NEBRASKA GEOLOGICAL SURVEY

Paper Number 8

GEOLOGIC CROSS-SECTION, FOREST CITY, MISSOURI TO DU BOIS, NEBRASKA

By
G. E. CONDRA

1935

Published by authority of the State of Nebraska

THE UNIVERSITY OF NEBRASKA

EDGAR A. BURNETT, Chancellor

BOARD OF REGENTS

HON. A. C. STOKES, Omaha
HON. FRANK A. TAYLOR, St. Paul
HON. EARL CLINE, Lincoln
HON. STANLEY D. LONG, Grand Island
HON. MARION SHAW, David City
HON. C. Y. THOMPSON, West Point

CONSERVATION AND SURVEY DIVISION

G. E. CONDRA, Dean and Director

NEBRASKA GEOLOGICAL SURVEY

G. E. CONDRA, State Geologist
EUGENE REED, Assistant State Geologist
CARL O. DUNBAR, Paleontologist
A. L. LUGN, Geologist
J. T. LINK, Toponomy
W. R. JOHNSON, Assistant Paleontologist
OLIVER R. SCHERER, Water Survey
HERBERT WAITE, Water Survey
HOWARD HAWORTH, Water Survey
CHABLES S. OSBORNE, Water Survey

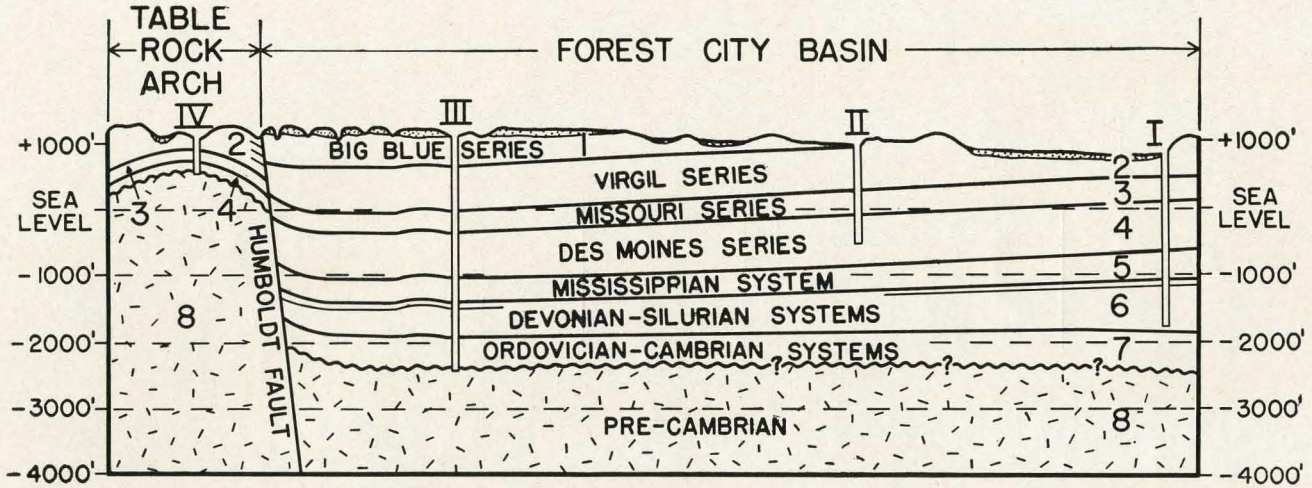

Figure 1.—Cross-section from near Forest City, Missouri to south of DuBois, Nebraska, view northward. The section is based on a study of outcrops and subsurfaces data obtained from the wells designated as follows: I, Davis; II, Rulo; III, Morgan; IV, Dubois. The major subdivisions of the rocks are shown by names and numbers for reference.

GEOLOGIC CROSS-SECTION, FOREST CITY, MISSOURI TO SOUTH OF DU BOIS, NEBRASKA

By
G. E. Condra

More than usual interest now centers in the region of this cross-section, mainly because of its structural features and their relation to the oil and gas possibilities. A well, recently drilled near the Nebraska-Kansas line, south of Dawson, made a small showing of oil, and, if our information is correct, a deep well will soon be drilled on a small, closed structure near that location.

This paper is based on a study of the outcropping formations, on the logs of four deep wells (Davis, Rulo, Morgan, and DuBois) and on the regional correlation of the Pennsylvanian and Permian formations. It is written for geologists and not for general readers.

Structural Features. This section (see Figure 1) crosses the Forest City Basin,[1] the Humboldt fault,[2] and the Table Rock arch [3] which is occupied at a comparatively shallow depth by a granite ridge which Moore named the Nemaha Mountains.[4] The strata in the Forest City basin persist westward with uniformity and with some warping and low, northwestward dip to where the pre-Pennsylvanian formations end abruptly against the granite at the fault line. They have an aggregate thickness of about 3763 feet in the Forest City basin in Nebraska above what probably is an eroded Pre-Cambrian surface.

The systems of sedimentary rocks in this traverse (see Figure 1) are Cambrian(?), Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian. Geologists are not in agreement regarding the horizon here provisionally correlated as Cambrian, which may prove to be basal Ordovician. The boundary between the Devonian and Silurian rocks is not well-defined, hence, these systems are shown in Figure 1 as Devonian-Silurian.

The Humboldt fault has a throw of several hundred feet. It is quite ancient, its major throw or throws dating back of Cherokee time, and its later development being in post-Big Blue time, when the formations were warped upward as the present Table Rock arch.

---

[1] Hinds and Green, Missouri Geol. Survey, Vol. XIII, Second Series, 1915, description pp. 206 and 208. The western border of the Forest City basin was referred to by G. L. Smith as the Brownville syncline. See Vol. 25, Iowa Acad. Sci., 1918.

[2] Condra, G. E., Bull. 1, Nebraska Geol. Survey, Second Series, 1927, pp. 15 and 212.

[3] Condra, G. E. Described and named in the Nebraska State Journal, 1917. See Bull. 1, Nebraska Geol. Survey, 1927, pp. 14-15 and p. 212.

[4] Moore, Raymond C., Bull. 3, Kansas Geo. Survey, 1917, pp. 140-147.

The Table Rock arch, as noted before, contains granite near the surface. The DuBois well was started on it at a horizon in the Topeka formation and reached granite below the Cherokee at a depth of 558 feet, the pre-Pennsylvanian sedimentaries being absent. Westward from this location, however, the granite lowers and is overlain by the older systems of rocks that occur in the Forest City basin.

The subsurface relations in the Table Rock arch, immediately north of this traverse, are not well understood. However, it is known that the granite ridge lowers here, and the Humboldt fault becomes several displacements that reach the surface. Farther north, where the relief and altitude of the granite ridge are reduced, the pre-Pennsylvanian systems of rocks cross the granite with reduced thicknesses and some faulting. The Cambrian rocks and the Sioux formation (quartzite) underlie the Ordovician in the vicinities of Lincoln, Nehawka, and Omaha.

Changes in Classification. The close study that has been made of the Pennsylvanian and Permian rocks in the northern Mid-Continent region during the past few years shows conclusively that the former boundaries of the major subdivisions of these systems were not well founded. In response to this, and as a result of his own investigation, Dr. R. C. Moore, Director of the Kansas Survey, has proposed what seems to be a more natural grouping of the major subdivisions of these systems, their major boundaries being at disconformities.

Dr. Moore places the base of the Big Blue series at a much lower stratigraphic level than formerly. He shifts the boundaries of the Virgil series and lowers the base of the Missouri series to include some beds that were formerly correlated with the Des Moines series. These and most of the other recent correlations by Moore are accepted by the Missouri and Nebraska surveys and are followed in this paper.

New Names. The Wabaunsee group, as now defined, is subdivided as three subgroups: Richardson, hereby named from Richardson County, Nebraska; Nemaha, named a few years ago by Condra and Bengtson from the Nemaha Valley areas of Nebraska; and the Sac-Fox subgroup hereby named from the Iowa-Sac-Fox Indian Reservation in southeastern Nebraska and northeastern Kansas. These subgroups represent natural subdivisions, convenient for mapping.

Several of the Permian members, established by Condra and Upp and by others, have been raised by Moore and his associates to formational rank or have been classified as members of new formations as follows: Bigelow formation, to include the Funston limestone, Blue Springs shale, and the Crouse limestone; the Bader formation, to include the Middleburg limestone, Hooser shale, and the Eiss limestone; the Beattie formation, to include the Morrill limestone, Florena shale, and the Cottonwood lime-

stone; and the Hamlin formation, to include the Oaks shale, Houchens Creek limestone, and Stine shale.

The writer here proposes the names South Fork limestone, Winnebago shale and Taylor Branch limestone for the members of the Burlingame formation, and the names Lehmer limestone, Reserve shale and Miles limestone for the members of the Falls City limestone formation.

The type localities for the new subgroups and members are located as follows: Richardson subgroup, the Big Nemaha Valley of southern Richardson County, between points south of Humboldt and southwest of Falls City; Sac-Fox subgroup, in the Missouri River blufflands, between the mouth of the Big Nemaha and Iowa Point, Kansas; Lehmer limestone, the top bed at the Lehmer quarry, about four miles southwest of Falls City; Reserve shale, in the upland near the state line, northwest of Reserve, Kansas: Miles limestone, in the high hill west of the Miles ranch, about two miles southwest of Falls City; South Fork limestone, high in hill about ¾ miles southwest of DuBois, at west side of South Fork Valley; Winnebago shale, in the Missouri River bluffs, south of the mouth of Winnebago Creek, north of Rulo, Richardson County; Taylor Branch limestone, the lowest heavy limestone at the top of the opening in the clay pit, south of Taylor Branch, south of Table Rock, Nebraska. The members of the Falls City and Burlingame formations have been traced through Kansas to Oklahoma.

Condra and Busby added the name Five Point limestone formation to the Nebraska nomenclature in 1931 for a unit exposed in Five Point Valley, Richardson County. This unit has been traced southward through Kansas to Oklahoma and is recognized by the Kansas Survey. Apparently all of the other names recently applied to the Pennsylvanian and Permian units of Kansas and Nebraska are defined in geological reports. This paper follows the latest approved nomenclature.

Key Well Logs. The four wells, noted before, that are favorably spaced in an east-west traverse of about 45 miles, and which supply data incorporated in this paper, are as follows:

1. DuBois well, on the Table Rock arch, about 2½ miles southeast of DuBois; near center of Section 25, T. 1 N., R. 12 E.; curb elevation about 1019 feet, at a horizon near the top of the Topeka formation; core-drilled by the Chicago, Rock Island & Pacific Railroad in 1887; depth 565 feet, ending 8 feet in granite, at 454 feet above sea level.
2. Morgan well, known also as the Salem well, located in the Forest City basin, 7 miles south and 1½ miles east of Dawson; about 12 miles east of the DuBois well and 8½ miles east of the Humboldt fault; in the S.E. of the N.E. of 26, T. 1 N., R. 14 E.; drilled in 1929-32; curb elevation about 1040 feet, at a horizon near the middle of the Hughes Creek shales; depth 3500 feet, ending about 8 feet in Pre-Cambrian, modified granite, at 2460 feet below sea level.

3. Rulo well, in the Forest City basin; about 19 miles east of the Morgan well; on the bottom land of the Big Nemaha, southwest of Rulo; in the S.W. of the N.E. of 24, T. 1 N., R. 17 E.; drilled at an early date, prior to the Davis well; driller's log obtained through Professor E. F. Schramm; curb elevation about 870 feet, at a level a few feet above the top of the Scranton shale; depth 1354 feet, ending in the Cherokee shale, at 584 feet below sea level.
4. Davis well, in the Forest City basin; in the S.E. of N.W. of 4, T. 59 N., R. 38 W.; southeast of Forest City, Missouri; about 14 miles from the Rulo well; core-drilled in 1901; curb elevation about 868 feet, at a horizon in the Tecumseh shale; depth 2500 feet, ending in the Silurian at 1814 feet below sea level.

THE GEOLOGIC COLUMN OF THE AREA

Knowing the horizon at which one is located, or at which a well is started, the following comprehensive resumé can be used to show with reasonable accuracy the succession and nature of the formations below. Persons not knowing the precise horizon exposed at any particular place, should write the State Geological Survey at the University of Nebraska for this information. The geologic column of the sedimentary formations in this area, listed from the highest outcrop to the lowest and oldest subsurface division, is as follows:

I. PERMIAN SYSTEM:

Big Blue Series, about 407′:

(I) Chase group, only 7′ of basal portion exposed:
  1. Fourmile limestone, the basal member of the Wreford limestone formation, exposed in the tableland-like upland near the state line southeast of Humboldt; stone, dark gray, and cherty, 7′.

(II) Council Grove group, measured on the outcrops located between 10 miles south of Humboldt and about ½ mile southwest of Salem, 293′:
  2. Speiser shale formation, largely argillaceous, 18′-19′:
    (1) Shale, olive colored, with thin limy-sandy seams, 2′+.
    (2) Limestone, gray, blocky, 6″-8″.
    (3) Shale, gray to olive, argillaceous, 3′-4′.
    (4) Shale, gray, gray-pink, or largely red, argillaceous, 6′.
    (5) Shale, gray, argillaceous, 2′-3′.
    (6) Shale, gray-red or red, argillaceous, 2′-3′.
    (7) Shale, gray or olive, argillaceous, 1′+.
  3. Bigelow limestone formation, about 41′:
    (1) Funston limestone, about 8′:
      a. Limestone, light gray, massive, dense, blocky; forms rounded boulders, 1′-1′6″.
      b. Shale, bright olive colored, argillaceous, crumbly, 3′-4′.
      c. Limestone, gray, massive, weathers irregular at base, 1′+.
      d. Shale, dark gray, irregular, 2″-6″.
      e. Limestone, gray, somewhat arenaceous, weathers yellowish-brown and irregular, 1′6″.
    (2) Blue Rapids shale, 22′+:
      a. Shale, greenish-gray, massive, argillaceous, 4′-5′.
      b. Sandy-lime, weathered buff and irregular, 8″-10″.
      c. Shale, olive colored, massive, argillaceous, with chocolate-red seam near base, 4′+.
      d. Mudstone, light gray to buff, somewhat arenaceous, weathers bedded, 2′.

e. Shale, gray, bedded, argillaceous, 1′2″.
f. Shale, chocolate-maroon, massive, blocky, argillaceous, 2′6″.
g. Shale, greenish-gray, largely bedded, argillaceous and crumbly, with some mudstone and vesicular box-work at places, 5′-6′.
h. Mudstone, greenish-gray, limy, arenaceous, indurated, weathers light gray, 1′.
i. Shale, dark gray, 1′+.

(3) Crouse limestone, 11′+:
a. Limestone, light gray, darker on surface, massive, granular, weathers gray-buff and at places pitted, 2′-3′.
b. Shale, olive colored, with some sandy seams and calcareous aggregate, 7′±.
c. Limestone, dark gray, earthy, shattered or slabby, quite fossiliferous, 1′6″+.

4. Easly Creek shale formation, about 14′:
(1) Shale, olive, argillaceous, weathers grayish, 4′.
(2) Shale, maroon-gray more or less mixed, about 10′.

5. Bader limestone formation, about 24′6″:
(1) Middleburg limestone, about 4′:
a. Limestone, gray, massive, granular, dense, weathers buff-gray, about 1′4″.
b. Limestone, variegated light to dark gray, massive, with many small dark-colored, high-spired gastropods, 1′6″.
c. Shale, olive, 6″-1′.
d. Limestone, dark gray, blocky, dense, 2″-3″.

(2) Hooser shale, 11′:
a. Shale, olive, calcareous-argillaceous, fossiliferous, weathers buff, 2′.
b. Shale, weathers buff, with boxwork at places, 1′.
c. Shale, grayish, with calcareous concretionary subzone near base and a reddish subzone below the middle, about 8′.

(3) Eiss limestone, about 9′6″:
a. Limestone, grayish, massive, siliceous, granular, dense; weathers gray-buff, 1′3″-2′.
b. Shale, olive, argillaceous, massive, with some lime aggregate, fossiliferous at base, 5′-7′.
c. Limestone, dark gray, shaly, especially so at top, very fossiliferous, 1′6″-2′.

6. Stearns shale formation, about 17′:
(1) Shale, olive, massive, crumbly, largely argillaceous, with some calcareous aggregate, weathers gray, 5′-6′.
(2) Mudstone, not well developed, 4″+.
(3) Shale, lavender-maroon, about 5′.
(4) Boxwork, gray, irregular, weathers buff, 1′.
(5) Shale, olive, with some calcareous material, 5′ or more.

7. Beattie limestone formation, 18′:
(1) Morrill limestone, two gray limestones separated by a thin shale; stone weathers brownish, about 3′-4′.
(2) Florena shale, olive colored at top, middle and base light gray with much calcitic material and quite fossiliferous, *Chonetes granulifer* abundant, 5′-10′.
(3) Cottonwood limestone, light gray, massive to slabby, with some small bodies of chert, quite fossiliferous at places, 6′-11′.

8. Eskridge shale formation, three subzones of gray, bluish-gray and red clay shales separated by two thin limestones, 30′-45′, average about 35′.

9. Grenola limestone formation, 30′-40′; usually about 30′:

(1) Neva limestone, 12′6″ exposed:
a. Limestone, top badly covered, gray, weathers brownish, pitted, almost vesicular, 2′±.
b. Shale, yellow in upper portion, brown or black in lower portion, with calcareous seams, 9′±.
c. Limestone, light gray, weathers reddish-buff, carries *Ambocelia* and small fusulinids, 1′6″.
(2) Salem Point shale, calcareous, 7′-8′.
(3) Burr limestone, 10′-11′:
a. Limestone, gray, massive, weathers buff-brown, upper 6″ pitted, with a crustal ostracodal layer, middle portion weathers yellow and slabby, contains a gastropodal layer, thickness 3′6″-4′.
b. Shale, gray and black, carbonaceous, fissile, with calcareous slabs, contains plant remains, weathers brownish, 3′6″.
c. Limestone, light gray, massive, in one, two or three layers with shale partings, 1′6″-3′6″.
(4) Legion shale, green, platy, 6′ exposed in road cut one mile southwest of Salem.
(5) Sallyards limestone, dark blue-gray, slabby, surface weathers "glazed", carries pelecypods, 1′±.
The Kansas Survey correlates subdivisions (4) and (5) above with the Roca shale formation.

10. Roca shale formation, largely gray shale with some scattered calcareous material, a zone of mudstone-limestone near base and a thin zone of red shale above it, 18′-20′, not including the Legion shale and the Sallyards limestone.
11. Red Eagle limestone formation, 12′:
(1) Howe limestone, gray, irregular, weathers buff and vesicular, 3′-4′.
(2) Bennett shale, gray above, black below, quite fossiliferous, 5′-7′.
(3) Glenrock limestone, dark gray, massive, blocky, with fusulinids, 1′-1′8″.
12. Johnson shale formation, gray and buff zones, irregular, 18′-20′.
13. Foraker limestone formation, 43′-50′:
(1) Long Creek limestone, usually irregular, impure and weathers yellowish, 3′-6′.
(2) Hughes Creek shale,* in three main zones, i.e., bluish-gray shale, 10′-12′; thin, gray limestone separated by gray and black shales, about 10′; and bluish-gray shale, massive at base, about 14′, all quite fossiliferous, fusulinids abundant, combined thickness 36′-38′.
(3) Americus limestone, at places one gray limestone, usually two limestones separated by gray to black shale, 2′-3′.

(III) Admire group, about 115′:
14. Hamlin shale formation, 42′-46′:
(1) Oaks shale, near Salem, about 17′-18′:
a. Shale, upper 2′ black, sub-fissile, lower 8″ gray-green, calcareous, combined thickness 2′8″.
b. Limestone, greenish-gray, impure, 4″-6″.
c. Shale, greenish-gray, calcareous, 14′-15′.
(2) Houchens Creek limestone, gray to buff, irregular, with lobulate bedding, weathers yellowish, 1′-4′.
(3) Stine shale, about 24′:
a. Shale, bluish-gray, argillaceous, weathers yellowish, about 14′.
b. Limestone and sandstone, about 2′6″:
(a) Limestone, gray, earthy, with pelecypods, brachiopods and bryozoa, 6″.
(b) Sandstone-limestone-shale, gray, irregular with a thin local pelecypodal limestone, about 1′6″.

* The Morgan well starts at a level about 18 feet above the base of the Hughes Creek shales.

(c) Limestone, bluish-gray, very dense and hard, locally known as "ironstone", top uneven, pelecypodal, 5″-8″.
c. Shale, bluish-gray, argillaceous, massive, 4′9″.
d. Limestone, dark gray, arenaceous-sandy, 4″-6″.
e. Shale, bluish-gray, argillaceous, massive, 2′9″.

15. Five Point limestone formation, one limestone, or, more commonly, two gray limestones separated by gray to dark shale, 1′-3′.
16. West Branch shale formation, about 25′:
    (1) Shale, bluish-gray, argillaceous, about 4′.
    (2) Stone, yellowish, shaly to sandy lime, cut by thin blades forming a "boxwork", 1′-1′6″.
    (3) Shale, yellowish, with many thin indurated seams, irregular and some blades, 5′.
    (4) Shale, largely bluish-gray and argillaceous, about 19′-20′.
17. Falls City limestone formation, at old Lehmer quarry, four miles S.W. of Falls City and in lower course of Five Point Creek, about 9′:
    (1) Lehmer limestone, gray but usually weathers brownish, soft porous, 3′-4′.
    (2) Reserve shale, blue-gray, argillaceous, about 4′6″.
    (3) Miles limestone, blue-gray, locally weathers brownish and porous, 1′+.
18. Hawxby shale formation, along ravine on Towle farm southwest of Falls City, about 12′6″-17′:
    (1) Shale, light bluish-gray, calcareous, cut by thin bladed material, 10′.
    (2) Shale, bluish-gray and locally red, with a subzone of argillaceous, 2′6″.
19. Aspinwall limestone formation, one irregular smoky-gray to bluish-gray limestone, which weathers as irregular debris, or two limestones separated by shale, 6″-2′+.
20. Towle shale formation, about 2′-2′6″ of gray shale at top; middle, 10′-11′ red shale; and basal 1′± gray shale; combined thickness about 14′ or more.

II. PENNSYLVANIAN SYSTEM, about 1994′: *

Virgil Series, 751′:

(IV) Wabaunsee group, about 351′

(IV)a Richardson subgroup, about 80′:

21. Brownville limestone formation, one light bluish-gray to dark gray, fossiliferous limestone, or, more commonly, two limestones separated by a thin gray fossiliferous shale, *Marginifera wabashensis* common, 2′-4′.
22. Pony Creek shale formation, 57′:
    (1) Shale, gray, sandy to argillaceous, 5′-6′.
    (2) Greyhorse limestone, dark gray, impure, 1′.
    (3) Caneyville shale, top portion gray and shaly, middle and lower portions shaly or sandy, with plant leaves, thickness 17′.
    (4) Nebraska City limestone, upper portion dark gray, impure, limestone; lower portion shaly and very fossiliferous; *Chonetes, Neospirifer, Punctospirifer, Derbya, Rhombopora* and crinoid joints abundant, combined thickness about 2′.
    (5) French Creek shale, about 7 miles south of Humboldt, 16′:
        a. Shale, gray, sandy, 0′-2′.
        b. Lorton coal, impure, 2″-4″.
        c. Shale, dull gray, argillaceous, laminated, 6′+.
        d. Limestone, dull-gray, irregular, impure, grades laterally to sandstone, 10″.
        e. Sandstone (or shale), gray-green, bedded locally, with plant remains, 6′.

* The measurement in the Morgan well is 2011 feet, a difference of 11 feet, which may mean that the Scranton and probably the Calhoun are recorded too thin in the general section.

(6) Jim Creek limestone, dark gray, arenaceous, locally conglomeratic, 6″-1′.
(7) Friedrich-Dry shale, about 17′:
a. Shale, gray, massive, fossiliferous at top, 10′.
b. Shale, maroon, crumbly, 2′6″.
c. Limestone (Grandhaven?), gray, nodular, arenaceous, 1′.
d. Shale, top greenish, largely maroon, blocky, 3′.

23. Dover limestone formation, dark gray, nodular to blocky, one bed or two beds separated by shale, quite fossiliferous, fusulinids common, 1′6″-4′.
24. McKissick shale formation, 10′-19′:
(1) Table Creek shale, gray to buff-green, argillaceous to sandy, Nyman coal near top, 7′-13′.
(2) Maple Hill limestone, gray to bluish-gray, impure, one bed, locally sandy, 1′+.
(3) Pierson Point shale, gray to dark at top and bottom, usually reddish in middle, 3′-5′.

(IV)b Nemaha subgroup, about 101′:

25. Tarkio limestone formation, gray, usually massive and filled with large fusulinids and *Osagea,* 3′-6′.
26. Willard shale formation, gray shale, some sand and sandstone, with two or more fossiliferous limestone seams in lower portion, about 28′.
27. Preston ("Emporia") limestone formation, 9′-11′:
(1) Elmont limestone, one bluish-gray bed or two or more beds separated by shale, 2′-5′.
(2) Harveyville shale, greenish, bluish, locally a subzone nearly black, argillaceous to calcareous, quite fossiliferous, 3′-4′; thickness eastward to 7′ or more.
(3) Reading limestone, bluish-gray, one or two beds, weathers brownish, about 3′.
28. Auburn shale formation, gray, red and bluish-gray zones, quite calcareous and fossiliferous near top, with *Allorisma, Chonetes,* and *Linoproductus,* 18′-30′.
29. Wakarusa limestone formation, usually three limestones separated by shale, stone bluish-gray, weathers yellowish-brown, quite fossiliferous, *Dictyoclostus, Chonetes* and crinoid joints common, about 3′.
30. Soldier Creek shale formation, in gray and red zones, argillaceous to very sandy, micaceous locally, 8′-12′.
31. Burlingame limestone formation, about 20′:
(1) South Fork limestone, one massive bluish bed, or two or three beds separated by shale, 2′-6′.
(2) Winnebago shale, bluish, argillaceous, with some limy fossiliferous seams, 8′-12′.
(3) Taylor Branch limestone, bluish-gray, massive, weathers brownish, 2′-4′6″.

(IV)c Sac-Fox subgroup, about 174′:

32. Scranton shale formation, 120′-125′ near DuBois; about 140′ southeast of Rulo:
(1) Silver Lake shale, bluish-gray, largely argillaceous, 10′-12′.
(2) Rulo limestone, dark gray, arenaceous, 6″-1′+.
(3) Cedar Vale shale, gray, largely argillaceous, bedded near top, indurated and yellowish near base, about 20′-25′.
(4) Happy Hollow limestone, yellowish-brown, nodular to massive, sandy to argillaceous, 1′6″-3′.
(5) White Cloud shale, exposed and subsurface, bluish-gray and argillaceous to sandy in upper 3′-5′; largely gray, irregular, bedded and cross-bedded sand, with thin seams of shale and one or more local seams of coal, about 100′±.

33. Howard limestone formation, ½ mile south of DuBois, about 7′:
    (1) Utopia limestone, dark gray, massive, weathers brown, 1′-2′. Locally there is a 3′ or more sandy lime transitional zone on this in which *Triticites acutus* and bryozoa are abundant.
    (2) Winzeler shale, blue to black, part calcareous, 6″-1′+.
    (3) Church limestone, brown, massive, quite fossiliferous, weathers brownish, with crinoid joints, about 4′.
34. Severy shale formation, 27′-29′ in eastern part of area and 22′ southeast of DuBois:
    (1) Shale, exposed below waterfall south of DuBois, 2′ or more:
        a. Calcareous, fossiliferous, 4″-6″.
        b. Black, massive to bedded, with many *Lingula,* 4″-7″.
        c. Grayish, fossiliferous, 5″-6″.
        d. Black, silty above, massive below, 6″.
        e. Rotted, fossiliferous, 2″-4″.
    (2) Nodaway coal, shown below waterfall on Lores Branch south of DuBois and at the old mill site southeast of DuBois, 1′2″-1′4″.
    (3) Shale, at site of old mill dam southeast of DuBois, 17′-18′:
        a. Gray, argillaceous, 6″.
        b. Black, slaty, 7″.
        c. Bedded, sandy, micaceous, with ripple marks at base, 3′6″.
        d. Bluish, bedded to massive, non-fossiliferous, argillaceous, 13′-14′.

(V) Shawnee group, about 266′:

35. Topeka limestone formation, on Turner Creek, near the center of Section 25, i.e., 1½ miles east and 1 mile south of DuBois; also along a creek, south in Kansas, 19′-20′:
    (1) Coal Creek limestone, 5′ or more:
        a. Limestone, dark gray, somewhat siliceous, with many fusulines and bryozoa, forms large flat blocks, 1′6″.
        b. Shale, bluish, argillaceous to calcareous, weathers buff, 1′6″.
        c. Limestone, blue, dense, massive, fossiliferous, weathers brownish, 1′+.
        d. Shale seam, dark, 4″-6″.
        e. Limestone, dark blue, massive, forms rectangular blocks, with specimens of *Myalina,* crinoid joints, and bryozoa, 7″-8″.
    (2) Holt shale, upper portion bluish-gray, argillaceous, with some calcareous material, lower portion black, fissile.
    (3) DuBois limestone, about 2′10″, combined thickness 2′3″:
        a. Limestone, dark blue, massive, 1′2″, upper surface roughened with large Myalinas.
        b. Shale seam, calcareous, 5″.
        c. Limestone, separated by shale seams, dark blue, dense, quite fossiliferous, with small Myalinas, 1′3″.
    (4) Turner Creek shale, bluish-gray, calcareous, with lime seams near top, 2′9″+.
    (5) Hartford (Curzon) limestone, usually four or five uneven, dark gray beds separated by shale seams, in places two beds separated by shale, about 6′-7′.
36. Calhoun shale formation, below Iowa Point, Kansas, about 25′:
    (1) Iowa Point shale, bluish-green, argillaceous, 11′.
    (2) Sheldon limestone, bluish-gray, massive, weathers buff or brownish, 2′6″-4′.
    (3) Jones Point shale, upper portion bluish and argillaceous, lower portion bluish-gray, bedded to massive, with thin seams or layers of lime, quite fossiliferous, 10′.
37. Deer Creek limestone formation, below Iowa Point, Kansas, below Forest City, Missouri, and in the Rulo and Morgan wells, about 34′:
    (1) Ervine Creek limestone, gray limes separated by thin shales, 16′.
    (2) Larsh shale, 5′.

(3) Rock Bluff limestone, steel gray, dense, locally pitted with vugs of iron oxide, 1′6″-2′.
(4) Oskaloosa shale, gray, largely argillaceous, 4′-7′.
(5) Ozawkie limestone, dark gray to bluish-gray, dense, about 5′.

38. Tecumseh shale formation, below Forest City, and in well logs, largely gray, with some limy material, about 50′.
39. Lecompton formation, in well logs, about 34′:
(1) Avoca limestone, bluish-gray, usually in two beds separated by shale, 2′-4′.
(2) King Hill shale, upper portion gray, lower portion locally maroon and at places arenaceous, about 4′.
(3) Beil limestone, usually two limestones separated by shale, very fossiliferous, many fusulinids and *Campophyllum,* 5′.
(4) Queen Hill shale, upper portion bluish, argillaceous, lower portion black, carbonaceous, platy to fissile, combined thickness 5′-6′.
(5) Big Springs limestone, bluish-gray, dense, massive, with many *Triticites,* 3′.
(6) Doniphan shale, gray to buff, much sandy, bladed material, thickness 3′ to the west and 7′-8′ to the east.
(7) Spring Branch limestone, dark gray, many echinoid spines, about 5′.
40. Kanwaka shale formation, in well logs, about 37′:
(1) Stull shale, bluish, argillaceous to sandy, probably 20′ or more.
(2) Clay Creek limestone, light gray, massive, probably 2′-3′.
(3) Jackson Park shale, dark gray, very calcareous, argillaceous to sandy, with some lime seams, probably 14′.
41. Oread limestone formation, in well logs, 54′:
(1) Kereford limestone, dark gray, massive, dense, locally oolitic, 6′-8′.
(2) Heumader shale, bluish or gray, mostly argillaceous, 3′-4′.
(3) Plattsmouth limestone, gray beds, thin shales, some chert, many fusulinids, 17′-18′.
(4) Heebner shale, bluish-gray above, black and fissile below, 5′.
(5) Leavenworth limestone, blue, brittle, massive, one or two beds, forms rectangular blocks, 1′4″-2′.
(6) Snyderville shale, bluish above, locally maroon below, massive, argillaceous, 11′-12′.
(7) Weeping Water (Toronto) limestone, dark gray to bluish-gray, massive to broken, 6′-8′.

(VI) Douglas group, from well records, probably 130′ or more:
42. Lawrence-Stranger formations, separated by a disconformity, largely gray and bluish-gray shales, with some red shale, sand, sandstone and thin limestones, 130′+.

DISCONFORMITY.....

III. Missouri Series, about 443′:

(VII) Pedee group, from well records, correlation not certain, about 57′:
43. Iatan limestone formation, gray, massive, probably 6′-9′.
44. Weston (Plattford) shale formation, largely gray and argillaceous, about 50′, decreasing westward.

(VIII) Lansing group, from well records, probably 5′:
45. Stanton limestone formation, about 29′:
(1) South Bend limestone, gray, shaly, 4′.
(2) Rock Lake shale, bluish, argillaceous, 3′-4′.
(3) Stoner limestone, gray, quite fossiliferous, bedded to massive, 15′ or more.
(4) Eudora shale, gray above, black and fissile below, 3′+.
(5) Captain Creek ("Meadow") limestone, bluish-gray, dense, 3′-4′.

(1) Farley limestone, 4'-5'.

46. Vilas shale formation, bluish-gray, gray and black, largely argillaceous, probably 20'.
47. Plattsburg limestone formation, gray, massive, with some shale, 12'-18'.

(IX) Kansas City group, from well records, about 156':

48. Bonner Springs shale formation, bluish-gray, argillaceous, massive to bedded, with an irregular zone of red shale and thin seams of fossiliferous lime in upper portion, 6'-8'.
49. Wyandotte limestone formation, 43'-44':
    (2) Island Creek shale, bluish-gray, massive, argillaceous, 4'.
    (3) Argentine limestone, gray, compact in upper portion, broken by thin, wavy shaly seams in lower portion, about 15'-16'.
    (4) Quindaro shale, dark gray, part black, 14'.
    (5) Frisbie limestone, dark-gray to bluish-gray, 6'.
50. Lane shale formation, bluish-gray, largely argillaceous, with some lime, about 18'.
51. Iola limestone formation, including the Raytown limestone, Muncie Creek shale, and the Paola limestone, 12'.
52. Chanute shale formation, bluish, argillaceous, calcareous, 6'-7'.
53. Drum limestone formation, including the Corbin City and Cement City limestones, gray, massive, 8'.
54. Quivira shale formation, largely bluish-gray and argillaceous, 14'.
55. Westerville limestone formation, gray limes separated by gray to dark shales, 17'.
56. Cherryvale shale formation, gray, bluish-gray and black shale and thin bluish limestones, about 30'.

(X) Bronson group, from well records, about 95':

57. Dennis limestone formation, includes the Winterset limestone, Stark shale, and Canville limestone; stone bluish-gray to gray, massive to bedded, cherty, with thin shale partings; shale gray to black; combined thickness about 41'.
58. Galesburg shale formation, bluish to dark colored, argillaceous, about 9'.
59. Swope limestone formation, including the Bethany Falls limestone, Hushpuckney shale, and the Middle Creek limestone; stone largely gray and massive; shales gray to black; combined thickness about 22'-23'.
60. Ladore shale formation, gray, bluish-gray and black, 8'-9'.
61. Sniabar (Hertha) limestone formation, gray, massive, 9'-17':
    (1) Limestone, weathers yellowish, slabby and somewhat uneven at top, more dense below, about 5'.
    (2) Shale, bluish, argillaceous, 1'-2'.
    (3) Limestone, weathers yellowish at top, main portion buff gray to light gray, massive, nearly solid, separated by thin, wavy shale seams near base; fossiliferous, with *Cyclotrypa barberi,* crinoid joints, *Marginifera splendens, Composita subtilita, Squamularia perplexa,* etc., about 18'. Depth to base in Morgan well, 1280'.

(XI) Bourbon group, from well records, consists of shales, thin limestones, and some coal; thickness about 70' in the Morgan well, depth of base about 1350'.

IV. Des Moines Series, about 790':

(XII) Marmaton group, largely shale, some limestone and thin coals, about 140' in Morgan well, with the base at 1490'; thinner in the Table Rock arch.

(XIII) Cherokee group, consists of shales, thin coals, little lime, and several sandstones; thickness in the Morgan well 650', with the base at 2140'; much thinner in the Table Rock arch.

III. MISSISSIPPIAN SYSTEM, with the Kinderhook well developed, thickness in Morgan well, 330', with base at 2470'; thickness reported in the Davis well near Forest City, Missouri, 412'.

DISCONFORMITY.....

IV. DEVONIAN AND SILURIAN systems, shales, limestones, and dolomites; Devonian probably 110'; Silurian about 470'; combined thickness in Morgan well 580', base at 3050'.

V. ORDOVICIAN SYSTEM, AND CAMBRIAN SYSTEM(?), about 442' in Morgan well:

(1) Maquoketa formation, shale, 62', base at 3112'.
(2) Galena formation, dolomite, 198', base at 3310'.
(3) Decorah formation, shale, 74', base at 3384'.
(4) Platteville limestone formation, 6', base at 3390'.
(5) Glenwood formation, shale, 51', base at 3441'.
(6) St. Peter formation, sandstone (Wilcox?), 2' depth to base, 3443'.

DISCONFORMITY.....

(7) Dolomite, St. Peter?, gray, about 12'.
(8) Sandstone: St. Peter(?), Prairie du Chien(?), Jordan of the Cambrian(?), 37'6", base at 3492'.

DISCONFORMITY.....

VI. PRE-CAMBRIAN(?), in Morgan well, reddish, clastic, probably modified granite, 8', drilled to 3500'. This may be either Ordovician or Cambrian, but more likely it is Pre-Cambrian.

LOG OF THE MORGAN WELL

The foregoing columnar section includes the beds penetrated in this well down to the base of the Bourbon group, i.e., from the curb to a depth of 1350 feet, below which the foregoing section is very general. Mr. Eugene Reed, Assistant State Geologist, logs this well below the Missouri series as follows:

I. DES MOINES SERIES, 790':

1. Marmaton group, 140':
   (1) Shale, black, carbonaceous, platy, with some limestone, 10'.
   (2) Shale, gray, calcareous, fossiliferous and some limestone, brownish-gray, dense, 10'.
   (3) Limestone (Pawnee), gray to buff, slightly granular to siliceous, with some fine-grained calcareous sandstone and black shale, 20', depth 1390'.
   (4) Limestone and shale: Limestone, gray, buff, granular, crystalline, dense; shale (Lexington coal equivalent), black, carbonaceous and olive, micaceous, 20'.
   (5) Shale, dark grayish-green, micaceous, indurated; samples from lower 30' missing but logged by driller as similar to above, 60', depth 1470'.
   (6) Limestone (Fort Scott), gray to buff, coarsely crystalline to vesicular, cherty, glauconitic in lower part, some olive green and black shale and some sand, 20', depth 1490'.
2. Cherokee shale, 650':
   (1) Sandstone, gray, coarse-grained, calcareous, cherty, friable, and some green micaceous, sandy shale, 20'.
   (2) Shale, dark green, sandy, in part maroon, with some gray to buff dense limestone, 20', depth, 1530'.
   (3) Samples missing, 20'.
   (4) Sandstone, moderately coarse, angular, friable, with some chert fragments, 20', depth 1570'.
   (5) Shale, buff to black, in part green and gray, with some gray limestone, 10'.
   (6) Sandstone and shale: Sandstone, moderately coarse; shale, green, buff, maroon-mottled, argillaceous, 10', depth 1590'.

(7) Shale, green to dark green, massive, 10′.
(8) Sandstone and shale: Sandstone, green to gray, fine-grained to coarse, well cemented; some shale, drab to green, massive and some gray to buff, finely crystalline limestone, 20′, depth 1620′.
(9) Samples missing, 10′.
(10) Shale, maroon to brick red, faintly green-gray, mottled, massive, 20′.
(11) Coal (Bevier), shale and sandstone: Shale, black, carbonaceous, dense, in part gray-green; sandstone, gray, coarse-grained, calcareous, 10′, depth 1660′.
(12) Shale, deep green, sandy and grayish-green, dense, massive, 10′.
(13) Sandstone, coarsely angular to finely rounded and frosted, feldspathic, and some light green to dark gray shale, 20′, depth 1690′.
(14) Shale, greenish-gray, dark gray, in part maroon-mottled, 30′.
(15) Shale and sandstone: Shale, black, carbonaceous, massive; sandstone, moderately coarse-grained, friable, 10′, depth 1730′.
(16) Coal (Tebo) and shale, gray, plastic, 10′.
(17) Shale and sandstone: Shale, black, carbonaceous, platy; sandstone, gray, fine-grained, micaceous, well cemented, 60′, depth 1800′.
(18) Sandstone, gray, fine-grained, micaceous and some gray, soft, massive shale, 10′.
(19) Shale, gray, soft, massive, 20′, depth 1830′.
(20) Shale and sandstone: Shale, black, dense, platy, carbonaceous, in part gray and maroon; sandstone, gray, fine-grained, angular, friable to well-cemented, 30′, depth 1860′.
(21) Sandstone, gray, fine-grained in upper 20′, moderately coarse in the middle 90′, very coarse in lower 40′, subrounded to angular, generally friable, 150′, depth 2010′.
(22) Shale, gray and buff, mottled, granular, massive, 10′.
(23) Sandstone, iron-stained, moderately fine-grained, rounded to angular, friable, 10′, depth 2030′.
(24) Shale, light blue gray, argillaceous, slightly granular, massive, 30′.
(25) Shale and sandstone: Shale, black, massive, slightly micaceous; sandstone, gray, fine-grained, well-cemented, 20′, depth 2080′.
(26) Shale, black, slightly micaceous, bituminous and gray, massive, 10′.
(27) Shale, grayish-green, massive, 50′, depth 2140′.

DISCONFORMITY.....

II. MISSISSIPPIAN SYSTEM, 290′ or 330′(?):

1. Post-Kinderhook (probably Osage and some Meramec): Limestone, light gray, and chert, gray to white, opaque, 90′, depth 2230′.
2. Kinderhook group, 200′:
   (1) Shale, yellowish-gray, mottled, limonitic, soft, 10′.
   (2) Shale, light bluish-gray, argillaceous, soft, massive, 190′, depth 2430′.
3. Kinderhook or Devonian(?): Limestone, brown to dark brown, finely granular, dense, in part light gray and finely crystalline, with occasional thin beds of bluish-gray, flaky shale, 40′, depth 2470′.

III. DEVONIAN SYSTEM, 110′:

1. Limestone, buff and light gray, crystalline, dolomitic, with occasional thin beds of light green shale, iron-stained in lower part, 65′.
2. Limestone and dolomite, light gray, finely granular to crystalline, 20′.
3. Limestone and dolomite, as above, chert-bearing, 5′.
4. Limestone, light gray to white, granular, pyritic, 5′.
5. Limestone, gray, dense, dolomitic, 5′.
6. Shale, bluish-gray, calcareous, soft, 10′, depth of base, 2580′.

IV. SILURIAN SYSTEM (Niagaran), 470′:

1. Dolomite, buff to light gray, finely crystalline, massive, with some white chert near the top, 90′.

2. Dolomite, light gray, crystalline, massive, with a small amount of light green, pyritic shale, 30′.
3. Dolomite, light gray, crystalline, massive, sandy, and some light green shale, 40′, depth 2740′.
4. Dolomite, light gray, crystalline, massive, 70′.
5. Dolomite, buff to gray, crystalline, 70′, depth 2880′.
6. Dolomite, light gray, crystalline, with white chert between 2910′ and 2935′, 65′.
7. Dolomite, light gray, crystalline, sparkling, 5′.
8. Dolomite, light gray to buff, crystalline, 25′, depth 2975′.
9. Dolomite, light gray, crystalline, 33′.
10. Dolomite, light gray to buff to pink, crystalline, 27′.
11. Dolomite, light gray, siliceous, vesicular, with green and gray chert and a little dark red, bright green and black shale, 15′, depth 3050′.

V. ORDOVICIAN SYSTEM, 442′ or less:

1. Maquoketa shale, dark green, indurated, subconchoidal, platy to massive, 62′, depth 3112′.
2. Galena dolomite, 198′:
   (1) Dolomite, buff, crystalline, with some white chert, 13′.
   (2) Dolomite, buff to brown, coarsely crystalline, pyritic, white chert-bearing, and shale, grayish-green, granular, 40′.
   (3) Dolomite, buff to brown, coarsely crystalline and white, opaque chert, 35′, depth 3200′.
   (4) Dolomite, brownish-buff, crystalline, 7′.
   (5) Dolomite, brownish-buff, crystalline and white chert, 48′, depth 3255′.
   (6) Dolomite and chert, as above, with some red shale, 20′.
   (7) Dolomite, brown, coarsely crystalline, some chert, 35′, depth 3310′.
3. Decorah shale (may include higher and lower beds), some samples missing, 74′, depth 3384′.
4. Platteville limestone, 31′:
   (1) Limestone, gray to brown, finely crystalline to dense, 6′.
   (2) Shale and limestone: Shale, green, indurated, bedded, may be caving from above; limestone, gray to brown, fine-grained, 11′.
   (3) Limestone, dark gray, brownish-gray, light gray, dense to finely granular, 14′, depth 3415′.
5. Platteville limestone(?), Glenwood formation(?), 26′:
   (1) Shale, dark gray to green with some limestone, 13′.
   (2) Limestone, gray, granular, slightly dolomitic and shale, grayish-green, 2′.
   (3) Limestone, brownish-gray to light gray, crystalline, 11′, depth 3441′.
6. St. Peter sandstone and possibly older beds, 51′:
   (1) Sandstone, light gray, friable, rounded and frosted grains, 2′.
   (2) Dolomite, gray to brownish, granular to crystalline, 9′, depth 3452′.
   (3) Sandstone, 41′:
      a. Sandstone, light gray, subrounded to angular, in part frosted, moderately fine to coarse, friable, 25′.
      b. Sandstone, gray to buff, fine to medium-grained, subrounded to angular, pyritic, 13′.
      c. Sandstone, gray to buff, coarse-grained, subrounded, pyritic, glauconitic, 3′, depth 3492′.

DISCONFORMITY.....

VI. CAMBRIAN OR PRE-CAMBRIAN, 8′:

1. Red Clastics: Buff sandstone, red shale and glauconite, 6′.
2. Possibly granitic rock (driller reports lower part drilled like granite), 2′, total depth 3500′.

Reasons for Correlation. The top of the Des Moines series is herein placed 70 feet below the base of the Hertha limestone, at a black shale which is thought to be the equivalent of the Dawson coal horizon. This conforms with current, accepted usage based on the recent work of Dr. R. C. Moore, Mr. F. C. Greene, and others. Under the old grouping, the rocks between 1280 and 1370 feet would be classed as "Pleasanton". The writer believes that the upper 70 feet of this interval represents the Bourbon group of the Missouri series.

It is believed that the interval between 1370 and 1410 feet represents the Pawnee limestone and may include the Lexington coal horizon. The interval between 1470 and 1490 feet is thought to be the Fort Scott limestone.

The correlation of the individual members of the Cherokee group is uncertain because of the continental nature of much of the material and the great distance from the outcrop areas. It is suggested that (1) the interval between 1550 and 1570 feet may be equivalent to the "Squirrel" sand of Missouri, (2) the coals at 1650 and 1730 feet may be the Bevier and Tebo respectively, or the coal at 1650 feet may be the Tebo coal and that at 1730 feet may be a lower unnamed coal, (3) the sandstone between 1670 and 1690 feet may be equivalent to the Bartlesville sand as evidenced by its feldspar content.

The base of the Kinderhook group is placed at 2470 feet, although the lower 40 feet may be Devonian in age. In the Jeep well at Papillion, Nebraska, however, similar strata were classified as Kinderhook.

The rocks between 2470 and 2580 feet in the Morgan well are classified as probably Devonian, in harmony with the correlation of what may be these beds in Iowa.

The correlation of the Ordovician section is definite to the top of the St. Peter sandstone. The simplest interpretation is that all of the section between 3441 and 3492 feet is correlative with the St. Peter sandstone, overlying the Pre-Cambrian. There is, however, some possibility that the dolomites between 3443 and 3452 feet may be an eroded remnant of the Prairie du Chien and that the sandstone between 3452 and 3492 feet is Cambrian in age.

Samples from 3492 to 3500 feet (total depth), although yielding no cuttings of granite, showed material similar to that occurring immediately above granitic rocks in many places and generally classified as "Red Clastics".

A comparison of the pre-Pennsylvanian intervals in the Morgan well, the Davis well [1] at Forest City, Missouri, and the Clarinda well of Iowa [2]

[1] Biennial Rep. of State Geologist, Mo. Geol. Surv., 1935, pp. 10-15.
[2] Iowa Geol. Surv., Vol. XXXVI, 1935, pp. 399-419.

reveals several interesting facts. The presence of 323 feet of Prairie du Chien and 666 feet of Cambrian at Clarinda, and the absence of any correlative material in the Morgan well is evidence that the Morgan well vicinity was either a positive area during Cambrian and Prairie du Chien time or else was subjected to very extensive pre-St. Peter erosion. The post-St. Peter Ordovician is reported to be 437 feet thick at Clarinda, and we find it to be 392 feet at the Morgan well. About 454 feet of Silurian was drilled at Clarinda and 470 feet at the Morgan well.

The site of the Morgan well was nearer to the center of the basin during Devonian and Kinderhook time than either the Forest City well or the Clarinda, Iowa, well. The thickness of the Devonian is reported to be 85 feet at Clarinda, 93 feet at Forest City, and 110 feet at the Morgan well. The Morgan well drilled 40 feet of lower Kinderhook(?) or Devonian(?) beds, apparently not present in the Forest City and Clarinda wells. The Kinderhook shale interval is reported as 91 feet at Clarinda, 127 feet at Forest City, and 200 feet at the Morgan well. The post-Kinderhook Mississippian is 90 feet at the Morgan well, 292 feet at Forest City, Missouri (the Missouri Survey places the lower 93 feet of this interval with the Kinderhook), and 406 feet at Clarinda. The westward thinning of the post-Kinderhook may be largely due to late Mississippian or early Pennsylvanian erosion.

The Cherokee in the Morgan well furnishes the earliest evidence of a source of clastic sediments from the west, probably from the upfaulted Nemaha mountains. However, this sediment does not include coarse feldspathic material as would be expected, yet the Cherokee section in the well is decidedly coarser in texture than equivalent beds at Forest City, although there is evidence that Cherokee deposition started earlier at Forest City with progressive overlap westward.

REVIEW AND DISCUSSION

In closing this paper, a brief statement is made regarding the origin of the stratigraphic and structural features of the area and their probable economic relations.

Persistence of Beds. That there is a marked persistence in the character and thickness of the units of the Pennsylvanian in this and adjacent areas is revealed by the measurements of the exposed formations at widely separated places in Kansas, Missouri, Iowa, and Nebraska, and by a comparison of the logs of wells in these states. The same is true of the Permian strata in Kansas and Nebraska.

It is observed, in this area, that some of the Pennsylvanian and Permian formations and members vary in thickness from place to place, and that most of these variations are compensated by corresponding increase and

decrease in the thickness of associated beds, making the measurements in the aggregate quite uniform, except at the borders of basins and where there are disconformities.

Again, the thickness of the Mississippian, Devonian, and Silurian rocks of this general area is more uniform than was expected, and the deepest wells show this to be true also of the Ordovician. This condition is shown by Figure 1, which is drawn to scale from surface and subsurface data.

The striking feature of the traverse is the uniform persistence of the older Paleozoic rocks westward to the Humboldt fault. This condition was not expected when the Morgan well was started, for it was then believed that granite would be reached in this hole at a comparatively shallow depth.

Origin of Structural Features. Our cross-section shows some problematic features relating to the age and development of the Humboldt fault, and the origin of the granite ridge and the Table Rock arch. Apparently, the Humboldt fault marks a line of recurring displacement associated with folding. Its maximum throw is located between points south of Seneca, Kansas, and southeast of DuBois, Nebraska, which course is at the high point on the granite ridge. The geologic dating of the inception of these deformations is not certain, yet it is believed that the deformations are along a line of ancient diastrophic weakness.

Without much doubt the older Paleozoic rocks were laid down across the belt now occupied by the Table Rock arch. This conclusion is evidenced by their recurrence in regular succession in both flanks of the narrow arch, and by the further fact that they cross the arch where the granite ridge is low. As against this view, it may be claimed that the high "monadnock-like" part of the granite ridge was never covered by these older Paleozoic rocks except against its slopes. Such view cannot be supported, because, if this condition had obtained, the beds in the Forest City basin would not have held their uniform thickness to and against a bold granite upland during their long periods of deposition without receiving coarse sediment from the granite highland. Since there is no evidence that coarse crystalline rock debris occurs in the older formations penetrated in the Morgan well, and since the theory of an abrupt highland with non-deposition seems not tenable, we are forced to the conclusion that the high position of the granite ridge in the eastern part of the Table Rock arch is due primarily to faulting with up-throw on the west.

The Humboldt fault in this area is shown in Figure 1 as one displacement with an eastward dip. However, it is not certain that the fracture may not be along more than one line and that the "drag" of the deep-seated beds may not be more or less than is represented in the section. The interpretation of the conditions is about the same as that made by

Betty Kellett and others in their admirable cross-section made of this fault in Kansas and published in the report of the Kansas Geological Society in 1932.

It seems that the older Paleozoic rocks were deposited in the area now occupied by the Table Rock arch, that their deposition was interrupted by periods of erosion, and that their aggregate thickness of accumulation here was somewhat less than in the Forest City basin. Following the deposition of the older Paleozoic rocks, the land probably was deformed upward and eroded down to the granite ridge. The deformation by faulting and folding occurred during late Mississippian or just prior to Cherokee time, following which the Pennsylvanian sediments were deposited generally on the eroded Mississippian and locally on the granite.

There is a thin remnant of the Des Moines beds on the crest of the granite ridge, yet these rocks may have been quite thick in this area prior to their erosion and the deposition of the younger Pennsylvanian sediments. This conclusion is based on the log of the DuBois well.

The Missouri, Virgil, and probably the Big Blue series were deposited somewhat thinner in the area known as the Table Rock arch than they were in the Forest City basin. Finally, the latest stage of deformation here was enacted by faulting and folding, which involved all of the geologic section. Its effects are shown in the present attitude of the exposed strata of the Virgil and Big Blue series, through which there has been erosion locally on the axis of the arch down to the base of the Topeka formation.

Boundaries of Rock Systems. The age of the beds lying below those classed as the St. Peter sandstone has not been determined beyond dispute. They may represent developments of the St. Peter and the Prairie du Chien, or they may be wholly St. Peter, Prairie du Chien or Cambrian. A comparison of the section here with those of the wells farther north in Nebraska leads to the conclusion that the lower strata in question may be in part of Cambrian age, yet there may be some error in our older correlations.

The lithologic and faunal study that has been made of the cuttings from the St. Peter in the Morgan well shows that this horizon is at or near the so-called upper Wilcox of Kansas and Oklahoma. This is the depth at which there was a showing of oil.

Just where to place the Devonian-Silurian boundary in the general section is a problem. The heavy dolomites, thickness about 470 feet, are plainly Niagaran. This leaves about 110 feet of sediments between the Niagara and the Kinderhook as probable Devonian. A communication received from Mr. Frank Green states that Dr. H. S. McQueen of the Missouri Survey correlates about 93 feet of Devonian in the Davis well, near Forest City, with the base at a depth of 2134½ feet. We provisionally

correlate 110 feet of sediments at this horizon in the Morgan well as Devonian. We also concur quite closely with the Missouri and Kansas surveys regarding the boundaries and thickness of the Marmaton and Bourbon groups.

Regarding the age of the so-called Pre-Cambrian rocks in the Forest City basin, where crossed by our traverse, the condition represented by Figure 1 is not well proved, and the clastic materials reached in the Morgan well may not be immediately on primary granite. This inference is supported by the logs of wells in southwestern Iowa (Clarinda) and by wells at or near Nehawka, Lincoln, and Papillion, Nebraska. On the contrary, however, many deep holes in the adjacent areas of Kansas are thought to have reached primary granite, classed as Pre-Cambrian, and the Cambrian sands and the Sioux formation, which occur at Lincoln, Omaha, and Papillion may not reach southward to this traverse. At any rate, it will require much additional subsurface investigation to decide with certainty just what age or ages of rocks lie below the clastic materials that were reached in the Morgan well.

Contour of Forest City basin. The base of the Cherokee, which marks the bottom of the Forest City basin, is about 754 feet below sea level in the Davis well and 1100 feet below in the Morgan well, a difference of about 346 feet. Its base is 461 feet above sea level in the DuBois well, i.e., about 1561 feet higher than in the Morgan well. This means that the deepest known part of the basin is farther west than was formerly supposed, i.e., near the Humboldt fault.

Although the deepest part of the basin lies near the fault line, the oldest Cherokee sediments yet found in this area are thought to lie beneath Forest City and perhaps westward to the border of Nebraska. This conclusion is based on a comparison of the sections of the Cherokee in the Morgan and Davis wells, which shows that the basal sediments of the group in the first named well rest upon older sediments of the group in the Davis well. Evidently the contour of the Forest City basin has shifted considerably since the basal Cherokee was deposited.

Oil and Gas Possibilities. The conditions shown by our traverse raise the question of the oil and gas possibilities in southeastern Nebraska. It is observed that the geologic section here contains many formations that extend through the oil regions of Kansas and Oklahoma, that the Cherokee sands are quite thick, that a deeper sand horizon, i.e., the St. Peter sandstone, which is at or near the horizon of the so-called Wilcox sand of Kansas and Oklahoma, has made a showing of oil, and that there are small closed structures in the Forest City basin not far east of the Humboldt fault.

Some geologists hold the opinion that faulting has released all oil and gas that may have originated in this region, whereas, others maintain that oil and gas may be trapped in deep granite wash and in the upturned beds just east of the fault. However, it is not certain that there is an accumulation of granite wash at a deeper level, and it cannot be safely concluded that the structural conditions favor the accumulation of oil immediately east of the fault line. Geologists are not agreed on this question.

Apparently, the crest of the Table Rock arch is now quite generally condemned for oil and gas, but there may be some chance for discovery in the small, closed structures in the basins bordering this arch. One of these apparently favorable structures lies northwest of the Morgan well. It was mapped by C. E. Busby of the Nebraska Geological Survey, and was recently checked by Eugene Reed and the author. This structure has been leased and probably will be drilled within a year. If production is found here, the other small structures in the area should be tested and no doubt "wild-catting" would be done in the flanks of the Table Rock arch.

Coal Beds. There are several thin coal beds in the area of this traverse, shown by outcrops and well logs. The Lorton, Nyman, Elmo, and Nodaway coals are exposed at places. Of these, the Lorton is too thin for mining, and the same may be said of the Nyman bed from which there was some output years ago near Pawnee, Elk Creek, and Tecumseh.

The Elmo coal has been mined in the bluffs below the mouth of the Big Nemaha, at the foot of the upland south of Rulo, and in the Missouri River bluffs north of Rulo. The Nodaway has been mined at places in the Table Rock arch, south and southeast of DuBois. It has been a source of considerable production near Clarinda and New Market, Iowa, and at various places in northwestern Missouri. No doubt, this coal underlies the southeastern part of Richardson County at a depth of about 140 feet below the Elmo bed where it probably is too deep and too thin for economic working.

Thin coals known as the Lexington, Summit, Bedford, Bevier, Tebo, and others occur in the Marmaton and Cherokee groups in southwestern Iowa and western Missouri. Some of them, the thickest being the Bevier and the Tebo, underlie southeastern Nebraska, but they are too deep and too thin for mining.

Bed Rock Water. The ground water of this area occurs principally in the mantle rock, but there is scant accumulation in some of the limestone bedrock. Although the deep wells penetrate considerable sand in the Marmaton and Cherokee groups, these sands seem to carry little water. Salt water was encountered in the Morgan well at a depth of about 3474 feet and strong brine at about 3490 feet.

Acknowledgements. The writer acknowledges assistance received from his associates in the preparation of this paper. C. E. Busby's detailed survey of the area has furnished valuable information. The log of the Morgan well made by A. L. Hornady, Jerry E. Upp, and Eugene Reed has been used. Mr. Eugene Reed assisted in the compilation of data, and Mr. R. R. Bennett prepared Figure 1. Miss Grace Wilmarth of the United States Geological Survey passed upon the names that are applied to the new subgroups and to the members of the Falls City and Burlingame formations.