

THE STRATIGRAPHY AND STRUCTURE OF A DEVONIAN LIMESTONE AREA IN CLARK COUNTY, INDIANA

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Introduction. This paper is primarily the result of commercial prospecting for oil and gas in the Devonian limestone area of Clark County, Indiana, during the summer of 1931. In connection with the commercial work, special attention was given to the location of the western boundary of the Silurian rocks which also outcrop in that region.

This work on the Devonian and Silurian limestones has provided several new geologic sections heretofore unpublished, and some revision of sections published in earlier reports; the discovery of a Silurian inlier at a point west of any previously reported inliers; some new facts regarding the lithology, thickness, and persistence of the Devonian formations; the proposal of a name for the chert bed of the Silver Creek formation; and a structural map of a large portion of Clark County.

It is felt by the writers that data of this nature will be of interest and of value to future workers in this region; and since the commercial aspects of these investigations did not permit an exhaustive study, the following paper is presented with the sole idea of adding to, or revising, former reports on the geology of Clark County.

The writers wish to acknowledge their gratitude for assistance rendered by the Louisville Cement Company of Louisville, Kentucky, and the Indiana Department of Conservation, Division of Geology. Without the aid of these organizations, this work would not have been possible.

Review of Literature. In a brief paper of this nature, it is impossible to review in any detail the work of all the previous writers who have studied the Devonian formations of Clark County. The earliest work in this region was, probably, that of Increase A. Lapham in 1827. Since that time a number of writers have contributed to the knowledge of the Devonian rocks in Clark County, notable among whom were Hall, Borden, Foerste, Kindle, and Siebenthal. An able resume of the publications by these earlier workers may be obtained by consulting Cumings' "Nomenclature and Description of the Geological Formations of Indiana."¹ Of the reports by the above writers, the State report by Kindle,² published in 1900, and Siebenthal's State report on the Silver Creek hydraulic limestone, written in the same year,³ have proved invaluable during the work upon which the following paper is based. Siebenthal's report is particularly valuable because of the geological

¹ Cumings, E. R. *Handbook of Indiana Geology*, Part IV, pp. 405-570 (1922).

² Kindle, Edward M. "The Devonian Fossils and Stratigraphy of Indiana." 25th Ann. Report, Ind. Dept. Geol. Nat. Resources (1900).

³ Siebenthal, C. E. "The Silver Creek Limestone of Southeastern Indiana." 25th Ann. Report, Ind. Dept. Geol. Nat. Resources (1900).

map which accompanies it and because of the number of detailed sections listed. These reports have been freely consulted in the preparation of the present paper.

Location and Topography. Clark County lies on the Ohio River in southeastern Indiana. Floyd and Washington counties lie to the west, and Jefferson and Scott counties lie to the north; the Ohio River forms the remainder of its boundaries.

In general, the topography of Clark County is that of a dissected plateau, sloping gently toward the west, where rises the Knobstone escarpment. The county is drained by two major streams, Silver Creek and Fourteen Mile Creek. Both streams flow in a southerly direction and empty into the Ohio River.

Physiographically, Clark County is situated upon the Muscatatuck Regional Slope, the Scottsburg Lowland, and the Norman Upland. The eastern part of the county lies within the western part of the Muscatatuck Slope, the western boundary of that unit being given as "the divide between Fourteen Mile and Silver Creeks in Clark County."⁴ In this eastern part of the county, the uplands are typically quite flat between streams and the gentle southwestern slope is not perceptible to the eye. The major drainage line, Fourteen Mile Creek, is canyon-like in character. Its tributaries entering from the east are much longer than those entering from the west, due probably to the dip of the underlying strata. Some underground drainage has been developed in the underlying limestones. Sinkholes are fairly numerous and small caves are frequently found in this part of the county. To the south, the uplands pitch off abruptly at the bluffs of the Ohio River in an escarpment about 400 feet in height.

As a regional slope, the eastern part of Clark County merges rather indistinctly into the Scottsburg Lowland on the west. In this lowland area the topography has a rolling character with flat-topped divides developed upon the underlying Devonian shale. The immediate relief is usually small and the streams have developed fairly wide and flat valleys. Subterranean drainage is also found in this part of the area, but the development of such drainage is somewhat greater than it is farther to the east. "Indian Cave," one of the largest caves in the area, is found just west of the city limits of Charlestown.

The Scottsburg Lowland area of Clark County is bounded on the west by the Knobstone escarpment which marks the eastern boundary of the Norman Upland. The rise into the rugged topography of the Knobs country is rather abrupt. The eastern face of the escarpment is not an unscalable bluff, however, but is a steep slope which rises rapidly to heights of 400 to 600 feet above the adjacent lowlands. The Knobs country is maturely dissected and has a well developed surface drainage cut deeply into the underlying Mississippian shales and sandstones.

The greater part of Clark County has been glaciated, but no large amount of drift has been left over its surface. The principal impress

⁴ Malott, C. A. "The Physiography of Indiana." Handbook of Indiana Geology, Part II, page 86 (1922).

left by the glaciers is confined, in the main, to the uniform, flat-topped appearance of the upland divides in some parts of the county.

The area investigated in Clark County by the writers comprised about 100 square miles, lying in the eastern and central portions of the county. The boundaries of the area are roughly as follows: The north and south boundaries are approximately on parallel lines which pass through Memphis and Watson respectively; the east and west boundaries, on parallel lines through the mouth of Fourteen Mile Creek and Speed respectively.

GEOLOGY

Rocks of four geological periods outcrop in Clark County. In order from east to west, these groups are the Ordovician, Silurian, Devonian, and Mississippian. Outcrops of the Ordovician and Silurian limestones are limited, in the main, to that portion of the county east of Fourteen Mile Creek and the Ohio River bluff as far south as Utica. The Mississippian rocks in the county consist of the Borden group of shales, sandstones and limestones which occupy an irregular area two to eight miles in width along the western border of Clark County. The remaining and major portion of the county is occupied by the rocks belonging to the Devonian period.

For the sake of clearness in later discussions, the geological section of the Devonian period, as represented in Clark County, is given below with a short description of the lithologic character of each formation.

Geological Section

Devonian—

- New Albany Shale
- Beechwood limestone
- Silver Creek limestone
- Jeffersonville limestone

Silurian—

- Louisville limestone

New Albany Shale. The New Albany shale is the uppermost member of the Devonian series found in Clark County. It is a dark gray to black, fissile, in places sheety shale which often contains a high percentage of bituminous matter. The thickness of the shale varies in Clark County from complete absence in the eastern part of the county to a maximum thickness of over 130 feet in the region near Henryville. The outcrop of the shale lies roughly between Fourteen Mile Creek on the east to Silver Creek on the west.

The New Albany shale lies disconformably upon the underlying Devonian limestones and the writers found the contact of the shale and limestone to be unreliable as a datum plane for structural mapping.

Beechwood Limestone. The Beechwood limestone is "that bed of white to gray crystalline limestone which overlies the cement rock (Silver Creek limestone), which underlies the New Albany Black shale, and which by various writers has been alluded to as the Crinoidal limestone, and to distinguish it from a crinoidal layer in the Corniferous (Jef-

ersonville limestone), as the Upper Crinoidal limestone.”⁵ The Beechwood is referred to as the “Sellersburg” by Siebenthal, from whose report the above quotation was taken, but more recent work by Butts,⁶ who proposed the name, has warranted the application of the name of “Beechwood” to this formation

The Beechwood limestone, as exposed in Clark County, is easily recognized by its hard, massive, coarsely crystalline characters and the abundance of fossil crinoid plates and stems that weather into relief on exposed surfaces. The limestone is usually thin, the average thickness being about four feet, although in some places the thickness is as much as ten feet. The Beechwood is a very persistent formation in Indiana, being present in practically every section that exposes both the New Albany shale and the Silver Creek limestone. The overlying shale often slumps down over the Beechwood, thus obscuring the bed where thin, and careful search is then necessary to reveal its presence in the section.

At or near the base of the Beechwood limestone there is generally a conglomeritic band characterized by shining black pebbles that are clearly rounded and water-worn. This band is frequently very sandy with the pebbles imbedded in this arenaceous matrix. In places, the conglomeritic band is as much as six inches in thickness and forms a definite stratum intercalated between the Beechwood and the Silver Creek limestones; at other points, the band is thin and appears to be distinctly related to the Beechwood formation. The natural conclusion is that this band represents a basal conglomerate, but certain features seen in the character of the pebbles and the physical appearance of the exposures of this band do not, at present, warrant a definite theory of its origin. The conglomeritic band is well developed in the outcrop exposed along a tributary of Sinking Fork Creek in Section 136 (see Section No. 33).

Because of the thinness of the Beechwood member, its persistence over a considerable area, and its easily recognized lithologic characters, this limestone serves as a very good key horizon for structural mapping.

Silver Creek Limestone. The Silver Creek limestone lies between the Beechwood limestone and the Jeffersonville limestone. It is typically developed in the region of Silver Creek, Clark County, and has received its name from that fact. The limestone is often termed “cement rock” because of its once extensive use for the manufacture of cement in Clark County.

The Silver Creek limestone is typically a fine-grained, bluish to drab, soft, fairly homogeneous, argillaceous magnesian limestone. It occurs in fairly massive beds, the average total thickness of which is about 15 feet in the area investigated in Clark County, but in places the thickness is reduced to as little as nine and one-half feet. According to Butts,⁷ there is a hiatus between the Beechwood and Silver Creek limestones and this may account for the variable thicknesses of the two formations. As is shown by sections below, the Beechwood limestone is thickest where the normal thickness of the Silver Creek is reduced and vice

⁵ Siebenthal, C. E. Op. cit., page 341.

⁶ Butts, Chas. “Geology of Jefferson County (Ky.)” Ky. Geol. Surv., Ser. IV, vol. 3, pt. 2 (1915).

⁷ *Ibid.*, p. 192.

versa. Regionally, the limestone thins to the north and, according to Siebenthal, disappears in the northern part of Scott County.

Previous writers on the Devonian limestone of Clark County have usually noted the presence of a cherty bed in the upper part of the Silver Creek formation. The bed is commonly referred to, in the literature, as "bastard rock" and is usually listed in each section as separate and distinct from the true "cement rock." Siebenthal⁸ believed that this chert bed was deposited contemporaneously with the Beechwood limestone.

This cherty horizon of the Silver Creek limestone received special attention during the work of the past summer. The bed was found to be a very distinct lithologic unit that varies from a few feet to as much as fourteen feet in thickness. In only a few places was the chert bed found to be absent from the section. The bed normally contains an abundance of chert, often in distinct horizontal bands, imbedded in a matrix of drab, fine-grained limestone that is lithologically similar to the Silver Creek limestone. Although some chert nodules are found scattered throughout the entire thickness of the Silver Creek formation, this particular chert bed, which occurs in the uppermost part of the formation, is characterized in its basal portion by the distinctly bedded character and extreme abundance of the chert as compared with that found in the lower part of the Silver Creek formation. In most cases the line of separation between the chert bed and the true "cement rock" is well marked; and in a few cases an inch or so of shale separates the two parts of the formation.

It is believed by the writers that the cherty portion of the Silver Creek limestone was deposited contemporaneously with the limestone matrix and that it is not a result of solution and replacement processes. The cherty bed was evidently deposited under slightly different conditions from those prevailing during the deposition of the lower, less cherty part of the formation. Contrary to Siebenthal's suggestion that the chert bed was deposited in Beechwood time, the writers have found typical Beechwood limestone overlying the chert beds at a number of places. This fact renders Siebenthal's view untenable.

Since this chert bed is a fairly persistent and distinct lithologic unit and since the earlier writers have seen fit to discriminate between the chert bed and the "cement rock," it is proposed that the bed be called the *New Chapel chert bed of the Silver Creek limestone*. The name "New Chapel" is taken from a small country church located in the southwest quarter of the southeast quarter of Sec. 37, Clark Grant, Clark County, Indiana. In a roadcut, just a few yards east of the church, the chert bed is well exposed near the top of a hill. (See Section No. 10 and Fig. No. 1.) Unfortunately, the type section selected for this cherty bed is not entirely satisfactory since the overlying Beechwood limestone is absent and the base of the cherty horizon is covered. Better exposures of the cherty bed are to be found at Watson (see Section No. 9) and north of Charlestown (see Section No. 33), where the overlying and underlying formations are present. Selection of either of these exposures as a type section was preferable, but due to the fact

⁸ Siebenthal, C. E. *Op. cit.*, p. 342.

that the name "Watson"⁹ was preoccupied and that the exposure north of Charlestown occurs on an unnamed stream, neither exposure could be selected as a type section.



Fig. 1. An outcrop of the New Chapel chert bed at the type locality. Note the abundance of distinctly bedded chert.

Jeffersonville Limestone. The Jeffersonville limestone lies beneath the Silver Creek limestone and above the Louisville limestone (Silurian) in the part of Clark County investigated by the writers. In other parts



Fig. 2. Outcrop of Devonian limestone showing contact of Silver Creek limestone and *Strophodonta demissa* zone of Jeffersonville limestone. Hammer rests at contact. Note the flaggy character of the Jeffersonville limestone, characteristic of weathered portions of the upper zone of that formation.

of the state the Pendleton sandstone or the Geneva dolomite occupies the base of the Devonian section, but no certain representatives of either of these formations were distinguished in any of the sections studied by the writers.

⁹ "Watson bed" was used by Rowley (Am. Jour. Sci., 4th ser., vol. 41, p. 318, 1916) for a part of the Silurian Edgewood limestone of Missouri. *New Chapel* has not been preempted.—Personal communication from M. Grace Wilmarth, Secretary, Comm. Geol. Names, U. S. G. S., Oct. 15, 1931.

Lithologically, the Jeffersonville limestone may be divided into three parts: (1) an upper, gray, shaly, very fossiliferous limestone, characterized by an abundance of *Athyris fultonensis*, *Stropheodonta demissa*, and several species of *Fenestella* and other bryozoa; (2) a middle, white to blue-gray, hard, massive limestone that composes the greater part of the formation; and (3) a basal, brown to blue-brown, crystalline limestone characterized by many corals (coral bed). (Fig. 2.)

The upper, shaly limestone is apparently the "*Stropheodonta demissa* zone" of Kindle and Siebenthal as it is the only portion of the Jeffersonville formation in which an abundance of this fossil was found by the junior author; many of the fossils in this zone are stained a dark purplish-red, particularly *Stropheodonta demissa*. The writers are 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. In most of the sections examined, including the section at the Louisville Cement Company quarry at Speed, the physical relationship of this zone seems to be more intimately associated with the Jeffersonville limestone than with the Silver Creek limestone. However, at the old Clark Mill quarry (see Section No. 5 below) the relationship seems to be reversed.

On account of the existing doubt regarding the age of the "*Stropheodonta demissa* zone," the junior author collected and has identified the following fossils from this zone:

List of Fossils From the *Stropheodonta demissa* Zone

	Utica Town- ship School (see Sec. No. 15)	Louisville Cement Co. quarry at Speed (see Sec. No. 2)	Diedrich Farm SE ¼, Sec. 132
<i>Athyris fultonensis</i> (Swallow)	x	x	x
<i>Aulopora serpens</i> Goldfuss	x		x
<i>Camarotoechia tethys</i> (Billings) . .	x		
<i>Crytina hamiltonensis</i> Hall	x		
<i>Fenestella verrucosa</i> Hall		x	
<i>Hadrophyllum d'orbigny</i> E. and H.	x	x	x
<i>Leptaena rhomboidalis</i> (Wilckens)	x	x	x
<i>Phacops</i> sp.			x
<i>Rhipidomella livia</i> (Billings)	x		
<i>R. vanuxemi</i> Hall	x	x	x
<i>Schizophoria striatula</i> (Schlotheim)	x	x	x
<i>Spirifer byrnesi</i> Nettleroth	x	x	x
<i>S. grieri</i> Hall	x		
<i>S. macrus</i> Hall	x		
<i>S. varicosus</i> Hall	x		x
<i>S. varicosus hobbsi</i> Nettleroth			x
<i>Stropheodonta demissa</i> (Conrad) . .	x	x	x
<i>S. inaequistriata</i> (Conrad)	x		x
<i>Terebratula jucunda</i> Hall		x	

Many specimens of *Fenestella* and other bryozoa collected from this zone have not been identified as yet because of their poor state of preservation.

Practically all the fossils listed above have been previously reported from the Jeffersonville formation. Some few, such as *Stropheodonta demissa*, *Athyris fultonensis*, *Rhipidomella vanuxemi*, *Leptaena rhomboidalis*, *Spirifer byrnesi* and *Spirifer varicosus*, have been reported from both the Jeffersonville (Onondaga) and the Silver Creek (Hamilton) formations. Species that have been reported only from the Jeffersonville (Onondaga) formation include *Camarotoechia tethys*, *Rhipidomella livia*, *Hadrophyllum dorbigny*. *Spirifer varicosus hobbsi* has never been reported from the Jeffersonville limestone but has been reported by Savage,¹⁰ from the base of the Silver Creek (Hamilton) formation, and by Nettleroth,¹¹ from the Beechwood (Hamilton) limestone. In as much as this fossil is a variety of *Spirifer varicosus* which is common in the Jeffersonville limestone, there appears to be no reason why the varietal form should not be present there. With this possible exception, the faunal affinities of the "*Stropheodonta demissa* zone" are with the Onondaga rather than Hamilton, and the shaly zone is regarded, therefore, as belonging to the Jeffersonville limestone rather than with the Silver Creek formation.

The middle, massive, white, crystalline portion of the Jeffersonville limestone is typical of the lithological character of the greater part of that formation. Directly below the *Stropheodonta demissa* zone and in the uppermost part of this middle portion occurs the "*Spirifer acuminatus* zone" of Kindle. This zone was found to be present wherever the top of the Jeffersonville horizon was exposed and may be as much as five feet in thickness. In addition to the abundant *Spirifer acuminatus*, the zone also contains many specimens of *Stropheodonta concava*. Near the base of the middle, crystalline portion of the Jeffersonville horizon, a few feet above the basal coralliferous portion, occurs the "*Spirifer gregarius* zone." This zone varies from a few inches to a little more than a foot in thickness and is rather easily recognized. The zone has been mentioned by Kindle, Savage, Siebenthal and others. Savage¹² correlates this zone with a similar one in the Grand Tower limestone of southwestern Illinois.

The basal portion of the Jeffersonville formation is the so-called "coral reef of the Falls of the Ohio." Cumings regards this coralliferous zone as a coral bed or layer rather than a true coral reef. "A coral reef refers to an upstanding mass on the sea bottom. The coral reef of the Jeffersonville limestone shows no evidence of ever having been such an upstanding mass, but is, rather, a wide-spread bed, from three to ten feet in thickness, that is composed chiefly of many species of corals."¹³ To the knowledge of the junior author, no true reef structure has ever

¹⁰ Savage, T. E. "The Devonian Rocks of Kentucky." Ky. Geol. Surv., Series IV, Vol. 33, p. 88 (1930).

¹¹ Nettleroth, Henry. "Kentucky Fossil Shells." Monograph, Ky. Geol. Surv., p. 122 (1889).

¹² Savage, T. E. *Op. cit.*, p. 88.

¹³ Cumings, E. R.—oral communication.

been found at this horizon and the term "coral bed" is, therefore, much more appropriate in referring to the coralliferous zone of the Jeffersonville formation. This coral bed of the Jeffersonville limestone is easily distinguished from that of the underlying Louisville (Silurian) limestone by the presence of the "chain coral" or *Halysites* in the latter and total absence of that form in the Jeffersonville limestone. The blue-brown color of the coralliferous zone of the Jeffersonville limestone is also distinctive.

Louisville (Silurian) Limestone. The Louisville limestone is the uppermost member of the Silurian rocks exposed in Clark County, Indiana. Only the upper part of the Louisville limestone is exposed in most of the area studied, although in the eastern part of the area and in the region of the Ohio River extensive sections of the Silurian rocks are exposed.

The upper part of the Louisville limestone is a blue-gray, massive, argillaceous limestone characterized by an abundance of *Halysites*, and several small species of *Favosites* and *Zaphrentis*. This horizon may represent the coral bed that is found at the top of the Louisville limestone in the vicinity of Louisville, Kentucky. The lower part of the Louisville formation is a light brown, fine-grained, crystalline limestone. The "*Stromboides* zone" is about twenty feet below the top of the formation and the "*Pentamerus oblongus* zone" is near the base of the formation. Where exposures were accessible for accurate measurement, the Louisville limestone was determined as being 50 to 60 feet in thickness, in the area studied.

An inlier of Louisville limestone was discovered along Pleasant Run in Sections 92, 93, and 94. This "window" of Silurian rock is worthy of special note since it has not been reported heretofore. The inlier is considerably west of any previously reported inliers.

FIELD PROCEDURE

The writers spent a total of seven weeks in Clark County collecting the data upon which this paper is based. The time was divided approximately as follows: two weeks in reconnaissance with aneroid barometer; three weeks in detailed surveying with a telescopic alidade and plane table; two weeks and a half rechecking sections and obtaining additional data in critical areas, constructing maps, identifying fossils, and doing other types of office work.

The reconnaissance work was done with a standard five-inch "Tycos" aneroid barometer. During the two weeks of reconnaissance work, the writers drove over practically all of the Devonian area of Clark County examining the more prominent outcrops in quarries, road cuts, along streams, and in similar exposed places. Two days were also spent on the Kentucky side of the Ohio River for the purpose of obtaining greater familiarity with the stratigraphy of the region. All outcrops were noted and aneroid elevations were taken upon one or more of the exposed horizons. Locations of outcrops were made by means of a farm plat map supplied by the Clark County State Bank of Jeffersonville.

After sufficient reconnaissance work had been done to show the most promising area for possible gas and oil structures, a detailed sur-

vey of approximately 100 square miles was made with the telescopic alidade and plane table. Primary traverses, totaling about 40 miles, were run along all the principal roads of the area; side shots were made from these primary traverses to all possible outcrops, in order to obtain the elevations of the key horizon. The top of the Silver Creek lime-

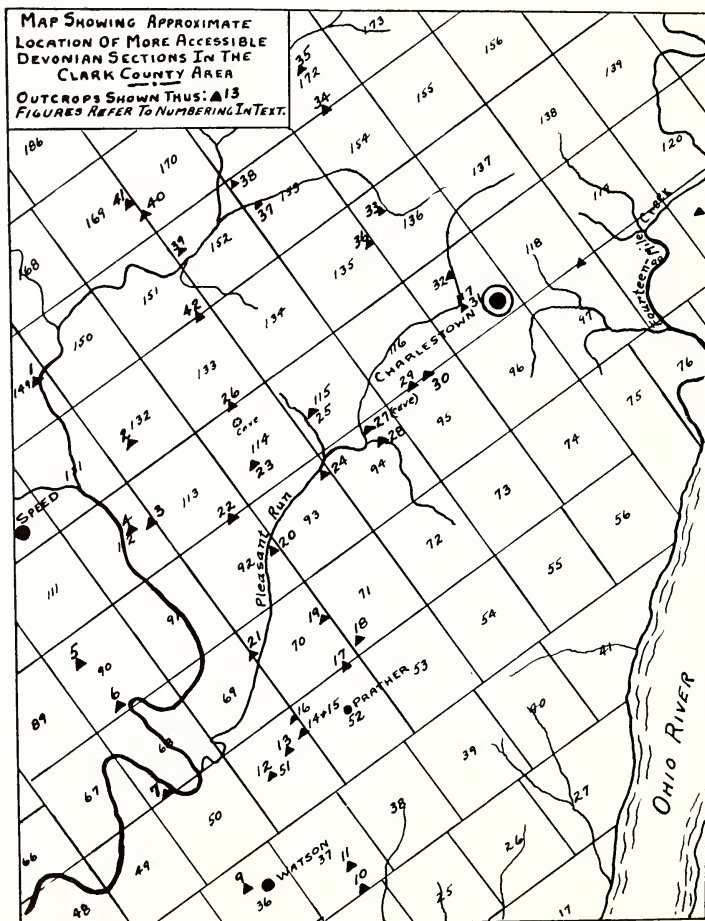


Fig. 3. Outline map of a part of the Devonian limestone area in Clark County, Indiana, showing the approximate location of the more accessible outcrops between Charlestown and Speed.

stone (including the New Chapel chert bed) was used as the key horizon. Elevations were often taken on the tops of other formations exposed in a section, thus insuring greater accuracy in determining the thicknesses of various formations as well as aiding in later interpolations necessary to the construction of the structural map. The railroad elevations used as permanent bench marks from which all traverses were run as follows: Charlestown, B. & O. R. R., 590 feet; Sellersburg,

Penn. R. R., 478.8 feet; Watson, B. & O. R. R., 503 feet; and Memphis, Penn. R. R., 489.7 feet.

With the aid of the plane table sheets and the farm plat map, each outcrop was accurately located upon a base map prepared from a copy of the county road commissioner's map. The elevations of the key horizon or interpolations to that horizon were then placed upon the map and the contours drawn upon the assembled data. In the final construction of the structural map, it was found that the data obtained from the first traverses were slightly inadequate to clearly delineate the structure and an additional week was spent in securing these necessary data.

The instrument work, construction of the structural map, and a portion of the geologic work necessary to the preparation of the present paper are due to the efforts of the senior author; the paleontological and stratigraphical phases of the work are almost entirely due to the ability of the junior author. Field assistance was given by Mr. George R. Freed during the survey work with the alidade.

LOCAL DETAILED SECTIONS

The following list of detailed sections from the Devonian limestone area of Clark County records, for the most part, new geologic sections not previously published. Each section, with only a few exceptions, is supplemented by one or more elevations taken at the contact of various formations exposed in the outcrop. In a few instances earlier reported sections are included either because of a desire to correct some discrepancy in former work, or because the section is needed to show the character of the stratigraphy.

Locations of the majority of these sections are shown on the accompanying map, (Fig. 3).

Speed and Vicinity

Section No. 1. On the west bank of Silver Creek, where the pike road turns east, near the center of Section 149, the following connected section is exposed along the road and in the creek bank:

New Albany shale	about 15 ft.
Beechwood limestone	3 ft.
Silver Creek limestone	4 ft.
Covered	20 ft.
Jeffersonville limestone	6 ft. to creek level

Elevation on the top of the Beechwood 464 ft. A. T.

Section No. 2. The quarry of the Louisville Cement Company at Speed, located near the center of Section 132, shows the following section:

New Albany shale	5 ft. plus
Beechwood limestone	3 ft.
Silver Creek limestone	16 ft.
Jeffersonville limestone	33 ft.
Louisville (Silurian) limestone (in sump)	6 ft.

Elevation on top of the Beechwood 486 ft. A. T.

The New Chapel chert bed is not well developed in this section and is confined to about four feet of moderately cherty Silver Creek limestone. The Jeffersonville limestone of the section includes a three-foot layer of corals at its base. Coralliferous Louisville limestone containing *Halysites* is found in a drainage sump at the west side of the quarry.

Section No. 3. The abandoned quarry of the old United States Cement Mill, near the center of the east line of Section 112, lies on the east side of Silver Creek, at the forks of the Charlestown-Sellersburg road. A section taken at this quarry shows:

New Albany shale.....	6 ft. plus
Beechwood limestone	3 ft.
Silver Creek limestone.....	13 ft. to quarry floor

Elevation on top of the Silver Creek formation... 486 ft. A. T.

The base of the Silver Creek limestone is not exposed in this quarry. The New Chapel chert bed of the Silver Creek is represented in this sec-

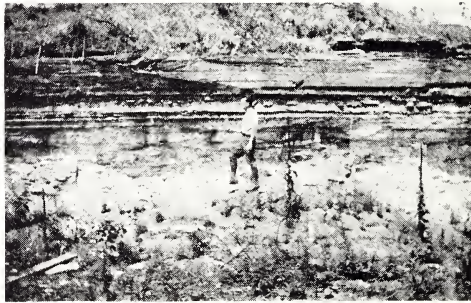


Fig. 4. Exposure of the Silver Creek formation at the old quarry of the U. S. Cement Mill, east of Sellersburg, Ind. The base of the New Chapel chert bed is marked by the senior author's hammer.

tion by four to five feet of moderately cherty limestone that is somewhat harder than the typical "cement rock." The chert is not very distinctly bedded and occurs most abundantly in the lower part of the New Chapel bed. (Fig. 4.)

Section No. 4. Just about 1000 feet west of the above section the Charlestown-Sellersburg road crosses Silver Creek. The east bank of that stream exposes the following section:

New Albany shale	
Beechwood limestone	2 ft.
Silver Creek limestone.....	15 ft.
Covered	25 ft.

Jeffersonville limestone

Elevation on top of the Silver Creek limestone..... 470 ft. A. T.

Bench mark, middle of floor, west end of Silver

Creek bridge

Section No. 5. A road metal quarry is now operating at the site of the former Clark County Cement Mill in the northwest quarter of

Section 90, about one-half mile south of the center of Sellersburg. A section of the north face of the quarry is as follows:

New Albany shale.....	3 to 4 ft.
Beechwood limestone	4 ft.
Basal conglomerate	3 to 4 in.
Silver Creek limestone.....	14 ft.
Jeffersonville limestone	33 ft.
Louisville limestone	16 ft.

Elevation on top of the Beechwood limestone..... 484.5 ft. A. T.

Elevation on top of the Jeffersonville limestone
(south side of quarry)..... 466.6 ft. A. T.

The cherty New Chapel bed of the Silver Creek formation is five feet thick at this point. A shaly zone, about one foot in thickness, containing an abundance of *Chonetes* species, separates the cherty bed from the lower eight feet of blue-gray, typical "cement rock." A zone of shaly, brownish limestone containing an abundance of *Stropheodonta demissa* is found in the top of the Jeffersonville limestone.

The upper five feet of the Jeffersonville limestone is not very crystalline. *Spirifer acuminatus* occur abundantly five feet below the top of the formation. The coral layers in both the basal portion of the Jeffersonville and the upper portion of the Louisville limestones are well developed at this quarry.

Section No. 6. Southeast towards Watson, on the road which passes the above mentioned quarry, in the southeast quarter of the southwest quarter of Section 90 is an abandoned road quarry on the farm of L. Dryer. This quarry exposes 22 feet of Jeffersonville limestone to the quarry floor. The upper 10 feet of the section is typical white, crystalline limestone but the lower 10 to 12 feet is composed of dark bluish-gray, crystalline limestone that scarcely resembles typical Jeffersonville limestone.

The floor of the quarry has collapsed in a number of places because of subterranean drainage channels.

Section No. 7. Southeast of this quarry, in the southwest quarter of Section 68, where the Watson-Sellersburg road crosses Silver Creek, Jeffersonville limestone is exposed in the west bank of that creek. About 12 feet of limestone is exposed to creek level at this point.

Section No. 8. South of Sellersburg, near the northeast quarter of the northwest quarter of Section 34 (about one mile south of Cementville), is a road metal quarry operated by K. Graves. The section at this quarry is as follows:

New Albany shale and soil.....	6 to 8 ft.
Beechwood limestone	3 to 8 in.
Silver Creek limestone.....	26 ft.
Jeffersonville limestone	6 ft. to quarry floor

The geological section exposed in this quarry presents a rather interesting stratigraphical problem. Directly beneath the New Albany shale is a very thin limestone which the writers have correlated as Beechwood. Although the limestone is not exactly typical of normal Beech-

wood, its coarsely crystalline character, dark gray color, and the presence of a few fossil crinoids are sufficient to warrant correlation with that formation.

The Silver Creek formation of this section is extremely abnormal in thickness and consists of two distinct beds, the New Chapel chert bed and the "cement rock." The New Chapel chert bed is fourteen feet in thickness. The chert is extremely abundant in the lower part of the bed and occurs in fairly regular bands, particularly in the basal four feet of the bed. The amount of chert decreases toward the top of the bed until the uppermost four or five feet are almost devoid of chert. The chert is in a matrix of bluish gray limestone that is practically as fine-grained as the true cement rock below, although it was noted that the limestone is somewhat more crystalline towards the top of the bed. Fossils are fairly abundant in this cherty bed.

A thin shale parting, one to two inches in thickness, separates the New Chapel chert bed from the lower bed of bluish-gray, fine-grained Silver Creek "cement rock" which is 12 feet in thickness. This bed of limestone is, lithologically, typical Silver Creek and contains only a few scattered nodules of chert.

As is shown in a following section taken at Watson, unmistakable Beechwood limestone does occur over the New Chapel horizon at that point, and from that evidence it is felt that the New Chapel chert bed should be correlated with the Silver Creek limestone. Certainly it was not deposited contemporaneously with the Beechwood limestone, as Siebenthal suggested.

Watson and Vicinity

Section No. 9. In the center of the north half of Section 36, a few yards east of where State Highway No. 62 crosses the north-south road to Sellersburg and Watson, is located the abandoned quarry of the old Queen City Cement Mill. A section of the north side of the quarry is as follows:

New Albany shale.....	5 ft.
Beechwood limestone.....	3 ft.
Covered	2 ft.
Silver Creek limestone.....	9½ ft.

Covered below

Elevation on top of the Beechwood limestone.....471 ft. A. T.

The conditions at this quarry are very similar to those described in the preceding section. The uppermost four feet of the Silver Creek formation is composed of a fine-grained, bluish gray limestone that contains an abundance of chert. This upper bed of cherty limestone is the New Chapel chert bed. It is not separated from the lower part of the Silver Creek formation by any definite break but the line of separation between the two beds is rendered very distinct by the absence of chert below a certain level and the abundance of chert above this level. The limestone matrix in which the chert occurs is lithologically the same as the limestone in the lower bed.

About fifty feet north of the face of the quarry, typical Beechwood

limestone is exposed to a thickness of approximately three feet. Although the base of the Beechwood is not exposed, only two feet of cover exists between the base of the outcrop and the top of the Silver Creek limestone in the quarry; and consequently, the total thickness of the Beechwood cannot exceed five feet at this point.

Siebenthal¹⁴ reported a thickness of 12 feet of "cement rock" (Silver Creek) and eight feet of "cherty bastard rock" (Silver Creek-New Chapel chert bed) from this section. The present condition of the quarry is not conducive to very accurate measurements of the entire section of Silver Creek limestone exposed, but Siebenthal's figure for the thickness of the chert bed is evidently in error as six feet would be the maximum thickness possible by adding the thickness of the covered zone.

Section No. 10. The New Chapel Methodist Church is located east of Watson, in the southwest quarter of the southeast quarter of Section 37. State Highway No. 62 passes on the south side of the church. At the east end of the church cemetery, where the highway passes down a long hill through a shallow cut, the following section is exposed along the north side of the cut:

Soil containing chert.....	4 ft.
Cherty Silver Creek limestone.....	6 ft.
Covered	8 ft.
Jeffersonville limestone.....	11 ft.
Covered	22 ft.
Jeffersonville limestone.....	1 ft.
Covered	9 ft.
Louisville (Silurian) limestone.....	2 ft. to stream bed

Elevation on top of the Silver Creek limestone... 525 ft. A. T.

The six-foot bed of Silver Creek limestone exposed at the top of the hill in this section is a very cherty, fine-grained limestone. The chert occurs in distinctly horizontal layers. It is from this exposure of cherty Silver Creek limestone that the name "New Chapel chert bed" has been taken. (see Fig. 1) As a type section, the exposure is unsatisfactory in that the Beechwood limestone is absent from above the bed and the contact of the cherty bed with the lower part of the Silver Creek formation is covered. However, the accessibility of the outcrop and the typical development of the cherty bed at this point do much to excuse the other unsatisfactory features of the section.

Section No. 11. A thousand feet north of the above section, on the west side of a dirt road, is an abandoned road metal quarry. The section exposed in the quarry is as follows:

Soil, chert, and silicified fossils	12 ft.
Silver Creek limestone	2 ft.
Jeffersonville limestone	18 ft. plus

The base of the quarry exposes the blue-brown coralliferous horizon of the Jeffersonville but it was not possible to determine the total thick-

¹⁴ Siebenthal, *Op. cit.*, p. 387.

ness of that horizon at this place. Judging by the total thickness of Jeffersonville limestone exposed at New Chapel church, just to the south, the coral horizon must be of considerable thickness in this area.

Prather and Vicinity

Section No. 12. In the vicinity of Prather several good sections are exposed. On the farm of R. Hilton, in the southeast quarter of the northwest quarter of Section 51, north of State Highway No. 62, is a small abandoned road quarry. The section at this quarry is as follows:

New Albany shale	about 3 ft.
Beechwood limestone	10 ft.
Basal conglomerate	6 in.
Silver Creek limestone	6 ft.
Covered below	

Elevation on top of the Beechwood limestone.....490 ft. A. T.



Fig. 5. Exposure of Beechwood limestone in old quarry on R. Hilton farm near Prather, Ind. Note massive character of this limestone.

This is one of the greatest thicknesses and one of the most typical sections of Beechwood limestone seen in this area. (Fig. 5.) The bed is massive, contains an extreme abundance of crinoid fossils, and is very coarsely crystalline.

The New Chapel chert bed of the Silver Creek formation is represented at this quarry by three to four inches of very cherty limestone that occurs in the uppermost part of that formation. This extreme thinness and often total absence of the cherty bed is a common occurrence at places where the Beechwood limestone reaches its greatest thicknesses. Conversely, it has been noted that the Beechwood limestone is thin in the sections where the New Chapel chert bed is present in any great thickness. These facts are indicative of a rolling upper surface of the Silver Creek formation upon which the Beechwood limestone was deposited disconformably.

Section No. 13. About 700 yards east of this quarry, an outcrop of 10 feet of Beechwood limestone is exposed along State Highway No. 62 in the west bank of a small gully. The Silver Creek limestone is exposed

below, and the New Albany shale rests on top of the Beechwood. The New Chapel chert bed of the Silver Creek limestone was not noted.

Elevation on top of the Beechwood limestone.....501 ft. A. T.

Section No. 14. In front of the Utica Township school, which is located in the southeast quarter of the northeast quarter of Section 51, the following section outcrops on the south side of State Highway No. 62:

- New Albany shale and soil..... 2 ft. plus
- Beechwood limestone 5 ft.
- Silver Creek limestone..... 7 ft.
- Covered below

Note that the Beechwood limestone has thinned from ten feet to five feet between this point and the preceding outcrop, a distance of approximately 500 yards. The New Chapel chert bed of the Silver Creek is absent from this section.

Section No. 15. Just a few yards east of No. 14 on the east side of the intersection of State Highway No. 62 and a north-south county road, the following section is exposed:

- New Albany shale and soil..... 3 ft. plus
- Beechwood limestone 5½ ft.
- Silver Creek limestone..... 9½ ft.
- Jeffersonville limestone 1 ft. exposed

Elevation on top of the Beechwood limestone.....506 ft. A. T.

This is one of the smallest thicknesses of Silver Creek limestone observed in the area studied. The New Chapel chert bed is absent.

Section No. 16. About 500 yards north of the cross-roads mentioned in Section No. 13 is a small, abandoned road quarry, on the west side of the county road. The quarry is entirely in the Jeffersonville limestone and exposes some twenty feet of strata. Most of the limestone is white, massive and crystalline, although in places it is rather lithographic. Some chert was observed in the limestone. The lower portion of the quarry exposes a blue-brown coralliferous layer, thus indicating proximity to the base of the Jeffersonville formation.

Section No. 17. A few yards north of the small village of Prather, the Baltimore and Ohio Railway passes through a small cut at an elevation of 530 ft. A. T. This cut exposes some thirty feet of New Albany shale but no limestone was observed. About 800 feet north of this point, in a gully on the west side of the tracks, the top of the Jeffersonville limestone is exposed at an elevation of 515 feet A. T.

Section No. 18. A county road crosses the Baltimore and Ohio Railway tracks a few yards north of the above outcrop. This crossing, known as "Gibson's Crossing," is located near the northeast corner of Section 52. About 100 yards north of this crossing, the Baltimore and Ohio Railway again passes through a shallow cut in which seven feet of typical Beechwood limestone is exposed down to the railway ditch. Six to seven feet of New Albany shale and soil overlie the limestone. The elevation on the railroad in this cut is 530 ft. A. T.

Section No. 19. Northwest from "Gibson's Crossing," along the county road, near the center of the east line of Section 70, the following section is exposed on the west side of the road in the barn lot of Mr. Glenn Pass:

Beechwood limestone	5 ft. plus, up to roadway
Silver Creek limestone.....	3 ft.
Covered below	

Elevation on top of the Beechwood limestone.....533 ft. A. T.

The Jeffersonville limestone outcrops in a small gully about 200 ft. west of Mr. Pass' house.

Section No. 20. A mile northwest of Mr. Pass' farm, the county road crosses Pleasant Run by means of a steel bridge. Three hundred feet west of and downstream from the bridge, four feet or more of Louisville (Silurian) limestone outcrop along the stream at an elevation of 462 feet A. T. This outcrop of Silurian has been traced by the writers for a distance of over a mile upstream and approximately a half-mile downstream from this point. The inlier of Silurian is considerably west of any previously reported inliers and is probably caused by Pleasant Run cutting across a structurally high point. As will be shown in connection with the structural map which accompanies this paper, this inlier is situated upon a structural terrace.

The section above the Silurian limestone is covered for eight feet, but above that, Jeffersonville limestone forms the north bank of Pleasant Run with 15 feet of cherty soil capping the limestone. The thickness of the Jeffersonville limestone was measured as 37.5 ft.

Elevation on top of the Jeffersonville limestone.....508 feet A. T.

Section No. 21. About a mile southwest of Section No. 20, another county road crosses Pleasant Run near the middle of the west line of Section 70. The following connected section was obtained along the road, north of the stream:

Red clay soil with chert.....	10	ft.
Silver Creek limestone with some chert nodules	4	ft.
Covered	3	ft.
Silver Creek limestone, typical;		
<i>Chonetes yandellanus</i> abundant.....	2	ft.
Covered	2	ft.
Jeffersonville limestone, white, crystalline; partly covered to creek bed...	28½	ft.
Jeffersonville limestone, brown, very coralliferous	1	ft. in creek bed

West of Charlestown

Section No. 22. About a half-mile northwest of the bridge mentioned in Section No. 18 is a road intersection located at the junction of Sections 113, 114, 92 and 93. Eight hundred feet southwest of this intersection, in the northeast corner of the northwest quarter of the

northeast quarter of Section 92, the following connected section was obtained:

New Albany shale and soil.....	8 to 10 ft. plus
Silver Creek limestone (partly covered).	16½ ft.
Jeffersonville limestone	18 ft.

The lower eight feet of the Jeffersonville limestone of the section is exposed in a spring 50 feet south of the road. No Beechwood limestone was found.

Two hundred yards north of the road, fifteen feet of Silver Creek and the top of the Jeffersonville limestones are exposed.

Elevation on top of the Silver Creek limestone.....534 ft. A. T.

Section No. 23. Northeast of the road intersection, in the northeast quarter of the southwest quarter of Section 114, on the farm of Mr. John Peyton, about 200 yards north of the barn, the following section was obtained.

Soil containing an extreme abundance of chert (New Chapel bed?).....	5 ft. plus
Silver Creek limestone; typical fine-grained limestone	5 ft.
Jeffersonville limestone (partly covered)	15 ft.

Just east of Mr. Peyton's house is located a spring house. The water issues from a joint crevice near the top of the Jeffersonville limestone. The crevice is three to four feet wide and about eight feet high.

The Jeffersonville limestone is very fossiliferous at this point.

Section No. 24. Northeast, toward Charlestown, the road crosses Pleasant Run in the northeast quarter of Section 93. A connected section measured along the road from stream level to near the top of the south wall of the valley is as follows:

New Albany shale and soil.....	17 ft.
Covered terrace	20 ft.
Jeffersonville limestone	47 ft.
Louisville limestone (Silurian).....	2 ft.

Elevation on top of the Jeffersonville limestone.....522 ft. A. T.

Elevation on top of the Louisville limestone.....475 ft. A. T.

The Silurian limestone exposed in the stream bed of this section is a continuation of the Silurian exposure described in Section No. 18. The easternmost limit of this inlier was found about 250 yards upstream from the point where the road crosses Pleasant Run.

The Jeffersonville limestone is abnormally thick in this area.

Section No. 25. North of the above section, near the center of the northwest quarter of Section 115, on the farm of Edward Brocklehurst, is a small abandoned quarry which exposes thirteen feet of Silver Creek and six feet of Jeffersonville limestones. The ten feet of soil above the Silver Creek limestone contains chert and an abundance of black, water-worn pebbles similar to those found in the basal conglomerate of the Beechwood limestone.

The quarry is located about 300 yards south of Mr. Brocklehurst's house. A small stream which flows past the quarry exposes most of the Jeffersonville limestone.

Section No. 26. West of the Brocklehurst quarry, near the center of the north line of the northwest quarter of Section 114, is a roadside outcrop of five feet of Beechwood limestone. The elevation on top of this outcrop is 518 feet A. T.

Six hundred feet south of the Beechwood outcrop, in a pasture on the farm of William Martin, is a small swallow hole entrance to a cave in the Jeffersonville limestone. The cave is situated near the bottom of a small valley and only the upper five to six feet of the Jeffersonville formation are exposed. The elevation on top of this limestone is 499 feet A. T. Only a foot or so of Silver Creek limestone is exposed above the Jeffersonville limestone, but judging from the elevations obtained, the formation is approximately 14 feet thick at this place.



Fig. 6. Entrance to cave in the Jeffersonville limestone on the Herbert Ross farm, about two miles west of Charlestown, Ind. Subterranean drainage is common and caves of considerable size are frequently found in the Jeffersonville formation.

Section No. 27. North and east toward Charlestown, near the middle and just south of the north line of Section 94, a small tributary from the east joins Pleasant Run. A few yards north of the junction of these streams is an excellent exposure of Jeffersonville limestone. The details of this section are as follows:

Slabby weathering, very fossiliferous, gray-brown, crystalline limestone.....	4	ft.
Massive, coarsely crystalline, white limestone	6	ft.
Massive, fine-grained, brownish-gray limestone	3	ft.
Slabby weathering, sub-crystalline to fine-grained, gray to white limestone.....	10	ft.
Dark blue-brown coralliferous limestone.	3½	ft.
<hr/>		
Total thickness	28½	ft.

There are two caves in the Jeffersonville limestone at this place. (Fig. 6.) The larger of the two caves has an abundance of drip-stone

on the walls and roof, but the interior of the cave is dry. The height of the entrance is about six feet. The smaller cave is a few yards south of the dry cave and contains a small spring, but no drip-stone. This cave is only three or four feet in height at the entrance. To the east of the caves are several large sinkholes.

Section No. 28. The county road to Charlestown crosses the above mentioned tributary of Pleasant Run about an eighth of a mile east of the forks of the two streams. The following connected section was obtained along the stream and road at that point:

New Albany shale.....	5 ft. plus
Beechwood limestone	3 to 4 ft.
Silver Creek limestone.....	13 ft.
Jeffersonville limestone	33 ft. to stream bed

Elevation on top of the Beechwood limestone.....552 ft. A. T.

The lowest portion of Jeffersonville limestone exposed in the stream bed is extremely coralliferous and is probably near the base of that formation. The top of this formation contains the usual densely fossiliferous zone in which the fossils are stained a dark purplish red.

The upper part of the Silver Creek limestone is cherty but it was impossible to obtain a definite figure for the thickness of the New Chapel chert bed.

Section No. 29. In the northeast quarter of the northwest quarter of Section 95, the following section is to be seen along the roadside:

New Albany shale.....	3 ft. plus
Beechwood limestone	4 ft.
Covered below	

Elevation on top of the Beechwood limestone.....570 ft. A. T.

Section No. 30. Three hundred yards northeast of the above outcrop, in the northeast quarter of Section 95, four feet of Beechwood limestone outcrop at the side of the road. The elevation on top of the limestone is 574 ft. A. T. Eight hundred feet northeast of this outcrop, across a dip in the road, the same limestone outcrops at an elevation of 584 ft. A. T.

North and Northwest of Charlestown

Section No. 31. Pleasant Run, which flows through the west side of Charlestown, exposes a continuous outcrop of Jeffersonville and Silver Creek limestones extending over a distance of about one mile. The west bank of this small stream offers many sections for detailed study, while the whole series of exposures presents an excellent picture of the Devonian stratigraphy of that immediate area. The two sections below were obtained along Pleasant Run and are representative of the stratigraphy along that stream.

At the west end of Water Street in Charlestown, Pleasant Run swings around the base of "Halcony Hill" and exposes a bluff of Jeffersonville limestone on the west bank. The details of this section are as follows:

Massive, crystalline, gray to yellowish-brown limestone containing crinoids..	15	ft.
Thin-bedded, white, crystalline limestone containing <i>Stropheodonta concava</i> and many <i>Fenestellas</i>	2½	ft.
Massive, white, crystalline limestone....	3	ft.
Thin-bedded, brownish, sub-crystalline limestone	2	ft.
Massive, gray, sub-crystalline limestone.	3	ft.
Shaly, buff to gray, sub-crystalline limestone	3½	ft.
Massive, buff to gray, crystalline limestone containing <i>Spirifer gregarius</i> and many corals	2	ft.

Section No. 32. A paved road runs north from Charlestown and crosses Pleasant Run, by means of a small concrete bridge, an eighth of a mile south of the middle of the north line of Section 117. The following connected section was obtained along Pleasant Run, from the bridge to a point about 800 feet downstream:

Soil	2	ft.
Silver Creek limestone.....	14	ft.
Jeffersonville limestone	3	ft. plus

The New Chapel chert bed of the Silver Creek limestone is very definite in this section and occupies the upper four feet of the formation. The chert is bedded in a massive, fine-grained gray limestone. Fossils are numerous in this cherty bed.

There is no definite break between the New Chapel chert bed and the lower 10 feet of Silver Creek limestone. The five to six feet of strata immediately below the New Chapel bed are composed of a massive, blue-gray, fine-grained limestone that contains some nodular chert. The next two feet of strata consist of fossiliferous, slabby, crystalline, gray limestone; and the basal two feet of the formation consist of a layer of brown, soft, argillaceous limestone. This basal layer is almost like a shale and fractures into blocky segments similar to some shales.

A few yards north of the bridge at this section, the New Albany shale is found above the Silver Creek limestone but no Beechwood limestone could be found. The Beechwood is evidently thin in this immediate area and obscured by the shale.

Section No. 33. Northwest of Charlestown, on the Henryville road, the following connected section was obtained in the northeast quarter of the northwest quarter of Section 136, along a tributary of Sinking Fork Creek:

New Albany shale.....	5	ft. plus
Beechwood limestone	3	ft.
Silver Creek limestone.....	19	ft.
Jeffersonville limestone	1	ft. to stream bed
Elevation on top of the Beechwood limestone.....	540	ft. A. T.

The Beechwood limestone in this section is very typical, being a massive, dark gray, coarsely crystalline, very crinoidal, hard limestone. The basal four inches of the Beechwood is composed of a conglomerate of black water-worn pebbles cemented in a matrix of sub-crystalline limestone. The conglomerate lies disconformably upon the New Chapel chert bed of the Silver Creek limestone.

The New Chapel chert bed of the Silver Creek limestone occupies the upper four feet of that formation. The chert occurs in abundance and lies in rather uniform layers. The top of the cherty horizon is very fossiliferous. Fifteen feet of argillaceous, blue-gray, fine-grained limestone lie below the cherty bed. There is some indication of a break between the two parts of the formation. The lower part of the Silver Creek formation contains some irregularly spaced chert nodules but the quantity is small compared with that in the New Chapel bed. The Silver Creek limestone in this section contains an abundance of silicified fossils.

Section No. 34. The Silver Creek limestone outcrops beneath the New Albany shale at an elevation of 528 feet A. T., along the side of the Henryville road, at the center of the north line of Section 154. No Beechwood limestone was observed.

Section No. 35. One-half mile northwest of the above outcrop, along the same road, the Beechwood limestone is found below the New Albany shale at an elevation of 508 feet A. T. The Silver Creek limestone is exposed below. The Beechwood member is partly covered but the maximum thickness probably does not exceed three feet.

Section No. 36. Several sections were obtained west of Charles-town, on the road to Memphis. The first exposure west of the forks of the Memphis-Henryville roads is at the base of a steep hill, near the center of the west line of Section 136. The connected section down this hill is as follows:

- New Albany shale..... 88 ft.
- Beechwood limestone 3 ft.
- Silver Creek limestone..... exposed

Elevation on top of the Beechwood limestone.....533 ft. A. T.

Section No. 37. The Memphis road crosses a small branch of Sinking Fork Creek near the center of the southwest quarter of the northwest quarter of Section 153. The Jeffersonville limestone is exposed in the stream bed. Two hundred and fifty yards east of this crossing, the following section is exposed in the south bank of the stream:

- Silver Creek limestone..... 14 ft.
- Jeffersonville limestone 12 ft.

Elevation on top of the Jeffersonville limestone.....584 ft. A. T.

There is a small cave in the Jeffersonville limestone, about three feet below the top of that formation.

Section No. 38. In the extreme northwest corner of Section 153, the upper four to five feet of Jeffersonville limestone is exposed at the

base of a gravelly hill. In a dirt road, a few feet north of the Jeffersonville outcrop, the Silver Creek limestone is exposed to a thickness of 10 feet. Probably a few feet should be added to this latter thickness to obtain the true thickness at this point.

Section No. 39. Near Stony Point church, which is located near the center of the west line of Section 152, three quarries expose the Jeffersonville limestone to a depth of 25 feet. A connected section measured at the quarries and exposures in a field to the north of the church gives the following thicknesses:

New Albany shale.....	— ft.
Beechwood limestone	1 ft.
Silver Creek limestone.....	17 ft.
Jeffersonville limestone	25 ft. plus

Elevation on top of the Beechwood limestone.....489 ft. A. T.

Section No. 40. About a mile north of Stony Point church, at the junction of the Charlestown-Memphis road with the Stony Point road, the Beechwood limestone is found below the New Albany shale at an elevation of 477 feet A. T.

Section No. 41. Two hundred and fifty yards northwest of the above road junction, the Silver Creek limestone is exposed on the west side of the road at an elevation of 465 feet A. T. No Beechwood limestone was observed; the New Albany shale apparently rests directly upon the Silver Creek limestone.

Section No. 42. In the northeast quarter of the northeast quarter of Section 133, the top of the Jeffersonville limestone is exposed in a road cut in front of E. Burnes' home. The Silver Creek limestone outcrops at the top of the hill, a few yards south of the house.

Northeast of Jeffersonville

Outcrops of the Devonian limestones are scarce from Jeffersonville eastward along the Ohio River to Utica. The rise from the river northward to the uplands is accomplished over a series of wide terraces composed of Pleistocene sands and gravels; and it is only at points where the larger streams have eroded through the Pleistocene deposits that bed rock is encountered. Two sections were obtained by the writers at points where the uplands merge with the river terraces.

Section No. 43. Near the center of the east line of Section 12, on the Gilmore Dairy Farm, the following section was obtained from an exposure just east of the Gilmore house:

Soil	1 to 2 ft.
Silver Creek limestone.....	10 ft.
Jeffersonville limestone	exposed

The New Chapel chert bed of the Silver Creek limestone is four feet in thickness at this point, and is well developed.

Section No. 44. About one mile east of the above section, near the center of Section 14, is a road quarry which exposes the following section:

Cherty soil	1 to 2 ft.
Silver Creek limestone.....	2 ft.
Jeffersonville limestone	25 ft.

The Jeffersonville limestone is exposed down to the dark brown, basal, coralliferous horizon of that formation.

North of Utica

The Ohio River follows a nearly due south course from Charlestown Landing to the vicinity of the town of Utica. This portion of the Indiana side of the river consists of high river bluffs with a comparatively narrow flood plain; in places there is barely enough room between the valley wall and the river's edge for the highway which parallels the stream. These bluffs, for the most part, are composed of Silurian rocks, and rise as sheer walls which vary from seventy-five to one hundred feet to several hundred feet in height. The base of the bluffs is heavily mantled by talus. The top of the bluffs is capped by several feet of basal Jeffersonville limestone and affords opportunity for collecting the corals which are so abundant in the base of that formation.

At Utica, these bluffs are quite high, but as noted above, from Utica to Jeffersonville, high bluffs are absent on the Indiana side of the river, although there are bluffs on the Kentucky side. This peculiar topographic condition is interesting and deserves further study. The abruptness with which the bluffs terminate at Utica suggests that a former bend of the river might have reduced the bluff between that point and Jeffersonville.

As the Devonian outcrops north of Utica are restricted to the Jeffersonville limestone, little time was spent by the writers in this area. Two sections are worthy of mention, however.

Section No. 45. One mile north of Utica, on the road to Charlestown, in a small quarry in the northwest quarter of the northwest quarter of Section 17, over eight feet of brownish, coralliferous, basal Jeffersonville limestone is exposed. The Louisville (Silurian) limestone is exposed below.

Although no particular study was made of the coralliferous horizon of the Jeffersonville limestone, there is some evidence that the horizon thins towards the west and north. For example, in this section it is over eight feet in thickness while at Speed it is only three feet in thickness.

Section No. 46. At Charlestown Landing, the thickness of the Jeffersonville limestone exposed at the top of the river bluff was determined to be 33 feet. The elevation of the contact of the Louisville and Jeffersonville limestone is 535 ft. A. T. at the side of the road leading up from the river to the top of the bluff.¹⁵

¹⁵ For topographic or structural work along the Ohio River in Clark County, the river level furnishes a convenient datum plane. Due to the river dam system, the water level at normal stage is approximately 420 ft. A. T., anywhere between Louisville, Ky., and Madison, Ind. Government engineers use this datum plane in doing flood-control mapping.

STRUCTURAL MAP

Clark County lies on the west flank of the Cincinnati arch. The regional structure has resulted from the deformation of strata during the uplift of the Cincinnati arch. The regional dip of the rocks of the county is, therefore, in a westerly direction. The regional strike of the rocks is approximately north and south.

The structural map which accompanies this paper (Fig. 7) is an attempt to show the structural conditions existing in an area of about 100 square miles in central Clark County. The top of the Silver Creek

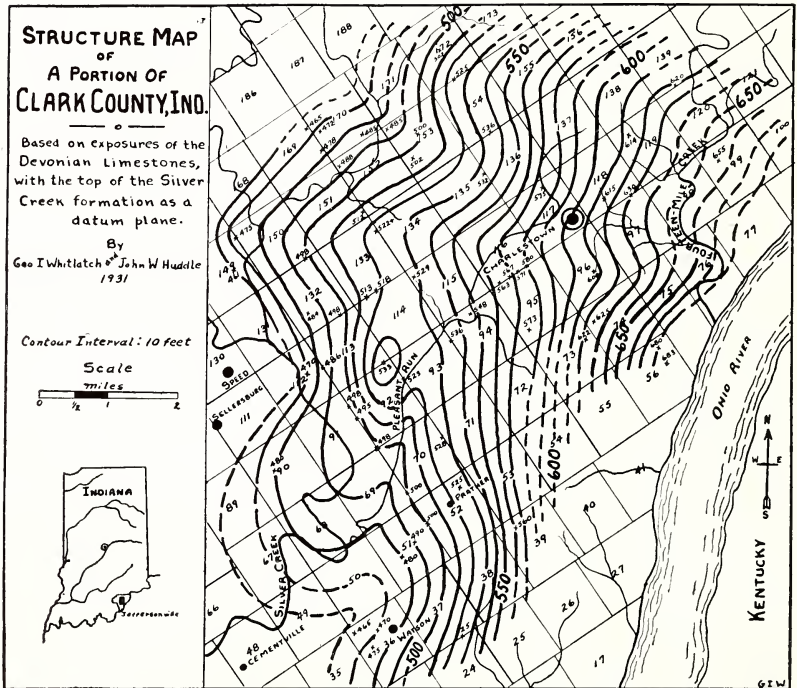


Fig. 7. Map of the eastern and central parts of Clark County, Indiana, showing the structural conditions of that area as determined upon the top of the Silver Creek (Devonian) formation.

limestone (including the New Chapel chert bed) was used as a datum in making the structural determinations. In the interpretation of the available structural data, some interpolations were necessary where the key horizon was absent. Much care, however, was necessary in making such interpolations because of local variations in thickness of the key horizon. As has been noted in the detailed stratigraphy above, the upper surface of the Silver Creek formation, apparently, has been eroded in certain areas; and it is necessary, therefore, to be thoroughly familiar with the characteristics of that horizon before attempting any interpolations.

The completed map has been checked with other maps prepared

from data obtained entirely from the Jeffersonville and the Beechwood horizons and these maps confirm, in all essential respects, the more completely delineated structure obtained by using all available data. This confirmation apparently justifies the use of the top of the Silver Creek limestone as a datum plane for structural mapping, despite any irregularities due to a possible rolling contact of the Silver Creek limestone with the overlying Beechwood limestone.

Two prominent structural features are indicated by the structural map. The first of these is a broad structural terrace or "nose" which extends nearly due west across the entire area. A shallow but very definite syncline bounds this "nose" on the north. To the south, this northern "nose" merges into a second structural terrace which is bounded on the southeast by a narrow syncline. Taken as a unit, the structural terraces form a single compound terrace that is approximately five miles in length and three to four miles in width.

East of the 540-foot contour line, structural irregularities are not very great. For the most part, the dip is in a general westerly direction at about 30 feet to the mile. The strike preserves a general north-south trend. The most pronounced irregularities in this eastern part of the area occur in the vicinity of Charlestown. These irregularities are due principally to the eastern extension of the northern terrace and syncline which bounds it. It is worthy of noting, however, that in the northeastern part of the area the structural lines tend to swing to the east. It is possible that additional structural features exist north and east of the area under discussion.

The structural irregularities become very pronounced west of the 540-foot contour line. It is in this western half of the area that the compound terrace occurs. The northern portion of the terrace is very uniform in outline with no abrupt steepening of dip. The axis of the "nose" of this part of the terrace extends nearly due east and west. The most prominent feature of the "nose" is a flattening of dip south of the axis between the 520 and 530-foot contours. This flatness of dip increases in width towards the south and culminates in parts of Sections 113, 114, 92 and 93, forming the second terrace of the structure.

In this southern part of the structure, the area between the 520 and 530-foot contours in Sections 114, 93, and parts of 92 and 113 is very flat. A possible reversal of dip is indicated by a single elevation of 533 feet A. T. obtained near the intersection of the above four sections. On the basis of that one elevation, a closed contour with a value of 530 feet A. T. was placed on this flat. West of the closed contour, the dip of the limestone steepens very rapidly for a distance of about one-half mile and then tends to flatten out again, so that to the southwest, the dip is only about 10 feet to the mile. This gives rise to a "flat nose" or subordinate terrace of considerable size.

Correlative evidence of the existence of a terrace or other structural high in the region of the intersection of Sections 113, 114, 92 and 93 is seen in the presence of the Silurian inlier in the bed of Pleasant Run, one-half mile to the south. This limestone is considerably west of its normal outcrop and its presence in this area is probably due to the stream cutting down into and across a structural high or terrace, as

shown by the map. Further evidence of the flatness of dip in this particular area is shown by two elevations obtained along Pleasant Run at the contact of the Jeffersonville (Devonian) and Louisville (Silurian) limestones. The elevation of that contact in the northeast corner of Section 93 is 475 feet A. T., while an elevation of that contact obtained a mile southwest, near the middle of the west line of the same section is 470 feet A. T., showing a dip of only five feet in that distance.

The syncline which bounds the southern part of the terrace on the southeast has been difficult to delineate for several reasons, among which are: (1) the absence of adequate exposures of the Silver Creek limestone in this immediate area; (2) an abnormal thickness of the Jeffersonville limestone in the vicinity of the syncline; and (3) the unconformable contact of the Devonian and Silurian limestones. All of those factors have been detrimental to accurate delineation of the syncline. The syncline may be deeper than is indicated, but from the structural data available, the syncline is not deeper than shown.

Regionally, the presence of a structural high is clearly indicated on the geological map which accompanies Siebenthal's report on the hydraulic limestone of Clark County. Study of this map combined with a knowledge of the topography of the county is sufficient to show that the width of the Devonian limestones outcrop is too great for the thickness of the combined formations. The Devonian limestones outcrop east of Fourteen Mile Creek and were the dip normal to the west, the width of the outcrop belt would be considerably less than it is from Fourteen Mile Creek through Charlestown to Speed. The structural conditions outlined above have prevented the limestones from dipping under at their normal rate, hence an increased width of outcrop. It was from such reasoning that the writers first suspected the presence of structural irregularities in Clark County.

SUMMARY

The Devonian limestone area studied by the writers in Clark County offers many interesting problems to both the stratigrapher and the paleontologist as well as to the structural geologist. In the above pages the writers have pointed out or have indirectly suggested a few of the outstanding questions connected with the Devonian formations. Lack of time prevented detailed investigations of any of the problems that arose during the course of the summer's work. It is felt, however, that the results accomplished have been worthwhile. Numerous new sections have been listed, several old sections published in earlier reports have been revised; a new inlier of Silurian rock is reported for the first time; the chert bed of the Silver Creek formation is named; and structural conditions in the area are presented by a detailed map.

In regard to the structural conditions, the present work has established the fact that, although there are minor irregularities of structure, the regional dip is, in the main, toward the west. Locally the dip becomes very slight and thus accounts for the unusual width of the Devonian outcrop in this part of Clark County. The regional direction of strike is not influenced greatly by the structural irregularities and is, for the most part, normal, i. e., in a general north-south direction.