.5	3.39	4.12	.13	.26	*	.060	.082	.15	41.9
12	7.8	Silver Creek	53.2	25.5	15.8	3.24	1.22	.13	.044	.51	.038	36.9
11	6.1	Silver Creek	60.6	19.2	14.1	3.99	.92	.16	.043	.60	.069	35.9
10	4.4	Speed	83.2	5.46	7.97	1.83	.66	.080	.042	.38	.48	38.6
9-8	12.3	Jeffersonville	92.2	4.29	2.45	.22	.32	.022	.044	.20	.41	42.0
7-6	8.6	Jeffersonville	92.2	3.82	2.66	.64	.46	.031	.022	.34	.008	42.6
5-3	11.1	Jeffersonville	95.0	1.76	2.26	.43	.30	.027	.017	.20	.006	42.5
2	3.7	Jeffersonville	92.7	1.98	4.47	.11	.18	-	.013	.075	.003	41.8
1	3.5	Louisville	75.6	4.54	16.9	1.36	.45	.091	.011	.20	.004	35.2

[1]All analytical results are expressed in precent

Table 6. --Chemical and spectrographic analysis of sample from Rockford limestone[1]
(Sampled 2. 5 miles southeast of Stop 5 at exposure on Indiana Highway 39.

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
- -	2.5	Rockford	75.8	7.88	9.24	2.34	3.50	.10	.10	.068	.085	38.3

[1]All analytical results are expressed in percent

Table 7. --Chemical and spectrographic analyses of samples from measured section at Stop 6, Scott County Stone Company quarry[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
12	4.9	Beechwood	81.5	14.2	2.53	.72	.52	*	.050	.27	.055	43.4
11	0.8	Silver Creek	48.7	31.0	12.0	4.77	1.40	.19	.044	1.06	.18	36.3
10-9	13.0	Speed	83.4	9.51	4.84	1.05	.67	.043	.088	.49	.31	41.2
8	8.0	Jeffersonville	92.2	6.32	1.12	.068	.16	-	.042	.058	.096	43.7
7	11.1	Jeffersonville	80.8	13.6	3.90	.65	.36	.033	.030	.20	.017	42.2
6-4	11.1	Jeffersonville	92.9	4.40	1.83	.15	.20	*	.020	.097	.004	43.0
3-2	9.8	Jeffersonville	85.2	13.2	.81	.14	.16	*	.019	.033	.002	44.3
1	2.8	Louisville	64.6	26.2	5.62	1.87	.58	.065	.016	.24	.008	41.8

[1] All analytical results are expressed in percent

Table 8. --Chemical and spectrographic analyses of samples from measured section at Stop 7, Paul Frank quarry[1]

Unit	Thickness (feet)	SiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	S	CO_2	Ignition loss
15	7.4	56.7	12.5	4.04	2.23	.098	2.42	.53	3.44	.67	.061	2.46	3.25	15.9
14[2]	20.4	62.9	15.6	3.70	2.18	.10	2.15	.49	4.55	.81	.038	.94	3.40	6.05
14	19.0	57.5	16.5	4.29	2.48	.11	3.49	.37	3.9	.65	.18	1.4	5.33	8.86
13	11.2	50.3	13.5	3.57	2.42	.089	5.72	.19	3.2	.50	.086	1.3	7.22	17.9

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
12	3.4	Beechwood	97.8	.50	.76	.12	.47	-	.10	.18	.65	42.2
11[3]	0.2	North Vernon (Silver Creek)	72.2	13.2	8.19	2.60	1.65	.17	.16	.94	2.25	35.8
10	3.0	North Vernon (Speed)	83.0	10.8	3.32	1.10	1.19	.050	.12	.90	.59	40.5
9	5.9	Jeffersonville	86.0	9.68	3.60	.085	.18	-	.078	.004	.076	42.4
8	4.45	Jeffersonville	64.8	32.0	1.88	.53	.34	.026	.044	.13	.016	45.2
7-6	11.7	Jeffersonville	64.0	32.2	2.40	.53	.44	.030	.036	.16	.015	45.0

Table 8. --Chemical and spectrographic analyses of samples from measured section at Stop 7, Paul Frank quarry- -Continued

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5	5.6	Jeffersonville	65.0	33.5	.65	.088	.37	*	.053	.060	.005	46.5
4	3.1	Geneva	56.0	41.1	1.88	.25	.25	-	.049	.062	.004	46.6
3	6.3	Geneva	54.3	40.0	4.81	.024	.31	-	.060	.047	.002	45.4
2	1.7	Geneva	56.4	41.5	1.16	.15	.29	-	.047	.077	.005	46.8
1	0.8	Geneva	56.9	41.4	.77	.047	.36	-	.047	.13	.002	46.9

[1]All analytical results are expressed in percent

[2]Analyses of two separate samples of Unit 14 are listed.

[3]Chemical analysis. Samples were obtained approximately 1,800 feet apart.

Table 9. --Chemical and spectrographic analyses of samples from measured section at Stop 8A, Meshberger Stone Company quarry[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
18	2.6	North Vernon (Beechwood)	94.3	1.05	2.28	.31	1.73	.049	.061	1.35	.50	41.0
17	7.4	Jeffersonville	89.8	4.22	5.16	.094	.15	*	.039	.064	.10	41.5
16	1.3	Jeffersonville	69.8	27.6	1.42	.38	.28	*	.043	.073	.14	45.2
15-11	11.0	Jeffersonville	59.9	33.4	5.27	.62	.20	.022	.036	.12	.017	44.3
10-7	11.2	Jeffersonville	59.2	33.6	5.09	.79	.25	.026	.035	.15	.019	44.2
6	2.7	Jeffersonville	63.8	33.4	1.63	.32	.31	-	.027	.11	.011	45.3
5	8.9	Jeffersonville	93.2	5.61	.39	.044	.25	-	.033	.053	.003	44.3
4	3.3	Jeffersonville	65.0	34.0	.20	.041	.43	-	.065	.044	.005	46.5
3	3.8	Geneva	59.2	39.7	.53	.089	.28	-	.036	.045	.009	46.8
2	upper 20.3	Geneva	58.6	39.7	.67	.092	.44	-	.033	.22	.005	46.6
2	lower 5.8	Geneva	58.9	37.6	2.45	.22	.25	-	.029	.068	.004	45.8
1	4.2	Louisville	59.8	37.1	1.79	.30	.48	.030	.038	.17	.007	45.4

[1]All analytical results are expressed in percent

Table 10. --Chemical and spectrographic analyses of samples from measured section at Stop 9, Gave Stone Company quarry[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
5-4	13.1	Jeffersonville	53.8	40.7	4.02	.56	.33	*	.028	.025	.019	45.2
3	7.4	Jeffersonville	56.4	39.1	2.94	.72	.32	.020	.022	.051	.014	45.1
2	11.1	Geneva?	62.2	36.5	.65	.20	.14	-	.014	.11	.004	46.1
1	6.9	Geneva	62.3	35.7	.12	.057	.28	-	.041	.041	.003	45.9

[1]All analytical results are expressed in percent

Table 11. --Chemical and spectrographic analyses of samples from measured Graham section[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
7	21.0	North Vernon	93.6	3.10	1.95	.53	.46	*	.084	.046	.14	42.5
6	10.0	Jeffersonville	83.4	12.0	3.59	.13	.20	-	.068	.013	.090	42.8
5	8.5	Jeffersonville	84.4	12.8	2.04	.035	.14	-	.061	.007	.042	43.5
4	10.4	Jeffersonville	92.2	7.30	.15	.040	.10	-	.044	.012	.004	44.4
3	18.2	Geneva	55.7	41.8	1.20	.21	.47	-	.035	.013	.008	46.2
2	5.0	Waldron	no analysis									
1	23.8	Laurel	61.0	32.8	4.57	.65	.55	*	.026	.063	.014	43.7

[1]All analytical results are expressed in percent

Table 12. --Chemical and spectrographic analyses of samples from measured Commiskey quarry section[1]

Unit	Thickness (feet)	Rock unit	$CaCO_3$	$MgCO_3$	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	S	P_2O_5	CO_2
4	4.6	North Vernon (Beechwood)	94.9	1.48	1.82	.66	.53	.037	.062	.15	.14	42.2
3	2.8	North Vernon	86.5	8.04	2.79	1.04	.52	.051	.061	.37	.43	41.8
2	1.4	North Vernon (Silver Creek and Speed?)	82.3	10.0	4.45	1.53	.68	.068	.068	.28	.19	41.3
1	2.7	North Vernon (Speed?)	83.5	8.52	3.51	1.48	.87	.065	.055	.50	.98	39.8

[1] All analytical results are expressed in percent

ADDENDA

A natural exposure along the bluff of Big Camp Creek includes a complete Devonian limestone section and 25 feet of Silurian. For those who are interested and who may be in this area again, this is a very worthwhile section. Because of the size of the group, we cannot visit this exposure, but the location and mileage are included.

Mileage	
0.0	Crossroad in Deputy. Turn east.
0.4	Sawmill.
1.6	Church and cemetery on right.
3.3	Road forks. Take left fork.
3.5	Cross Big Camp Creek.
3.8	Stop. A cemetery is on right. The Graham section is in the ravine on the west edge of the cemetery. Follow this ravine to Big Camp Creek.

Graham section

Location: N½SW¼ sec. 13, T. 4 N., R. 8 E., a quarter of a mile northeast of the community of Graham in Jefferson County. (See p. 66 for chemical and spectrographic analyses of samples from this section.)

	DEVONIAN	Feet
	New Albany shale	
8.	Shale: Black, weathered	1.0
	North Vernon limestone	
7.	Limestone: Gray, crystalline, thin- to medium bedded	21.0
	Jeffersonville limestone	
6.	Limestone: Gray and tan, crystalline, massive, dolomitic, cherty (Spirifer acuminatus zone)	10.0
5.	Limestone: Brown, finely crystalline, massive, dolomitic. Contains corals and small amount of chert in lower part	8.5
4.	Limestone: Brown and tan, crystalline, dolomitic, coralline	10.4
	Total thickness of Jeffersonville limestone	28.9
	Geneva dolomite	
3.	Dolomite: Dark-brown, sugary, massive	18.2

SILURIAN

Feet Waldron shale

2.	Shale: Covered	5.0

Laurel limestone

1.	Limestone: Gray, crystalline, thin-bedded, dolomitic; contains some chert	23.8
	Total thickness of measured section	96.9

Commiskey quarry section

The Commiskey quarry section is included in the Addenda because this location is the farthest north that recognizable Silver Creek facies is observed. This abandoned quarry is in the NE¼SE¼ sec. 21, T. 5 N., R. 8 E., a quarter of a mile east of Indiana Highway 3 at Commiskey, Jennings County. (See p. 67 for chemical and spectrographic analyses of samples from this section.)

	North Vernon limestone	Feet
4.	Limestone: Gray, in part reddish, granular, fossiliferous. Top 1.1 feet crinoidal. Rock weathers to platy appearance along bedding planes (Beechwood member?)	4.6
3.	Limestone: Gray, granular, fossiliferous; weathers tan to pinkish and platy	2.8
2.	Limestone: Gray, argillaceous; lower 0.9 foot massive and weathers and breaks conchoidally (Silver Creek lithology). Top 0.5 foot Speed lithology. Gradation at boundary between the two lithologies	1.4
1.	Limestone: Gray, granular, fossiliferous, argillaceous, platy (Speed lithology)	2.7
	Total thickness of measured section	11.5

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