Proceedings of the Iowa Academy of Science

Volume 64 | Annual Issue Article 44

1957

A Correlation and Structural Interpretation of the Missourian and Virgilian Rocks Exposed Along the Middle River Traverse of Iowa

T. L. Welp
Iowa Highway Commission

L. A. Thomas
Iowa State College

H. R. Dixon
McCarthy Construction Company

A Correlation and Structural Interpretation of the Missourian and Virgilian Rocks Exposed Along the Middle River Traverse of Iowa

By T. L. WELP,[1] L. A. THOMAS,[2] and H. R. DIXON[3]

INTRODUCTION

During the summer of 1956 the authors undertook an extensive study of the Pennsylvanian rocks exposed in Iowa and the adjacent states of Nebraska and Missouri, in an effort to locate rock formations that would be suitable for the production of aggregate for use in highway construction work.

The rocks exposed along the Middle River, that extends from the vicinity of Winterset, Madison County, to just southwest of Casey, Adair County, a distance of about 35 miles is one of the first areas that has been thoroughly investigated.

Purpose and Scope

The purpose of this report is to propose what is thought to be a correct regional correlation of Missourian and Virgilian rocks exposed along the Middle River valley and its tributaries in Madison and Adair Counties, Iowa; and to present a revised correlation and structural interpretation of the exposures in the vicinity of Howe, Adair County.

Lack of subsurface information and a thick mantle of glacial drift has previously obscured the structural features present in the vicinity of Howe. Recently, the Howe quarry has been extended southward exposing strata that dip steeply to the southeast, exactly the opposite direction to that assumed by earlier workers. Extensive core drilling in this area has shown this structure to have a structural rise of about 160 feet in a horizontal distance of about 2500 feet. It is possible to trace the beds exposed in the Howe quarry northwestward along the river to Sec. 17, T. 77 N., R. 31 W., where new quarrying operations of the Schildberg Construction Company have exposed the sequence from the Winterset limestone to the base of the Bethany Falls limestone.

Previous Work

Early work in this area was done by White (1870), Tilton and

[1]Iowa Highway Commission, Ames.
[2]Iowa State College, Ames.
[3]McCarthy Construction Company, Davenport.

Bain (1896), Gow and Tilton (1916), and Tilton (1919, 1920). The most recent work has been done by Wood (1932), Condra and Upp (1993), and Condra and Reed (1937).

Condra and Upp in their 1933 report classified the exposures in the Howe quarry (Sec. 12, T. 76 N., R. 31 W.) as belonging to the Deer Creek formation. Condra and Reed repeated this classification with some modifications in 1937, however they were not too certain of the exact stratigraphic position of these beds.

Stratigraphy

The sequence of rocks exposed along the traverse includes the following formations, from top to base: the Oread, Lawrence, Stranger (?), Vilas (?), Plattsburg, Bonner Springs, Wyandotte, Lane, Iola, Chanute, Drum, Cherryvale, Dennis, Galesburg, Swope, Ladore, and the Hertha. These formations are remarkable in their persistence throughout the midcontinent region, but are considerably thinner in this area than in the type areas.

This northward thinning and the absence of some major limestones has made correlation of the shale units especially difficult, particularly in the Snyderville-Island Creek interval of this traverse.

In the following sections all possible outcrops[1] were visited and each exposure carefully measured and studied. Whenever possible comparison was made with other exposures of the same beds in Iowa, Nebraska, and Missouri in order to determine the persistence, lateral variation, and continuity of these units. Particular attention was devoted to the exposures in the Platte River valley (Condra and Scherer, 1939), and the vicinity of Weeping Water, Nebraska.

Each of the composite sections was made to show lithology and thickness of units along various portions of the traverse (see Figure 1). In each case it is possible to trace a key bed from one portion of the traverse to the next along exposed outcrops, except from section 1 to section 2, where these units were traced in cores.

Section 1

Winterset, Madison County, to one mile southeast of Howe, Adair County.

The formations of this section were measured and described from the following locations: Division 1 (1-7), Oread limestone, measured in the right bank of the river, and from a core recovered just north of the river in the E. ½, S.E. ¼, Sec. 18, T. 76 N., R. 30 W.; division 1 (1-5) exposed in S.W. ¼ Sec. 7, T. 76 N., R. 30 W.; division 1 (5-7) exposed and measured in road gutters in S. ½

[1]A more complete listing of locations of exposure can be found in papers by Wood (1932) and Condra and Upp (1933).

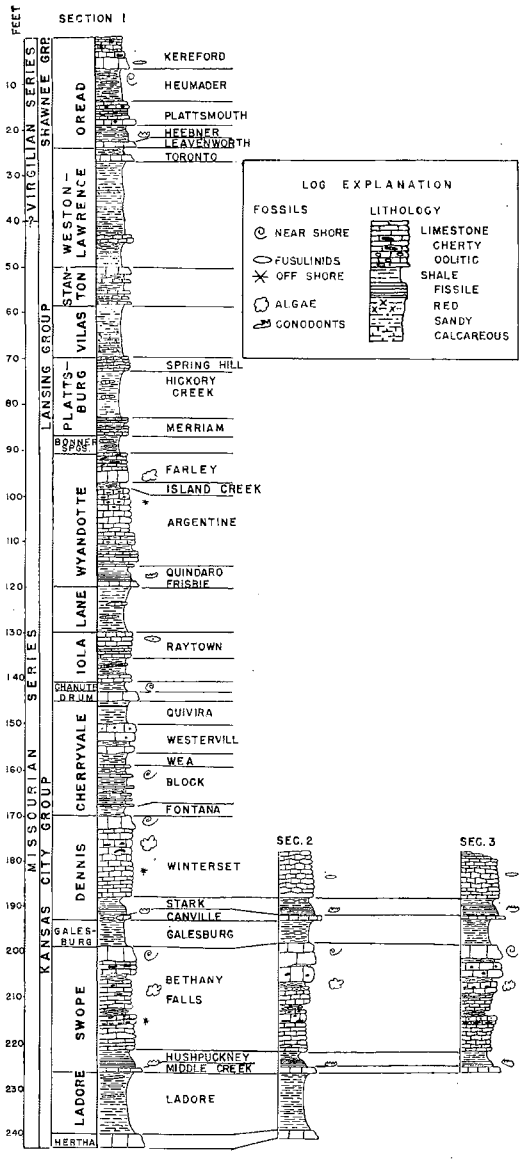


Figure 1. Correlation chart of exposures along Middle River.

Sec. 26, T. 76 N., R. 30 W. Division 2 (1-3), Snyderville shale to Vilas shale formation, in ravines in the N.E. ¼ Sec. 7, T. 75 N., R. 29 W.; division 2 (4) to 4 (4), Plattsburg limestone to Wyandotte limestone, in Schildberg's quarry in the N.W. ¼, S.E. ¼, Sec. 5, T. 75 N., R. 29 W.; division 4 (4-5) Argentine limestone to the top of the Lane shale, along the right bank of a stream in N.E. ¼, N.W. ¼, Sec. 23, T. 75 N., R. 29 W. Divisions 4 (3) to 10, Argentine limestone to the top of the Dennis limestone, in ravines at the intersection of Secs. 2, 3, 10, and 11, T. 75 N., R. 28 W., and in a road cut and gullies in N.E. ¼ Sec. 22, T. 75 N., R. 28 W.; divisions 10-14, Dennis limestone to the top of the Pleasanton shale, along Highway 169, north and south of Winterset, and in various quarries in Sec 27, T. 76 N., R. 27 W.

Kanwaka Shale, about 10′ exposed in Sec. 26, T. 76 N., R. 30 W., but not included in this section.

1. Oread formation, about 27 feet:
   - (1) Kereford limestone member, about 7 feet
     - a. Limestone, gray, weathers slabby and nodular, with some brown chert nodules ..... 3.0′
     - b. Limestone, gray, one massive bed, filled with *Triticites,* crinoid columnals, productids, shaly at base..... 4.0′
   - (2) Heumader shale member, with limestone layers, grayish-buff, soft, with abundant fossils ..... 7.0′
   - (3) Plattsmouth limestone member, blue-gray, uneven beds separated by thin shales, some black chert, lower one foot a persistent massive bed ..... 5.5′
   - (4) Heebner shale member,
     - a. Shale, gray argillaceous ..... 1.5′
     - b. Shale, black, hard, fissile ..... 1.3′
     - c. Shale, gray, soft, plastic, abundant fossils ..... 0.3′
   - (5) Leavenworth limestone member, blue-gray, one massize bed, *Ottonosia* algea masses ..... 1.1′
   - (6) Snyderville Shale member, gray, argillaceous, bedded, extremely fossiliferous at top, ostracods ..... 2.0′
   - (7) Toronto limestone member (?) blue-gray, hard, one massive bed.. 1.0′ Condra and Upp did not report the occurrence of this limestone in the road gutter in the S. ½ Sec. 26, T. 76 N, R. 31 W. This limestone not present in all exposures.
2. Snyderville-Island Creek interval, about 73 feet.
   - (1) Snyderville-Weston formations (?)
     - a. Shale, dark gray-black, with a calcareous zone 2′ from top, lower 4′ bedded, with many *Crurithyris, Chonetes,* and *Bryozoa* at top. Upper two feet assigned to Snyderville ..... 8.0′
     - b. Shale, grayish-red top 5′, bluish-gray lower 6′, arenaceous and micaceous ..... 11.0′
     - c. Limestone, greenish-gray, nodular with shale seams, lower few inches composed of bands of mud-cracked lithographic limestone, two indistinct beds ..... 2.0′
     - d. Shale, blue-gray, arenaceous ..... 5.0′
   - (2) Stanton formation (?), mostly dark gray, arenaceous and micaceous, bedded shale, four or five layers of fossiliferous blue limestone containing carbondized wood fragments; limestone grades laterally into shale ..... 8.0′
   - (3) Vilas formation, 10-12 feet.
     - a. Shale, blue-gray, fossiliferous at top ..... 5.0′
     - b. Shale, mostly reddish, calcareous, blocky ..... 6.5′

(4) Plattsburg formation about 15 feet.
a. Spring Hill limestone member (?), greenish-gray, *Osagia* algae producing "oatmeal texture," weathers nodular ..... 2.0′
b. Hickory Creek shale member (?), bluish-gray top and bottom, mostly maroon to purple in middle 5′ ..... 10.0′
c. Merriam limestone member (?), blue-gray, much euhedral pyrite top 0.5, shaly part near top ..... 3.0′

3. Bonner Springs formation, shale, olive to dark gray, with a 1″ persistent coal-like layer about 0.7′ from top, lower 3′ contains numerous limestone nodules, numerous *Chonetes* and *Crurithyris* ..... 4.0′

4. Wyandotte formation, about 22 feet:
(1) Farley limestone member, about 7.0′
a. Limestone, gray, weathers buff, flaggy, some brown chert, sometimes greenish and argillaceous with small tubules filled with green clay ..... 3.0′
b. Limestone, algal, *Osagia* with "oatmeal texture," shaly toward base, one massive bed ..... 4.0′
(2) Island Creek shale mmber, green to gray with layers of nodular limestone ..... 1.8′
(3) Argentine limestone member, about 14 feet:
a. Limestone, light gray, with brown chert nodules in upper 3′, indistinct wavy bedding, lower 2′ as two massive beds, grades into shale below, many well preserved *Composita* ..... 10.2′
b. Shale, gray, weathers buff, calcareous, with some thin limestone layers ..... 1.5′
c. Limestone, dark gray, soft, argillaceous, as three beds separated with shale partings ..... 2.5′
(4) Quindaro shale member, about 4 feet:
a. Shale gray, soft ..... 0.5′
b. Limestone or mudstone, gray, argillaceous ..... 0.4′
c. Shale, gray, soft, argillaceous ..... 1.6′
d. Shale, black, hard, fissile, conodonts ..... 1.5′
e. Shale, gray, argillaceous, many *Crurithyris* ..... 0.2′
(5) Frisbie limestone member, blue-gray, dense, vertically jointed, with large productids on top ..... 1.0′

5. Lane formation, about 10.5 feet:
(1) Shale, gray to buff, some greenish masses, some limestone nodules and layers ..... 7.5′
(2) Shale, reddish, lower 2′ poorly exposed ..... 3.0′

6. Iola formation, about 10 feet:
(1) Raytown limestone member, about 10 feet:
a. Limestone, gray to buff, massive, 2″ shale at base, very fossiliferous, with fusulinids, brachiopods, corals, etc. ..... 1.8′
b. Limestone, light gray, very fine-grained, wavy bedded, with shale seams, many brachiopods, and crinoids ..... 4.0′
c. Shale, gray with nodular limestone, *Neospirifer* ..... 0.8′
d. Limestone, purplish-brown, as one continuous nodular bed, with some brown chert, dwarf fauna. This bed is persistent in several exposures in this area ..... 0.2′
e. Limestone, buff, argillaceous, weathers nodular ..... 1.2′
f. Shale, greenish, with hard thin limestone layers ..... 0.8′
g. Limestone, nodular, argillaceous, brachiopods ..... 1.0′

7. Chanute shale formation, bluish-gray top 0.7′, lower part dark to nearly black, with many *Crurithyris* at base ..... 2.0′

8. Drum formation, limestone, banded or blotched brownish-gray, usually one or two massive beds, with *Composita* ..... 2.0′

9. Cherryvale formation, about 24.5 feet:
(1) Quivira shale member, greenish gray, blocky, with a 1″ dark coal-like layer 6″ to 1′ below top ..... 5.0′

(2) Westerville limestone member, about 6 feet:
a. Limestone, light gray, with dark chert pebbles about ½" in diameter, base fucoidal, as three massive beds ..... 3.3'
b. Shale, bluish green, poorly exposed ..... 1.5'
c. Limestone, gray, poorly exposed ..... 2.2'
(3) Wea-Fontana shale members, about 13.5 feet:
a. Shale, dark, with some thin beds of dark blue limestone, many *Chonetina, Chonetes, Rhombopora* ..... 4.5'
b. Limestone, dark blue, with dark shale partings, may represent the Block limestone member ..... 3.7'
c. Shale, dark, with many thin beds of dark blue limestone, fossiliferous ..... 5.3'

10. Dennis formation, about 23.0 feet:
(1) Winterset limestone member, 15-17 feet:
a. Limestone, greenish-gray, silty, argillaceous, with randomly oriented tubules filled with green clay, massive, weathers soft and slabby, top uneven, many *Myalina*. This shallow water aspect of the cyclothem is not always present ..... 4.0'
b. Limestone, gray to dark gray, oolitic and algal ..... 3.9'
c. Limestone, medium gray, wavy beds averaging about 0.4' thick, separated by shale partings; brown chert nodules top three feet, shaly lower part ..... 9.0'
(2) Stark shale member, about 4.0 feet:
a. Shale, gray, argillaceous, plastic ..... 1.6'
b. Shale, black, hard, fissile, conodonts ..... 2.4'
(3) Canville limestone member, bluish-gray, discontinuous nodular band, not always present..... 0.8'

11. Galesburg shale formation, gray, argillaceous ..... 8.0'

12. Swope formation, about 27.0 feet:
(1) Bethany Falls limestone member, about 23 feet:
a. Limestone, greenish-gray, silty, tubules filled with green clay, weathers slabby, contains *Myalina* ..... 3.1'
b. Limestone, light gray, fine-grained, fossiliferous, very algal, occasional small chert nodule, massive ..... 2.5'
c. Shale and thin layers of limestone, forms a reentrant on exposed face, many brachiopods ..... 1.0'
d. Limestone, light gray, some chert nodules, wavy beds ..... 6.9'
e. Shale, gray, with a thin limestone in the middle, forms a reentrant on face ..... 1.2'
f. Limestone, gray, more or less massive with indistinct beds, with some dark chert nodules in top, and a persistent nodular brown chert band about 1.5' from top of unit ..... 7.2'
(2) Hushpuckney shale member, about 4 feet:
a. Shale, gray, argillaceous, with *Crurithyris,* pelecypods ..... 1.9'
b. Shale, black, hard, fissile, with conodonts ..... 2.0'
(3) Middle Creek limestone member, blue-gray, dense, one bed ..... 0.8'

13. Ladore shale, 13 to 15 feet:
a. Shale, gray, calcareous, with blue limestone layers at top ..... 8.0'
b. Shale, gray, argillaceous, blocky ..... 6.5'

14. Hertha formation,
Limestone, dark-gray, sandy, top surface weathers fucoidal, algal, fossiliferous ..... 3.2'

15. Pleasanton shale, exposed in ravines in vicinity of Winterset .....

Correlation and Discussion

The authors, after a careful study of exposures in Iowa and the Platte River valley (Condra and Scherer, 1939) Nebraska, believe that the classification of some of these units should be revised. This

proposed revision is presented in the following paragraphs. In each citation the division numbers are from the preceding section, the first stratigraphic name is that used by Condra and Upp, or Condra and Reed. This is followed by the present stratigraphic reclassification.

Oread Formation

Division 1 (1) a and b, "Upper Plattsmouth limestone" becomes the Kereford limestone.

Division 1 (2) "Plattsmouth limestone" becomes the Heumader shale.

Division 1 (3) "Basal Plattsmouth limestone" becomes the Plattsmouth limestone (restricted).

Division 1 (6) Included in the Snyderville-Weston interval becomes the Snyderville shale member when underlain by the Toronto (?) limestone.

Divsion 1 (7) Not described in previous publications, but occupies the position of the Toronto limestone.

Condra and Reed (1937) assigned divisions 1 (1, 2) to the Plattsmouth limestone. Our study has shown these units to persist southwestward in Iowa and they can be identified in both the outcrop and subsurface. Because of their lithologic and faunal resemblance to the Kereford and the Heumader it is believed they should be assigned to these units. It is proposed that the term Plattsmouth be restricted to division 1 (3).

The limestone, division 7, that is exposed just below the Leavenworth limestone in the road gutters in the S. ½, Sec. 26, T. 76 N., R. 31 W., is not everywhere present, but in several localities it is over one foot thick, and in some exposures can be traced laterally into a calcareous shale. The authors believe that where this unit is present it is possible to separate the Snyderville shale from the underlying Lawrence shale.

Snyderville-Island Creek Interval

Division 2 (4) a, "Plattsburg limestone" becomes the Spring Hill limestone.

Division 2 (4) b, "Bonner Springs shale" becomes the Hickory Creek shale.

Division 2 (4) c. "Farley limestone" becomes the Merriam limestone.

Division 3 "Island Creek shale" becomes the Bonner Springs shale.

Wyandotte Formation

Division 4 (1) a and b, "Upper Argentine limestone" becomes the Farley limestone.

Division 4 (2) "Upper Argentine limestone" becomes the Island Creek shale.

Division 4 (3) b and c, "Lane shale and Raytown limestone member of the Iola formation," here included in the Argentine limestone.

Division 4 (4) a-e, "Muncie Creek shale" becomes the Quindaro shale.

Division 4 (5) "Paola limestone" becomes the Frisbie limestone.

The shales of the Snyderville-Island Creek interval have thinned considerably from the type areas and it has become nearly impossible to recognize the Lawrence, Stranger, and Weston formations in this section. The revised correlations of the members of the Plattsburg formation and the Farley and Island Creek members of the Wyandotte formation are now in agreement with the classification by Condra and Scherer (1939.

Lane-Hertha Interval

Division 5, "Chanute shale" becomes the Lane shale.

Division 6 (1) a-g, "Cement City limestone" becomes the Raytown limestone member of the Iola formation. The Muncie Creek shale and the Paola limestone may be absent or united with the Raytown limestone.

Division 7, Part of the "Cement City limestone" becomes the Chanute Shale.

Division 8, basal part of the "Cement City limestone" becomes the Drum limestone.

There are many excellent outcrops of these beds in the vicinity of Pammel State Park, all of which are easily accessible for detailed study. It will be found that the thickness and lithologic character of some of these units between the Winterset and the Argentine show some variability. The Raytown limestone is sometimes thinner or more shaly, with a corresponding thickening or thinning of the Chanute shale and the Drum limestone. The Quivira shale is remarkably consistent, and can be easily identified by the coal-like layer near the top. The Westerville limestone is only about three feet thick in the N.E. ¼ Sec. 11, T. 75 N., R. 28 W., but is thicker in exposures south and west of Pammel State Park.

Section 2

Howe Quarry, Adair County

All units of this section were measured in the quarries located in the N.E. ¼ Sec. 12, and Sec. 1, T. 76 N., R. 31 W. The Hushpuckney, Middle Creek, Ladore, and Hertha were measured from a

quarry core taken by the Schildberg Construction Company. This core is on file at the Iowa State Highway Commission.

1. Dennis formation, top eroded, about 17.0 feet:
   (1) Winterset limestone member, about 13 feet:
      a. Limestone and shale, weathered buff and soft ..... 2.0′
      b. Limestone, light gray when fresh, weathers buff, massive top and bottom, wavy bedded with shale seams, fusulinids numerous, brachiopods, and crinoid columnals .....10.0′
   (2) Stark shale member, about 4 feet:
      a. Shale, gray, weathers buff, soft ..... 1.5′
      b. Shale, black, fissile, hard, with conodonts ..... 2.5′
   (3) Canville limestone member, discontinuous nodular, blue ..... 0.5′
2. Galesburg shale formation, blue-gray top to light gray below, some limestone nodules, hard, massive, grades to bed below ..... 5.5′
3. Swope formation, 31-33 feet:
   (1) Bethany Falls limestone member, 21-23 feet:
      a. Limestone, greenish-gray, argillaceous, with randomly oriented clay filled tubules, laminated, weathers soft and slabby, many *Myalina* ..... 3.5′
      b. Limestone, light gray, usually 2 beds, dark chert nodules in top one foot ..... 3.3′
      c. Shale, grayish, weathers buff, hard, thin-bedded, some limestone slabs, forms reentrant on face ..... 0.8′
      d. Limestone, gray, wavy bedded, with some shale seams up to 0.1′ thick, dark chert at top, fossiliferous ..... 4.5′
      e. Shale, olive to gray, weathers buff, with a thin limestone in the middle, forms reentrant on face ..... 1.1′
      f. Limestone, gray, wavy bedded with shale seams, and shaly limestone layers, some chert nodules near top and a persistent nodular brown chert band about 1.6′ from top, fossiliferous with *Neospirifer, Composita, Rhombopora,* grades to shale below ... 9.5′
   (2) Hushpuckney, shale member, about 3 feet:
      a. Shale, gray, soft, plastic ..... 1.0′
      b. Shale, black, fissile, hard, with conodonts ..... 2.0′
   (3) Middle Creek limestone member, blue, hard, conchoidal fracture, some *Ottonosia* type algal masses ..... 0.7′
4. Ladore shale formation, blue-gray, massive, sandy at base .....10.0′
5. Hertha limestone formation, gray, nodular, shaly, arenaceous ..... 2.0′

The core continues 20 feet beneath the Hertha limestone.

Correlation

Condra and Reed (1937) assigned division 3 (1) a-e to the Topeka formation, and division 3 (1) f to 3 (3) to the Deer Creek

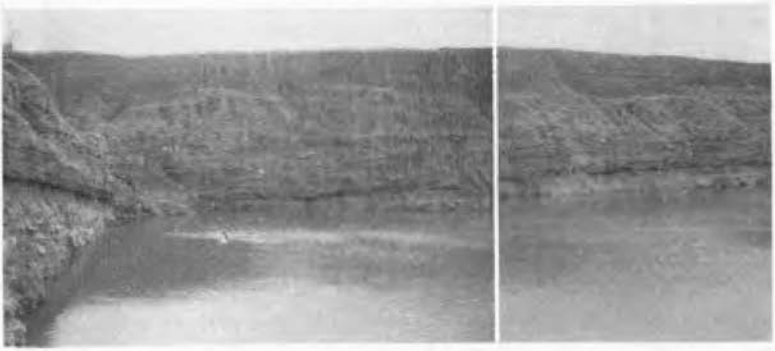
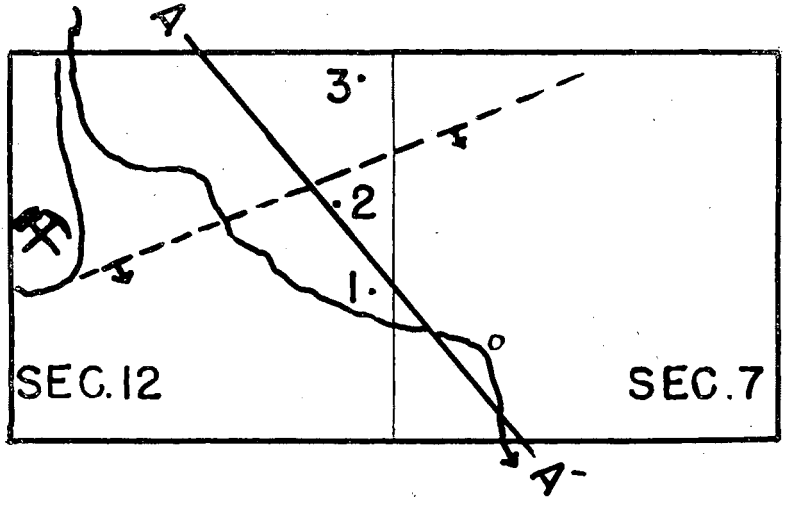
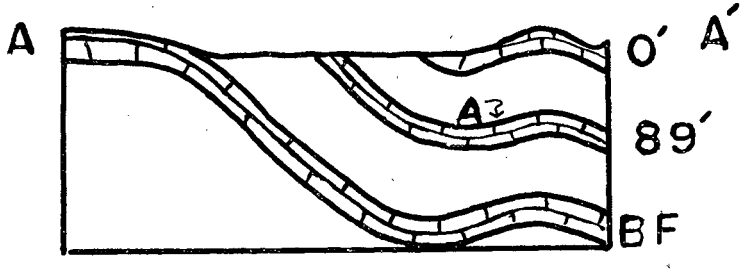


Figure 2. Photograph at the southeast end of the Howe Quarry showing the southeastward dip of the Swope-Dennis formations.





AXIS OF FOLD
O= OREAD
A= ARGENTINE
BF=BETHANY FALLS

Figure 3. Sketch showing the location, trend and cross-section of the structure crossing section 12, T. 76 N., R. 31 W.

formation. Their description of the underlying units correlated by them as the Tecumseh formation appears to correspond to the Ladore and Hertha formations of present usage.

Since 1937 the quarry in Sec. 12 has been extended to the southeastward exposing a steep monoclinal fold and the Dennis formation. The correlation of strata exposed in the quarry is based on a careful

study of the newly uncovered units and several cores drilled in Sec. 12, by the Schildberg Construction Company.

Structure

Previous workers in this area have assumed the dip of the beds to remain constant to the northwest, thus postulating that the Oread formation passed under younger beds (Deer Creek) in the Howe quarry. The southeastward extension of the Howe quarry has revealed a steep monoclinal fold (figure 2) that has a southward component of dip of about 10 feet in 100 feet, and an eastward component of about 5 feet in 100 feet. The strike of the fold is north of east. The structural rise is about 160 feet in 2,000 feet, with the steepest dip occurring about 30-50 feet south of the axis of the fold in the quarry, and then flattening out to the south.

Study of a series of cores in this area has shown no indication of faulting, but that the fold is the limb of an asymmetrical structure trending northeast-southwest. (See figure 3.)

A 109-foot core, drilled just north of the river and about 100 feet west of the north-south section line road in the E. ½, N.E. ¼, Sec. 12, T. 76 N., R. 31 W., encountered the top of the Wyandotte formation at about 82 feet of depth, and this core extended to the base of the Frisbie limestone. A second core taken from a position about 800 feet north of the first, encountered the base of the Argentine limestone beneath 20 feet of overburden, and the top of the Winterset limestone at a depth of 69 feet. This core extended to the top of the Ladore shale, and the section in the core is almost identical with that exposed in the southeast end of the quarry. Other cores in this area establish an apparent dip of about seven feet in 100 feet of horizontal distance to the southeast.

From the position where the 109 feet of core was taken and the N.E. ¼, S.E. ¼, Sec. 7, T. 76 N., R. 30 W., where the top of the Oread formation is exposed 20 feet above river level there is a reversal of dip within a distance of approximately one-half mile.

About one mile southeastward from the exposure in Sec. 7 in the E. ½, Sec. 18, T. 76 N., R. 30 W., the Kereford limestone is exposed at river level, with the remainder of the Oread formation occurring beneath the surface. This assignment has been verified by a core taken at this location. The exposure here is identical to that described by Condra and Upp as their section number 14, and it is suspected that they have mislocated this section.

It is believed that a small narrow syncline and anticline occur in the southeast limb of the major fold in Sec. 12. A striking feature of the entire structural zone is the almost complete absence of surface

evidence of its existence, and the sharpness of the structural flexing. Within a distance of about 100 feet the beds change from essentially flat lying to steeply dipping. In the north half of the Howe quarry in Sec. 12, and across the road in Sec. 1 the Bethany Falls limestone maintains an essentially horizontal attitude. The limestone rises northwestward with the gradient of the stream to just southeast of Casey. It is believed that this deformation is a part of the Redfield structural trend, and it appears that the dip is sufficient to account for the entire section between the base of the Plattsmouth and the base of the Bethany Falls (see Condra and Reed, 1938).

Section 3
Jefferson Quarry, Adair County
N.W. ¼, Sec. 17, T. 77 N., R. 31 W.

1. Dennis limestone formation, 15.3 feet:
   (1) Winterset limestone member, top eroded, about 11 feet:
      a. Limestone, pinkish-gray, fresh, weather yellow, soft, argillaceous, beds average 0.5′ thick, very algal, with crinoid fragments, brachiopods, etc. ..... 4.5′
      b. Shale, yellow-green, some thin limestone layers, numerous fusulinids ..... 0.5′
      c. Limestone, pinkish-gray when fresh, weathers yellow, numerous shale partings, with brachiopods, crinoid fragments and fusulinids, grades to unit below ..... 6.0′
   (2) Stark shale member, 3.8 feet:
      a. Shale, yellow, silty, blocky ..... 1.3′
      b. Shale, black, hard, fissile, with condonts ..... 2.5′
   (3) Canville limestone member, dark, blue-gray, argillaceous, vertically jointed, with algae and gastropods ..... 0.5′
2. Galesburg shale formation, gray to dark-gray, soft, silty ..... 5.7′
3. Swope limestone formation, about 24.6 feet exposed to quarry floor.
   (1) Bethany Falls limestone member, 23.6 feet:
      a. Limestone, greenish-gray, silty, numerous randomly oriented tubules filled with green clay, weathers slabby, pelecypods abundant, a 0.1′ green shale at base ..... 3.0′
      b. Limestone, light gray, with small (1″) chert masses, *Osagia* type algae, one massive bed ..... 3.5′
      c. Shale, gray to buff, calcareous, with abundant brachiopods..... 0.5′
      d. Limestone, light gray, cross-bedded on weathered surface, uneven base with chert nodules in lower 0.5′, soft and shaly at base, very algal, with black fish teeth (?) ..... 2.0′
      e. Limestone, light gray, fine-grained, numerous shale partings, thin bedded ..... 5.1′
      f. Shale, buff to gray, argillaceous, with a limestone layer in the middle, forms a reentrant on face ..... 1.0′
      g. Limestone, brownish-gray, hard, with occasional black chert nodule ..... 1.0′
      h. Limestone, buff to gray, nearly filled with brown chert ..... 0.5′
      i. Limestone, light gray, thin uneven beds becoming more shaly toward base, fossiliferous ..... 7.0′
   (2) Hushpuckney shale member, poorly exposed in sump ..... 3.5′
   (3) Middle Creek limestone member, light gray. This and underlying units reported in cores ..... 0.5′
   (4) Ladore shale formation ..... 14.0′
   (5) Hertha limestone formation ..... 2.0′

Discussion and Correlation

As near as can be determined from available subsurface information these beds do not extend more than a mile or so to the north of

the Jefferson quarry, where the Des Moinesian shales have been recovered in cores. The Jefferson quarry beds are assigned to the Dennis and Swope formations because (1) the stratigraphic sequence of the exposed and cored units are comparable to these formations, (2) a comparison of the units with those at Winterset and at Earlham indicates nearly identical sections, and (3) these beds have been traced southward to the Howe quarry.

Economic Use

Of the ledges exposed along this traverse only the Winterset, Bethany Falls, and the Argentine limestones are presently being used for road construction. The only rock of sufficient quality to be used in Portland Cement Concrete is about the top eight feet of the Argentine limestone. The Winterset and the Bethany Falls limestones have been used for road surfacing, and in type B asphaltic concrete. The Plattsmouth limestone in this area is of very poor quality and quite thin.

Some of the shale formation may have possibilities for use in the ceramic industry.

References

Broadhead, G. C. 1872. Missouri Geol. Surv., Vol. I.

Condra, G. E., and Reed, E. C. 1937. Correlation of the members of the Shawnee group in southeastern Nebraska and adjacent areas of Iowa, Missouri and Kansas: Nebraska Geol. Surv., Bull. 11, 2nd series, pp. 1-64.

Condra, G. E., and Upp, J. E. 1933. The Middle River traverse of Iowa: Nebraska Geol. Surv., Paper 4, pp. 1-24.

Condra, G. E., and Scherer, E. O. 1939. Upper Carboniferous formations in the Lower Platte Valley Nebraska; Nebr. Geol. Surv. Paper no. 16.

Condra, G. E., and Reed, E. C. 1938. The Redfield Anticline of Nebraska and Iowa; Nebr. Geol. Surv. Paper no. 12.

Gow, J. E., and Tilton, J. L. 1916. Geology of Madison County, Iowa: Iowa Geol. Surv., vol. 27, pp. 279-344.

Moore, R. C. 1936. Stratigraphic classification of the Pennsylvanian rocks of Kansas: Kansas Geol. Surv., Bull. 22, pp. 1-256.

———. 1949. Division of the Pennsylvanian System in Kansas: Univ. Kansas Publications, State Geol. Surv. of Kansas, Bull. 183.

Smith, G. L. 1908. The Carboniferous section of southwestern Iowa: Iowa Geol. Surv., vol. 19, pp. 605-657.

Tilton, J. L., an Bain, H. E. 1896. Geology of Madison County, Iowa: Iowa Geol. Surv., vol. 7, pp. 491-539.

Tilton, J. L. 1919 and 1920. The Missouri Series of the Pennsylvanian System in southwestern Iowa: Iowa Geol. Surv., vol. 29, pp. 278-297.

Todd, J. E. 1906. Proc. Iowa Acad. Sci.: vol. 1, pt. 1 and vol. 13.

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

Wood, L. W. 1932. A generalized section for the Missouri Series in Madison County, Iowa: Proc. Iowa Acad. Sci.

IOWA HIGHWAY COMMISSION
AMES, IOWA
IOWA STATE COLLEGE
AMES, IOWA

DAVENPORT, IOWA