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The Middle River Traverse of Iowa

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NEBRASKA GEOLOGICAL SURVEY

Paper Number 4

THE
MIDDLE RIVER TRAVERSE
OF IOWA

BY G. E. CONDRA AND J. E. UPP



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Conservation & Survey Division
113 Nebraska Hall
University of Nebraska-Lincoln

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The Papers of the Nebraska Geological Survey are reports on special research projects. They are more restricted in content than the Bulletins of the Survey.

The Middle River Traverse of Iowa

BY G. E. CONDRA AND J. E. UPP

This report is based on a study of the Pennsylvanian outcrops in Middle River Valley and its tributaries. The traverse extends from the vicinity of Winterset, Madison County, to ten miles north and one mile east of Greenfield, Adair County, Iowa, a distance of about 32 miles.

The purpose of this investigation and report is to determine what relation the strata exposed in the traverse hold to the Nebraska section, and to correlate and classify the beds for use in future investigations in geology, stratigraphic paleontology and economic development.

Previous Work.—The formations of this traverse have been studied and described by White,¹ Tilton & Bain,² Gow & Tilton,³ Tilton,⁴ and others. The earlier workers sectioned the various exposures, but did not classify the beds. Tilton (4) correlated the beds with those of Missouri, Kansas and Nebraska. Since that time, however, the Pennsylvanian in much of the Northern Mid-Continent Region has been re-studied. Dr. Raymond C. Moore, and his co-workers on the Kansas Survey, traced out the lower members of the Missouri series in Kansas and correlated them into the Kansas City section. This work revealed certain errors in the old classification of the formations and made it necessary to name new units and revise the old nomenclature, which was done by Moore.

The geologists of Missouri and Nebraska have also participated in this regional cooperative investigation, which has established the occurrence of geologic units irrespective of state boundaries and systematized the Pennsylvanian section in the Northern Mid-Continent Region. The problem

¹ White, C. A., Geological Survey of Iowa, Vol. 1, 1870, pp. 241-250; 305-309; 336-339.

² Tilton, J. L., and Bain, H. F., Geology of Madison County, Iowa; Iowa Geol. Surv., Vol. VII, 1896, pp. 491-539.

³ Gow, J. E., and Tilton, J. L., Geology of Adair County, Iowa; Iowa Geol. Surv., Vol. XXVII, 1916, pp. 279-344.

⁴ Tilton, J. L., The Missouri Series of the Pennsylvanian System in Southwestern Iowa; Iowa Geol. Surv., Vol. XXIX, 1919 and 1920, pp. 278-297.

now is to carry the correlation to the outlying Pennsylvanian areas and thus complete the regional classification.

Our problem is to correlate the formations and members of the Middle River traverse with those of the type localities in Missouri, Kansas and Nebraska. This area is isolated from the Pennsylvanian outcrops in the other states, due to the thick mantle of Pleistocene deposits in the intervening uplands, and due also, at places, to the burial of the Pennsylvanian beds beneath the sandstones and shales of the Dakota group (Cretaceous). Consequently, because of this isolation, and because of the Pleistocene cover in the area, field study is more difficult here than it is where the formations are exposed generally and it is possible to trace the key beds through nearly continuous outcrops for long distances.

G. C. Broadhead,⁵ in his monumental work on the Missouri Valley traverses, laid a basis for future stratigraphic investigation in the Northern Mid Continent Region. Todd,⁶ Haworth,⁷ Keyes,⁸ Smith,⁹ Hinds & Greene,¹⁰ Moore,¹¹ Condra¹² and others made use of the basic investigation inaugurated by Broadhead in the further study and description of the Pennsylvanian in the region. The work of each of these geologists has contributed in some manner to the content of this paper.

Investigation leading to this report was inaugurated several years ago by Condra, when he ran reconnaissance traverses from the Missouri Valley sections up the Grand and Platte valleys in Missouri and Iowa. Then, in 1926, Carl O. Dunbar & Condra made a section at Winterset, Iowa, and collected a suite of fossils therefrom. Our study of the Middle River traverse was made in 1931 and 1932 and completed for publication in 1933.

⁵ Broadhead, G. C., Missouri Geological Survey, Vol. 1, 1872.

⁶ Todd, J. E., Proc. Iowa Acad. Sci., Vol. 1, part 1, 1889 and Vol. 13, 1906.

⁷ Haworth, Erasmus, University Geological Survey of Kansas, Vol. 1, 1895; Vol. 2, 1896 and Vol. 3, 1897.

⁸ Keyes, C. R., Various reports of the Iowa Geological Survey, and the Iowa Academy of Science.

⁹ Smith, G. L., Iowa Geol. Surv., Vol. XIX, 1908.

¹⁰ Hinds, H., & Greene, F. C., Missouri Bureau of Geology and Mines, Vol. XIII, 2nd Ser., 1915.

¹¹ Moore, R. C., Geological Survey of Kansas, Bull. 3, 1917.

¹² Condra, G. E., Nebraska Geological Survey, Vol. 1, 2nd Ser., 1927.

In the fall of 1932, Greene, Moore & Condra traced the formations of the Kansas City section through northwestern Missouri and southern Iowa and tied them into the Middle River sections. They found that the "DeKalb limestone" of the type locality in Iowa, as defined by Bain, is the Winterset, which is the Hogshooter of Oklahoma; that the Westerville of Iowa is the "Drum" of the Kansas City section; that the Argentine, widely known as the "Iola" of the Kansas City section, persists to the Middle River area, and that the sequence of geologic units in our traverse, from the Sniabar ("Hertha") limestone up to and including the Argentine, is the same as at Kansas City.

The authors have correlated the beds quite conclusively from the vicinity of Winterset to Section 12, T. 76 N., R. 31 W., in Adair County, beyond which, due to the badly covered outcrops, there is some uncertainty. A close study of this latter part of the section will require sub-surface study, preferably by core drilling.

The strata of the Middle River section dip westward in Madison County and for a short distance in Adair County, where they drop locally northward, then rise slightly or are nearly level along the traverse to about one mile northwest of Arbor Hill, where they rise northward and northwestward with the gradient of the river to near the east side of Section 12, T. 76 N., R. 31 W. In the middle of this section (12) the attitude of the beds is not certain. In the $W\frac{1}{2}$ of section 1, north of section 12, the beds drop northeastward, but from near this point they rise northwestward with the valley floor to the end of the traverse.

Unfortunately, the Middle River area has not been mapped topographically, and we have not run precise levels to the outcrops on which sections have been made. The altitude at the railway stations at Winterset and Greenfield are 1127 and 1368 feet, respectively. Gow & Tilton (3, p. 284) give a number of elevations in Adair County, as do Tilton & Bain (2, p. 498) for Madison County.

We have found no proof that Tilton's (4, p. 297) Thurman-Wilson fault crosses the Middle River traverse in section 18, about 2 miles northwest of Arbor Hill, nor find that this fault crosses the traverse at some point farther northwest.

Acknowledgments.—We are indebted to C. E. Busby, who drafted the figures in the report, and to George W. Dunn, Jr., who typed the manuscript.

Our traverse is now described in connection with the following numbered sections, starting in the vicinity of Winterset and ending in Adair County.

SECTION NUMBER 1

Madison County, Iowa

Location: Along Highway No. 169, just south of the east part of Winterset; at a quarry and in the ravine leading to Middle River; in the $W\frac{1}{2}$ of Section 6, T. 75 N., R. 37 W. See Figure 1. The section:

1. Cherryvale shale (?)—Winterset limestone (?), about 6' exposed at the top of an abandoned quarry located east of highway:
 - (1) Limestone, bluish-gray, weathered buff, badly shattered, 8"-1'.
 - (2) Shale, gray, argillaceous, part arenaceous, with slabby seams of limestone, not very fossiliferous, weathers yellowish, 7'. No doubt, the lower part of this is the upper zone of the Winterset. The full thickness of the Cherryvale outcrops elsewhere, near this location.
2. Winterset limestone, the main portion, about 13' 6".
 - (1) Limestone, the main quarry bed, gray to dark gray, massive, colitic, with some chert, 3' 6"-4'.
 - (2) Limestone, in face of quarry and below quarry floor, medium dark gray, in even massive beds separated by shale partings, quite fossiliferous, weathers gray-buff, about 9'.
3. Galesburg shale, roadside cut south of quarry, 10' or less:
 - (1) Shale, gray, argillaceous, 1' 6".
 - (2) Shale, black, fissile, 1' 6" or more.
 - (3) Shale, gray, argillaceous, bottom very uneven, 4'-7'.
4. Bethany Falls limestone, measured in east-side road cut, about 22':
 - (1) Limestone, light gray, top uneven, slabby and weathered buff at places, basal 2' or more massive and very fine-grained, quite fossiliferous; combined thickness, about 6'.
 - (2) Shale and thin layers or lenses of limestone, gray, fossiliferous, forms a reentrant on face of outcrop, 10"-1'.
 - (3) Limestone, light gray to medium dark gray, massive, wavy-bedded, breaks down as thin layers, quite fossiliferous, about 6' 10".

- (4) Shale, gray, fossiliferous, with a thin limestone in middle, forms a reentrant on face of exposure, 1'-1' 2".
- (5) Limestone, gray, massive, fossiliferous, with some chert near top, quite fossiliferous, 7' 2".
- 5. "Ladore shale", about 19':
 - (1) Hushpuckney shale, in cutbank west of highway, about 3' 8":
 - a. Shale, gray, argillaceous, with pelecypods, *Ambocoelia*, *Derbya*, etc., 1' 6".
 - b. Shale, black, fissile at places, 2'.
 - (2) Middle Creek limestone, in cutbank, bluish-gray, dense, one bed, 6"-8".
 - (3) Elm Branch shale, in cutbank west of highway, 14'-15':
 - a. Shale, gray, calcareous and fossiliferous at top, 1' 10".
 - b. Limestone-mudstone, dark gray, probably not persistent, 1'±.
 - c. Shale, gray, argillaceous, 4'.
 - d. Limestone-mudstone, dark gray, uneven, about 1' 3".
 - e. Shale, gray, with a poorly defined reddish sub-zone near base, about 6'.
- 6. Sniabar ("Hertha") limestone, at foot of cutbank west of highway, dark gray, massive, dense; with crustal, oolitic layer at top; basal portion irregular, shaly, shattered; contains *Composita*, bryozoa, crinoid joints, etc., combined thickness, 3'.
- 7. "Pleasanton shale", about 22' exposed in the section:
 - (1) Shale, gray, with rod-like, calcareous bodies at top, calcareous, about 5' exposed.
 - (2) Covered slope, 12'.
 - (3) Limestone, exposed in ravine east of lower roadcut, dark gray, fragmental, irregular, fossiliferous, about 5'. This is known as the fragmental limestone.

Correlation: Tilton & Bain (2, p. 511), place the fragmental limestone, No. 7(3), of this section, at the base of the Missouri group. They (2, p. 509) use the term Bethany Falls to include all beds of the Missouri group exposed in the vicinity of Winterset, restrict the application of the term Winterset to its present usage (p. 512), and call the Bethany Falls proper the Earlham limestone.

Tilton (4, p. 282) classes the fragmental limestone as the Hertha and uses the terms Cherryvale, Winterset, Galesburg and Bethany Falls about as they are now applied.

Division 5 of the section constitutes the "Ladore" shale of the earlier surveys, and number 7 is in the upper part of the "Pleasanton" shale. The Hushpuckney, Middle Creek and Elm Branch members of the "Ladore" were recently defined by Doctor Moore to apply in Kansas and Missouri, and we find that they persist to this section.

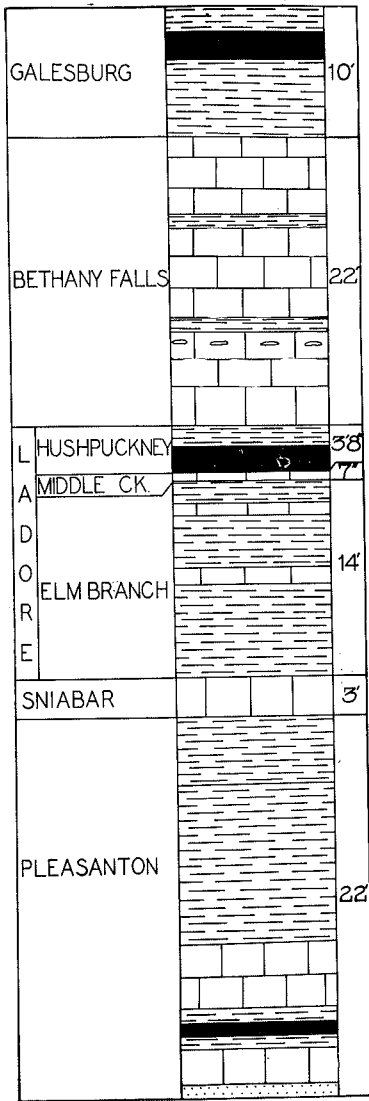


Figure 1.—Columnar Section in the vicinity of Winterset, Iowa.

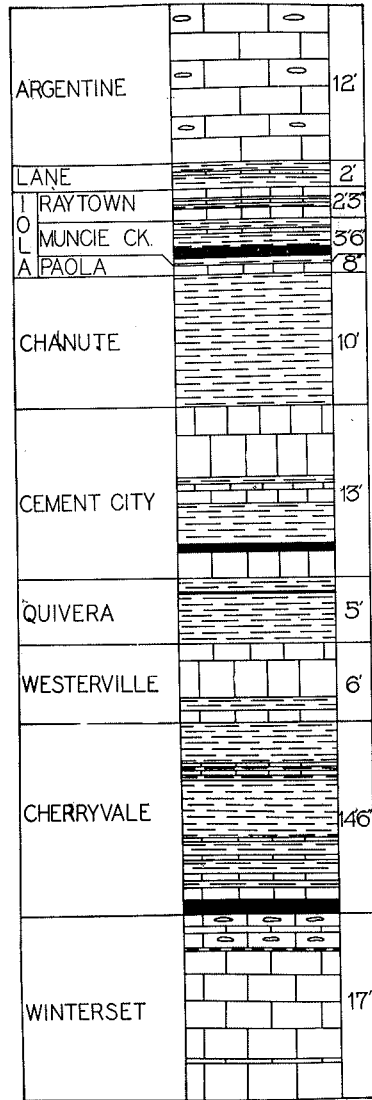


Figure 2.— Columnar Section southwest of Winterset, Iowa.

SECTION NUMBER 2

Madison County, Iowa

Location: Cutbanks west side of Perkins Branch, which is a south-side tributary of Middle River; about 2½ miles south of the southwest corner of Winterset; near center of Section 3, T. 75 N., R. 38 W. The section:

1. Sniabar limestone, exposed quite high in slopes, forms large blocks, with numerous fossil fragments in a thin crusted layer at the top, about 3'.
2. Shale, poorly exposed, bluish gray to light gray, largely argillaceous, part loose and crumbly, about 12'.
3. Limestone, exposed in cutbank west of creek, about 3':
 - (1) Limestone, dark bluish-gray, fossiliferous, 4".
 - (2) Shale, gray, argillaceous, 1"-2".
 - (3) Limestone, dark gray, dense, fossiliferous, 6".
 - (4) Shale, gray, argillaceous, about 10".
 - (5) Limestone, dark gray, forms blocks, 1' 2".
4. Shale, about 1' 2"±; top gray and soft; lower portion dark.
5. The Ovid coal, 1'±.
6. Underclay, light bluish-gray, 1'.
7. Limestone, dark gray, irregular, fragmental, nodular at top, with *Dielasma bovidens*, *Hustedia mormoni*, *Squamularia perplexa*, *Composita subtilita*, *Marginifera splendens*, and small gastropods, 3'-4'.
8. Shale, gray and red, and some sandstone, 20' exposed above.

Correlation: In the above section all of the subdivisions exposed below the Sniabar limestone are in "Pleasanton" shale. Tilton (4) classes them with the Des Moines group.

The correlation between this and the preceding section is as follows: No. 1 here is No. 6 there; 2 here is 7(1) and in 7(2) there; 3 to 6 here are covered there; 7 here is 7(3) there, and 8 here is below the basal part of the section there.

Beds higher in the section than the Sniabar are poorly exposed at the site of Section No. 2. They have been shown in Section No. 1 and are not repeated here.

SECTION NUMBER 3

Madison County, Iowa

Location: About two miles due southwest of Winterset; in ravine north of Middle River; in the NE of section 10 and the NW of Section 11 of T. 75 N., R. 38 W. The outcrops on which this section is measured are reached from the west side of Winterset as follows: West on Highway No. 2, 1½ miles, thence south 1¼ miles. The section begins west of

the road and extends southeastward across the road and along the ravine to near the river. See Figure 2. Section:

1. Argentine limestone, west of highway, grayish, wavy-bedded, quite fossiliferous, with some chert, 12' exposed.
2. Lane shale (former upper "Chanute"), west of road, about 2':
 - (1) Shale, light greenish, 10".
 - (2) Limestone, yellowish-gray, 2"-4".
 - (3) Shale, bluish-gray, weathered yellowish, no fossils observed, 10"-1'.
3. Iola limestone, about 6' 6":
 - (1) Raytown limestone, west of highway, 2' 3':
 - a. Limestone, gray, impure, nodular, 10".
 - b. Shale, dark gray, 2".
 - c. Limestone, dark gray, argillaceous, 5"-7".
 - d. Shale, dark gray, 4".
 - e. Limestone, dark gray, argillaceous, 5".
 - (2) Muncie Creek shale, west of highway and in highway gutter north of bridge, 3' 6":
 - a. Shale, grayish, argillaceous, brownish at top, 9"-10".
 - b. Limestone, gray, nodular, 4"-5".
 - c. Shale, gray, fossiliferous at base, 1' 7".
 - d. Shale, black, fissile, 1' 9".
 - (3) Paola limestone in north side ravine, just west of highway, dark bluish-gray, dense, argillaceous, 6"-10".
4. Chanute shale, badly covered in highway cut but apparently gray to bluish-gray and largely argillaceous, about 10'.
5. Cement City limestone, exposed just east of highway, about 13':
 - (1) Limestone, weathered buff, fairly massive, with many *Triticites* and crinoid joints, brachiopods, etc., 2' 4".
 - (2) Limestone, light, bluish-gray, wavy-bedded, with brachiopods,* crinoid joints, bryozoa, etc., 3'.
 - (3) Shale, bluish-green, crinoid joints, 6".
 - (4) Limestone, gray, fossiliferous, 6".
 - (5) Limestone, with shale seams, fossiliferous, 1'.
 - (6) Shale and nodular layers of limestone, fossiliferous, 2'.
 - (7) Shale, 1' 11"; top bluish-gray; lower part dark to nearly black.
 - (8) Limestone, a dark gray bed, 2'.
6. Quivira shale, gray, massive, with a 1" coal-like layer 1' below top, 5'.
7. Westerville limestone, about 6':
 - (1) Limestone, gray, weathers yellowish-brown, top weathered rounded, base fucoidal, with pebbles, algal pellets, small *Triticites* and gastropods, 1' 6".
 - (2) Limestone, gray, massive, nodular and some shale, 2' 6".
 - (3) Shale, bluish-gray, argillaceous, 1' ±.
 - (4) Limestone, gray, conglomeratic at places, lower face fucoidal, forms waterfall, 10" ±.
8. Cherryvale shale, about 14' 6":
 - (1) Shale, top light gray; base bluish-gray with *Septopora biserialis*, *Polypora*, *Rhombops*, *Derbyas*, etc., 3' 6".
 - (2) Limestone, bluish-gray, with bryozoa, *Allorisma*, etc., 3".
 - (3) Shale, dark, base fossiliferous, 3".

* For brachiopod nomenclature used in this paper, see Bulletin 5, Second Series, Nebraska Geological Survey.

- (4) Limestone, dark bluish-gray, quite fossiliferous, with *Fistulipora*, small *Triticites*, *Meekellas*, crinoid joints, bryozoa, etc., 3".
 - (5) Shale, dark, argillaceous, 3'.
 - (6) Limestone, dark bluish-gray, with crinoid joints, *Polypora*, *Rhomboporas*, *Limoproductus*, etc., 4".
 - (7) Shale, dark, 1'±.
 - (8) Limestone, bluish-gray, 4".
 - (9) Shale, dark, 1'±.
 - (10) Limestone, split up by shales, bluish-gray, with pelecypods, etc., 6".
 - (11) Shale, dark gray, 8".
 - (12) Limestone, dark gray, about 1'.
 - (13) Shale, largely black, 1'.
9. Winterset limestone, about 17'; top 3' shaly, weathered brownish; next zone massive, gray, oolitic limestone; lower zone less massive limestone with thin shale seams.

Correlation: The Galesburg shale and the Bethany Falls limestone outcrop lower in the ravine and along the river to the south. The Argentine limestone, recently defined by Moore, is the "Iola" at Kansas City, but according to the Kansas geologists, it is higher in the general section than the Iola of the type locality which includes the Raytown limestone, Muncie Creek shale (new name) and Paola limestone (new name).

The Westerville limestone is the "Drum" of the Kansas City section; the Quivira (new name), defined by Moore, is the lower shale member of the "Chanute" shale at Kansas City. Moore has separated the Cherryvale as three members, and named them the Wea shale, Block limestone and Fontana shale. Numbers 8(1) to 8(11) of the preceding section are the Wea shale; No. 8(12) is the Block limestone and No. 8(13) together with some shaly material below it, is the Fontana. The Cement City limestone, according to Moore, is the true Drum limestone of the type locality. The middle shale of the "Chanute" at Kansas City is the Chanute of the type locality and the Lane shale of the type locality is the upper "Chanute" at Kansas City.

A section measured in a ravine located about one mile west of where we made Section No. 3 is nearly identical with the latter. It shows the Westerville limestone better than at other places in our traverse.

SECTION NUMBER 4

Madison County, Iowa

Location: In a new roadcut and a ravine near the center of Section 8, T. 75 N., R. 28 W. The outcrops on which this section is measured are reached from Winterset as follows: 3½ miles west on Highway No. 2, thence south 1½ miles, thence west ½ mile. The section:

1. Argentine limestone, a few feet of the basal portion exposed.
2. Lane shale, 2'±:
 - (1) Shale, gray, 3"-6".
 - (2) Limestone, irregular, 2"-4".
 - (3) Shale, greenish-gray, 6".
 - (4) Limestone, gray, 3"-4".
 - (5) Shale, gray, poorly-bedded, 8".
3. Iola limestone, about 7' 8":
 - (1) Raytown limestone, well-shown in cutbank west of road, 2':
 - a. Limestone, bluish-gray, separates into two beds, 11".
 - b. Shale, 1".
 - c. Limestone, 5½".
 - d. Shale, 1".
 - e. Limestone, 5"-6".
 - (2) Muncie Creek shale, measured in road-cut, 5':
 - a. Shale, largely dark gray, 10".
 - b. Limestone, gray, argillaceous-nodular, contains *Lophophyllum*, crinoid joints, etc., 4".
 - c. Shale, dark gray, 1' 6".
 - d. Shale, black, fissile, 1' 8".
 - e. Shale, dark, many *Ambocoelia*, 8".
 - (3) Paola limestone, measured in road-cut, bluish-gray, dense, 8".

Note: The Cherryvale shale, Winterset limestone and the Bethany Falls limestone are exposed in the ravine and along the river below the above exposures. The Bethany Falls and the Winterset outcrop prominently here and westward in the Middle River Valley to Section 13, T. 75 N., R. 29 W., beyond which they drop below the river level, the latter going below in the SW of Section 14, T. 75 N., R. 29 W.

The Argentine limestone outcrops westward and northwestward in Middle River valley from the above section to just southeast of Webster, where it goes below the river level, and up Brushy Branch for about ¾ mile. Its maximum thickness here is about 18'.

Tilton (4, pp. 288, 289) miscorrelates the Argentine as "DeKalb". Evidently he and Bain did not study the exposures closely in sections 5, 7, 8 and 9 of T. 75 N., R. 29 W.

SECTION NUMBER 5

Madison County, Iowa

Location: In a north-side ravine just west of road, in the NE of Section 7, T. 75 N., R. 29 W.; along Brushy Branch in section 7 west of this road, and along this creek east of the road, i.e., in section 8, to Middle River. This location is reached from Winterset via Highway No. 2 to $\frac{7}{8}$ mile west of Middle River, thence south about $\frac{3}{8}$ mile. See Figures 3 & 4, Section:

1. Oread limestone formation, in north-side ravine west of road, about 11' exposed:
 - (1) Plattsmouth limestone, basal zone exposed, thickness, 5'-6'; stone, bluish-gray, fine-grained, in dense beds which weather distinctively yellowish and are separated by shaly seams; the basal 1' is massive, with some dark chert. Fossils: productids, *Chonetes*, *Lophophyllum*, crinoid joints (common), *Ambocoelia planoconvexa*, etc.
 - (2) Heebner shale in north-side ravine west of road, about 3' 10":
 - a. Shale, gray, argillaceous, blocky, 1' 10".
 - b. Shale, black, fissile, 1' 6".
 - c. Shale, dark gray to black, mealy, with *Ambocoelia planoconvexa* abundant and some plant material, 5"-6".
 - (3) Leavenworth limestone, in north-side ravine west of road, dark bluish-gray, very dense, with vertical joints, forms rectangular blocks, contains minute fusulinids, high-spined gastropods, bellerophonitids, abundant algae growth and some bryozoa, 1' 2".
2. Snyderville-Island Creek shale, about 67':
 - (1) Snyderville-Weston shale, exposed in ravine west of road, about 25'-26':
 - a. Shale, 8'; upper 3' 6"-4' almost black when wet, with *Chonetes*, *Ambocoelia* and *Rhombops* at top; lower 4' dark gray, bedded.
 - b. Shale, gray-reddish, nodular above, bedded and arenaceous below, about 5'.
 - c. Shale, bluish-gray, arenaceous, bedded, micaceous, with limy arenaceous seam at base, 6'-7'.
 - d. Limestone, bluish-gray, sandy, composed of two or more irregular, arenaceous limestones and shale seams, weathers buff, 1' 6".
 - e. Shale, bluish-gray, argillaceous-arenaceous, bedded, 5'.
 - (2) Stanton limestone and shales (?), exposed in ravine west of road and in gutters of road on hillside north of bridge, about 8'+:
 - a. Limestone, dark bluish-gray, dense, with *Derbyas* (large), *Neospyrifers*, *Compositus*, *Polyporus*, *Rhombops*, *Bellerophons*, etc., 1' 3". This bed forms a waterfall in the ravine.
 - b. Shale, dark gray, 1'.
 - c. Limestone, dark bluish-gray, dense, granular, with crinoid joints, 6"-8".
 - d. Shale, gray, bedded, micaceous, upper part slabby and arenaceous, about 2'.

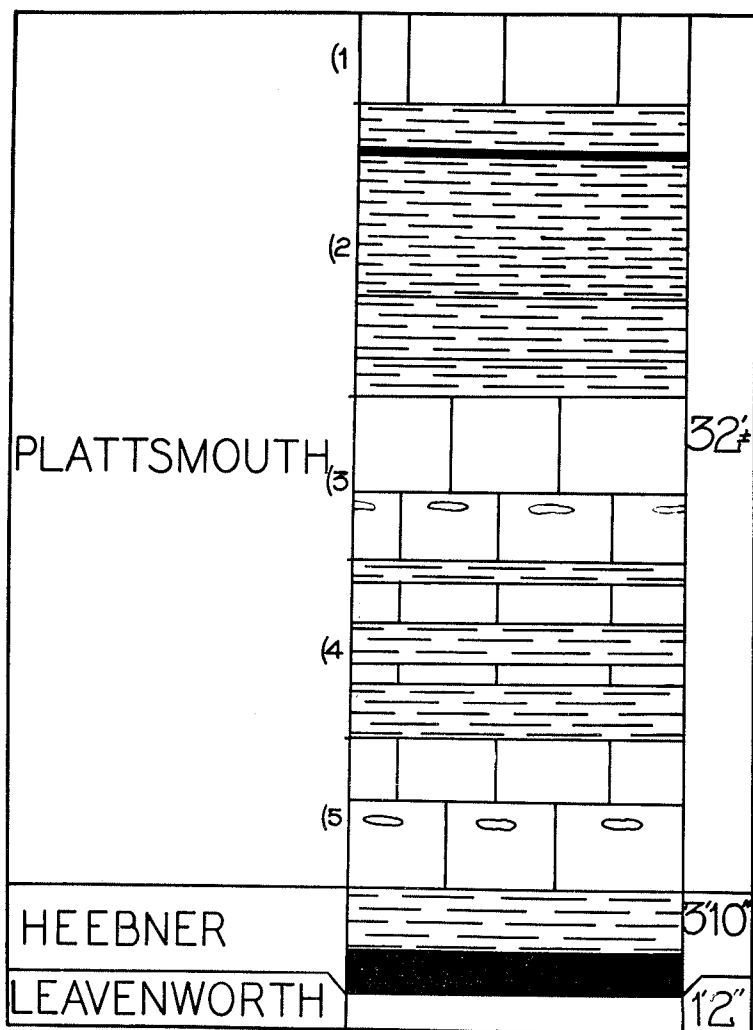


Figure 3.—Upper part of the Columnar Section on Brushy Branch.

- e. Limestone, dark gray to bluish-gray, dense, with gastropods, bryozoa, crinoid joints, brachiopods, etc., 6"-8".
 - f. Shale, bluish-gray to dark, bedded, platy, micaceous, arenaceous, with crinoid joints, *Polypora*, etc., 9".
 - g. Limestone, one or two beds, dark gray, earthy, base nodular, with brachiopods, bryozoa, horn corals, and crinoid joints, 4"-6".
 - h. Shale, bluish-gray to dark, with *Chonetes*, *Neospirifers*, *Rhombops* and crinoid joints, 10".
 - i. Limestone, forms waterfall in ravine, bluish-gray, irregular, wavy-bedded, crinoidal, 8".
- (3) Vilas shale (?), not exposed in ravine, best shown in cutbank south side of creek $\frac{3}{8}$ mile west of bridge, about 12' 6":
- a. Shale, bluish-gray, fossiliferous at top, with *Chonetes*, etc., 5'.
 - b. Shale, largely red, limy at base, 7' 6".
- (4) Plattsburg limestone (?), exposed in ravine and across road north of bridge; best shown at cutbank $\frac{5}{8}$ mile west of bridge, light bluish-gray, pebbly, 4'; top 2' limy shale; lower 2' solid, fragmental limestone with brachiopods and bryozoa.
- (5) Bonner Springs shale (?), about 10':
- a. Shale, best shown at cutbank $\frac{3}{8}$ mile west of bridge, bluish-gray, bedded, weathers crumbly, 6".
 - b. Shale, lavender-maroon to purplish, about 5'-6'; top 4' 6" exposed $\frac{3}{8}$ mile west of bridge; the rest covered.
 - c. Shale, dark gray, argillaceous, calcareous, with many *Chonetes*; thickness, about 4' at bridge.
- (6) Farley limestone (?), best exposed in cutbank north of creek about 200 yards northeast of bridge, 2' 10":
- a. Limestone, gray, irregular, fossiliferous, 6"-8".
 - b. Shale, nodular, limy, weathers yellowish, 6".
 - c. Limestone, bluish-gray, nodular at base, bedded at top, weathers buff, very fossiliferous, with *Chonetes*, *Marginifera*, *Compositas*, bryozoa and crinoid joints, 1' 8". In places the above zones form a nearly solid ledge.
- (7) Island Creek shale (?), best shown at cutbank northeast of bridge, about 4':
- a. Shale, bluish-gray to olive, bedded, contains some *Marginifera* and *Chonetes*, 8".
 - b. Shale, dark, carbonaceous, coal-like, 1". (This probably is quite persistent.)
 - c. Shale, gray to dark, with many limy seams containing abundant *Ambocoelia*, *Derbyas* and *Chonetes*, weathers yellowish to buff, 3'-3' 8".
3. Argentine limestone, exposed intermittently from below the bridge on the north-south road eastward to Middle River; top best shown 200 yards northeast of bridge where it is light gray, pseudo-oolitic, and a coquina of small osagea-like incrustations. Farther east, on the south side of the creek, the middle and basal zones of the formation are exposed, making the thickness of the formation here about 17' or 18'.
4. Lane shale, exposed at a south-side cutbank of Brushy Branch near its junction with Middle River, about 2'.
5. Raytown limestone, top poorly exposed below the Lane shale, near the mouth of Brushy branch.

Note: Apparently Tilton (4, p. 289) miscorrelates all of the beds in the Brushy Branch section. He probably did not

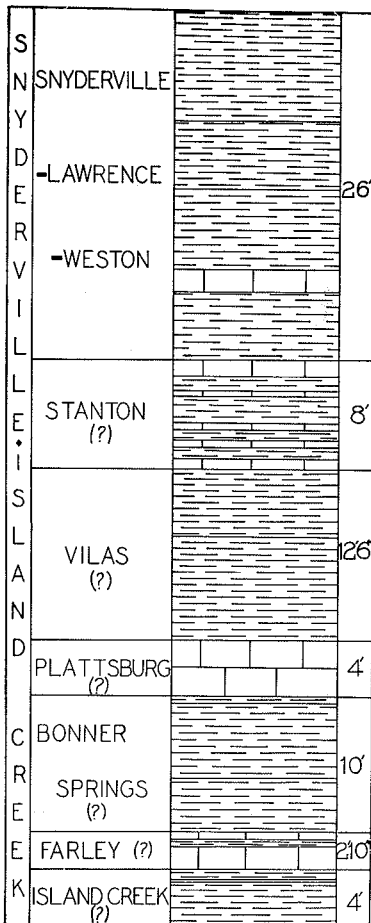


Figure 4.—Middle and lower portions of the Columnar Section on Brushy Branch. (Figure 3 continued.)

because of these conditions, we class division 2(1) of the section as Snyderville-Weston.

It appears that division 2(2) of our section is the Stanton formation or part of it. This is evidenced by observations we have made along the Platte and Grand rivers at points in northwestern Missouri and southern Iowa, in which the formation changes northward to approximately the condition re-

see the exposures of the Oread formation in the NE $\frac{1}{4}$ of section 7, where the upper part of our section was measured.

Correlation: We correlate the Argentine limestone, Leavenworth limestone, Heebner shale and the basal zone of the Plattsmouth in the preceding section with assurance, but hesitate to definitely assign the subdivisions between the Argentine and Leavenworth. Consequently, this part of our section, with a thickness of 67 feet, is classed as Snyderville-Island Creek in age.

Apparently the Weeping Water limestone (basal member of the Oread) does not persist to the Brushy Branch section, which brings the Snyderville and Lawrence shales into contact. Also, the Iatan limestone probably is not in the section, which means that the Lawrence and Weston shales are coalesced, if present. Therefore, be-

presented by sub-division 2(2). The correlation of subdivisions 2(3), 2(4), 2(5), 2(6) and 2(7) are only approximately correct. They are based on sequence, more than on lithology and faunal content.

The formations in the interval between the Argentine and Leavenworth limestone have a combined thickness of about 350 feet in the Missouri Valley traverse between Kansas City and Atchison, and only 67 feet in the Middle River area. This means that they thin quite rapidly northward and that some of their members do not persist to this section. Therefore, in view of this condition, we make only provisional correlations of the subdivisions of this part of the section in the Middle River traverse.

EXPOSURES NEAR WEBSTER

Madison County, Iowa

The first of these exposures is in a ravine just south of the river and west of the road south from Webster. Here the lowest zone of the Plattsmouth, the Heebner shale, Leavenworth limestone, and beds down to and including the thin limestones thought to be the Stanton, outcrop with the same features as in our Section Number 5.

There are nearly continuous outcrops west of Webster, but the best exposures of the Plattsmouth limestone, Heebner shale, Leavenworth limestone and about 18 feet of the shales below the latter are in the S $\frac{1}{2}$ of Section 36, T. 76 N., R. 30 W. They are at a cutbank east of a creek just south of Middle River. Tilton (4, p. 291) miscorrelates the beds exposed here and about one mile farther northwest, as Chanute, Iola, Lane and Plattsburg.

SECTION NUMBER 6

Adair County, Iowa

Location: Ravine and road gutters just west of Middle River; at the south side of Section 26, T. 76 N., R. 30 W. This is two miles west and about $\frac{1}{2}$ mile north of Webster.
Section:

1. Plattsmouth limestone, in five zones, about 31' 6":
 - (1) Limestone, in ravine south of road and across road, bluish-gray, weathers buff, about 3'.

- (2) Shale, badly covered, part exposed in road gutter, largely shale, about 10'.
 - (3) Limestone, light gray to buff, with considerable algal material in top and many *Triticites* in the lower portion, 5'-6'.
 - (4) Limestone and shales, weathered bluish-gray to buff, contains *Chonetes*, crinoid joints, brachiopods, etc., about 7'.
 - (5) Limestone, in dark bluish-gray, uneven beds, which weather yellowish, contains small horn corals, brachiopods, *Fistuliporas*, etc., and some black chert, about 5'-6'. The basal 1' of this zone is massive and weathers yellowish-brown.
2. Heebner shale, 3' 10":
 - (1) Shale, gray, bedded, 2' 2".
 - (2) Shale, black, massive, 1' 8".
 3. Leavenworth limestone, dark bluish-gray, dense, with considerable algal growth, large bellerophontids and some minute high-spired gastropods, 1' 2".
 4. Snyderville shale (?), dark gray, and a lens of sandy lime, 4' exposed. The top of this is about 25 feet above the river level south-east.

Correlation: Locally the beds here dip northward. Divisions 1(5), 2 and 3, of this section, are correlative with 1(1), 1(2) and 1(3) of the preceding section. Division 4 is without doubt, the upper part of the Snyderville-Weston horizon of Section No. 5, if it persists this far north.

Tilton (4, pp. 292, 293) correlates the beds of Section No. 6 as follows: 1(1) as Lecompton limestone; 1(3), Oread (Plattsmouth) limestone; 1(4), Lawrence shale; 1(5), Iatan limestone; 2, Weston Shale; 3 and the shale and the lensing limestone next below, as Stanton limestone; and No. 4, as Vilas shale.

We class divisions 1(1) and 1(2) as the upper zones of the Plattsmouth because they persist in the general section from Plattsmouth, Nebraska, to Folsom,¹³ Stennett, Griswold and Lewis,¹⁴ Iowa, and have the same relation to the main body of the Plattsmouth (zones 3-5) here as at those places. Division No. 1(2) has practically the same lithology and faunal subzones here as at those places and its thickness increases northeastward from Nebraska. However, division 1(1) is cherty and more massive in the sections at Lewis, Folsom and Plattsmouth, and is non-cherty here. This suggests that it may be a member of the Lecompton, the upper zone of

¹³ Condra, G. E., The Missouri Valley Traverse of Iowa, North of the Jones Point Deformation; Nebr. Geol. Surv., Paper No. 2, 1933.

¹⁴ Condra, G. E., and Upp, J. E., The Red Oak-Stennett-Lewis Traverse; Nebr. Geol. Surv., Paper No. 3, 1933.

the Plattsmouth having failed, but we do not find in it, or in this section, diagnostic Beil fossils, the beds bearing fossils more like the Avoca limestone. It seems, however, in view of the fact that the sub-zones of Zone 2 of the Plattsmouth, located just below our Zone 1, have persisted to this traverse, we should conclude that our Zone 1 has also persisted between Lewis and this traverse, and that it marks the boundary with the Lecompton, since the Kanwaka has failed.

Again it might be supposed that the beds just above the top zone of the Plattsmouth are the equivalents of the Kereford and Heumader members at the top of the Oread. Evidently, these members reach from Kansas into southeastern Nebraska and northwestern Missouri and but a short distance into Iowa, not to this traverse. Therefore, since the Heumader shale, Kereford limestone and the Kanwaka shale pinch out south of this traverse, we conclude that the beds just above the Plattsmouth in this traverse are Lecompton.

Zones 3, 4 and 5 of this section are practically the same as at Lewis, Cass County, Iowa, lithologically and faunally. These zones and the Heebner and Leavenworth members of the Oread have been traced through various outcrops from south of Webster to and beyond this section. They are well exposed about 1 mile southeast of our Section Number 6.

SECTION NUMBER 7

Adair County, Iowa

Location: Ravine leading northeastward to Middle River; in the W $\frac{1}{2}$ of Section 26 and E $\frac{1}{2}$ of Section 27, T. 76 N., R. 30 W. This is $\frac{3}{4}$ mile northwest of the preceding section, and about 2 $\frac{1}{4}$ miles east and 1 mile south of Arbor Hill. Section:

1. Plattsmouth limestone, about 28' 2" exposed:
 - (1) Limestone, part of Zone 1, in south-side cutbank, gray, massive, has a buhr-stone-like appearance on a fresh fracture, weathers dark rusty brown; contains abundant small crinoid stems and *Marginifera*, *Chonetes* and *Rhombops*, 10". Evidently there are limestones higher in this section, too badly obscured for measurement.
 - (2) Shale, Zone 2, 10' 4":
 - a. Shale, olive to bluish-gray, bedded, weathers crumbly, contains *Marginifera*, *Ambocoelia* and *Chonetes*, 2'.

- b. Coal-smut, $\frac{1}{2}$ ".
- c. Shale, olive-colored, massive, blocky, with nodular limestone seams near middle, 5' 8".
- d. Shale, purplish-maroon and olive, contains some yellowish, nodular, limy material, 2' 4".
- e. Shale, bluish-gray, blocky, 1' 4".
- (3) Limestone, Zone 3, about 6':
 - a. Limestone, gray to buff, irregular, nodular, weathers yellowish-brown, somewhat shaly, contains *Aviculopectens*, gastropods and some brachiopods, 3' 6".
 - b. Limestone, gray, massive, weathers buff to yellowish-brown, forms resistant ledge, contains some chert, abundant *Triticites* and some brachiopods, 2' 6".
- (4) Shale and some limestone, Zone 4, 6' 2":
 - a. Shale, yellowish to olive, very limy, 1'.
 - b. Limestone, yellowish, nodular, fossiliferous, *Chonetes* common, 1' 6".
 - c. Shale, bluish-gray, very limy, with many *Chonetes*, 1'-2'.
 - d. Limestone, irregular, weathered yellowish, 8".
 - e. Shale and shaly-limestone, quite fossiliferous, 2'.
- (5) Limestone, Zone 5, about 4' exposed:
 - a. Limestone, bluish-gray, blocky, bedded, 1' 6"-2'.
 - b. Limestone, massive, with dark chert, 2' exposed above creek bed.

Correlation: The Plattsmouth zones in the above section are nearly identical with those of the preceding section. In the east bank of the river and north of the bridge on the east-west section line road and about $\frac{3}{4}$ mile north of our Section No. 7, is a good outcrop of the basal zone of the Plattsmouth, thickness about 5' 6".

SECTION NUMBER 8

Adair County, Iowa

Location: Ravine in a hog lot in the NW of the NW of Section 26, T. 76 N., R. 30 W. Section:

1. Lecompton-Oread, about 13'-14' exposed:
 - (1) Limestone, with irregular blocky fracture, top irregular, badly disintegrated, contains *Rhombopora*, *Polypora*, etc., 6"-10".
 - (2) Shale, bluish-gray, with a 4"-6" seam of lavender shale near top, 3' 6".
 - (3) Limestone and shale seams, with about 4"-5" of solid limestone at places; combined thickness, 10"-1'.
 - (4) Shale, bluish-gray, bedded, 1' 6".
 - (5) Limestone, greenish-gray, very argillaceous, irregular and rough on upper surface, contains *Polypora*, *Rhombopora* and some *Triticites*, 1'+.
 - (6) Shale, olive to bluish-gray, very limy, weathers crumbly, thickness 6"+.
 - (7) Limestone, gray, massive, weathers rusty-brown, contains many small crinoid joints and large *Rhombops*, 8"+.

- (8) Shale, bluish-gray to olive, 5'-6' exposed to bed of ravine. This contains a 1½" smut seam about 1' 6"-2' below the top, and there is a nodular fossiliferous lime seam just above this smut.

Correlation: Division 1(8) of this section is the top of Zone 2 of the Plattsmouth; divisions 1(3) to 1(7) are the top zone of the Plattsmouth, and 1(1) and 1(2) are thought to be in the Lecompton, but we are not able to correlate them with any particular member of that formation.

SECTION NUMBER 9

Adair County, Iowa

Location: This is in the SW of Section 22, T. 76 N., R. 30 W., about 1¼ miles east and ½ mile south of Arbor Hill. The outcrops are in cutbanks of a south-side creek and in a south-side bank of the river about ¼ mile east from the creek. Section:

1. Tecumseh shale, about 15':
 - (1) Rakes Creek shale (?), in cutbank of the ravine followed by a trail, about 5' exposed:
 - a. Shale, bluish-gray, calcareous, with *Chonetes* above middle and *Marginifera* below middle; basal 10" dark gray; all bedded; combined thickness exposed, 4'±.
 - b. Shale, black, quite carbonaceous, 3"±.
 - c. Shale, gray, bedded, calcareous, with *Ambocoelia*, 4".
 - (2) Ost limestone (?), in cutbank of creek and northward to near the site of the former river bridge, bluish-gray, dense, blocky, impure, top weathered yellowish, contains *Ambocoelia*, productids, *Derbyas*, *Marginifera*, *Orbiculoidea*, crinoid joints, *Aviculopectens*, *Myalinas*, bellerophonitids, *Polyporas*, etc., about 10"-1'.
 - (3) Kenosha shale (?), in west-side cutbank of creek, bluish-gray, with lavender band 3' thick near middle; all largely argillaceous, but with nodular lime near base, about 9'.
2. Lecompton formation (?), about 10' 6":
 - (1) Limestone, in cutbank of ravine and at cutbank of river ¾ mile west, with gray shale (filled with nodular lime) and about 1' of light bluish, irregular limestone at base; combined thickness, about 3'; *Polyporas*, *Rhombops*, etc., occur in the limestone at an exposure just west of the cutbank of the river.
 - (2) Shale, in opening just west of cutbank of river, largely bluish-gray and argillaceous, with fossiliferous limy nodules, 5' 6".
3. Plattsmouth limestone, 13' 6" exposed:
 - (1) Limestone, top zone, 2'±:
 - a. Limestone, light bluish-gray, top shaly or shattered, base massive, forming large blocks, with *Compositas*, crinoid joints, *Rhombops*, *Polyporas*, and some *Triticites*, 1' 2"±.
 - b. Shale, gray, about 1".
 - c. Limestone, in cutbank of river, bluish-gray, badly disintegrated, becoming yellowish-brown, about 8"-1'.
 - (2) Shale, Zone 2, in cutbank of river, largely bluish-gray, with a 1" seam of dark smut 2' below top, and a 2" seam of dark gray,

fossiliferous lime just above it. Much of the section below the smut is covered by talus, but most of it appears to be gray shale, with a sub-zone of red near base. The fossils in the lime seam and in the base of the shale above it are *Ambocoelia*, productids, *Chonetes* and crinoid joints. The combined thickness of this division is 10' 6".

- (3) Limestone, top 1' of Zone 3, exposed on river bed at the cutbank, and the top shown $\frac{3}{8}$ mile west, at the site of a former river crossing.

Note: The Tecumseh and Lecompton members of Section No. 9 are correlated provisionally. The beds here rise north-westward with the gradient of the river, with scattered outcrops of Zone 1 of the Plattsmouth between the preceding section and the site of the Port Union mill dam (out), west of Arbor Hill. The faunal zones and the smut seam of Zone 2 of the Plattsmouth are very persistent in the Middle River traverse, as they are in the outcrops of the Nishnabotna Valley in Montgomery and Cass counties. The smut seam becomes a dark gray to black shale southwestward.

SECTION NUMBER 10

Adair County, Iowa

Location: South bank of Middle River $\frac{3}{8}$ mile southwest of Arbor Hill; in the NE of SW of Section 21, T. 76 N., R. 30 W. Section:

1. Tecumseh shale, 10' or more:
 - (1) Ost limestone (?), yellowish, badly disintegrated, about 1'.
 - (2) Shale, largely gray, part reddish, about 10'.
2. Lecompton-Plattsmouth, about 10' poorly exposed:
 - (1) Slope, badly covered, with evidence of thin limestone and shales, about 7'-8'.
 - (2) Limestone, bluish-gray, weathers brownish, about 2'; contains *Rhombops*, *Polyporas*, *Myalinas* and crinoid joints; the upper surface is very rough and irregular. This bed is poorly exposed in the river bank. It is thought to be the top zone of the Plattsmouth.

Note: Divisions 1(1) and 1(2) here are 1(2) and 1(3) of the preceding section and 2(1) and 2(2) here are 2(1), 2(2) and 3(1) there. No doubt, the top of Zone 3 of the Plattsmouth limestone is about 9 feet below the level of the river here. Limestone 2(2) of this section outcrops in the right bank of the river southwest of Arbor Hill.

SECTION NUMBER 11

Adair County, Iowa

Location: Site of old Port Union Mill dam (out); $\frac{1}{2}$ mile west of Arbor Hill; near center of Section 20, T. 76 N., R. 30 W. Section:

1. Lecompton-Plattsmouth beds, about 10' 6" exposed:
 - (1) Shale, greenish-gray, bedded, with a 3" purplish-red streak near middle, 1' 6".
 - (2) Limestone, shaly, badly disintegrated, weathered bright yellowish, 5".
 - (3) Shale, grayish and part purplish-red, bedded, crumbly when dry, 2'.
 - (4) Limestone, gray, irregular, weathers with ropy-like surface, contains *Aviculopectens*, *Derbyas*, crinoid joints, *Rhombops*, etc., 8".
 - (5) Limestone, gray to greenish-gray, top irregular and rough, forms large blocks, argillaceous, weathers massive and buff-gray, contains abundant *Rhombops*, some crinoid joints and many shell fragments, 8".
 - (6) Shale, greenish-gray, bedded, weathers dark and crumbly, about 4'; contains lime nodules in the upper portion, and thin limy seams above middle. This limy subzone is very fossiliferous, containing *Derbyas*, *Rhombops*, *Aviculopectens*, *Schizedus*, *Lino-productus*, etc.
 - (7) Limestone, 3' or more; top shelly and eroded; lower part light gray, very dense, fine-textured, irregularly bedded.

Correlation: Division 1(7) of this section is Zone 1 of Plattsmouth and the subdivisions above it are thought to be in the Lecompton formation.

Tilton (4, pp. 295, 296) correlates the beds exposed at the site of the Port Union Mill as Deer Creek, and states (p. 296) that the Deer Creek outcrops by the river side a mile northwest of Port Union Mill. We correlate the beds exposed at the latter place as the top of Zone 3 of the Plattsmouth and trace it northwestward to the east side of Section 12, T. 76 N., R. 31 W.

SECTION NUMBER 12

Adair County, Iowa

Location: East bank of river; north of bridge on east-west section-line road; in S $\frac{1}{2}$ of Section 7, T. 76 N., R. 30 W. Section:

1. Oread limestone, 23' shown:
 - (1) Plattsmouth limestone, zones 1 and 2 removed by erosion; zones 3, 4, 5 remaining as follows:
 - a. Limestone, typical 3d zone, light gray, filled with *Triticites*, about 6'.

- b. Shale and lime, typical 4th zone, weathered yellowish, very fossiliferous, 6'-7'.
 - c. Limestone, typical 5th zone, bluish-gray beds separated by shale seams, basal bed massive, all fossiliferous, 5' 6". This basal part of Zone 5 has persisted in exposure in which the basal Plattsmouth is above the river, from Brushy branch to this section. It is a distinctive layer.
- (2) Heebner shale, bluish-gray above, black below, about 4'.
 - (3) Leavenworth limestone, above river level at bridge, but obscured by talus, 1'+.

Note: Apparently Tilton did not see this outcrop of the Oread. Nor does he describe the outcrop in the cutbank of a creek about $\frac{3}{8}$ mile southwest, shown by the following section.

SECTION NUMBER 13

Adair County, Iowa

Location: Cutbank south of creek, in NW of Section 18, T. 76 N., R. 30 W. Section:

- 1. Plattsmouth limestone, 13' exposed to creek bed:
 - (1) Shale, gray, about 1' 6" exposed at top of cutbank.
 - (2) Limestone, weathered yellowish and sandy, about 1' 6".
 - (3) Shale, weathered yellowish, 6"-8".
 - (4) Mudstone-limestone, weathered yellowish, 1' 2".
 - (5) Shale, bluish-gray, dark at base, massive, with *Chonetes*, *Ambocoelia*, *Rhombops*, *Derbyas*, etc., in lower portion, 2'.
 - (6) Limestone, dark gray, irregular, earthy, fossiliferous, with *Ambocoelia*, crinoid joints, etc., 6".
 - (7) Shale, gray, blocky, about 4".
 - (8) Shale, black, bedded, 8".
 - (9) Shale, bluish-green, massive, with brownish nodular, calcareous material, 6' 6" exposed to creek bed.

Note: Divisions 1(1) and 1(2) of this section are thought to represent the middle and basal sub-zones of Zone 1 of the Plattsmouth, and all of the subdivisions below are in Zone 2 of the Plattsmouth, in which the faunal sub-zones are the same as in the preceding sections. The top of Zone 3 of the Plattsmouth is on the creek bed below Division 1(9).

Thurman-Wilson Fault: Tilton (4, pp. 296-297) says that the Thurman-Wilson fault crosses Middle River in the center of section 18 of Harrison Township, Adair County, a mile up-valley from the site of Port Union mill. However, in an earlier report he maps the fault as crossing the valley about 7 or 8 miles farther northwest.

Evidently, Tilton did not see the well-defined outcrop of the Plattsmouth limestone, located just north of section

18, and it appears that he wrongly correlated an outcrop of the Plattsmouth located in the SE of section 18 extending into the $W\frac{1}{2}$ of section 17. Then, too, the Plattsmouth extends westward under a younger limestone formation (probably the Deer Creek) in Section 12, T. 76 N., R. 31 W. It is evident, therefore, that no fault of any consequence crosses the valley in section 18.

SECTION NUMBER 14

Adair County, Iowa

Location: Near east side of Section 12, T. 76 N., R. 31 W.; in south bank of river and bluff just west of bridge on the north-south road. Section:

1. Tecumseh-Lecompton, badly covered in the bluff, with evidence of gray and reddish shale and some limestone, about 18'.
2. Plattsmouth limestone, about 19' 6" exposed:
 - (1) Limestone, zone 1, bluish-gray, weathers brownish, 2' 6"; upper portion nodular and irregular, with *Chonetes*, productids, crinoid joints, etc.; lower portion more massive, with some *Triticites*.
 - (2) Shale, zone 2, badly covered, largely bluish-gray, about 10'.
 - (3) Limestone, zone 3, about 7' exposed:
 - a. Limestone, gray, slabby, forms rounded, shingle-like debris, weathered yellowish, with a few fossils, 1' 6"±.
 - b. Limestone, light gray, fine-grained, massive, contains some brownish chert, abundant *Triticites*, crinoid joints and productids, about 4'-5' exposed to river.

Note: The beds of this section pass under the Deer Creek formation shown in our Section No. 15 following, but we found no place where all the interval between the Plattsmouth and the Deer Creek is exposed.

SECTION NUMBER 15

Adair County, Iowa

Location: Quarries, ravines and a cutbank in the NW of Section 12, T. 76 N., R. 31 W. See Figure 5. The section:

1. Deer Creek formation, about 26':
 - (1) Jones Point shale (?), in main quarry, top eroded, quite calcareous, weathered yellowish, 1' 6"-2' exposed.
 - (2) Ervine Creek limestone, about 21':
 - a. Limestone, one bed, separated irregularly at places, light gray, massive, mealy structure, pseudo-oolitic, jointed vertically, with dark chert near middle, weathered gray to buff, contains fragments of brachiopods, gastropods, crinoid joints, etc., 4' 2".
 - b. Shale, olive-colored, bedded, with thin limy lenses, weathered yellowish, contains *Rhombops*, *Ambocoelia*, etc., 8".

- c. Limestone, light gray to bluish-gray, massive, with *Allorisma*, *Compositas*, etc., 2' 10"-3'.
- d. Shale, olive to bluish-gray, limy, bedded, with seams of dense limestone which contain *Juresania nebrascensis*, 1'.
- e. Limestone, in two light gray, massive beds which weather yellowish-buff, 1' 3"; contains many large echinoid spines, *Compositas*, *Neospirifers*, etc.
- f. Shale, about 1'-1' 2":
 - (a) Shale, olive-colored, massive, 4".
 - (b) Limestone, earthy, disintegrated, 4"-6".
 - (c) Shale, dark gray, crinoidal, crumbly, 2".
- g. Limestone, in wavy beds separated by shale seams, about 10'; limestone, weathered gray or faint buff, very fossiliferous with crinoid joints, *Marginifera*, *Neospirifers*, *Punctospirifers*, productids, *Composita subtilita*, *Dielasma bovidens*, *Rhombops*, etc. There is some dark nodular chert near the top of this subdivision.
- (3) Larsh-Mission Creek shale, about 2' 6" exposed; upper portion covered but probably bluish-gray; lower portion black and fissile.
- (4) Rock Bluff limestone, dark bluish-gray, very dense, with sharp conchoidal fracture, 6"-8".
- 2. Tecumseh shale, about 10' exposed to river level:
 - (1) Shale, in cutbank north of main quarry, bluish-green, massive, weathered crumbly, about 6'.
 - (2) Mudstone-limestone, bluish-gray, nodular, weathers yellowish, about 1'.
 - (3) Shale, exposed to river, bluish-gray, bedded, about 3'.

Discussion: Although his statement is not clear, Tilton (4, p. 296) seems to infer that the main limestones of the preceding section are the Pawnee of the Des Moines group. He states: "Close to the next section west (13 of Grove township) fragments of a limestone appear that traced northward along the river, attains a greatest thickness of outcrop a mile north (Section 12) where it was formerly quarried. It is the base of this same limestone that outcrops by the bridge in the southeast quarter of Section 21, Jefferson township, and lies just below the limestone that is at the level of the river in the southwest quarter of Section 16, where it is fifty feet below Stuart, or at a level of 1157 feet above sea level. In Section 21 of Jefferson township, the writer found *Marginifera muricata* (the index fossil of the Des Moines series), *Ambocoelia planoconvexa*, *Composita subtilita*, *Hustedia mormoni*, *Spirifer cameratus*, also *Fusulina*, Bryozoa and coral." Tilton concludes as follows: "This limestone is the upper member (Pawnee) of the Henrietta division of the Des Moines group."

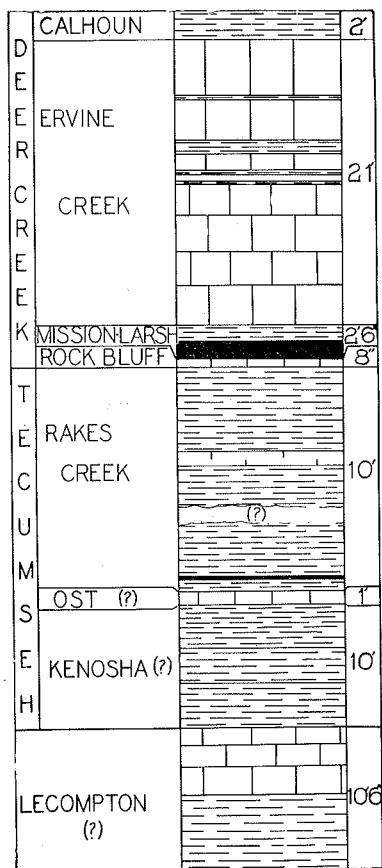


Figure 5.—Columnar Section in N. W. of Sec. 12, T. 76 N. R. 31 W., Adair Co., Iowa.

The foregoing statement by Tilton caused us to study our Section No. 15 and the outcrops in the valley northwest to sections 21 and 16 of Jefferson township rather closely. We concluded that the upper strata exposed where our Section 15 was measured, and those exposed up-valley therefrom, are of the same age. Then, having traced the Plattsmouth limestone from the Brushy Branch outcrops to the east side of section 12, the problem arose in regard to the age of the beds in the northwest quarter of this section, which, according to Tilton, are Pawnee.

We compared the beds of our Section No. 15 with the Pawnee as exposed in Kansas, Missouri and Appanoose County, Iowa, and with the Argentine, Winterset, and Bethany Falls of the sections in this traverse, and concluded, that, on a basis of thick-

ness, lithology and faunal assembly, they are not correlative with either of them. This was done, because, by faulting with the up-throw on the west, one of these formations might have been brought to the surface in this part of the traverse. It was then found that the main part of our Section No. 15 is nearly identical lithologically and faunally with the Ervine Creek limestone member of the Deer Creek in the exposures in the Missouri River bluffs east of Haynies, Mills County, Iowa. This, with the failure to find a fault crossing section 12 west of where the Plattsmouth is exposed.

and the fact that the Plattsmouth seems to pass beneath our Section No. 15 at about the proper depth, caused us to conclude with assurance, that the limestone quarried in our Section 12 is in the Deer Creek formation, and is not the Pawnee.

There remains the problem of the thickness and character of the beds between the Deer Creek and Oread formations in this traverse. The interval should include the Tecumseh, Lecompton and Kanwaka formations. Apparently, the Kanwaka does not extend to this traverse and the Lecompton is quite thin, with its point of contact with the Tecumseh not clear, due to the badly covered outcrops. The thickness of the Tecumseh, the Lecompton and Kanwaka in the vicinity of Atchison, Kansas, is 120 feet or more, but only about 50 feet in the exposures in the Missouri bluff east of Haynies, Mills County, Iowa, and probably is 40 feet or less in this traverse. The thickness exposed in this interval is 9 or 10 feet, lying below the Deer Creek, and about 18 feet lying above the Plattsmouth, making about 28 feet. Apparently a few feet of the middle portion of this part of the section is covered. There is some chance, however, that the mudstone-limestone in the basal part of our Section No. 15 is the Ost limestone (?) of Section No. 9 and that the beds between the Deer Creek and Plattsmouth have a thickness of only about 28 feet in the Middle River traverse. A drilling should be made on the floor of the quarry in section 12 to determine the thickness and nature of the beds down to the Plattsmouth because, under the conditions which obtain, this horizon cannot be measured and described without sub-surface data.

OTHER OUTCROPS

There are a few exposures along Middle River Valley from our Section No. 15 northwestward for a distance of about 6 miles. They are in sections 1 and 2 of Township 75 N., R. 31 W., and sections 27, 21, 16 and 20 of T. 76 N., R. 31 W.

Except in the NW of section 1, and the NE of section 2, where they dip locally northeastward, the strata of this

part of our traverse rise northwestward with the gradient of the valley-floor. We correlate the beds in these outcrops as the Ervine Creek member of the Deer Creek formation. However, as stated before, Tilton claims to have found *Marginifera muricata*, a Des Moines series fossil, in an outcrop in section 21. On the contrary, we do not find this fossil there, but we do find *Marginifera lasallensis*, *Triticites* and species of brachiopods which occur in the Ervine Creek limestone. We conclude, therefore, on a basis of the faunal content, and the apparent position of the beds in the stratigraphic section, that the strata exposed in section 21, and between this point and our section No. 15, are the Ervine Creek limestone and not the Pawnee limestone. However, we believe that a drilling test should be made in section 21 to determine the exact sub-surface section to the base of the Plattsmouth.

CONCLUSIONS

1. The Pennsylvanian outcrops of the Middle River area are isolated from exposures of the same strata in northwestern Missouri and southwestern Iowa, due to the mantle of Pleistocene deposits in the uplands between, and due also to a thick cover of Cretaceous deposits in parts of the intervening area.
2. The thick mantle of loess and glacial drift in the Middle River area make close stratigraphic study difficult.
3. The Pennsylvanian formations we have studied in the Middle River traverse are, in age: Sniabar ("Hertha") to and including the Ervine Creek member of the Deer Creek formation.
4. All formations and members of the Kansas City section, from the base of the Sniabar limestone to the top of the Argentine limestone ("Iola" of the Missouri Survey) are in this traverse.
5. The "DeKalb limestone" of the Iowa Survey, defined by Bain, is a synonym of the Winterset, and the name should be discontinued because the latter has priority.
6. The Westerville limestone, defined by Bain, is the "Drum limestone" of the Kansas City section.

7. Dr. Raymond C. Moore's Elm Branch shale, Middle Creek limestone and the Hushpuckney shale, which are members of the "Ladore shale" occur in this traverse in about the same thickness as in the Kansas City section.
8. The members of the Cherryvale shale, recently defined by Dr. Moore, are in this traverse. They are the Fontana shale, Block limestone and Wea shale.
9. Certain black fissile shale zones of the Missouri Valley area persist to the Middle River traverse. They are remarkably uniform in thickness.
10. The Iowa Survey miscorrelates the Argentine limestone in this traverse as "DeKalb", also as Winterset.
11. The Kereford limestone, Heumader shale and the Weepingwater limestone, all members of the Oread formation, do not persist northward to this traverse, but the Plattsmouth, Heebner and Leavenworth members of the formation do occur here.
12. Zones 2 and 4 of the Plattsmouth in Nebraska thicken northeastward to the outcrops at Stennett, Iowa, beyond which, Zone 3 (a limestone) pinches out and Zones 2 and 4 are united at Lewis, from which they persist in about the same thickness and character to this traverse, where they are classed as Zone 2 of the Plattsmouth.
13. The Plattsmouth and Ervine Creek limestones have about the same thickness in the Missouri Valley outcrops and here.
14. The Iowa Survey (after Tilton) miscorrelates the Ervine Creek limestone of this traverse as the Pawnee limestone.
15. The formations from the Sniabar ("Hertha") to the top of the Argentine have a thickness of about 195 feet in the Missouri Valley and 150 feet in this traverse.
16. The formations from the Argentine to the base of the Leavenworth member of the Oread formation have a thickness of about 350 feet in the traverse between Kansas City and Atchison and only 67 feet in the Middle River area.
17. That part of the general section extending from the base of the Leavenworth limestone to the top of the Ervine Creek limestone of the Deer Creek formation has a thick-

ness of about 180 feet in the Missouri Valley outcrops and about 112 feet here.

18. The Tecumseh-Lecompton-Kanwaka interval measures about 115 feet in the vicinity of Atchison, Kansas, and 40 feet or less in this traverse.
19. The combined thickness of the formations in the interval between the Sniabar ("Hertha") limestone and the top of the Ervine Creek limestone is about 725 feet in the Missouri Valley traverse and 330 feet here.
20. The Thurman-Wilson fault, which was described and mapped by Tilton, probably does not cross the Middle River traverse.