

A REPORT UPON THE WALDRON SHALE AND ITS HORIZON,

In Decatur, Bartholomew, Shelby and Rush Counties, Indiana, together with
Such Other Information concerning the Region Surveyed, as is
of Probable General Interest.

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INTRODUCTORY.

As only six weeks were spent in the field gathering data for this report, the writer wishes to state at the outset that many interesting observations were omitted, especially touching upon the physiographical and glacial phase of the subject, and that the line marking the horizon of the Waldron shale, as indicated on the accompanying map, is, in detail, correct only along some of the larger streams where outcrops were numerous. It is believed, however, that in general the location of the shale horizon, one of the principal features of this report, is correct.

The work was somewhat handicapped by the heavy drift and the alluvial deposits distributed over a large portion of the area mapped. In fact, at quite a number of places, the drift was so heavy that the exact locating of this line was not only unsatisfactory but altogether impossible.

On the accompanying map, along the streams where outcrops were numerous, a continuous line marks the horizon of the Waldron shale. At places the shale was observed, while at other points probably the base of the overlying limestone or top of the underlying limestone was noted, in which case the line was drawn as a continuous one. The broken line indicates the probable horizon of the shale following the contour line as modified by the assumed dip of the rocks. The dash and two dots indicate that portion where the drift is heavy, completely covering all exposures, and where the location of the line is merely an arbitrary matter.

An effort was made to work out the eastern limit of the shale in the drifted area from well sections, but, owing to the limited and more or less confused condition of the knowledge obtainable through the farmers and well men, this effort was abandoned as altogether unprofitable. An inspection of the accompanying map will reveal the fact that the line marking the eastern extension of the shale in Decatur County is, indeed, a general one. Quite a number of wells are located on the map, while only comparatively few well sections are incorporated in the body of the report. The omission of the sections is due largely to the fact that they throw but little, if any light, upon the distribution of the Waldron shale. Well men invariably report a continuous limestone formation down to the Lower Silurian shales. Only in very few instances was the shale reported. It is quite probable that over a large part of the territory lying east and northeast of Greensburg, included in the shale area, the shale, if ever deposited, has been removed. This is to receive further discussion under the heading, "The Probable Eastern Extension of the Waldron Shale in Decatur County." At present, suffice it to say, that this part of the work was attended with no few inconveniences, due largely to the presence of a rather heavy drift.

Incidentally, some little attention was given to the Laurel limestone and Osgood beds.*

In eastern and southern Decatur County a number of gas wells were located, marking the limit of the gas field in that section of the county. Largely for the sake of simplicity, the detailed discussion of the subject in hand will be taken up by counties.

DECATUR COUNTY.

This county is situated in the southeastern part of the State, and has an area of 380 square miles. Greensburg, the county seat, locally known as the "Lone Tree City," is located near the center of the county. That part of the county mapped in this report includes all of townships 11 N., R. 9 and 10 E.; 10 N., R. 8, 9 and 10 E., and 9 N., R. 8 E., and parts of the townships 8 N., R. 8 and 9 E.; 9 N., R. 9 E.; 11 N., R. 8 E., and 12 N., R. 8, 9 and 10 E. These townships and parts of townships comprise all of the county except the eastern and southeastern parts, which lie outside of the eastern extension of the Waldron shale. Quite a number of observations were made outside of the mapped territory, but as this report is to be primarily a

* For fuller report upon the Laurel limestone see the reports of this Department for 1896 and 1897.

report upon the Waldron shale, but few of these observations have been incorporated in the report.

The outcropping strata in the unmapped area belong to the Upper and Lower Silurian formations. The Laurel limestone forms a large per cent. of the outcrops in the eastern part of the county. This limestone is quarried at a number of places along the streams, and furnishes not only building stone for local uses, but is shipped to various points in and outside of the State.*

Drainage and Topography.—The northwestern part of the county is drained by Big Flat Rock Creek, Little Flat Rock Creek and Clifty Creek. The last mentioned stream, with its branches, crosses the county from a point one mile southwest of Richland, Rush County, to a point one-half mile west of Adams. The central and southwest parts are drained by Sand Creek and its tributaries.

The topography runs from narrow, level creek valleys to rather high, irregularly dissected uplands, with hills rising from 30 to 75 feet or more above the adjacent creek valleys. The topography in the main is glacial and post-glacial. The streams usually have narrow flood plains, with here and there rather steep banks. In fact, there are two distinct types of valleys; viz., the typical post-glacial valley with a narrow or no flood plain, and the post-glacial valley as modified by pre-glacial valleys where the streams usually have flood plains and gently sloping banks. The former type is seen along Clifty Creek at Adams and Milford, and a number of other places, while good examples of the latter are seen along Flat Rock Creek.

It is more than probable that during pre-glacial and glacial times Little Flat Rock Creek and probably Big Flat Rock Creek left their present course south of Downeyville and followed down the old channel of Flat Rock Creek, as marked on the accompanying map, emptying into Clifty Creek above Milford. The old valley is very marked, passing in a curved line from a point southwest of the junction of Big Flat Rock and Little Flat Rock creeks to the valley of Clifty Creek in Section 4, north of Milford. The average width of this valley is about 375 yards, with banks running from 20 to 35 or 40 feet in height. The narrowest point is near the southern end, where it is not over 250 yards wide. The bottom of the channel is covered with drift, and no wells have been dug to determine the thickness of the deposit. At present Hog Creek and Pond Branch occupy the lower half of this old valley.

*See same as above.

SURFACE GEOLOGY.

This county is included in the glaciated portion of the State. The northwestern half of the county is included in the Wisconsin till plain, and the southeastern part is covered with the loess-covered Illinoian drift sheet. The southeastern limit of the Wisconsin sheet is marked by a well-defined, though not conspicuous moraine, which crosses the county from the northeast to the southwest corner, passing south of Greensburg. Some of the best exposures, showing the character of this morainic deposit, are found south of Greensburg, in sections 13 and 24, and along Sand Creek in sections 14 and 23.

DETAILED DISCUSSION OF THE WALDRON SHALE AND ITS HORIZON.

Stratigraphically, the Waldron shale belongs to the upper part of the Upper Silurian, but does not form the top of this formation, as has been previously correlated by some writers. At a number of places, to be indicated below, some 10 or 12 feet of intervening limestone is to be found between the shale and the base of the Devonian. This limestone, we believe, belongs to the Niagara, and forms the top member of the Upper Silurian in this territory, corresponding stratigraphically to Foerste's Louisville limestone, farther south.*

As it is customary to give local names to outcrops, especially where the relation between such formations and their stratigraphic equivalent is uncertain, we shall call this limestone, occurring in part of the area mapped, overlying the Waldron shale, and below the sandy limestone, which seems to be the base of the Devonian, the Hartsville bed, realizing the fact, however, that this formation is not very prominent in the immediate vicinity of Hartsville. To follow this formation south and determine its exact relation to the Louisville division would be a very interesting piece of work for the paleontologist. At a number of places, some nine or ten feet of limestone was observed resting upon the Waldron shale, the correlation of which is very uncertain, due to the absence of fossils; while, at other places, the base of the Devonian rests upon the Laurel limestone, the intervening strata, including the Waldron shale, having been removed by subsequent erosion, if ever deposited.

* For fuller report upon this limestone see the reports of this Department for 1896 and 1897.

Below is given a generalized section of the stratigraphy of this area, indicating the relative position of the different strata, together with their maximum and minimum thickness.

	<i>Ft.</i>
1. Devonian	0 to 40
2. The Hartsville limestone, the stratigraphical equivalent of the Louisville limestone.....	0 to 10
3. Waldron shale	0 to 6?
4. Laurel limestone	15 to 40?
5. Osgood limestone and shale.....	15 +

EASTERN EXTENSION OF THE WALDRON SHALE.

As is stated above, the exact location of the eastern limit of this shale, due to existing conditions, was impossible. By an inspection of the accompanying map, it will be seen that the line approximating the eastern limitation of the shale extends in almost a due northern direction, from a point one and one-half miles northwest of Layton's mill, to a point two miles west of New Salem, in Rush County. Southeast of Greensburg, along Cobb's Fork of Sand Creek, the line turns southwest, following in a curved line across the southwest corner of T. 10 N., R. 10 E., to "Dry" falls, one-half mile southeast of Greensburg, where it turns and follows down the creek to the mouth of a branch of Sand Creek, at which point it turns north to Greensburg, and then down Sand Creek, following rather close to the stream down to Harris City, where it leaves the stream and falls west of Horace and Old Lett's Corner, but turns east and passes east of Westport. The location of this line was determined largely by well sections, and owing to the limited number of wells, together with a greater limitation of well sections, its location is, indeed, very uncertain. In a general way, the sections reported west of this line contain either the Waldron shale or what seems to be the base of the Devonian, while those east of the line contain only the shale and limestone of the Upper and Lower Silurian formations. Below are given some of the sections found east of the line, as indicated on the map.

At Mechanicsburg, in Secs. 11 and 12, T. 10 N., R. 10 E., the following section was reported by Mr. Johnson:

	<i>Ft.</i>
1. Drift	98
2. Hard, blue limestone	30
3. Sandy clay	3
4. Shale	2
5. Hard rock	1

The limestone in the foregoing section was considered as the Laurel limestone and the shale as the Osgood shale.

Section at the Big Four quarries at Rossburg, in Sec. 8, T. 10 N., R. 11 E.:

	<i>Ft.</i>	<i>In.</i>
1. Drift	10	..
2. Hard, blue Laurel limestone.....	..	3
3. Hard, blue Laurel limestone.....	..	5
4. Hard, blue Laurel limestone.....	..	6
5. Hard, blue Laurel limestone.....	..	10
6. Hard, blue Laurel limestone.....	..	9
7. Hard, blue Laurel limestone.....	..	7
8. Hard, blue Laurel limestone.....	..	6
9. Hard, blue Laurel limestone.....	..	6
10. Hard, blue Laurel limestone.....	1	..
	15	4

Section at the bridge across the small stream in the northwest quarter of the northwest quarter of section 35, one mile northwest of Smyrna:

	<i>Ft.</i>	<i>In.</i>
1. Drift	6	..
2. Hard, blue limestone.....	..	10
3. Hard, blue limestone.....	..	3
4. Hard, blue limestone.....	..	4
5. Hard, blue limestone.....	..	5
6. Hard, blue limestone.....	..	8
7. Hard, blue limestone.....	..	6
8. Hard, blue limestone.....	..	8
9. Hard, blue limestone.....	..	8
10. Hard, blue limestone.....	..	6
11. Hard, blue limestone.....	..	9
	11	7

The limestone, which is evidently the Laurel limestone, is free from chert and would make very good stone for bridge work and building purposes. Above this exposure, in a small ravine north of the road, is an old limekiln, where a considerable amount of lime has been burned. The rock is reported as fairly good for this purpose.

Section of the exposed strata at the stone bridge across Cobb's Fork, near the southwestern corner of Sec. 35, 9 N., R. 10 E., two and one-half miles southwest of Layton's mill:

	<i>Ft.</i>
1. Drift and loose chert.....	20
2. Hard, blue limestone (Laurel).....	4
3. Bed of creek.....	0
	<hr/>
	24

Near the bed of the creek is a thin layer of chert.

Outcrops along Cobb's Fork of Sand Creek, in Secs. 21 and 28, 10 N., R. 10 E., four miles southwest of Greensburg:

Above the stone bridge, near the southwest corner of section 21, in the bed of the creek, a number of loose, sandy limestone boulders were observed, which seem from a lithological standpoint to be the equivalent of the sandy limestone found along Sand Creek, southeast of Greensburg. At a point or two in the east bank of the creek, and one hundred yards or more above the bridge, this limestone seems to be in position, with a probable total thickness of not over three feet. Below the limestone is six feet of loose chert and drift. Following up the stream for one-half mile the exposures are covered. One mile above this point, in the bed of the creek, in the northwest corner of section 22, is a fine exposure of five feet of Laurel limestone. The Devonian, if present east of the creek, correlating the sandy limestone as Devonian, probably occurs as a detached body, as indicated on the accompanying map.

GREENSBURG AND VICINITY.

Below is given a series of sections taken along Sand Creek, southeast of Greensburg one-quarter of a mile, beginning at "Dry" Falls, 250 yards below the railroad bridge.

	<i>Ft.</i>	<i>In.</i>
1. Hard, sandy, impure limestone.....	1	3
2. Softer, sandy limestone.....	..	9
3. Soft, sandy limestone.....	..	5
4. Sand, clay and limestone fragments.....	..	6
5. Hard, irregularly bedded limestone.....	2	..
6. Bed of creek.....	0	..
	<hr/>	<hr/>
	4	11

Limestone No. 5, in the foregoing section, has quite a lot of soft to hard chalk white chert mixed promiscuously through it. No. 1 forms the top of the falls. The total height of the falls is three feet. The exposed sandy limestone, correlated as Devonian, seems to represent the total thickness of this formation at this place.

Section of the south bank of the creek, 205 yards below the falls:

	<i>Ft.</i>	<i>In.</i>
1. Hard, sandy limestone.....	1	3
2. Sand, clay and limestone.....	..	1 to 3
3. Hard, flinty limestone.....	..	2 to 4
4. Hard, bluish limestone.....	..	2 to 4
5. Soft, whitish chert.....	..	½ to 1½
6. Hard, bluish limestone.....	..	3
7. Hard, blue limestone mixed with chert.....	1	..
8. Hard, blue, cherty limestone.....	..	6
9. Hard, blue limestone.....	..	5
10. Hard, blue, cherty limestone.....	..	4
11. Hard, blue, cherty limestone.....	..	5
12. Bed of creek.....	0	..
	<hr/>	<hr/>
	5	2½

Section twenty yards below the above section:

	<i>Ft.</i>	<i>In.</i>
1. Hard, sandy limestone.....	2	..
2. Clay, sand, chert and limestone.....	..	6
3. Hard, blue limestone.....	..	2
4. Limestone .....	..	8
5. Hard, blue, cherty limestone.....	..	7
6. Hard, blue, cherty limestone.....	..	8
7. Hard, blue, cherty limestone.....	..	8
8. Hard, blue, cherty limestone.....	..	5
9. Hard, blue, cherty limestone.....	..	6
10. Bed of creek.....	0	..
	<hr/>	<hr/>
	6	2

Section of the west bank of the creek, 175 yards below the foregoing section:

	<i>Ft.</i>	<i>In.</i>
1. Drift	10	..
2. Shaly, broken, sandy limestone.....	3	..
3. Hard, whitish, sandy limestone.....	2	..
4. Hard, blue limestone.....	..	4½
5. Stratum of hard, blue limestone with a layer of chert near the top and bottom.....	..	7
6. Hard, blue limestone, with chert near the bottom ..	..	3
7. Hard, blue limestone.....	..	6
8. Hard, blue limestone.....	..	8
9. Hard, blue, cherty limestone.....	..	7
10. Hard, blue limestone.....	..	6
11. Chert .....	..	2
12. Limestone .....	..	7
13. Chert	2

	<i>Ft.</i>	<i>In.</i>
14. Cherty limestone.....	..	9
15. Chert	1
16. Limestone	8
17. Bed of creek.....	0	..
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	20	10½

Nos. 1, 2, and 3 belong to the Devonian, the other strata belong to the upper division of Upper Silurian.

Section 100 yards farther down the creek, as obtained from exposed strata in the west bank:

	<i>Ft.</i>	<i>In.</i>
1. Arenaceous limestone	1	8
2. Fragmentary limestone .....	..	3
3. Hard limestone .....	..	4
4. Broken limestone, poorly bedded.....	..	4
5. Hard, cherty limestone, irregularly bedded, which breaks down in small, irregular, sharp-cornered pieces	2	..
6. Hard, blue, bedded, cherty limestone.....	4	..
7. Bed of creek.....	0	..
	<hr/>	<hr/>
	8	7

Section 250 yards above the lower bridge and 200 yards below the last of the above sections:

	<i>Ft.</i>	<i>In.</i>
1. Drift	10	..
2. Hard, sandy limestone.....	4	..
3. Hard, blue limestone.....	..	8
4. Hard, blue limestone.....	..	6
5. Bed of creek.....	0	..
	<hr/>	<hr/>
	15	2

At all of the exposures where the above sections were made, the limestone was non-fossiliferous. The Devonian seems to continue along this stream with a thickness of from three to four feet. Below the Devonian is this loose, broken, irregularly bedded cherty limestone, which is quarried a great deal for road and street purposes. The Waldron shale is absent, and was probably never deposited in this locality.

Section along Sand Creek three-quarters of a mile south of Greensburg:

	<i>Ft.</i>	<i>In.</i>
1. Drift	15	..
2. Hard limestone .....	..	4
3. Chert .....	..	2
4. Limestone .....	..	5
5. Chert .....	..	0 to 2
6. Blue to whitish, irregularly bedded limestone	2	6
7. Chert .....	..	3
8. Limestone .....	..	8
9. Limestone .....	..	6
10. Limestone .....	..	5
11. Chert .....	..	0 to 2
12. Hard limestone	1	2
13. Hard limestone	1	1
14. Bed of creek.....	0	..
	22	10

If the Devonian occurs along the creek at this point, the formation is covered. Indications are that the drift rests upon the Niagara.

Along the branch of Sand Creek that passes through Greensburg, the line of parting between the Upper Silurian and Devonian formations follows up the stream to the bridge, on the street that runs south past the depot. Below the bridge and west of the cemetery, some of the Laurel limestone has been quarried for road and street purposes. The stone has its characteristic color, together with its regular bedded condition, the strata thinner, however, than their average thickness. Just below the bridge, and on the north side of the stream, rather high in the bank, is an exposure of an irregular, slightly sandy limestone, which, apparently, is the lithological equivalent of the stratum forming the top of "Dry" Falls and the base of the Devonian. It should be remembered, however, that, owing to the absence of fossils, this correlation was made wholly upon lithological characteristics—a very unsatisfactory and uncertain basis.

One mile west of Greensburg, at the stone bridge across Muddy Fork of Sand Creek, the sandy limestone is exposed in the bed of the creek. In composition it varies from a very sandy to a pure limestone. Its color runs from a light gray to a dirty brown. It is irregularly bedded, non-fossiliferous, and free from chert. Above the bridge, some twenty yards, is a small running fall of a few feet. On the east side of the creek, 100 yards below the bridge, is an old limekiln, where quite a lot of lime, reported as of good quality, has been burned.

The rock used was taken from the bank and bed of the creek. No lime has been burned for a number of years. The kiln was run last by Albert Smith, of Greensburg.

Following down the creek, the Devonian forms the bed of the creek to a point one-half mile or more above Harris City, where the Laurel limestone sets in, thickening rapidly. The Devonian was observed 250 yards below the railroad, in section 10, and at the road crossing near the center of section 21, one and one-fourth miles above Harris City, where it appeared as a sandy, impure limestone. The greater part of the creek bed is drift, the country rock rarely appearing.

The thickness of the drift varies greatly about Greensburg, running from 20 to 150 feet, with a probable average of 50 feet. The greatest thickness is to the north and northeast. Below is given the thickness of the drift in the vicinity of Greensburg, as reported in well sections. At the Hamilton gas well, one and one-half miles north of Greensburg, the drift was reported 80 feet thick; in section 21, four and one-half miles northeast of Greensburg, only 30 feet thick; in section 16, just north of section 21, 28 feet thick; at Kingston, six miles northeast of Greensburg, 40 feet thick; one mile southeast of Kingston, in section 35, 105 feet thick; in section 34, west of section 35, 100 feet thick. Three-fourths of a mile southwest of Kingston the following section was reported: Drift, 78 feet; chert and clay, 10 feet; limestone, 12 feet. Along the road running east from Greensburg, the drift varies from 30 to 70 feet, and on the road running southeast from Greensburg, as far as Layton's Mill, the variation is from 10 to 90 feet. South, along Cobb's Fork of Sand Creek, the drift, on the whole, is not so heavy, due in part at least to the greater denudation in this territory. In sections 9 and 16, two miles southwest of Greensburg, the drift runs from 29 to 50 feet or more. Farther south, in the vicinity of Harris City, the average thickness is probably not over 30 feet. In the vicinity of Horace post-office the drift has a maximum and minimum thickness of 30 and 70 feet. At a mill just southeast of Horace the following section was obtained: Drift, 30 feet; hard, blue limestone, apparently the Laurel limestone, 20 feet. It was due largely to this section that the line marking the eastern extension of the Waldron shale was drawn west of this point.

At Old Lett's Corner the following section was reported: Drift, 80 feet; shaly rock, 3 feet (?); "hard pan," 2 feet, and hard, flinty limestone, 30 feet. This limestone probably belongs to the Laurel limestone, presumably the upper strata.

CLIFTY CREEK.

All the rock exposures along the head waters of this creek, in this county, belong to the Devonian (?). The greater part of the creek bed is drift, the country rock rarely appearing. Observations were made at the following places, along the creek just north of Ewington post-office, where the following section was obtained:

	<i>Ft.</i>
1. Drift	8
2. Irregularly, thin bedded, white to grayish limestone (Devonian ?).....	5
3. Impure, rather hard, dull colored limestone to bed of creek (Devonian ?).....	4½
	17½

Good exposures are found along the creek from west of the school-house to the road running north at Ewington, and farther. Irregularities in the creek bed, with alternating exposures of limestone and drift, indicate the irregularities of pre-glacial topography. This is especially true just north of Ewington.

Section obtained at the old quarry and limekiln, one-fourth mile below Ewington:

	<i>Ft.</i>	<i>In.</i>
1. Rather sandy limestone, with poorly marked bedding planes	5	..
2. Light grayish, sandy limestone.....	2	11
3. Dull grayish, sandy limestone.....	..	8
4. Dull grayish, sandy limestone.....	1	11
5. Sandy limestone, with chert.....	1	5
6. Dark brown to red colored, impure, sandy limestone	2	5
7. Rather hard, dark brown limestone.....	2	6
	16	10

More than fifteen years ago this limestone was quarried and burned for lime. The lime and quality of rock for this purpose was reported favorable. Above and below this exposure, which is probably 100 yards east and west, the bed of the creek is lower and of drift, suggesting the thought that probably the exposure marks the top of some pre-glacial hill or divide. The drift in this neighborhood is thinner than the average. The limestone, after some little hesitancy, was correlated from a lithological basis as Devonian.

One and one-half miles west of Ewington, where the road crosses the creek at the northwest corner of section 23, all country rock are covered by drift. This is true along the creek for two miles or more. At the point where the road crosses the creek in section 30, two miles northwest of Newburg, there is an exposure of eight inches or more

of impure, sandy limestone in the bed of the creek along the road and extending up the creek 300 yards or more. Over this limestone there is some 20 feet of drift as indicated by the creek banks. The same limestone outcrops in a bed of a tributary of this creek, at the road crossing one-fourth mile south. From this point down the creek to the county line all country rock are covered. In section 31, four miles northwest of Forest Hill post-office, a hard, dark-colored sandy limestone is exposed where the road crosses Middle Fork.

One and one-fourth miles west of Forest Hill post-office, at Mr. Sanders', the following well section was reported:

	<i>Ft.</i>
1. Drift	60
2. Shaly limestone.....	2
3. Quicksand	1
4. Shaly limestone	5
5. Quicksand	1+

69

Clifty Creek crosses the county in a southwesterly course from the northeast corner to a point two miles south of west of Burney. The Waldron shale is exposed at several places along its course from a point one and one-half miles east of Sandusky to the west county line. The eastern extension of the shale is probably not far from Spring Hill post-office; its covered condition here, as in many other places, makes its exact location impossible. On the accompanying map the line approximating the eastern extension of the shale is about one mile east of Spring Hill post-office. The stream bed both above and below this place is of drift, no country rock being exposed above the southwest quarter of section 5, two miles west of Spring Hill. At this last mentioned place quite a fine exposure occurs in the bed of the stream. It is non-fossiliferous; free from chert; with poor bedding planes, and from lithological characteristics was correlated as Devonian. Two hundred and fifty yards below this point, in the southeast corner of the southeast quarter of section 6, two miles east of Sandusky, is an exposure of the Waldron shale. The shale is poorly exposed near the level of the creek in the north bank. The following imperfect section was obtained at this exposure:

	<i>Ft.</i>	<i>In.</i>
1. Drift	30	?
2. Sandy limestone	2	..
3. Waldron shale	1	6
4. Covered to bed of creek.....	2	..

At this exposure the shale was free from clay and limestone. But very little exposed; occurring at only this one point. The length of the exposure along the bank of the stream was not over two feet.

This point marks the first appearance of the shale in descending Middle Branch. Only a few yards above this exposure limestone occurs in the bed of the creek, and is presumably above the horizon of the shale.

On South Branch, one-fourth mile above where it empties into Middle Branch, the following section was obtained:

	<i>Ft.</i>
1. Drift	20
2. Waldron shale mixed with drift.....	4
3. Limestone free from chert.....	4
4. Cherty limestone to bed of creek.....	3
	<hr/>
	31

Above this point at a number of places in the bed of the creek the Devonian (?) limestone outcrops; in the southwest corner of section 7, the northeast corner of section 18, and in the south half of section 16. A further idea of the stratigraphy of this region is given by the following well section.

Section of Frank Bird's well in the northwest quarter of section 16, two miles northwest of Spring Hill post-office:

	<i>Ft.</i>
1. Drift	27
2. Hard limestone	21
3. Shale (Waldron shale).....	2
4. Flinty limestone	15
5. Hard sandy (?) limestone.....	30
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	95

Section of well in the southeast quarter of the southeast quarter of section 5, one mile west of Spring Hill post-office:

	<i>Ft.</i>
1. Drift	40
2. Solid limestone	25
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	65

The shale seems to be absent in this locality. The depth of the drift ranges from five to twenty feet in the neighborhood of Spring Hill post-office.

The Waldron shale is exposed at the top of the stone quarry one-half mile east of Sandusky. The following section was obtained at the quarry:

	<i>Ft.</i>	<i>In.</i>
1. Covered	8	..
2. Clay shale	2	..
3. Soft, impure, shaly, dirty to light colored limestone	1	6
4. Bedded Laurel limestone.....	8	..
	19	6

The upper two feet of the Laurel limestone lies in courses from two to four inches in thickness; the lower six feet lies in courses from four to ten inches in thickness, with a union of these strata at places forming much thicker course, at one place measuring four feet. The one and one-half feet of rubble limestone above the Laurel limestone belongs with the Waldron shale, having the shale fossils and forming in a way the transition from the shale proper to the Laurel limestone. The Waldron shale, proper, is of a light blue to a drab color, with an abundance of fossils. From the bottom of the quarry to the bed of the creek is about five feet, making a total thickness of about 15 feet of Laurel limestone exposed at this place. This limestone seems to be of a very good quality and well adapted in the thickness of its courses for building, bridge, and flagging purposes.

Section of the north bank of the creek, 100 yards above Douglas Hole, one-fourth mile east of Sandusky:

	<i>Ft.</i>
1. Hard, bluish crystalline limestone, with crinoid stems and corals.....	2
2. Waldron shale.....	4
3. Thin, imperfectly bedded limestone.....	4
4. Irregularly bedded, cherty limestone.....	5
5. Covered to bed of creek.....	4
	19

The Waldron shale is quite calcareous, containing irregular masses of limestone. It is very fossiliferous, the fossils, apparently evenly distributed from bottom to top. In No. 3 in the foregoing section there is a layer of crinoidal limestone near the center.

Following up North Branch to the center of section 1, three-fourths of a mile northeast of Sandusky, an exposure of the Waldron shale is found in the west bank of the creek above the road crossing. The following section was obtained at this exposure:

	<i>Ft.</i>	<i>In.</i>
1. Drift, as seen in sloping hill.....	30	?
2. Fossiliferous shale, with a pale drab to pale dirty color where weathered.....	3	?
3. Cherty Laurel limestone.....	2	..
4. Covered to bed of creek.....	8	..
	43	..

Along the stream above this point, as far as examination extended, the country rock were covered with drift. Observations were made along the road and where the road running east from Williamstown crosses the stream.

Section of the north bank of Clifty Creek, between the railroad bridge and the pike bridge, north of Sandusky:

	<i>Ft.</i>	<i>In.</i>
1. Drift	2	..
2. Sandy limestone	1	..
3. Waldron shale	4	..
4. Hard, blue Laurel limestone.....	6	..
5. Hard, blue Laurel limestone.....	7	..
6. Hard, blue Laurel limestone.....	7	..
7. Hard, blue Laurel limestone.....	5	..
8. Hard, blue Laurel limestone.....	3	..
9. Hard, blue Laurel limestone.....	3	..
10. Hard, blue Laurel limestone.....	11	..
11. Creek bed	0	..
	10	6

At this exposure the Waldron shale has but few fossils, and with six inches of shelly limestone at its bottom. This limestone belongs with the shale and represents the transition from the period of shale deposition to the formation of the limestone. Years ago limestone was quarried at this place. The same strata are poorly exposed east of the railroad bridge.

Following down the stream no good exposures occur between this point and Adams. In general the valley is wider than the average width. The stream seems to follow an old pre-glacial valley at this point in its course.

Along Shiloh Branch, a tributary emptying into Clifty Creek two miles above Adams, all exposures were covered. The following section of the gas well east of the cross roads at the north side of section 22, three miles northeast of Adams, was reported:

	<i>Ft.</i>
1. Drift	9
2. Limestone	5
3. Shale	6?
4. Limestone	?
5. Shale and limestone.....	?
6. Trenton at 880 feet.	

Combined section of exposures along Clifty Creek, south of railroad bridge west of Adams:

	<i>Ft.</i>	<i>In.</i>
1. Drift	4	..
2. Soft, sandy, irregularly bedded limestone.....	2	6
3. Sandy limestone	1	6
4. Hard, sandy, cherty, whitish limestone.....	1	..
5. Very variable, non-fossiliferous, sandy limestone..	4	6
6. More or less irregularly bedded, hard whitish and blue limestone, with discontinuous chert layers..	5	..
7. Bed of creek	0	..
	<hr/>	<hr/>
	18	6

Detailed section of No. 6 in the foregoing section:

	<i>Ft.</i>	<i>In.</i>
1. Hard limestone	8	
2. Hard limestone	1	6
3. Chert layers	3	3
4. Soft, whitish to grayish limestone.....	7	
5. Chert layers	1	
6. Hard, streaked, sandy limestone.....	6	
7. Whitish to grayish friable sandy limestone.....	7	
8. Chert layer, soft.....	2	
9. Hard, pale blue to reddish sandy limestone.....	5	
10. Impure, whitish limestone.....	7	
11. Chert layer	1/2	
12. Limestone	1 1/2	
13. Bed of creek.....	0	..

The strata have a decided dip to the south. The occurrence of the discontinuous chert beds suggests the upper strata of the Laurel limestone, but if this correlation be true, the occurrence of the intervening limestone strata is exceptional. From a lithological standpoint, the sandy limestone suggests the Devonian. It was at first thought that No. 5, in the foregoing section, marked the horizon of the Waldron shale, but later, owing to the absence of fossils, this correlation was considered very questionable. It is the writer's opinion, however, that the bed of the creek is Silurian and the upper strata exposed in the stream banks are Devonian, with the Waldron shale absent. As will be seen later, the non-appearance of the Waldron shale is not exceptional along this stream.

Section of the west bank of Clifty Creek, one-fourth mile below the iron bridge below Adams:

	<i>Ft.</i>
1. Massive, impure, sandy limestone.....	11

This outcrop is divided by poorly marked bedding planes into three strata:

	<i>Ft.</i>
A rather hard, sandy limestone.....	4
A sandy limestone.....	3
A sandy limestone.....	4

These strata form a projecting ledge or cliff along the creek. Below the lowest ledge given in the section, no strata are exposed to the bed of the creek. On the opposite side of the stream, and corresponding in height to the part covered, is an exposure of two feet of rather hard, blue to gray limestone, divided into courses of two to five inches. The correlation of this exposure is very uncertain. Probably the greater part belongs to the Devonian.

A section of the south bank of Clifty Creek, 100 yards below the stone arch across the creek at the southeast corner of section 26, one and one-half miles northeast of Milford, is as follows:

	<i>Ft.</i>	<i>In.</i>
1. Massive, sandy (?) limestone.....	14	..
2. Hard, reddish dull-colored limestone.....	3	6
3. Blue to drab shale.....	..	$\frac{1}{2}$ to $\frac{3}{4}$
4. Hard, blue limestone.....	..	8
5. Very hard, blue limestone.....	..	1
6. Hard, blue limestone.....	..	10
7. Persistent chert streak.....	..	1
8. Hard, cherty limestone.....	..	10
9. Hard, cherty limestone.....	..	8
10. Thin-bedded, cherty limestone.....	1	2
11. Cherty limestone.....	1	1
12. Hard, blue limestone to bed of creek.....	..	10
	23	9 $\frac{3}{4}$

No. 1 is not as sandy as what seems to be the same stratum at Adams. The shale under No. 3 is not persistent, running for only 100 yards along the cliff and then disappearing. The thickness of the upper half is constant, while the lower half varies, entirely disappearing near the south end of the cliff. The position of this thin streak of shale lithologically indicates the Waldron shale, and probably should be so correlated. Nos. 8, 9, and 10, 50 yards farther down the stream, are divided into some five or six strata of alternating limestone and chert layers, the latter running from one to three inches in thickness, and the limestone layers from two to five inches.

A small unconformity occurs at this point. See sketch below.



Fig. 1. Unconformity along Clifty Creek, 1½ miles northeast of Milford.

a-b—Line of unconformity.
 x—Lower end of shale streak.
 yy—Layers of chert.

The total length of unconformity, as exposed, is probably not over 45 yards.

Section of the south bank of Clifty Creek, 100 yards below the stone arch across the stream, one-half mile north of Milford:

	<i>Ft.</i>	<i>In.</i>
1. Soft, sandy limestone.....	5	..
2. Sandy, variable, irregularly bedded limestone.....	2	6
3. Hard, cherty limestone.....	6	..
4. Hard, blue Laurel limestone.....	4	..
5. Hard, blue Laurel limestone.....	1	2
6. Hard, blue Laurel limestone.....	10	..
7. Hard, blue Laurel limestone.....	11	..
8. Covered to bed of creek.....	1	..
	12	3

No. 2 in the foregoing section presents the appearance, in places, at least, of a stone wall built of irregular, angular pieces. This probably corresponds to the Hartsville bed, and marks the horizon of the Waldron shale which is absent. The hard, blue limestone below No. 2 is unquestionably the Laurel limestone. Its outcrops are non-fossiliferous. Some little stone has been quarried here for bridge purposes.

Section of the west bank of Clifty Creek, 20 yards below the west end of the bridge across the creek, at Milford:

	<i>Ft.</i>	<i>In.</i>
1. Soft, sandy limestone.....	4	..
2. Harder, sandy limestone, irregularly bedded.....	3	6
3. Waldron shale	10	..
(a) Drab shale	3	..
(b) Shale and shaly limestone.....	4	..
(c) Drab shale	4	..
4. Regularly bedded Laurel limestone—		
(a) Hard, blue limestone.....	4	..
(b) Hard, blue limestone.....	5	..

	<i>Ft.</i>	<i>In.</i>
(c) Hard, blue limestone.....	..	3½
(d) Hard, blue limestone.....	..	4
(e) Hard, blue limestone.....	..	5
(f) Hard, blue limestone.....	..	3
(g) Hard, blue limestone.....	..	8
(h) Hard, blue limestone.....	..	10
(i) Hard, blue limestone.....	1	4
(j) Hard, blue limestone.....	..	10
(k) Hard, blue limestone.....	1	..
(l) Cherty limestone to bed of creek.....	2	..

It seems very questionable whether the Hartsville bed is present at this place. Above the bridge there is seven feet of irregularly bedded limestone, which may represent this bed. In the foregoing section the limestone overlying the Waldron shale is also irregularly bedded and may represent the Hartsville bed, but owing to the lack of fossils and characteristic lithological traits, the correlation is rendered very uncertain.

A section of the center of the cliff on the south side of Clifty Creek, 250 feet below the iron bridge west of Milford:

	<i>Ft.</i>	<i>In.</i>
1. Massive, sandy limestone.....	12	..
2. Irregularly bedded limestone (Hartsville) (?)...	3	..
3. Waldron shale .....	..	2 to 5
4. Well defined layers of Laurel limestone, varying in thickness from 2 to 14 inches.....	11	..
5. Bed of creek.....	0	..
	<hr/>	<hr/>
	26	5

The horizon of the shale is marked at this place, although the shale is very thin. At the upper end of the cliff the shale is covered, and following down the cliff the shale grows thinner with a maximum thickness of not over one inch at the lower end, which probably represents the total deposition. The heavy, massive limestone above weathers more slowly than the shale and adjacent layers of limestone, forming a projecting ledge. The figure on page 101 represents the cliff in profile.

The views on Plate I represent fairly well the exposed strata at this place, together with some of their physical characteristics. In view (a) the position of the Waldron shale is located by Mr. Fisher's hand where the shale is one and one-half inches thick. In front of him the shale disappears; its horizon is indicated, however, by the top of the irregularly bedded Laurel limestone. Behind him, the thin shale streak is easily recognized. Above the shale there is some three feet

or more of irregularly bedded limestone, the correlation of which is very uncertain. It probably represents the Hartsville bed, but owing

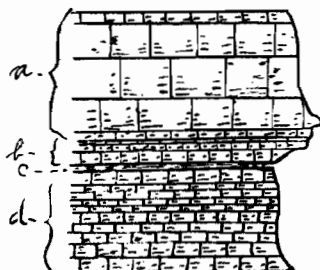


Fig. 2. Profile of south cliff of Clifty Creek, Milford, Ind.

- (a)—Base of the Devonian (?).
- (b)—Hartsville bed (?).
- (c)—Waldron shale.
- (d)—Laurel limestone.

to the non-fossiliferous condition, all attempts to correlate it were futile. Below the shale horizon occurs the regularly bedded, hard, bluish Laurel limestone.

In view (b) the position of the Waldron shale is marked by the regular groove running across the picture from side to side. Above is the irregular, broken to massive limestone; below is the regularly bedded Laurel limestone.

Section of the lower end of the cliff, seen in view (a) Plate I, some 50 yards lower than the preceding section:

	<i>Ft.</i>	<i>In.</i>
1. Drift	2	..
2. Sandy limestone	2	6
3. Sandy limestone	5	..
4. Sandy limestone	2	6
5. Irregularly bedded, sandy limestone, very variable	2	8
6. Waldron shale, with small limestone nodules.....	..	1½
7. Laurel limestone, hard, bluish.....	..	8
8. Laurel limestone, hard, bluish.....	..	5
9. Laurel limestone, hard, bluish.....	..	2
10. Laurel limestone, hard, bluish.....	..	8
11. Laurel limestone, hard, bluish.....	..	5
12. Laurel limestone, hard, bluish.....	..	10
13. Hard, grayish to blue limestone.....	..	4
14. Hard, bluish Laurel limestone.....	1	..
15. Hard, bluish Laurel limestone.....	..	10
16. Hard, bluish Laurel limestone.....	..	10
17. Hard, bluish Laurel limestone.....	..	5
18. Hard, bluish Laurel limestone.....	1	..

	<i>Ft.</i>	<i>In.</i>
19. Hard, bluish Laurel limestone.....	..	4
20. Hard, bluish Laurel limestone.....	..	8
21. Bed of creek.....	0	..
	<hr/>	<hr/>
	23	4½

On the north side of the creek, opposite the cliff, where the foregoing sections were obtained, is located a limekiln owned by Mr. Rodman, of Milford. The stone quarried lies above the horizon of the Waldron shale. It is reported by the owner to be a good lime rock, making a fine quality of lime. The capacity of the kiln is 750 bushels. The lime is used to supply local trade.

Section of the south bank of Clifty Creek, at the bend in the stream at the northwest quarter of the northwest quarter of section 3, one-half mile southwest of Milford, and above the old Critser mill dam:

	<i>Ft.</i>	<i>In.</i>
1. Massive, sandy limestone.....	20	..
2. Light grayish limestone.....	..	2 to 6
3. Light grayish limestone.....	..	4
4. Light grayish limestone.....	..	2½
5. Light grayish limestone.....	..	4
6. Light grayish limestone.....	..	4
7. Hard, bluish limestone.....	..	6
8. Hard, bluish limestone.....	..	11
9. Hard, bluish limestone.....	..	10
10. Covered to the edge of water in the mill dam ..	..	4
	<hr/>	<hr/>
	24	3½

The foregoing section was run at the south end of the cliff, some 750 yards above the mill dam. As is seen in the section, the Waldron shale is here absent, but its position is probably marked by the light, grayish non-fossiliferous limestone Nos. 2 to 6, inclusive. The bedding plane between the overlying limestone and the thin grayish limestone is very irregular. The upper stratum of grayish limestone varies greatly in thickness. The strata form cliffs here and there at the sharp turns in the stream. The upper strata of sandy limestone form projecting ledges of some three or four feet. The cliff above the dam is probably 300 yards long and 25 to 35 feet high. The channel of the stream is post-glacial at this point, and as far as the bridge at Milford and farther. In the road above the cliff the Devonian is exposed, coming within a few feet of the level of the adjacent country. The drift is probably lighter here than at any other point in this vicinity.

Section of the west bank of Clifty Creek; 150 yards above the iron bridge in the northeast quarter of the northeast quarter of section 4, one and one-half miles southeast of Milford:

	<i>Ft.</i>	<i>In.</i>
1. Drift	8	..
2. Massive, sandy limestone.....	15	..
3. Light, hard, sandy limestone.....		6
4. Light grayish limestone.....		2 to 4
5. Sand and clay.....		0 to 2
6. Light grayish limestone.....		5
7. Light grayish limestone.....		4
8. Hard, grayish limestone.....		8
9. Hard, grayish limestone.....		10
10. Hard, grayish limestone.....	1	1
11. Hard, bluish limestone.....	2	5
12. Hard, bluish limestone.....		10
13. Hard, bluish limestone.....		5½
14. Hard, bluish limestone.....		6
15. Hard, bluish limestone.....		9
16. Hard, bluish limestone.....		10
17. Chert		1
18. Hard, blue limestone.....		10
19. Hard, blue limestone.....		3
20. Chert streak		1 to 2
21. Hard, blue limestone.....		2
22. Hard, blue limestone.....		6
23. Hard, blue limestone.....	1	8
24. Hard, blue limestone.....		6
25. Hard, blue limestone.....		4
26. Bed of creek.....	0	..
	37	7½

The correlation of the exposed strata at this point is, in part, questionable. The massive sandy limestone belongs to the Devonian, and the sand and clay and the grayish limestone is questionable. The hard, blue limestone is unquestionably the Laurel limestone. Some 50 yards up the creek the irregularly bedded, non-fossiliferous limestone, which may mark the horizon of the Waldron shale, weathers rapidly, forming a horizontal crevice along the cliff and leaving a residue of clayey, sandy dirt. If this limestone represents the Waldron shale, it has evidently become very calcareous, which is indicative of the fact that the shale is subjected to decided local variations, running from a fine shale to an impure limestone. This variation is seen at other points, and is to receive due notice farther on. At the east end of the bridge, on each side of the road, is an exposure, including the exposures at the

forks of the road, which has a probable thickness of 20 feet, of a very arenaceous limestone. A greater per cent. of this exposure is sand than that of any other examined in this county. The rock is soft, irregularly bedded and easily crushed.

A good exposure of the Waldron shale is found near a small spring east of Clifty Creek and north of the road, at the center of the south side of section 7, two miles west and north of Burney, where the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Thin, irregularly grayish, non-fossiliferous limestone, which is probably the Hartsville bed.....	3	..
2. Argillaceous shale	2	2
3. Calcareous shale	1	8
4. Laurel limestone in bed of branch.		

The shale runs from a clay shale at the top to a shaly limestone near the center, and then to a shale in the lower one-third. Few Waldron shale fossils were observed. Outcrops also occur near the center of section 18, two miles west of Burney.

The Waldron shale is exposed just south of the railroad bridge across the creek and to the east of the road. The total thickness of the shale at these places is not exposed. The exposed part, a clay shale, is one and one-half feet thick. The road running north along the creek follows the horizon of the shale for some 500 yards. The overlying limestone was exposed at only one place. Below the shale to the bed of the creek occurs the Laurel limestone, which forms the small cliff, with an average height of 12 feet, along the road side. Some of this stone has been quarried for bridge purposes. At a small stream 300 yards south of the railroad bridge the Waldron shale horizon is noticeable at the road side.

A section 200 yards west of the ford across Clifty Creek, in the southwest quarter of the southwest quarter of section 18, two and one-half miles southwest of Burney, is as follows:

	<i>Ft.</i>	<i>In.</i>
1. Covered	20	..
2. Arenaceous limestone	2	..
3. Waldron shale	1	1
	<hr/>	<hr/>
	23	1

This exposure is north of the road in a small ravine, and is 10 feet or more above the bed of Clifty Creek. The upper six inches of the exposure is a pure shale while the lower seven inches is more or less calcareous. This exposure is just over the county line in Bartholo-

mew County, but owing to its relation to the preceding sections, it was thought advisable to insert it in this connection.

As is seen in the foregoing sections, the shale along Clifty Creek in this county is subjected to great variation, both as to thickness and composition, running from a thickness of three or four feet to naught inches, and from a pure shale to argillaceous limestone. Overlying the shale is from two to seven feet of more or less irregularly thin bedded limestone of questionable age. This is due to its non-fossiliferous condition and a lack of characteristic lithologic features. Above this questionable limestone, which we are inclined to refer to the Upper Silurian, is some 8 to 15 feet of rather heavy massive, arenaceous limestone referable to the early part of the Devonian Age.

EXPOSURES ALONG BIG AND LITTLE FLAT ROCK CREEKS.

Along Little Flat Rock Creek, from the Rush County line to Downeyville, the exposures are not very plentiful; all observed belonging to the Niagara Group. Along the road beside the creek in section 3, two miles northeast of Downeyville, the Laurel limestone is exposed and contains a number of crinoid stems. A good point for the observation of the crinoid beds is just south of the center of section 3, on the south side of the creek and on the north side of the road. At Downeyville there are good exposures of the Laurel beds, and they are so located as to offer fairly good inducements for quarrying. At the gas well west of the creek, at this point, the drift was reported 80 feet thick.

It is quite probable that during glacial or pre-glacial times Little Flat Rock and Big Flat Rock creeks were united just above Downeyville. This is indicated by the narrow post-glacial valley of Little Flat Rock Creek at and below Downeyville, the narrow divide of drift at the forks of the road in the southeast quarter of the southeast quarter of section 6, one-fourth mile above Downeyville, and the wide flood plain of Big Flat Rock Creek at this place. Near the junction of these two streams below Downeyville there are a number of sand and gravel hills.

Below the gorge, west of Downeyville, is "Danta Hole," a rather large semi-circular body of water reported to be 12 to 20 feet deep. Above the hole is a rapid of three or four feet. The origin of this hole is due to the erosion of the water falling over the edge of the Laurel limestone. Quite a number of fabulous stories are current in the neighborhood as to the origin and depth of this "remarkable hole." "Danta Hole" suggests Douglas Hole, a like body of water with a

similar history, on Clifty Creek above Sandusky. The Devonian, if present along the creek at this place, is far back in the hills and covered by drift.

One mile and a half north of Downeyville, on Big Flat Rock Creek at Lemmon's quarry, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Hard, grayish limestone.....	4	..
2. Grayish limestone, burns well into lime.....	8	..
3. Hard, blue limestone in regular courses of 2 to 8 inches	9	..
4. Rough ledge of hard, blue limestone, with two discontinuous chert layers.....	3	..
5. Hard, blue limestone.....	..	5
6. Hard, blue limestone (milk trough ledge).....	1	2
7. Hard, blue limestone.....	1	..
8. Hard, blue limestone (18-inch ledge).....	1	6
No. 8 has an iron streak 3 inches from the top.		
9. Hard, blue limestone to bottom of the quarry, which is about 11 inches above the bed of the creek	1	..
	29	1

The quarry is located on the south side of the creek, above the iron bridge. At this point the creek channel is very narrow, evidently post-glacial, while above and below this narrow channel of some 250 yards in length, the valley is much wider and is probably pre-glacial.

Across the creek from Lemmon's quarry is Hayes's quarry, where the same stone is quarried. In both of these quarries a dirt seam running from two to six inches was observed, and was reported by Mr. Lemmon as crossing the creek, he having observed it many times in the bed of the creek when the water was low. At the Goswell gas well, one-half mile north, Mr. Lemmon reports dirt, or drift, 260 feet thick below which was shale down to the Trenton limestone, which was struck at a depth of 900 feet, and he is of the opinion that this dirt seam continues north and was struck in this well. Whether this be true or not is impossible to say. He further states that he was present when the well was shot, and that quite a lot of fragmentary fossils were blown up, similar to the ones found on Conn's Creek below Waldron. Below is given a sketch of the dirt seam as seen in the Lemmon quarry:

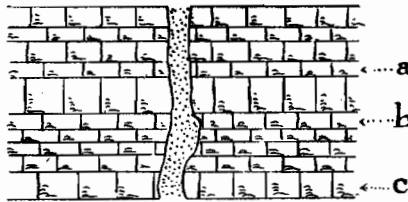


Fig. 3. Section showing dirt seam in the Lemmon quarry.

- (a)—Rough ledge.
- (b)—Milk trough ledge.
- (c)—18 inch ledge.

The following section was obtained at Garret's quarry a short distance below the Lemmon quarry:

	<i>Ft.</i>	<i>In.</i>
1. Drift	4	..
2. Hard, blue limestone.....	6	8
3. Hard, blue limestone.....	8	5
4. Hard, blue limestone.....	5	3½
5. Hard, blue limestone.....	6½	5½
7. Hard, blue limestone (18-inch ledge).....	1	4½
8. Hard, blue limestone.....	8	4
9. Hard, blue limestone.....	8	2
10. Hard, blue limestone.....	4	5
11. Hard, blue limestone.....	1	2
	10	5

The rough ledge is found as boulders above the stone quarried at this quarry. All of the exposures at these quarries belong to the Niagara limestone.

Along the crooked branch through section 1, east of St. Omer, quite a lot of arenaceous limestone is exposed. Below the road, through the southeast quarter of the southeast quarter of section 4, this sandy limestone is found in the bed of the branch and continues for 400 yards outcropping in the bed and banks of the branch. This limestone is believed to be Devonian. Farther down in the bed of the branch the Laurel limestone outcrops. The Waldron shale is absent or covered.

Exposures in the vicinity of St. Paul, in this and Shelby counties.

Section of the H. C. Adams quarry on Big Flat Rock Creek, just east of St. Paul:

	<i>Ft.</i>	<i>In</i>
1. Chert and thin, irregularly bedded limestone (Laurel)	18	..
2. Hard, blue Laurel limestone.....	1	9
3. Hard, blue Laurel limestone.....	1	2
4. Hard, blue Laurel limestone.....	..	10
5. Hard, blue Laurel limestone.....	1	6
6. Hard, blue Laurel limestone.....	1	6
7. Hard, blue Laurel limestone.....	1	2
8. Hard, blue Laurel limestone.....	1	2
9. Hard, blue Laurel limestone.....	1	6
10. Hard, blue limestone (milk trough ledge).....	1	9
11. Hard, blue Laurel limestone.....	1	2
12. Hard, blue Laurel limestone.....	..	8
13. Hard, blue Laurel limestone.....	2	4
14. Hard, blue Laurel limestone.....	2	8
15. Hard, blue Laurel limestone.....	1	..
16. Hard, blue Laurel limestone.....	1	4
17. Hard, blue Laurel limestone.....	3	4
18. Hard, blue Laurel limestone.....	..	7
19. Soft, reddish Osgood limestone.....	1	9
20. Harder Osgood limestone (the green ledge).....	1	9
21. Soft Osgood limestone.....	1	..
22. Soft Osgood limestone.....	4	..
23. Osgood shale	3+	..
	<hr/>	<hr/>
	54	11

The Osgood beds are not exposed; their thickness and texture were reported by quarrymen. Across the creek from the Adams quarry is another quarry, where exposures similar to those in the foregoing section occur.

Along the creek one-half mile above St. Paul, the Laurel limestone is quarried quite extensively. At this quarry and at the quarries at St. Paul what seems to be the upper courses of the Laurel limestone are exposed. Above these exposures, as far as observations showed, is drift. The line marking the supposed horizon of the Waldron shale at this point was located without observing either the shale or the Devonian. A reported section of a gas well in St. Paul fails to show the presence of the shale or Devonian.

Section of well—

1. Drift	<i>Ft.</i>
2. Hard limestone (Laurel).....	28
3. Shale	40
4. Trenton	700
	25

793

Gas was found at a depth of 14 feet in the Trenton.
Pressure, 225 pounds.

The reports obtained of different wells in St. Paul point to the conclusion that the Waldron shale and Devonian limestone are absent at this place, despite the fact that only a short distance below the town along Big Flat Rock Creek, and far below the level of the town, there occurs the heaviest deposit of the Waldron shale found anywhere in the county. This incongruity may be due to an error in the reported sections or the lack of a deposition of the shale at this particular place, or subsequent erosion after deposition. Below is given the section obtained at the Scrantan quarries below St. Paul along the creek where the Waldron shale is exposed:

	<i>Ft.</i>	<i>In.</i>
1. Drift	5	..
2. Waldron shale	6	..
3. Hard, blue Laurel limestone.....	..	8
4. Hard, blue Laurel limestone.....	..	4
5. Hard, blue Laurel limestone.....	..	6
6. Hard, blue Laurel limestone.....	..	5
7. Hard, blue Laurel limestone.....	..	9
8. Hard, blue Laurel limestone.....	..	8
9. Hard, blue Laurel limestone.....	..	3
10. Hard, blue Laurel limestone.....	..	5
11. Hard, blue Laurel limestone.....	..	7
12. Hard, blue Laurel limestone.....	..	7
13. Hard, blue Laurel limestone.....	..	6
14. Hard, blue Laurel limestone.....	..	7
15. Hard, blue Laurel limestone.....	..	8
	17	11

The Waldron shale at this place has a drab to blue color, and is free from calcareous masses. The exposure occurs at the lowest of the three quarries. At the time of examination the quarries were not in operation, and were in the hands of a receiver. At the iron bridge, across the creek below the quarries, the Laurel limestone is exposed six feet or more above the bridge, and is overlain by drift. Following down the creek to Vickhart's flouring mills a number of good exposures of the Laurel limestone were observed; but the Waldron shale, if present, is covered.

WESTPORT AND VICINITY.

From the report given of the well at the Owen Hotel in Westport, the Devonian, presumably, underlies the town. Below is given the section as reported by the proprietor:

	<i>Ft.</i>
1. Drift	40
2. Soft, sandy limestone (Devonian).....	14+

No outcrops of this sandy limestone were observed east of the town along Cobb's Fork of Sand Creek. It probably thins out before reaching the creek. Along the creek were numerous exposures of the Laurel limestone and the Osgood beds, the latter occurring low in the hill. A good exposure of the Osgood beds is found along the roadside just west of the creek at the bridge one and one-half miles southeast of Westport. At the Westport limestone quarry, and at the Hollinsbe quarry, the following combined section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Clay and drift.....	3 to 4	..
2. Hard, blue, irregularly bedded Laurel limestone, the courses varying in thickness from 3 to 23 inches.....	16	7
3. Osgood limestone and shale.....	10+	..
	30	7

One stratum of the Osgood limestone, three feet two inches thick, was reported as an excellent stone for building purposes. The Laurel limestone is quarried quite extensively at these quarries.*

One and a half miles east of Westport, at the McGee quarry, typical exposures of the Laurel limestone are found. Here quarrying is carried on quite extensively, notwithstanding there is no railroad connection. The stone is of a good quality, with desirable and variable thickness, and similar to the stone quarried southeast of Westport. Overlying the thin, irregularly bedded and cherty limestone, marking the top of the Laurel beds, is a light deposit of drift and clay. The Devonian does not outcrop, and if it extends east to the creek, it lies high in the hills drift covered. On this supposition, the line marking its eastern extension at this place was located on the accompanying map. One mile west of Westport the Devonian outcrops along Wyalusing Creek. The following section was taken of the eastern bank of the creek above the bridge:

	<i>Ft.</i>	<i>In.</i>
1. Drift	6	..
2. Massive, hard, light to dark-colored arenaceous limestone	8	..
3. Hard, dark-colored, irregularly bedded limestone... ..	..	6
	14	6

*For fuller report see the 22d Annual Report of this Department.

At the Cora quarry, recently opened, along the creek one-fourth mile above the bridge, the following section was obtained:

- | | |
|---|------------|
| | <i>Ft.</i> |
| 1. Soft, sandy, light-colored, irregularly bedded Devonian limestone, courses running from 6 to 24 inches to bed of creek | 8 |

This stone is quarried for road use and is reported as an excellent stone for this purpose.

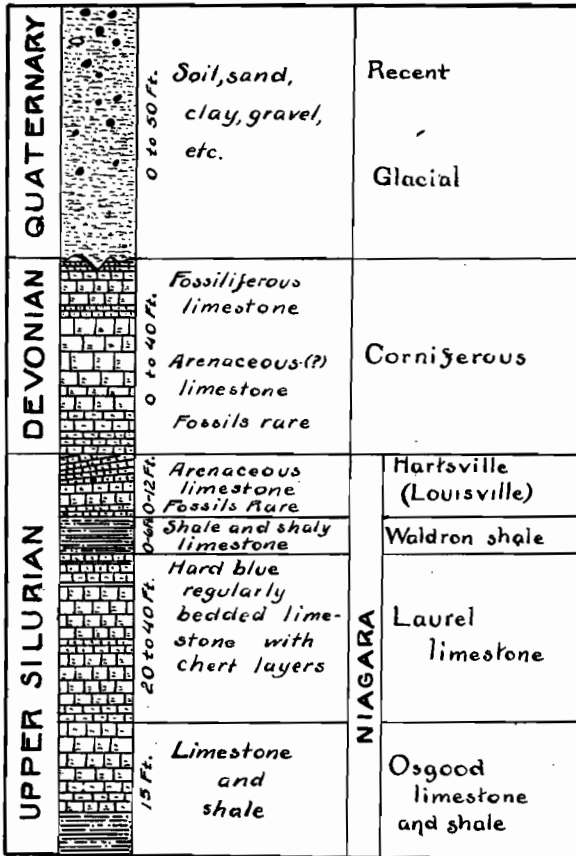


Fig. 4. Columnar section of the rocks of that part of Decatur County included in this report.

Near a small spring, south of the road, near the center of section 25, one and one-half miles northwest of Westport, is an outcrop of four feet of irregularly bedded limestone. Above the spring where the branch crosses the road is an exposure of hard, sandy limestone.

At the Cain quarry, in the northwest quarter of the same section, some six feet of hard, slightly arenaceous, irregularly bedded, non-fossiliferous limestone, which is quarried for road use, outcrops; the same stone as outcrops at the Cora quarry in section 36.

The topography of this region runs from level and slightly dissected areas to a rough broken country along the largest streams. To the north and northwest of Westport, in the vicinity of Waynesburg, the country is nearly level with few meandering post-glacial stream valleys. The drift runs from 12 to 50 feet in thickness.

Three and a half miles northeast of Westport, in section 20, is a monument, reported as 18 feet high, which marks the center of population for the United States in 1890.

The section ends with the Osgood shale. Underlying this shale is the lower Osgood limestone, and beneath this is the Clinton limestone. The last two formations were not observed, but it is quite likely that in the eastern part of the area mapped, along Sand Creek, they may occur, especially the Lower Osgood limestone. No careful examination was made for them.

BARTHOLOMEW COUNTY.

Geographic—Bartholomew County lies west of Decatur County, and is bounded on the south by Jennings and Jackson counties, on the west by Jackson and Brown counties, and on the north by Johnson and Shelby counties. Only about 36 square miles in the northeast corner of the county are covered by this report; the strip being four miles wide from east to west, and nine miles long north and south. Hartsville and Newburn are the only villages in the territory mapped, Hartsville lying near the east side, east and west, and near the center north and south. The entire area mapped is included in the glaciated portion of the county. The deposits are not strewn over the surface regularly, but in some cases are 30 or 50 feet deep, though elsewhere there may be no more than a mere veneer of boulder clay. Indeed, at quite a number of places, especially along the streams, the surface is bare rock.

DRAINAGE AND TOPOGRAPHY.

The south half of the territory is drained by Clifty Creek, which crosses the area from northeast to southwest, passing by Hartsville and Newburn. The north half is drained by Flat Branch, Duck Creek, and Little Haw Creek. The topography runs from level plains, crossed by post-glacial valleys, to more or less irregularly broken lands along

Clifty Creek, where the hills may rise 50 or 60 feet above the creek valley.

With reference to the surface geology and glaciation, the following extract is taken from Frank Leverett's Water Supply and Irrigation Papers of the United States Geological Survey:

"The entire county was apparently glaciated, although the glacial boundary lies but little west from the front of the prominent hills on the county line. The portion of the county east from the East White River valley was nearly all covered by the later ice, and a narrow belt along the west side of the stream in the north part of the county was also covered by that invasion. There remains, therefore, only a narrow strip on the southern and western borders of the county where the older sheet of the drift alone is present. There are morainic features along the borders of the east White River valley from the north line of the county southward to the vicinity of Columbus. There are also two well defined moraines eastward and northeastward from this valley across the country. The southernmost one, which lies near the line of Bartholomew and Jennings counties, marks the southern limit of the later Wisconsin sheet of drift. The other lies near the borders of Clifty Creek. Each of these moraines has a breadth of two or three miles, but stand only 30 or 40 feet above the bordering plain.

"The surface of the older drift in this county is generally plane. The thickness of the drift ranges from a mere trace to a deposit fully 100 feet in depth. Along the east White River valley there is a gravelly belt from two to five miles or more in width, and the morainic knolls just referred to appear in the midst of this gravelly district. Flat Rock valley also contains a broad gravel plain. In the remainder of the county the drift is mainly till. Very few deep wells occur, there being generally an abundant water supply within 35 or 40 feet of the surface."

DISTRIBUTION OF THE WALDRON SHALE.

Nearly all of the outcropping rocks in this territory belong to the Devonian Age. Along Clifty Creek and some of its largest tributaries the Upper Silurian rocks are exposed, the parting line between the two formations running from 10 to 25 feet above the creek beds. Above the Waldron shale there are four or five feet of non-fossiliferous limestone which corresponds lithologically to what was correlated farther north as the Hartsville bed. This division, which, as stated above, corresponds to Foerste's Louisville, is very indistinct, the gradation between it and the overlying arenaceous limestone being so gradual that it is impossible to say just where one quits off and the other begins.

However, it is believed that a few feet of the limestone overlying the shale belongs to the Niagara. This formation forms the upper and hard ledges at the top of Anderson and Long's falls, south of Hartsville.

It has been stated that the Waldron shale forms the top of the Niagara. At this point, however, there is naught to eight or more feet of Upper Silurian limestone overlying the shale. To fully settle this question of correlation a great deal of time and paleontological research are necessary, and an interesting problem here exists for the paleontologist well versed in Devonian and Upper Silurian fauna.

Two and a half miles southwest of Burney the Waldron shale is exposed 200 yards east of the ford across Clifty Creek. (See section on page 104.)

A section of the west bank of Clifty Creek, 650 yards below the ford mentioned in the preceding section, and in the southeast quarter of the southeast quarter of section 24, three miles north of Hartsville, is as follows:

	<i>Ft.</i>	<i>In.</i>
1. Covered to top of hill.....	20	..
2. Sandy limestone	5	..
3. Covered and apparently the horizon of the Waldron shale	2	..
4. Thin, irregularly bedded limestone, which probably represent the calcareous base of the Waldron shale .....	..	5
5. Hard, blue Laurel limestone.....	..	11
6. Hard, blue Laurel limestone.....	2	11
7. Hard, blue Laurel limestone.....	..	10
8. Hard, blue Laurel limestone.....	..	9
9. Covered to bed of creek.....	1	6
	<hr/>	<hr/>
	34	4

At the large spring, one-fourth mile down the creek and above the old mill dam, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Arenaceous limestone	2	..
2. Covered	8	..
3. Irregularly bedded limestone.....	1	6
4. Hard, blue Laurel limestone.....	1	7
5. Hard, blue Laurel limestone.....	..	4½
6. Hard, blue Laurel limestone.....	1	..
7. Hard, blue Laurel limestone.....	1	10
8. Hard, blue Laurel limestone.....	1	2
9. Hard, blue Laurel limestone.....	..	9
	<hr/>	<hr/>
	18	2½

The arenaceous limestone in No. 1 belongs to the Devonian, and the Waldron shale, if present, is covered. Above the spring, to the turn of the creek, the sandy ledge forms a small cliff with a thickness of 8 to 12 feet: Beyond the turn of the creek, and below the last of the foregoing sections but one, the Waldron shale was poorly exposed and mixed with gravel, soil, etc.

Across the creek from the spring, and in the southeast quarter of the southeast quarter of section 24, two and a half miles above Harts-ville, the following strata were exposed in a small ravine:

	<i>Ft.</i>	<i>In.</i>
1. Massive, sandy limestone.....	6	6
2. Hard, sandy limestone.....	3+	..
3. Covered	1	6?
4. Thin, irregularly bedded limestone that may represent the base of the Waldron shale.....		6
5. Hard, blue Laurel limestone.....		4
6. Hard, blue Laurel limestone.....		5
7. Hard, blue Laurel limestone.....		7
8. Hard, blue Laurel limestone.....		3
9. Hard, blue Laurel limestone.....		2
10. Hard, blue Laurel limestone.....		6
11. Hard, blue Laurel limestone.....		9
12. Hard, blue Laurel limestone.....		7
13. Hard, blue Laurel limestone.....		4½
14. Hard, blue Laurel limestone.....	1	..
15. Hard, blue Laurel limestone.....		5
16. Hard, blue Laurel limestone.....		6
17. Covered		3½
18. Water in old mill dam.....	0	..
	17	8

If the Waldron shale occurs here at all it is very thin. No. 2 in the above section probably belongs to the Devonian. We are inclined to believe that the shale is absent at this place, probably having been removed after its deposition. However, at no point was the sandy limestone observed resting directly upon the Laurel limestone. The covered space was only a few feet, but enough to conceal a thin stratum of shale. The massive sandy limestone breaks down in large pieces, together with soil, boulders, and other debris, and covers the shale horizon. The road seems to run in general not far from the top of the Laurel limestone.

Down the creek at the center of the south side of section 24, and two miles above Hartsville, where the road through section 25 joins the creek road, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Sandy limestone	8+	..
2. Covered	7	..
3. Shale to argillaceous shale.....	2+	..
4. Covered	1	6
5. Light, grayish, irregularly bedded limestone.....	..	10
6. Laurel limestone	5	..
7. Covered to creek.....	7	..
	<hr/>	<hr/>
	31	4

Just above the Waldron shale three or four sandy limestone boulders are exposed. No. 5 probably represents the base of the shale. Along the creek road, above the forks of the road where the foregoing section was taken, the sandy limestone is exposed at a number of places—soft, massive, and arenaceous.

Close observation failed to reveal the Waldron shale along Hiner Branch, one mile north of Hartsville, although high in the hills were heavy exposures of the sandy limestone, and near the branch the Laurel limestone was exposed. The horizon of the shale was covered. The exposures were followed up the branch until the Devonian formed the bed of the creek. At one place, where a farm road crosses the branch and climbs the south bank, the Devonian limestone is very sandy; almost a pure sandstone.* Here it resembles very closely the exposures referred to above at the east end of the bridge across Clifty Creek, in section 4, one and one-half miles north of Burney.

From the mouth of Hiner Branch to the bridge across Clifty Creek, north of Hartsville, the horizon of the Waldron shale follows along just above the creek road at most places, some 15 to 20 feet above the creek. About half way down to the bridge from the mouth of Hiner Branch the Waldron shale is poorly exposed along the roadside. The exposure is argillaceous, mixed with soil. Only a few inches are exposed. Below the shale horizon down to the bed of the creek the regular bedded Laurel limestone is exposed. Two hundred and fifty yards below the bridge, and on the west side of the creek, the following section was obtained:

*See report on Niagara Limestone in the Twenty-Second Annual Report of this Department.

	<i>Ft.</i>
1. Drift	10
2. Massive, arenaceous limestone.....	12
3. Covered (Waldron shale horizon).....	6
4. Thin, irregularly bedded limestone.....	1
5. Hard, bluish to grayish limestone.....	9
6. Bed of creek.....	0
	<hr/>
	38

The sandy limestone forms a small cliff, which runs along the hillside at places increasing in thickness to a maximum thickness of 18 feet. The regularly bedded limestone near the bed of the creek is the Laurel limestone, and the sandy limestone near the top of the hill belongs to the Devonian Age. The Hartsville bed and the Waldron shale, if present, are not exposed.

HARTSVILLE AND VICINITY.

West of Hartsville, along the creek on the west side, good exposures of the Devonian limestone are found; lower and nearer the bed of the creek, especially at the ford bridge, occur good exposures of Laurel limestone. East of the creek, along the road leading to the southwest from Hartsville, and just outside of the town limits, occur typical exposures of the Laurel beds. At one point on the west side of the creek, not far northeast of the old limekiln, a few inches of Waldron shale were noted.

At the old stone quarry on the east side of the creek, one-fourth mile below Hartsville, the Waldron shale is exposed. The following section was obtained at this exposure:

	<i>Ft.</i>	<i>In.</i>
1. Drift	2 to 4	..
2. Waldron shale	5	3
3. Hard, blue to gray limestone.....	1	3
4. Hard, blue to gray limestone.....	1	10
5. Hard, blue to gray limestone.....	..	6
	<hr/>	<hr/>
	12	10

The Waldron shale is exposed above the exposed rock strata in the quarry, and is, with the exception of the bottom 15 inches, a pure shale. The bottom 15 inches consist largely of irregularly bedded to shelly limestone, forming what seems to be the transition between the shale and underlying limestone.

Section of the Laurel limestone exposures at the west end of the foot bridge across Clifty Creek, one-fourth mile below Hartsville:

	<i>Ft.</i>	<i>In.</i>
1. Hard, blue Laurel limestone.....	3	..
2. Hard, blue Laurel limestone.....	1	2
3. Hard, blue Laurel limestone.....	2	2
4. Hard, blue Laurel limestone.....	1	10
5. Hard, blue Laurel limestone.....	..	10
6. Hard, blue Laurel limestone.....	1	7
7. Hard, blue Laurel limestone.....	1	6
8. Hard, blue Laurel limestone.....	..	4
9. Hard, blue Laurel limestone.....	..	8
10. Hard, blue Laurel limestone.....	..	7
11. Hard, blue Laurel limestone.....	..	10
12. Covered	1	..
	<hr/>	<hr/>
	15	6

The top of this section reaches up to the road and apparently to the top of the Laurel limestone. The Waldron shale is not exposed at this place, but only a few yards down the creek and on the same side of the stream, at the small Dietrich quarry the shale is exposed. The following section was taken at the quarry:

	<i>Ft.</i>	<i>In.</i>
1. Soil	2	..
2. Argillaceous shale to pure shale.....	1	6
3. Hard, blue Laurel limestone.....	..	4
4. Hard, blue Laurel limestone.....	..	2
5. Hard, blue Laurel limestone.....	..	5
6. Hard, blue Laurel limestone.....	..	6
7. Hard, blue Laurel limestone.....	..	6
8. Hard, blue Laurel limestone.....	..	9
9. Hard, blue Laurel limestone.....	..	8
10. Hard, blue Laurel limestone.....	..	10
11. Hard, blue Laurel limestone.....	..	2
12. Hard, blue Laurel limestone.....	..	7
13. Hard, blue Laurel limestone.....	..	6
14. Hard, blue Laurel limestone.....	..	6
15. Hard, blue Laurel limestone.....	..	6
16. Hard, blue Laurel limestone.....	..	6
	<hr/>	<hr/>
	10	5

The high-water mark of Clifty Creek is three feet below the Waldron shale in the foregoing section.

Across the creek from the Dietrich quarry, at the turn in the road, occurs an exposure of the shale. Only a few inches are exposed. The shale at this, and other close exposures, seems to be non-fossiliferous.

At the head of a small ravine near Mr. Yelley's house, on the south side of the creek, in the northeast quarter of the northeast quarter of section 2, one-half mile below Hartsville, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Irregularly bedded sandy limestone of questionable age	5	6
2. Shale and shaly limestone.....	2+	..
3. Covered	4	..
4. Laurel limestone to bed of creek.....	15	?
	<hr/>	<hr/>
	26	6

Just west of the exposure, the massive sandy limestone comes down to what seems to be the horizon of the Waldron shale. The strata immediately over the shale in the ravine form the top of a small waterfall. Following down the creek to the mouth of Falls Fork, the Waldron shale was observed at the head of two ravines; one near the south side of the northeast quarter of the northeast quarter of section 12, where the shale was one and one-half feet plus; the other, 250 yards above the mouth of Falls Fork, where the shale was four and one-half feet thick.

Two hundred yards southeast of the bridge across Falls Fork Creek, near its mouth, is a good exposure of the shale. It occurs in deep gullies, where it is probably four or five feet thick and is very fossiliferous, especially the lower half. This is an excellent place to gather Waldron shale fossils.

Across the bridge east of the road is an old "digging," where Waldron shale fossils were obtained years ago. At present the shale is covered. The following section was obtained at this place:

	<i>Ft.</i>	<i>In.</i>
1. Drift	20 to 30	..
2. Sandy limestone	2	6
3. Hard, bedded limestone.....	3	..
4. Covered (horizon or shale).....	4?	..
5. Covered to creek.....	20?	..
	<hr/>	<hr/>
	59	6

Following down the creek on the south side to Turn Hole, the shale was observed outcropping in the meadow below the bridge. At Turn Hole, one-half mile below the bridge, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Bedded, hard limestone.....	2+	..
2. Clay shale, poorly exposed, fossiliferous.....	3?	..
3. Regularly bedded Laurel limestone to creek..	15 or 18	..
	<hr/>	<hr/>
	23	..

The lower six inches of the Waldron shale are very calcareous. Usually the lower six or eight inches of the shale is calcareous, and often contains an abundance of fossils. As has been previously stated, this shaly to pure limestone marks the transition from the Waldron shale as a shale to the Laurel limestone.

The shale is also exposed at Tarr Hole, only a short distance from Turn Hole. At the latter place the Laurel beds form a perpendicular cliff some 15 feet high. The massive, sandy limestone exposed along the creek, west of Hartsville, and a number of other places, is not exposed at this place. It seems as though the sandy strata have lost their arenaceous character and occur as hard, thin bedded limestone.

A section of the northwest bank of Clifty Creek, one mile northwest of Newbern, in the northeast quarter of section 10, is as follows:

	<i>Ft.</i>	<i>In.</i>
1. Light, rather soft, sandy limestone.....	3	6
2. Hard, blue Laurel limestone.....	..	2 to 4
3. Hard, blue Laurel limestone.....	..	1 to 5
4. Regularly bedded, Laurel limestone, with courses 2 to 6 inches.....	3	..
	<hr/>	<hr/>
	7	3

The Waldron shale is absent, and it is believed that the sandy limestone in No. 1 belongs above the shale, and the lower beds are unquestionably Laurel limestone. There is what seems to be a slight unconformity between Nos. 1 and 2. This helps to explain the non-occurrence of the shale at this place.

A section of the north bank of the creek, 200 yards above the place indicated in the foregoing section, is as follows:

	Ft.	In.
1. Soft, massive (?) sandy limestone.....	2	..
2. Hard, irregularly bedded limestone of questionable age		0 to 6
3. Laurel limestone		3
4. Laurel limestone		4
5. Laurel limestone		1½
6. Laurel limestone		3
7. Laurel limestone		2
8. Laurel limestone		1½
9. Laurel limestone		3
10. Laurel limestone		2
11. Laurel limestone		1½
12. Laurel limestone		4
13. Laurel limestone		3½
14. Laurel limestone		3½
15. Laurel limestone		3½
16. Laurel limestone		6
17. Laurel limestone		6
18. Laurel limestone		7
Water's edge	0	..
	7	1

The shale has probably been removed at this place, as the Devonian seems to rest unconformably upon the Laurel limestone. A slight unconformity occurs between Nos. 2 and 3.

At a sharp turn in the creek in the northwest quarter of section 10, three-fourths miles above Newbern, some 10 feet of sandy limestone is exposed running down to the water's edge. At the time of examination the creek was slightly swollen, and probably during low water the Laurel limestone might be exposed, but judging from the dip of the strata above this place the assumption is that the line marking the horizon of the shale has passed below drainage. The sandy limestone at this place is the typical sandy limestone, weathering into a rough, irregular surface.

On the south side of the creek, one-half mile above Newbern, there are some 20 feet of sandy, massive limestone exposed running down to the water's edge. This sandy limestone runs into a grayish to blue irregularly thin bedded limestone above. The Waldron shale horizon is below drainage.

Under the south end of the bridge, across the creek at Newbern, eight feet plus of sandy limestone is exposed. This runs down to the bed of the creek. Higher in the hill the limestone is not so arenaceous.

The exposures were examined along the creek below Newbern for

two miles, and found to be Devonian. Above the bridge, two miles below Newbern, there occurs in the bed of the creek a good exposure of the sandy limestone.

South of Hartsville, on Boner Branch, between the old college campus and the cemetery, and between the wagon bridge and foot bridge, occurs a small waterfall, where the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Sandy limestone, the lower ledge of which forms the top of the falls.....	6	..
2. Hard, poorly bedded limestone which breaks down in irregular sharp-cornered pieces.....	3	7
3. Sandy clay, poorly exposed.....	..	6+
4. Covered	2?	..
5. Laurel limestone	4	6
	16	7

No. 2 weathers faster than the overlying sandy limestone, which forms an overhanging rock at places. The correlation of this limestone (No. 2) is questionable, and, owing to the scarcity of fossils, is practically impossible with the passing examination that was given it. However, from the brief examination I am inclined to consider this as the stratigraphic equivalent of the Hartsville bed found at Long's Falls and Anderson Falls, and at places along Clifty creek. No. 3, in the foregoing section, probably marks the horizon of the Waldron shale, although the exposure was only observed at the one place, i. e., at the base of the falls. The exposure was such that it was impossible to say definitely that it was modified shale. Its arenaceous character seemed to be due to the disintegration of the sandy limestone. Two or three feet lower, and immediately under the foot-bridge, occurs an outcrop of Laurel limestone, regularly bedded with courses running from one to eight inches in thickness. The sandy limestone, with its rounded knolls and corresponding pockets, is found exposed at a number of places along this branch. Below this place, where the road leading south from Hartsville crosses the branch, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Covered	9	..
2. Limestone and chert.....	4	6
3. Light-colored limestone	1	..
4. Covered	8	..
5. Poorly exposed, sandy limestone.....	15	..
	37	6

The horizon of the Waldron shale is probably marked by No. 3. The shale, as a shale, seems to be absent at this place. The lower limestone belongs to the Laurel beds. Between this point and the college campus but very few exposures are found, making it impossible to trace the horizon of the shale by actual observation.

A section at Long's Falls, on Middle Fork, one and one-half miles south of Hartsville, was as follows:

	<i>Ft.</i>	<i>In.</i>
1. Slightly arenaceous limestone as seen above and on the north side of the falls.....	..	10
2. Hard, irregularly bedded, blue to grayish limestone	4	6
3. Waldron shale	2	3
4. Calcareous shale to light shelly limestone.....	..	4
5. Laurel limestone in bed of creek.....	0	..
	—	—
	7	11

No. 1 belongs to the Devonian limestone, and No. 2 is questionable, but probably belongs to the Niagara. This limestone (No. 2) forms the top of the falls, and measures three feet in thickness. There is an excellent exposure of the shale at the base of the falls. The upper three to five inches is a clay shale; two to six inches lower the shale runs from a pure shale to a shaly limestone. Below the falls on each side of the stream the shale is exposed for some 200 or 300 yards, the exposure being best on the south side of the creek. Below the falls, some 350 yards, the Laurel limestone is exposed in the bed of the creek, where some quarrying has been done. The quarried stone is used principally for building purposes. Below this exposure, down to the mouth of the stream, but few exposures are found. The bed of the stream is of loose boulders, sand and clay. South of the school-house, at the forks of the road, the flood plain of the stream is very broad and continues so to the west side of the section, only a small ridge separating it from the narrow channel of Falls Fork.

In the accompanying view of Long's Falls, Plate II, the 10 inches of arenaceous Devonian limestone is not shown, it lying to the left and above the exposures as here revealed. The irregularly bedded limestone as seen over the shale is the questionable formation at this place. The smooth surfaced stone in the foreground is the Laurel limestone, and lies in the bed of the creek, which was dry at the time of examination.

The falls are interesting from another standpoint, showing as they do the necessary rock structure for the formation of one class of falls.

The overlying limestone which forms the crest of the falls, weathers much slower than the soft underlying shale. As the shale falls down and is removed by the moving water, the overlying limestone forms projecting ledges, which in the course of time, due to their own weight, break down in rather large irregular masses, two of which are seen near the center of the picture, and in this way the recession of the falls is brought about.

Only a short distance below the junction of Middle Fork and Falls Fork, at the east end of the foot bridge, in the northeast quarter of the northeast quarter of section 11, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Rather massive, arenaceous limestone.....	5	6
2. Hard, grayish, irregularly bedded limestone.....	3	6
3. Shale and clayey shale.....	4	..
4. Regularly bedded Laurel limestone.....	8	..
	<hr/>	<hr/>
	21	..

No. 1 belongs to the Devonian and Nos. 2, 3, and 4 to the Niagara.

Just north of the foot bridge, at the sharp turn in the creek, a slight unconformity exists between the Devonian and the underlying Silurian limestone. The Waldron shale is about three feet thick at this place.

Only a short distance below the foot bridge, mentioned above, between the road and the creek, the following section was obtained along a short ravine:

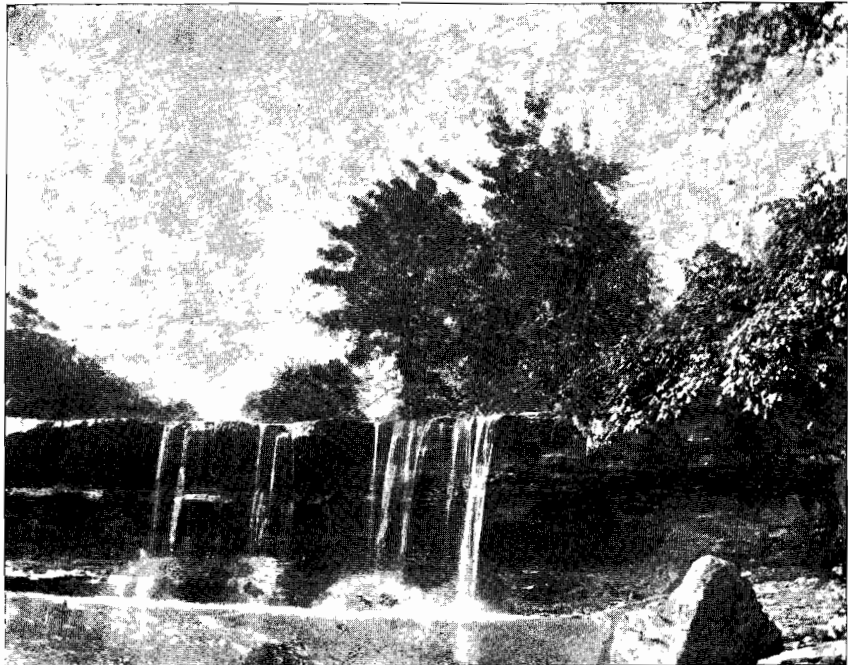
	<i>Ft.</i>	<i>In.</i>
1. Drift	15	..
2. Arenaceous limestone	10	..
3. Hard, rather massive and slightly arenaceous limestone	3	6
4. Waldron shale	3	4+
5. Covered	2	..
6. Laurel limestone to bed of creek.....	10	..
	<hr/>	<hr/>
	43	10

Good exposures are found at a number of places along this creek, making the location of the Waldron shale horizon comparatively an easy matter.

In the northeast quarter of the southwest quarter of section 12, two miles south of Hartsville on Falls Creek, occurs Anderson Falls. These falls are higher than Long's Falls, but are formed by the same formations, which are thicker at this place. Above the falls for some 500



(a) View of Long's Falls on Middle Fork, $1\frac{1}{2}$ miles south of Hartsville, Indiana.



(b) View of Anderson Falls on Falls Fork, two miles south of Hartsville, Indiana, showing the Hartsville limestone and the underlying Waldron shale. In the right-hand corner in the fore-

yards good exposures occur along the creek reaching up to the foot bridge near the south side of the section. Below is given a combined section of the exposures above and at the falls:

	<i>Ft.</i>	<i>In.</i>
1. Rather soft, arenaceous limestone.....	4	..
2. Hard, arenaceous limestone, with poorly marked bedding planes	9	6
(This reaches down to the top of the falls.)		
3. Hard, non-fossiliferous limestone, corresponding to the Hartsville ledge.....	4	11
(This stratum forms the top of the falls.)		
4. Limestone	1	4
5. Hard to shaly limestone.....	1	1
6. Coarse, drab to fine shale.....	3	..
7. Shale to shaly limestone.....	..	10
8. Shale	1	2+
	25	10

Edge of water in the pot hole below the falls.

It is believed that the heavy, and rather massive arenaceous limestone above the falls along the creek belongs to the Devonian Age, and that the limestone forming the crest of the falls belongs to the Silurian Age. The formations seem to be non-fossiliferous. At this, and other places, where formations have been given in this report as non-fossiliferous, it is to be understood that they were so reported judging from a hasty examination, and it is indeed quite probable that close and extended examination would reveal the presence of fossils, but since this report was to deal principally with the mapping of the territory, this finer paleontological work was left for the paleontologist.

It is quite probable that in the above section very few inches less than the total thickness of the shale is revealed; that part below the water's edge probably not running over three or four inches in thickness. Below the center of the shale occur a few rather heavy masses of limestone running to a shale through a shaly limestone at their edges. These masses stand out as a projecting ledge here and there in the stratum of shale. In the accompanying picture of the falls (see Plate II) they are seen near the water's edge to the left. To the right of the falls the Hartsville and Devonian limestone form quite a precipitous cliff with a maximum height of 20 feet. The shale is exposed for a short distance below the falls on each side of the creek. The fact that these falls are higher than Long's Falls is due to two things, viz., to an increased thickness in the Waldron shale, and to a greater volume of water carried by the stream.

North of Rugby, along Duck Creek, the arenaceous Devonian limestone is exposed in the bed of the creek. A good exposure was observed above the bridge just north of the village. To the west along Big and Little Haw creeks the drift is rather heavy and no exposure of country rock is shown.

At Hope the drift was reported running from 7 to 30 feet. An exposure of Devonian limestone was observed east of Duck Creek, along a small ravine just north of the road along the south side of section 28, two and a half miles northeast of Hope. From well sections reported through the county south of Hope and east to Clifty Creek, it seems more than probable that all of this territory is underlain with the Devonian limestone.

SHELBY COUNTY.

This county lies north of Bartholomew and Decatur counties, east of Johnson and Marion counties, south of Hancock County, and west of Rush and Decatur counties. Shelbyville, the county seat, is located centrally in the county.

Only a small portion of the county is covered in this report. The area mapped lies in the southeast corner of the county, and includes all of the civil township of Noble, and parts of Washington, Addison and Liberty townships.

The territory is drained by Big Flat Rock Creek, Conn's Creek, Bear Creek, and a few other smaller streams. The general direction of the drainage is to the southwest. The topography runs from slightly undulating till plains to a somewhat broken country along the largest streams.

This section of the country lies wholly within the glaciated portion of the State, and is covered with a drift coating, mainly till, running from only a few feet to 80 or more feet in thickness.

The following section of a well at Waldron is taken from the eleventh report of this Department:

	<i>Ft.</i>
1. Yellow till	10
2. Sand and gravel.....	14
3. Gray till	28
4. Sand	1
5. Rock, thought to be sandstone (probably the arenaceous limestone of this report).....	3

At St. Paul, on the boundary line between this and Decatur County, the drift varies from 10 to 90 feet.

Waldron lies near the center of the east half of the territory mapped.

DISTRIBUTION OF THE WALDRON SHALE.

VICINITY OF WALDRON AND SOUTH TO GENEVA.

The first examinations that were made in this vicinity were along Conn's Creek, one mile below Waldron, at the famous Waldron shale fossil beds. So much has already been written about these beds and the fossils, that we feel that this part of the territory can be dismissed with brief descriptions.

Going one mile south from Waldron and then 600 yards west, the bridge across Conn's Creek is reached, where the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Covered	1	..
2. Light grayish, rather soft and slightly arenaceous limestone		6
3. Light grayish, arenaceous limestone.....		5
4. Light grayish, arenaceous limestone.....		8
5. Rather hard, reddish limestone.....		5
6. Rather hard, reddish limestone.....		4½
7. Light grayish, arenaceous limestone.....		6
8. Light grayish, arenaceous limestone.....		2
9. Reddish, arenaceous limestone.....		6
10. Reddish, arenaceous limestone.....		10
11. Hard, grayish to bluish limestone, thin bedded....	6	..
	11	4½

Nos. 2 to 10, inclusive, belong to the Devonian Age, and No. 11 to the Silurian Age. This last mentioned division corresponds to the stone quarried in the Avery quarry, and is the Hartsville bed. This section was run 150 yards above the bridge, and on the east side of the creek. Only a short way below the bridge on the east side of the creek some little stone has been quarried. The stone quarried is the Hartsville bed. The base of the quarry is formed by the Waldron shale, which is here near the level of the creek bed. Only a short distance farther down the creek, and just above the mouth of Bear Creek, is the Avery quarry. Here quarrying is carried on quite extensively for local purposes. At the quarry the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Drift	5	..
2. Arenaceous limestone	2	..
3. Discontinuous shale and clay bands		0 to 1½
4. Thin, irregular beds of shaly limestone.....	11	
5. Hard, gray to bluish limestone.....	9	
6. Hard limestone, running from a gray to a blue from top to bottom.....	10	
7. Grayish limestone	3	
8. Grayish limestone	7½	
9. Grayish limestone	8½	
10. Gray to blue limestone.....	1	..
11. Gray to blue limestone.....	4½	
12. Gray to blue limestone.....	1	3½
13. Gray to blue limestone.....		11
14. Gray to blue limestone.....		7
15. Gray to blue limestone.....		5
16. Gray to blue limestone.....		8
17. Gray to blue limestone.....	1	1
18. Gray to blue limestone.....		4
19. Bottom of the quarry, which is formed by the Wadron shale, reported by quarrymen to be five feet thick.		
	17	10½

The following correlation seems to be the correct one for the exposed strata:

No. 2 belongs to Devonian, Nos. 3 to 18, inclusive, to the Silurian, forming the total thickness of the Hartsville bed. An unconformity exists between the Silurian formation and the overlying Devonian. This unconformity is seen best in the northeast corner of the quarry. Below in Figure 5 this unconformity, together with overlying and underlying formations, is shown.

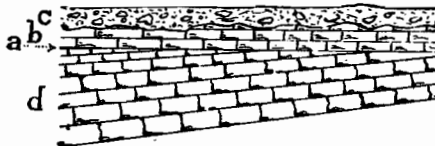
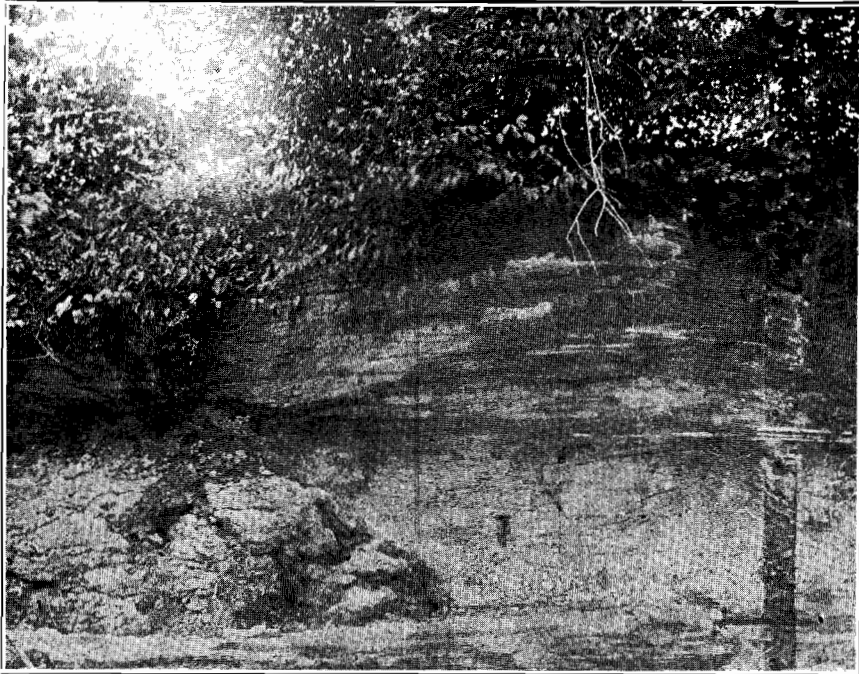


Fig. 5. Sketch of the north astend of the Avery quarry on Conn's Creek, one and a half miles below Waldron, Indiana.

- a—Line of unconformity.
- b—Devonian limestone.
- c—Drift. d—Hartsville limestone.

The rocks below the line of unconformity have a decided dip to the northwest. The total thickness of the limestone in the southeast corner of the quarry is five feet, and in the northeast corner 9 feet.

a



(a) View of the Waldron shale and overlying limestone, two hundred yards below the famous Waldron shale "diggings" on Conn's Creek, one and a half miles below Waldron, Indiana.

b



(b) View of the Waldron shale below the iron bridge at Milroy, Indiana.

On the opposite side of the creek from the quarry, and only a few yards down the creek, are the famous Waldron shale fossil beds. But little digging has been done here for years, and the exposures are almost completely covered by debris. From the poorly exposed strata the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Drift	10	..
2. Light grayish, poorly bedded non-fossiliferous limestone	3	6
3. Waldron shale, light gray to light blue and drab... 1	1	..
4. Covered to bed of creek.....	4	6
	<hr/>	<hr/>
	19	..

Two hundred yards down the creek, and on the west side, there is a good exposure of the shale. The following section was made at this exposure:

	<i>Ft.</i>	<i>In.</i>
1. Soil	4	..
2. Light, sandy Devonian limestone.....	2	..
3. Thin bedded, rather hard, grayish to blue limestone (the Hartsville bed).....	5	6
4. Shale and shaly limestone.....	4	8
	<hr/>	<hr/>
	16	2

The upper 21 inches of the shale consists of shale and shaly limestone with alternate thin streaks of clay and clayey shale. The discontinuous shaly limestone courses run from naught to four inches in thickness. Below this upper division of the shale occurs 18 inches of shale with an occasional, irregular mass of shaly limestone. Below this division occurs 11 inches similar to the top division. The bottom division consists of rather hard, shaly limestone. At the north end of the exposure the shale and shaly limestone turns to a harder shale and thin bedded limestone. The shale is exposed for a distance of about forty yards. Near the southern end of the exposure there is one very large, irregular, fossiliferous mass of limestone and limestone shale. The lower half of the shale seems to have the greater number of fossils. Below the shale to the bed of the creek there is exposed 18 inches of Laurel limestone.

In the accompanying view of this exposure (see Plate III) the large mass of limestone is seen to the left in the foreground. The best exposure of the Waldron shale is seen to the right of the limestone mass. Above the shale is the somewhat poorly bedded Hartsville limestone.

Following down the creek for only a short distance there is a sharp turn in the stream. Along on the east bank there are a number of

springs which seem to come from just above the Waldron shale horizon. Near the mouth of these springs and along on the bank only a few feet above the bed of the creek occurs a heavy deposit of calcareous tufa, presumably deposited by the spring water. The entire mass, running almost to the foot bridge below, a distance of some 400 yards, is a loose, spongy mass having a very characteristic tufaceous texture.

At the east end of the foot bridge, across Conn's Creek, in the southeast quarter of the southeast quarter of section 6, one and three-fourths miles below Waldron, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Drift and soil.....	15	..
2. Sandy limestone	2?	..
3. Hard, grayish, and at places sandy limestone in courses 5 to 8 inches thick.....	3	..
4. Irregularly, thin bedded, non-fossiliferous limestone	3	6
5. Shale and shaly limestone, light grayish where long exposed, but more of a slate color where newly exposed	1	6
6. Fossiliferous shale	3	..
7. Covered	?	..
8. Hard, blue, irregularly bedded Laurel limestone..	6	..
Bed of creek.....	0	..

Section at the small water falls in the small ravine south of Mr. Fred Stickford's residence in the southeast quarter of the southeast quarter of section 6, two miles south of Waldron:

	<i>Ft.</i>	<i>In.</i>
1. Drift	12	..
2. Thin bedded, rather hard, grayish, arenaceous limestone	7	..
3. Shale and shaly limestone.....	1	6
4. Covered to creek bottom.....	8?	..
	28	6

Section along a small ravine south of Mr. G. W. Carlisle's residence in the southeast quarter of the southeast quarter of section 6, two miles south of Waldron:

	<i>Ft.</i>	<i>In.</i>
1. Hard, irregularly bedded limestone.....	3	..
2. Covered	2	..
3. Shaly limestone, with Waldron shale fossils.....	..	2
4. Shale and clay.....	..	2
5. Shaly limestone .....	..	4
6. Shale .....	..	1½

	<i>Ft.</i>	<i>In.</i>
7. Shaly limestone		1½
8. Shale		1
9. Shaly limestone		3
10. Shale		1
11. Shale and shaly limestone.....		5
12. Shale and shaly limestone.....		3
13. Shale		6
14. Covered		1½
15. Hard, grayish to blue limestone.....		6
16. Hard, blue limestone.....		5
17. Hard, blue limestone.....		6½
18. Hard, blue limestone.....		3½
19. Hard, blue limestone.....		5
20. Hard, blue limestone.....		8
21. Hard, blue limestone.....	1	9
22. Light to blue shaly limestone.....		3
23. Shale and shaly limestone.....	3	..
24. Hard, blue crinoidal limestone.....		6
25. Hard, blue, irregularly bedded limestone.....	1	1½
26. Blue to slightly reddish limestone.....		8
27. Reddish to a dull-colored limestone.....		4
28. Bed of Conn's creek.....	0	..
	18	1

Below is given the correlation of the strata in the foregoing section.

Nos. 3 to 13, inclusive, belong to the Waldron shale. The alternation of the shale and the shaly limestone strata is very noticeable in this section. This horizon was very fossiliferous, a number of good Waldron shale specimens were found. Nos. 15 to 21, inclusive, belong to the Laurel limestone. The Laurel courses are thinner here than at most exposures, and the total thickness of this formation has decreased decidedly, for below No. 21 occur the Osgood limestone and shale. These Osgood beds are only exposed at this one place, being covered above and below and presumably dipping below drainage. The exposure is along the roadside near Mr. Carlisle's barn. Dr. Washburn, a local paleontologist, of Waldron, reported having found a number of cystideans at this place. From here to the mouth of Conn's Creek, the country rocks are covered.

The somewhat circular field, shown on the accompanying map at the mouth of Conn's Creek marks, in a general way, the area included in the gas explosion, which occurred at this place August 11, 1890. The local accounts vary somewhat with reference to the violence of this "blow-out." The prevailing, and what seems to be the correct one, is as follows: Following the heavy explosion, which threw rocks, soil, mud, etc., to a height of three hundred feet or more, came a blaze

which ran higher. The escaping gas was ignited from a fire then burning in old driftwood near by. Large fissures were formed in the earth's crust, one of which crossed Flat Rock Creek just above the mouth of Conn's Creek, and into which the creek flowed for 24 hours. A few banks and depressions remain to mark the site of the explosion. A number of clay relics, made from the ejected clay, are kept by the citizens of the neighborhood.

Above the mouth of Conn's Creek, on the west side, the line marking the supposed position of the Waldron shale turns to the west and follows in a westerly direction across the east half of section 12, and then turns to the southwest to the creek's bank at the southwest corner of the section. It is more than probable that at some time Flat Rock Creek flowed west across the north part of the east half of section 12, and then turned south and joined its present channel. Between its old channel and its present one occur some rather high sand and drift hills.

A section of the west bank of Flat Rock Creek west of Geo. Wright's residence, in the northwest quarter of the northwest quarter of section 13, one and three-fourths miles above Geneva, is as follows:

	<i>Ft.</i>	<i>In.</i>
1. Sandy limestone	2?	..
2. Thin bedded, light grayish to blue limestone.....	5	6?
3. Shale and shaly limestone.....	2	..
4. Covered	2	..
5. Shaly limestone .....	..	6
6. Hard, blue limestone in courses from 2 to 10 inches	5	6
	17	6

The wagon road along the creek at this place follows the horizon of the Waldron shale for some three hundred yards.

The following section of the east bank of Flat Rock Creek, fifty yards above the forks of the road, in the northwest quarter of the northwest quarter of section 13, and 200 yards southwest of Geo. Wright's residence, was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Drift	15	..
2. Grayish limestone	1	6
3. Grayish limestone .....	..	10
4. Grayish limestone .....	..	6
5. Hard, grayish to blue limestone.....	1	7
6. Hard, grayish to blue limestone.....	..	10
7. Hard, grayish to blue limestone.....	1	7

	Ft.	In.
8. Shale and shaly limestone.....	5?	..
9. Hard, blue limestone.....	..	9
10. Hard, blue limestone.....	..	6
11. Covered to creek.....	..	8
	28	9

The Waldron shale is very fossiliferous, and this is an excellent place to gather Waldron shale fossils.

The following species were recognized:

Rhyncotreta cuneata, *Atrypa reticularis*, *Meristina nitida*, *Orthis hybrida*, *Spirifera crispa*, *Rhynchonella neglecta*, *Rhynchonella indianensis*, *Rhynchonella whitii*, *Favosites forbesi*.

At the forks of the road along Flat Rock Creek, at the east side of section 14, there is an exposure of some 12 feet of rather soft, massive, sandy limestone the base of which is probably eight feet above the creek.

A section of the west bank of Flat Rock Creek, one-half mile above Geneva, is as follows:

	Ft.	In.
1. Soft, massive, arenaceous limestone.....	5	..
2. Soft, sandy limestone.....	..	5
3. Hard, grayish limestone.....	..	7
4. Hard, light grayish to bluish limestone.....	..	4
5. Hard, light to bluish limestone.....	..	4½
6. Hard, light to bluish limestone.....	..	7½
7. Hard, light to bluish limestone.....	..	3½
8. Hard, light to bluish limestone.....	1	..
9. Hard, light to bluish limestone.....	..	3
10. Hard, light to bluish limestone.....	..	3
11. Hard, light to bluish limestone.....	..	7
12. Hard, light to bluish limestone.....	..	4
13. Hard, light to bluish limestone.....	..	11
14. Hard, light to bluish limestone.....	..	6
	11	5½

There is a slight unconformity between Nos. 1 and 2. Nos. 3 to 14, inclusive, belong to the Hartsville bed, corresponding to the stone quarried at the Avery quarry near Waldron. Some little stone has been quarried at this exposure. The bottom of the quarry is probably three feet above the bed of the creek. The Waldron shale probably lies below the quarry and near the creek bed.

The following is a section of the south bank of Flat Rock Creek at the turn in the stream three-eighths of a mile above Geneva:

	<i>Ft.</i>	<i>In.</i>
1. Soft, massive, sandy limestone.....	12	..
2. Irregularly bedded limestone.....	1	6
3. Hard, gray to blue limestone.....	6	6
4. Bed of creek.....	0	..
	<hr/>	<hr/>
	20	..

The Waldron shale has passed below drainage. The rocks have a decided dip to the west.

Section taken at the Gregory limekiln at Geneva:

	<i>Ft.</i>	<i>In.</i>
1. Drift	3	..
2. Thin bedded limestone.....	2	..
3. Impure limestone	1	6
4. Grayish, thin bedded limestone, courses running from 2 to 6 inches.....	2	2
5. Continuous stratum of limestone.....	3	4
6. Thin bedded limestone.....	2	6
7. Hard, grayish limestone.....	..	3
8. Hard, grayish limestone.....	..	4
9. Hard, grayish limestone.....	..	3½
10. Hard, grayish limestone.....	..	9
11. Hard, grayish limestone.....	..	3
12. Hard, grayish limestone.....	..	2
13. Hard, grayish limestone.....	..	10
14. Hard, grayish limestone.....	..	2
15. Hard, grayish limestone.....	1	5
16. Hard, grayish limestone.....	..	10
17. Hard, grayish limestone.....	..	8
18. Bottom of quarry, which is about 15 feet above the bed of the creek.....	0	..
	<hr/>	<hr/>
	20	5½

One hundred and fifty yards above the mouth of Douglas Creek, in the northeast quarter of the southeast quarter of section 14, and one-half mile above Geneva, the following section was made at the upper end of the gorge along the creek:

	<i>Ft.</i>	<i>In.</i>
1. Massive, arenaceous limestone, which grows harder from top to bottom.....	7	..
(This stratum forms projecting ledges along the sides of the narrow gorge.)		
2. Hard, light to bluish limestone.....	..	8
3. Hard, light to bluish limestone.....	1	1
4. Hard, light to bluish limestone.....	..	6

	<i>Ft.</i>	<i>In.</i>
5. Hard, light to bluish limestone.....	2	2
6. Hard, light to bluish limestone.....	2	2
7. Hard, light to bluish limestone.....	2	2
8. Hard, light to bluish limestone.....	3	3
9. Hard, light to bluish limestone.....	2	2
10. Hard, light to bluish limestone.....	3	3
11. Hard, light to bluish limestone.....	2	2
12. Hard, light to bluish limestone.....	2	2
13. Soft, sandy limestone, which forms the top layer of the Waldron shale.....	10	10
14. Shale.....	6+	6+
15. Bed of creek.....	0	..
	<hr/>	<hr/>
	12	1

Purely from a lithological standpoint, the following correlation was made of the exposures at this place:

No. 1 the base of the Devonian; Nos. 2 to 12, inclusive, the upper division of Upper Silurian, or the Hartsville bed; and Nos. 13 and 14 the Waldron shale. Between the sandy Devonian limestone and the underlying hard to bluish Silurian formations, there exists a slight unconformity. The Silurian rocks dip to the west. This unconformity is similar to others referred to in this report, and which indicate that there must have been an elapse of no short intervening period between the deposition of these two formations. A small cascade exists at the head of the gorge. Above the cascade the Devonian is exposed in the bed of the creek.

The following report was given by the drillers of the Geneva gas well, which was just completed at the time of my visitation:

	<i>Ft.</i>	<i>In.</i>
1. Drift.....	1	6
2. Hard limestone, free from shale.....	150	..
3. Shale.....	30	..
4. Hard, brown sandstone (?)......	45	..
5. Shale.....	500	..
6. Trenton limestone.....	17	..
	<hr/>	<hr/>
	743	6

A light flow of gas was struck.

A number of observations were made along Flat Rock Creek below Geneva. At the cross roads in the north half of section 22, one mile below Geneva, there occur in the bed of the creek excellent exposures of the sandy, Devonian limestone.

At Flat Rock Cave, one-fourth mile above Bynum, on the north side of the creek, there is an exposure of heavy, sandy limestone. The cave, which occurs near the base of this exposure, is near high water mark. Below the heavy limestone and below the entrance to the cave, two feet of thin, irregularly bedded limestone is exposed. Above the heavy, massive, sandy limestone, some eight feet of hard, light to blue, thin, irregularly bedded limestone is exposed.

Below the bridge at Bynum there is an exposure of some 12 or 15 feet of irregularly bedded limestone. At the top of the exposure, as seen on the west side of the creek, there is some five feet of hard, bluish limestone. Below this there occurs some seven or eight feet of irregularly bedded limestone to bed of creek. At places in this exposure there is an alternation of hard, blue and sandy limestone strata. The limestone found along the creek at Geneva has probably passed below drainage at this place, and the sandy limestone here probably represents a larger division of the Devonian. The exposure is non-fossiliferous.

Two miles south of Bynum, on the road to Norristown, the drift was reported two to five feet thick, with fifty feet plus of hard underlying limestone. West of the road and north of a small branch near the center of the east side of section 29, one-half mile north of Norristown, is an outcrop of nine or ten feet of poorly exposed limestone. The limestone seems to be poorly bedded, with a pale blue to light blue color, and at places quite soft and sandy, especially where long exposed. Near the top of the exposure are two strata of chert two to five inches thick.

Some five miles east of Norristown, along Duck Creek, exposures of the sandy Devonian limestone were noted at the following places: In the northeast quarter of the northwest quarter of section 33; near the center of the north side of section 32; and at the southwest corner of section 32. The drift in the vicinity of Duck Creek runs from 3 to 35 feet.

At Middletown, on Conn's Creek, one mile above Waldron, there is an exposure of the sandy limestone in the bed of the creek just west of town. Shale was reported in the creek, but an examination failed to verify the report. However, at the time of the examination the creek was slightly swollen, and it is barely possible that the shale does outcrop. Judging, however, from the sandy limestone, the horizon of the shale seems to be some eight or ten feet below the bed of the creek. The stone exposed lithologically corresponds to the sandy limestone above the Hartsville bed at the Avery quarry, below Waldron. To the west and northwest of Middletown the country is level

dissected here and there by narrow, post-glacial valleys. A number of observations were made along Conn's Creek and its tributaries above Middletown, but the country rock was concealed by the rather heavy drift.

RUSH COUNTY.

Rush County lies north of Decatur County, and is bounded on the east by Fayette and Franklin counties, on the west by Shelby and Hancock counties, and on the north by Hancock and Henry counties. Only the southwestern portion of the county is included in this report. The area mapped has a breadth of nine miles north and south and a length of 15 miles east and west. Milroy, the largest village in the mapped area, lies east and south of the center. The territory is drained by Big and Little Flat Rock creeks. The topography and surface geology is in a general way similar to that of the adjacent counties described above.

DISTRIBUTION OF THE WALDRON SHALE.

Section of the east bank of Little Flat Rock Creek, 40 yards below the bridge at Milroy:

	<i>Ft.</i>	<i>In.</i>
1. Soil	5	..
2. Irregularly bedded, grayish to dark-colored, arenaceous limestone	4	..
3. Shale	2	1
(a) Shale and clayey shale.....	..	2
(b) Shale to shaly limestone.....	..	1 to 3
(c) Blue to drab shale.....	..	16
(d) Shaly to shaly limestone.....	..	4
4. Laurel limestone in the bed of the creek.....	0	..
	<hr/>	<hr/>
	11	1

No. 2 breaks down in small, irregular, sharp-cornered pieces, increasing in size from top to bottom. It is non-fossiliferous. Years ago the stone was burned for lime. The shale is exposed for 100 yards or more along the east bank of the stream. On Plate III is given a view of the exposure at this place.

The Waldron shale at the bridge seems to be in the trough of a gentle synclinal fold, for one-fourth of a mile above the bridge the shale horizon is more than two feet above the bed of the creek, and one-half mile below the bridge eight feet above the bed of the creek. Above the bridge the Laurel limestone forms the bed of the creek for one-fourth mile or more. The shale is exposed 150 yards above the bridge, where it is one and one-half feet above the creek. In following up the creek the shale disappears. On the south bank of the creek, just above where the branch enters from the north, near the center of section 12, the shale is absent, the sandy, irregularly bedded limestone resting directly on what seems to be the Laurel beds. The exposures are poor, and non-fossiliferous. One stratum is present which resembles the base of the shale. If the underlying limestone is really the Laurel limestone it has changed from its usual color, having at this exposure a dull red to brownish color.

Above the railroad bridge northeast of Milroy, in the bed of the creek, occur good exposures of the arenaceous limestone, which lies above the Laurel beds. This indicates that the horizon of the Waldron shale has passed below drainage. Owing to the more or less covered condition of the exposures, it was impossible to determine just where the shale passes below drainage. In fact, it seems that the shale is absent just north of Milroy and that the Devonian (?) rests unconformably upon the Laurel beds. It is possible that denudation removed the shale during the intervening period between the deposition of these two formations. The sandy limestone passes below drainage in section 7, northwest of Milroy, not reappearing along the head waters of the creek. Observations were made at a number of places along Conn's Creek and the head waters of Little Flat Rock Creek, and together with reports gathered from the farmers warrant the above statement. Observations were extended eastward to and beyond the north fork of Clifty Creek, but no Devonian limestone was observed. To the east the Laurel and Osgood beds were noted. The eastern extension of the Devonian is concealed beneath the drift. At Bulltown, on Salt Creek, east of Andersonville, the Laurel and Osgood beds are exposed.

The exposures along Clifty Creek are covered. In the creek valley one mile east of Richland, at the Anderson gas well, the drift was reported 122 feet thick; at Richland from 50 to 80 feet.

Section at the Rarden quarry, on Little Flat Rock Creek, one-half mile below Milroy:

	<i>Ft.</i>	<i>In.</i>
1. Soil	2	..
2. Thin, irregularly bedded limestone.....	2	..
3. Shale		8
(a) Shale and clayey shale.....		1 $\frac{2}{3}$
(b) Shale and shaly limestone.....		5 $\frac{2}{3}$
(c) Clayey shale		$\frac{2}{3}$
4. Hard, blue Laurel limestone in regular courses running from 2 to 6 inches.....	6	..
5. Laurel limestone with chert nodules.....	3	..
6. Bed of creek.....	0	..
	13	8

The shale grows thinner in going down the creek, running from four to eight inches. The exposure of shale at the quarry is about fifty yards long. On the opposite side of the creek, near the little spring, the shale seems to be absent.

South of the bridge, locally known as the White Bridge, across Little Flat Rock Creek south of Milroy, there is an exposure of eight feet of chert and thin strata of limestone, evidently the upper beds of the Laurel limestone. On the north side of the creek there is a large gravel pit. From this point south to Decatur County, the location of the shale horizon is uncertain. The drift is heavy, and very rarely do exposures of country rock appear. In the road along the north side of the northeast quarter of section 26, there is an exposure of the Laurel beds. Following the road west to the creek and then following up the creek for a short distance, there occurs an exposure of thin courses of limestone. The exposure forms a cliff seven feet high. It is seen best on the east side of the creek.

MOSCOW AND VICINITY.

Section of the northeast bank of Big Flat Rock Creek, 200 yards above the bridge at Moscow:

	<i>Ft.</i>	<i>In.</i>
1. Irregularly bedded limestone.....	7	..
2. Dull brownish, arenaceous limestone.....	4	6
3. Laurel (?) limestone, courses 2 to 4 inches thick....	2	6
4. Covered to bed of the creek.....	2	..
	16	..

Section of the same bank thirty yards farther up the creek:

	<i>Ft.</i>	<i>In.</i>
1. Sandy limestone, massive to poorly bedded.....	15	..
2. Shale and clayey shale.....	..	3
3. Shale to shaly limestone.....	2	6
4. Hard, bluish Laurel limestone.....	3	..
5. Bed of creek.....	0	..
	20	9

Nos. 2 and 3 mark the portion of the Waldron shale which is here quite calcareous. Following the exposure of the shale up stream it gradually grows thinner, until its thickness is only 11 inches where it disappears. At this point of disappearance it is divided into two fairly well defined strata; viz., two inches of shale to clayey shale and nine inches of shale to shaly limestone.

The sandy limestone at the top of the section forms quite a large cliff, with here and there overhanging ledges. On Plate IV is given a view of the cliff with its more or less irregularly bedded strata forming the greater part of the picture. To the right, where the vegetation has been removed, is seen a dark spot locating the horizon of the shale. The disintegration of the shale forms a soil in which many forms of plant life take root. Above and below this horizon, owing to the absence of soil, plant life is not so abundant. To the left of the dark spot, marking the position of the shale, is seen the heavy growth of plant life, while above and below this horizon but few forms of plant life are seen. In the foreground is the rather smooth surface of the Laurel limestone. The exposures are non-fossiliferous. If the Hartsville bed occurs here, it resembles so closely the overlying limestone that no distinction can be made. Following up the stream from this, the last exposure of shale above the bridge, the Laurel limestone soon passes below drainage, and the Devonian(?) limestone occurs in the bed of the creek.

Section of the north bank of Big Flat Rock Creek, near the center of the east side of section 6, one mile northeast of Moscow:

	<i>Ft.</i>
1. Hard, dull-colored, irregularly bedded, and at places sandy, limestone	15

Near the bottom of the exposure occurs a rather heavy sandy stratum. Above the small cliff formed by these exposures occurs an outcrop of dull grayish limestone. Following down the creek for one-fourth mile, the same exposures, as found in the cliff, outcrop. At the ford on the road to Moscow the top half of the exposure is thin

bedded, while the lower half is more or less massive. These exposures form cliffs at the sharp turns in the creek. From this point north, observations were made along the creek as far north as Rushville. At most places the bed of the creek consists of sand, clay and gravel. However, near the northeast corner of section 6, two and one-half miles above Moscow, the following section was obtained.:

	<i>Ft.</i>	<i>In.</i>
1. Irregularly bedded, hard, grayish to blue crystalline limestone	5	6
The lower ledge of this outcrop forms a projecting rock of two feet or more, and runs along the creek bank for 225 yards.		
2. Hard, flinty limestone.....	3	5
This outcrop breaks down in very irregular, sharp-cornered pieces.		
3. Hard, dark bluish to reddish limestone to bed of the creek	1	..
	9	11

The noticeable change in the structure of the outcropping rocks along the creek, in following up the stream from one-half mile above Moscow, is the gradual transition from a more or less soft, arenaceous structure to a hard, flinty structure.

Section of the southwest bank of Big Flat Rock Creek, 200 yards below the bridge at Moscow:

	<i>Ft.</i>	<i>In.</i>
1. Rather hard, dull to grayish sandy limestone..	4	..
2. Clay to clay shale.....	..	2 to 4
3. Shale to shaly limestone.....	3	8
4. Shale to shaly limestone, forming the base of the Waldron shale .....	..	6
5. Thin bedded Laurel limestone.....	3	..
6. Thicker bedded Laurel limestone.....	2	6
7. Bed of creek.....	0	..
	14	..

The Waldron shale at this exposure is slightly fossiliferous. An exposure of Waldron shale three feet thick occurs on the opposite side of the creek, just below the east end of the bridge.

Following down the creek one-fourth mile from Moscow, exposures of the shale are found in the east bank. At the upper exposure, the following section was obtained:

	<i>Ft.</i>	<i>In.</i>
1. Irregularly, bedded, arenaceous limestone.....	4	8
2. Arenaceous limestone	2	3
3. Clay to shale, with 2 inches of shelly limestone at the bottom	1	5½
4. Hard, regularly bedded Laurel limestone to bed of the creek	12?	..
	20	4½

Some 250 yards farther down the creek, and on the east side, is an old quarry, where the following section was obtained:

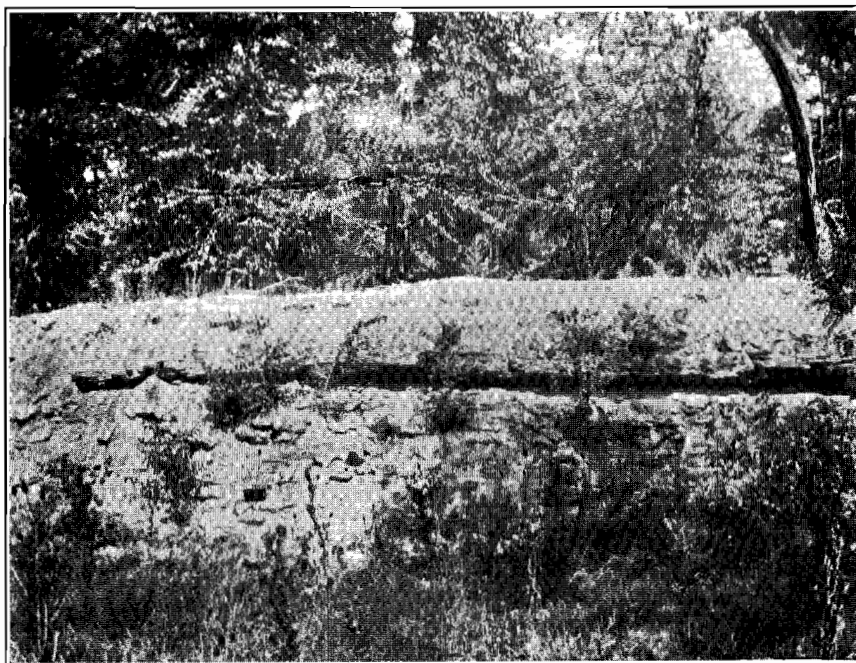
	<i>Ft.</i>	<i>In.</i>
1. Irregularly thin bedded, grayish arenaceous limestone	4	..
2. Shale and clayey shale.....	1	6
3. Shaley limestone, forming the base of the Waldron shale		3
4. Laurel limestone		3½
5. Laurel limestone		2
6. Laurel limestone		3½
7. Laurel limestone		4
8. Laurel limestone		3
9. Laurel limestone		3½
10. Laurel limestone		5
11. Laurel limestone		4
12. Laurel limestone		2
13. Laurel limestone		2
14. Laurel limestone		6
15. Laurel limestone		3
16. Laurel limestone		5
17. Laurel limestone		5
18. Laurel limestone		3
19. Laurel limestone		4
20. Laurel limestone		5
21. Laurel limestone		5½
22. Laurel limestone		8
23. Laurel limestone		5
24. Chert streak		2
25. Covered to creek.....	2	..
	14	9

a



(a) View of the cliff above the bridge across Big Flat Rock Creek, Moscow, Indiana.

b



On Plate IV is given a view of the exposures at this place. The horizon of the Waldron shale is marked by the horizontal line near the center of the picture. Below this horizon is seen the thin, regularly bedded Laurel limestone courses. The exposures are non-fossiliferous. The Waldron shale has an average thickness of 20 inches.

Some 200 yards below the exposure shown in the picture, and on the same side of the stream, the Laurel limestone is exposed, with intervening chert layers. The Waldron shale and overlying limestone are covered.

At the old mill dam in the southwest quarter of the southwest quarter of section 20, one and one-fourth mile below Moscow, seven feet of limestone and intervening chert layers are exposed, presumably the upper courses of the Laurel limestone. At this point and south to the county line the location of the line marking the Waldron shale horizon is largely an arbitrary matter. Observations were made along Little Hurricane Creek, but no rock exposures were found. The drift runs from 20 to 50 or more feet in thickness.