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## Deep Wells at Lincoln, Nebraska


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# Deep Wells at Lincoln Nebraska

*G. E. Condra and E. C. Reed*



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OF NEBRASKA  
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DEEP WELLS AT LINCOLN, NEBRASKA

BY

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AND

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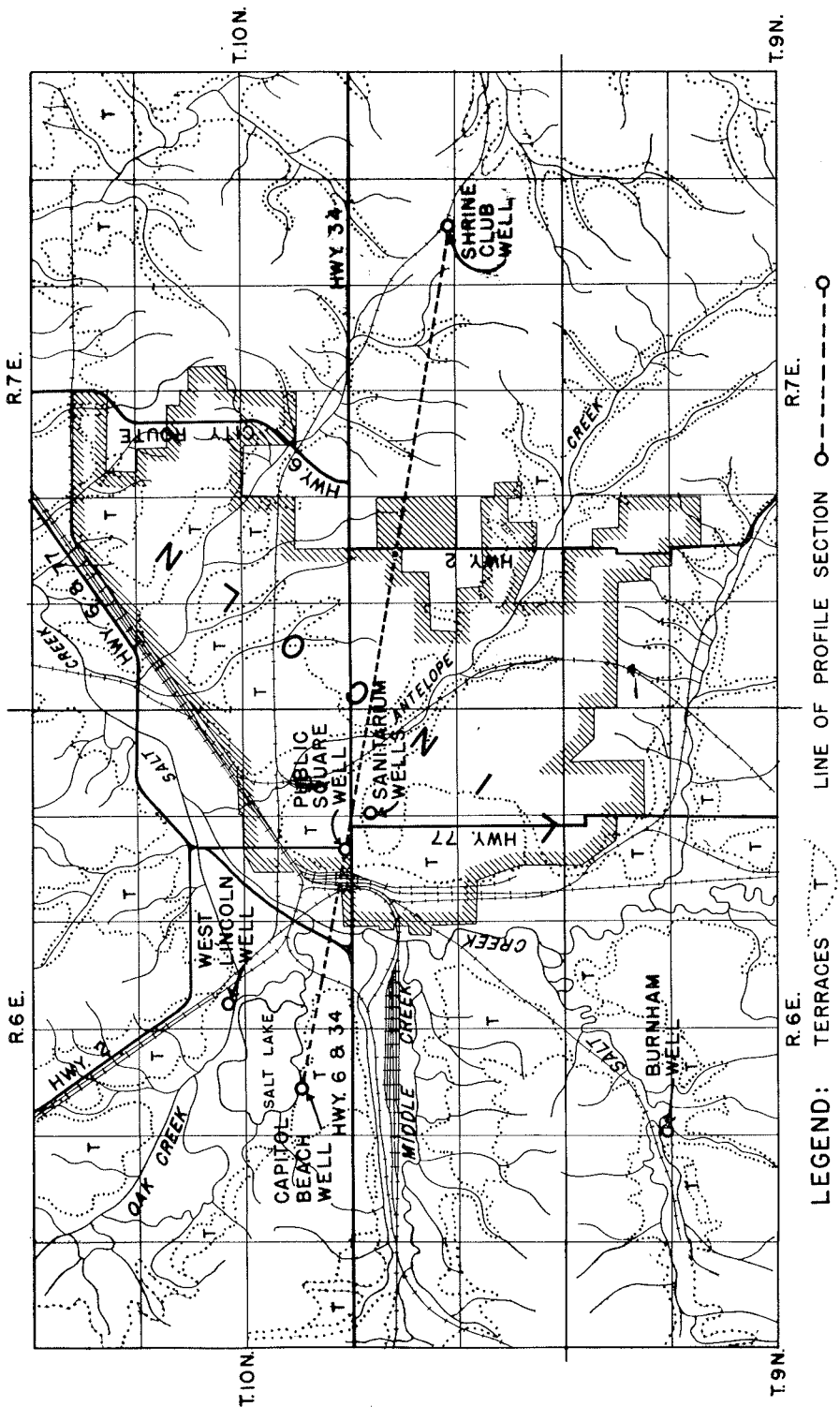


Fig. 1.—Index map, showing location of deep wells drilled in Lincoln and vicinity.

# Deep Wells at Lincoln, Nebraska

G. E. CONDRA AND E. C. REED\*

SEVEN comparatively deep drillings have been made at or near Lincoln. They are known as the Capitol Beach, West Lincoln, Public Square, Shrine Club, Burnham and two Sanitarium wells, fig 1. Most of them were drilled 40 years ago or more, prior to the legislative enactment which requires the State Geological Survey to secure and preserve the cuttings, cores, and logs of deep wells drilled in Nebraska. Consequently, we do not have complete geological data on all of the wells, but the information gathered from various sources is sufficient for the logging and correlation of three of them and for the general description of the others.

In our logging of these wells, the thickness of every natural subdivision, the elevation above sea level of the top of the main formations, and groups, and the depth to base are given (in feet and tenths of feet) because of the importance of such data in stratigraphic and structural study. The altitudes (elevations) are referred to mean sea level.

## CAPITOL BEACH WELL

The Capitol Beach well is located on lowland about two miles west of Lincoln, on the south shore of Capitol (Burlington) Beach, near the northeast corner of the southwest quarter of sec. 21, T 10 N, R 6 E. It was drilled on state-owned saline lands, with state funds, and completed in 1887. Its depth is 2463 feet and the elevation of the curb is about 1160 feet. Mr. B. P. Russell was geologist in charge of the drilling, which consisted of jetting to 205 feet and core-drilling from this depth to the bottom. A 4-inch core was taken from 205 to 365 feet, and below 365 feet the diameter of the core is 2 inches. Nine-inch casing was car-

ried to 49 feet, 7-inch casing to 205 feet, 5-inch casing to 269 feet and 4-inch casing to 365 feet, which was later under-reamed to 1113 feet.

The core of this well was stored at the statehouse and later deposited in the University Museum but not made available for study until 1939, when it was obtained through the efforts of Stanley D. Long, retiring president of the Board of Regents. We now have the core in quite good condition.

The Capitol Beach well was allowed to discharge its brine to surface drainage and later to the lake for a period of about fifty years until it was plugged in 1937. There is no surface flow from it at this time.

Mr. Russell's report on the well was published in the Sixth Biennial Report of the Commissioner of Public Lands and Buildings, December 1, 1888 (see pages 57-84 of report). It is quite accurate and gives a general description of the rocks drilled, the history of drilling, and the depths of the salt water zones, but does not correlate the formations further than to refer them to major age subdivisions.

Dr. N. H. Darton, Dr. E. H. Barbour, and other geologists have described the Capitol Beach well in various publications, but without making detailed correlation of the formations. Dr. Darton's (1898)<sup>1</sup> correlation of the major geologic subdivisions of this well is about as follows:

Recent Cretaceous, 0-269.1 feet  
Carboniferous, 269.1-1099.1 feet  
Age unknown, 1099.1-1813.2 feet  
Trenton (?), 1813.2-1947.5 feet  
St. Peter sandstone, 1947.5-2008 feet  
Lower Magnesian limestone, 2008-2121.1 feet  
Potsdam red sandstone, 2121.1-2192.7 feet  
Sioux quartzite, 2192.7-2463 feet

The senior author studied Mr. Russell's report on the Capitol Beach well and published a general correlation of same (Condra 1927), and with others restated his cor-

\* The writers gratefully acknowledge the assistance received from the persons who have contributed to our knowledge of this area's geology and furnished information in regard to the records and history of the wells drilled near Lincoln. Mr. O. J. Scherer drafted the figures, and, with the assistance of Mr. Robert Lawrence, measured the elevations of the curbs of most of the wells.

<sup>1</sup> Dates refer to Bibliography, p. 25.

relation in greater detail four years later (Condra *et al.* 1931). Revision of the correlation of 1931 is now necessary, however, in order to conform to changes which have been made in regional classification and be-

cause of the junior author's recent study of the core which affords valuable new data. The following correlation of the well is now made with considerable certainty.

#### CORRELATION OF CAPITOL BEACH WELL

QUATERNARY SYSTEM (Recent and Pleistocene), thickness 57':<sup>2</sup>

Soil (sandy loam), 4'.

Sand, gray, medium to medium coarse grained, subrounded to subangular and abraded. 16'.

Sand, as above, but coarse grained, with feldspar and limestone pebbles, 4.7'.

Sand, coarse, and gravel with pebbles of feldspar, chert, and schist, 23.6'.

Sand, salt and pepper gray, medium coarse, 3.7'.

Gravel and sand, variable composition, silty, 5', depth 57'.

UNCONFORMITY: Upper and middle formations of the Dakota group removed by erosion.

CRETACEOUS SYSTEM (Lakota formation), 149.3', elevation 1103':

Sandstone, yellowish gray, medium coarse, subangular to subrounded, predominantly quartz, friable, 17'.

Sandstone, as above, even grained, light gray to yellowish, 26'.

Sandstone, yellowish gray, friable, with some gravel (cave?), 12.5', depth 112.5'.

Sample missing, reported as white sand with much gravel (probably friable sandstone with gravel cave), 21.2'.

Sandstone, light gray to yellowish, medium fine grained, slightly pyritic, friable, 1.3'.

Sandstone, ochre yellow, medium coarse, friable, with some ochre silt, 12.7'.

Sand and gravel (cave?), with common limonitic ironstone, 16.7'.

Sandstone, yellowish gray, medium coarse, subangular, friable, 15.3'.

Sandstone, light gray, medium to coarse grained, subangular to rounded, friable, 15.3'.

Sandstone, as above, coarse grained to pebbly, with strong brine (salimeter test 35-40°), 10'.

As above, with common limestone pebbles, in part deeply weathered (reported to be a conglomerate), 1.3', depth 206.3'.

UNCONFORMITY: Jurassic, Triassic, and Permian missing due in part to non-deposition and in part to erosion after deposition.

CARBONIFEROUS SYSTEM, 890.7', elevation 953.7':

Upper Carboniferous (Upper Pennsylvanian) series, 754.8':

Virgil subseries, 503.7':

Wabausee group, 256.5':

Richardson subgroup, 71.5' (not including Table Creek shale):

Friedrich-Dry formations, 66.9':

Sandstone, pepper and salt gray, fine grained, subangular, friable, 2.5'.

Clay shale, brownish pink and varicolored, silty, .5'.

Siltstone, light gray to white, slightly calcareous, friable, 4.8', depth 214.2'.

Sandstone, brownish gray, fine grained, subangular, ferruginous, friable, 30.2'.

Sandstone, medium gray to brownish to pinkish, fine grained, argillaceous, finely micaceous, noncalcareous, with some carbonaceous areas, 3.3'.

<sup>2</sup> The system of notation for the geological sections presented in this paper is as follows:

SYSTEM:

Series:

Subseries:

Group:

Subgroup:

Formation:

Member:

Zone.



- Sample missing, reported as sandstone, reddish, fine grained, friable, 19.4'.  
 Sandstone, medium gray to brownish, slightly argillaceous, fine grained, moderately micaceous, noncalcareous, friable, 2', depth 269.1'.  
 Ironstone, red, indurated, fine grained, silty, pyritic, grading downward to calcareous siltstone, .7'.  
 Shale, bluish gray to reddish, silty, calcareous, with fragmentary fossils, 3.5', depth 273.2'.  
 Dover formation, limestone, light gray, finely granular, fossiliferous, with crinoid joints, *Ambocoelia*, *Dictyoclostus*, etc., 4.6', elevation 886.8', depth 277.8'.  
 Nemaha subgroup, 102.7', elevation 882.2':  
 Table Creek-Willard formations, 34.5':  
 Shale-siltstone, medium gray to brownish, finely micaceous, noncalcareous, laminated, .8'.  
 Sandstone, light and dark gray speckled, medium grained, subangular, micaceous, calcareous, moderately friable, .8'.  
 Sandstone, brownish gray, fine to medium grained, subangular, argillaceous, friable, 21.7', depth 301.1'.  
 Shale, medium dark gray, argillaceous to slightly silty, finely micaceous, bedded to laminated, 11.2', depth 312.3'.  
 NOTE: The Table Creek formation is measured with the Nemaha subgroup as above because the Tarkio limestone which occurs at the top of this group at most places seems to be missing here, leaving no marked boundary between the Nemaha and Richardson subgroups.  
 Elmont-Reading formations, limestone, light gray, slightly argillaceous, granular with finely crystalline areas, fossiliferous, with chonetids, spines, crinoid joints, etc, 11', elevation 847.7', depth 323.3'.  
 Auburn formation, 29':  
 Shale, light green-gray, silty, finely micaceous, calcareous, massive, 4.5'.  
 Shale, bluish gray to dark gray, very calcareous, with abundant crinoid joints and some brachiopods, 7'.  
 Shale, light greenish, argillaceous to silty, noncalcareous, massive, 1', depth 335.8'.  
 Sandstone, medium light gray speckled, medium grained, subangular, very micaceous, calcareous, 8.8', depth 344.6'.  
 Shale, dark gray, argillaceous, moderately calcareous, bedded, fossiliferous, with spines, crinoid joints and brachiopods, 7.7', depth 352.3'.  
 Wakarusa formation, limestone, medium light gray with dark carbonaceous splotches, granular, fossiliferous, with crinoid joints and brachiopods, grades to blue-gray and dark mottled, calcareous shale, 7.5', elevation 807.7', depth 359.8'.  
 Soldier Creek formation, 14.7':  
 Siltstone, brownish red, finely micaceous, massive, indurated, above and shale, light green-gray, silty, massive, with nodular, limy material below, 2.4'.  
 Siltstone, medium gray to yellowish to reddish, very calcareous, platy, thin bedded, 2.8', depth 365'.  
 Shale, dark gray, argillaceous, calcareous, carbonaceous, finely micaceous, bedded, 9.5', depth 374.5'.  
 Burlingame formation, limestone, finely to moderately crystalline, in part granular, fossiliferous, with crinoid joints and some gastropods, 6', elevation 785.5', depth 380.5'.  
 Sac-Fox subgroup, 82.3':  
 Silver Lake-White Cloud formations, 69.2':  
 Shale, bluish gray, calcareous, massive, fossiliferous, with some crinoid joints, etc., 3.3'.  
 Shale, dark gray to black, fissile, with fragmentary fossils and ostracods (*Geisina* sp.); some blue-gray shale; may be at horizon of Elmo coal, 2', depth 385.8'.  
 Shale, light green-gray to blue-gray, calcareous, massive, slightly fossiliferous, 6.2', depth 392'.  
 Shale, deep red, silty, indurated, noncalcareous, massive, 10', depth 402'.  
 Shale, blue-gray to medium dark gray, argillaceous, finely micaceous, slightly calcareous, fossiliferous, with rhombops, *Ambocoelia*, chonetids, pectinoids, 47.7', depth 449.7'.

- Howard formation, limestone, light gray, finely crystalline, dense, fossiliferous, with some secondary calcite, some geodes, 5.1', elevation 710.3', depth 454.8'.
- Severy formation, shale, bluish gray, finely micaceous, calcareous, silty, fossiliferous, with *Ambocobelia* casts, 8', depth 462.8'.
- Shawnee group, 198', elevation 697.2':
- Topeka-Deer Creek formation, 42.1':
- Coal Creek limestone, sample missing, reported as limestone, fine grained, dense, in part silty, crinoidal, 4', depth 466.8'.
  - Holt shale, in part blue-gray, slightly calcareous, with some fossil casts, in part black and carbonaceous, 1.8', depth 468.6'.
  - Du Bois limestone, medium gray and dark gray mottled, silty, 1.2', depth 469.8'.
  - Turner Creek-Jones Point members, 10.1', depth 479.9':
    - Siltstone-sandstone, medium light gray, calcareous, micaceous, laminated to massive, 1.5'.
    - Shale, blue-gray, silty, finely micaceous, slightly calcareous, thin bedded, 8.6', depth 479.9'.  - Lower Topeka-Deer Creek formations, sample missing, reported as limestone, white, dense, fossiliferous, with fusulines, etc., 25', elevation 680.1', depth 504.9'.
- Tecumseh formation, sandstone, pinkish red to brownish gray, fine grained, micaceous, moderately friable, 39.8', depth 544.7'.
- Lecompton-Oread formations, 116.2', elevation 615.3':
- Ost-Avoca limestone, light gray to white, finely granular, irregular, streaked with red shale 10', depth 554.7'.
  - King Hill shale, maroon, argillaceous to silty, slightly calcareous, massive to nodular, 10.3', depth 565'.
  - Beil limestone, medium gray with dark gray shaly streaks, argillaceous, granular, fossiliferous, with crinoid joints, fusulines, etc., 8.5', elevation 595', depth 573.5'.
  - Queen Hill shale, light green-gray, silty, calcareous, massive, in part dark brown and bedded, 5', depth 578.5'.
  - Big Springs-Plattsmouth limestone, light gray, finely crystalline, stylolitic, in part finely granular with dark shaly streaks, in part pseudo-oolitic, fossiliferous, with fusulines, etc., lower part slightly dolomitic and very cavernous (reported to contain 1.7' of reddish sandstone at 600.5'), with an artesian flow of weak brine (salimeter test 12-14°) at 600', thickness 50.2', elevation 581.5', depth 628.7'.
  - Heebner shale, black and dark gray, speckled, carbonaceous, very fissile, 4', depth 632.7'.
  - Leavenworth limestone, reported as a common limestone, containing some iron pyrite, 1.6', elevation 527.3', depth 634.3'.
- Snyderville shale, 17':
- Shale, green-gray, argillaceous to silty, calcareous, massive, 8', depth 642.3'.
  - Shale, red to maroon, argillaceous to silty, calcareous, massive, 9', depth 651.3'.
- Weeping Water limestone, medium light gray, finely granular and argillaceous to crystalline, irregular, fossiliferous, with crinoid joints and brachiopods, in part chalcidized, 9.5', elevation 508.7', depth 660.8'.
- Douglas group, 37.1', elevation 499.2':
- Lawrence-Stranger formations, 37.1':
- Shale, red, argillaceous to silty, finely micaceous, calcareous, massive, 13', depth 673.8'.
  - Siltstone, purplish, reddish and yellowish streaked, calcareous, granular, massive, 5.3', depth 679.1'.
  - Shale, blue-gray, argillaceous, slightly calcareous, laminated, with some sandy laminae, may include an erosional cutout, 2.3', depth 681.4'.
- Cass limestone, 16.5', elevation 478.6':
- Limestone, light gray to white, finely crystalline, stylolitic, with common fusulines, 14', depth 695.4'.
  - Shale, black and dark gray speckled, carbonaceous, fissile, 1.5', depth 696.9'.
  - Limestone, medium dark gray, finely granular to finely crystalline, slightly to moderately argillaceous, crinoidal, 1', depth 697.9'.

- Douglas-Pedee groups, with erosional cutouts in upper portion, 12.2':  
Shale, light blue-gray to greenish, argillaceous and calcareous, massive, 3.3', depth 701.2'.  
Shale, deep red to purple, argillaceous and calcareous, massive, nodular, with some green-gray shale, 8.9', depth 710.1'.
- Missouri subseries, 251.1', elevation 449.9':  
Lansing group, 65.7':  
Stanton formation, 48.7':  
South Bend limestone, medium dark gray, finely granular, argillaceous, fossiliferous, with *Ambocoelia*, etc., 12.2', depth 722.3'.  
Rock Lake shale, green-gray and maroon, argillaceous to calcareous, massive, with limy areas, 3.8', depth 726.1'.  
Stoner-Captain Creek limestone, medium light gray, finely granular, dense, fossiliferous, with chonetids, and other brachiopods, 32.7', elevation 433.9', depth 758.8'.  
Vilas formation, samples missing, reported as shale, dark, calcareous, with some bands of impure limestone, 1.3', depth 760.1'.  
Plattsburg formation, 15.8', elevation 399.1':  
Limestone light gray to white, oolitic, crystalline, with *Osagia* and some fusulines, 3.6', depth 763.7'.  
Chert, medium gray, conchoidal, fossiliferous, with brachiopod spines and *Osagia*, .3', depth 764'.  
Limestone-siltstone, medium gray and reddish mottled, finely granular, nodular, 11.8', depth 775.8'.
- Kansas City group, 118.8', elevation 384.2':  
Bonner Springs formation, samples missing, reported as slightly calcareous, clay shale, 10.4', depth 786.2'.  
Wyandotte formation, limestone, medium dark gray, finely crystalline to finely granular, crinoidal, with dark gray, argillaceous streaks, 17.5', elevation 373.8', depth 803.7'.  
Lane-Chanute formations, 16.5':  
Shale, dark gray, calcareous, fossiliferous, with crinoid joints and rhombops, grades to an argillaceous limestone (may represent the Lane shale and Raytown limestone), 1', depth 804.7'.  
Shale, black and dark gray speckled, carbonaceous, fissile (probably Muncie Creek), 1', depth 805.7'.  
Shale, blue-gray, calcareous, massive to bedded, reported to have bands of shaly limestone (may include Raytown limestone at top), 13', depth 818.7'.  
Shale, red with green mottling, argillaceous, slightly calcareous, massive, 1.5', depth 820.2'.  
Drum formation, 15.5', elevation, 339.8':  
Limestone, light gray to white, finely crystalline to finely granular, in part thin bedded, with an artesian flow of weak brine at about 828' (salimeter test of combined flows 16-18°), 12.5', depth 832.7'.  
Limestone, medium light gray, finely crystalline, fossiliferous, with spines, crinoid joints, etc., 3', depth 835.7'.  
Quivira formation, 6.2':  
Shale, black, carbonaceous, argillaceous, fissile, with carbonized plant remains, 4', depth 839.7'.  
Shale, greenish gray, silty, finely micaceous, massive, 2.2', depth 841.9'.  
Westerville formation, 38', elevation 318.1':  
Samples missing, reported as limestone, white, in part shaly, 9.5', depth 851.4'.  
Shale, bluish gray to dark, calcareous, and limestone, medium gray, slightly argillaceous, lithographic, 10.1', depth 861.5'.  
Shale, green-gray and maroon (?), in part calcareous and nodular, massive, 5', depth 866.5'.  
Sample missing, reported as limestone, with fragmentary fossils, in part argillaceous and pyritic, 13.3', depth 879.8'.  
Cherryvale formation, 14.8', elevation 280.2':  
Shale, black, carbonaceous, fissile, 7', depth 886.8'.

- Sample missing, reported as slate shale, with nodular, calcareous material, 7.8', depth 894.6'.
- Bronson group, 57.6', elevation 265.4':
- Dennis formation, 32':
- Winterset limestone, 21.5':
- Limestone, light gray, finely crystalline, with dark, granular, argillaceous areas, crinoidal, 6', depth 900.6'.
- Limestone, gray to tan with dark gray areas, finely crystalline to lithographic, pyritic, 10', depth 910.6'.
- Limestone, medium dark gray, finely granular to crystalline, crinoidal, grades to very calcareous dark shale, 5.5', depth 916.1'.
- Stark shale, 6.5':
- Shale, black, fissile, with carbonized plant remains, 2.5', depth 918.6'.
- Sample missing, reported as slate shale and shaly limestone, with fragmentary fossils, 4', depth 922.6'.
- Canville limestone, light gray, finely crystalline, with shaly areas, pyritic, fossiliferous, 4', elevation 237.4', depth 926.6'.
- Galesburg formation, shale, light gray to greenish, granular to finely micaceous, silty, calcareous, with rare productids and rhombops, 3', elevation 233.4', depth 929.6'.
- Swope (Bethany Falls) formation, limestone, light gray to white, finely granular, with some chalcedonized crinoid joints and spines, 10.8', elevation 230.4', depth 940.4'.
- Ladore formation, probably includes Hushpuckney shale of the Swope formation, 5.5', elevation 219.6':
- Shale, dark gray, argillaceous, slightly calcareous, in part black and carbonaceous, with fragmentary fossils, 1.7', depth 942.1'.
- Coal, black, woody, .3', depth 942.4'.
- Reported as carbonaceous shale, 3.5', depth 945.9'.
- Hertha formation, limestone, medium gray and medium dark gray, finely crystalline, pyritic, in part brecciated, 6.2', elevation 214.1', depth 952.2'.
- Bourbon group, 9', elevation 207.8':
- Shale, blue-gray, argillaceous, pyritic, massive, 1.8', depth 954'.
- Siltstone-sandstone, brick red, micaceous, massive, 7.2', depth 961.2'.
- UNCONFORMITY: Upper beds of the Marmaton group missing.
- Middle Carboniferous series (Des Moines subseries), 115.2', elevation 198.8':
- Marmaton group, 86.4':
- Bandera formation (?), 15.7':
- Reported as shaly limestone, 1', depth 962.2'.
- Reported as shale, dark gray, slightly calcareous, 5', depth 967.2'.
- Shale, greenish gray, calcareous, massive, with *Ambocoelia* and crinoid joints, grading to argillaceous limestone, 9.7', depth 976.9'.
- Pawnee formation (?), 29.4', elevation 183.1':
- Limestone, light gray, finely crystalline, with fusulines, and shale, green-gray, very calcareous, fossiliferous, with *Ambocoelia*, etc., 15.8', depth 992.7'.
- Shale, light green-gray to yellowish, argillaceous and calcareous, massive to bedded, with small limy concretions, 2', depth 994.7'.
- Limestone, light gray to light green-gray, argillaceous, in part with *Osagia* and fragmentary fossils, .5', depth 995.2'.
- Shale, light blue-gray to yellowish, argillaceous and calcareous, massive, in part light gray, granular limestone, 7.1', depth 1002.3'.
- Calcareous shale and argillaceous limestone, as above, 4', depth 1006.3'.
- Labette formation (?), 20.1', elevation 153.7':
- Sample missing, reported as sandstone, red, fine grained, argillaceous, 11', depth 1017.3'.
- Sample missing, reported as dark shale, 2.4', depth 1019.7'.
- Limestone, light gray, granular to coarsely crystalline, grades to shale, blue-gray to yellowish, calcareous, finely micaceous, .9', depth 1020.6'.
- Shale, blue-gray to yellowish, finely micaceous, calcareous, massive, 2.2', depth 1022.8'.
- Sample missing, reported as shaly limestone, 1.3', depth 1024.1'.
- Sample missing, reported as red shale, 2.3', depth 1026.4'.

Fort Scott formation (?), 21.2', elevation 133.6':

Sample missing, reported as soft, shaly limestone, 10', depth 1036.4'.

Sample missing, reported as dark shale, 7.3', depth 1043.7'.

Limestone, light gray, crystalline to granular, grades to calcareous shale, 3.9', depth 1047.6'.

Cherokee group, 28.8', elevation 112.4':

Reported as red shale, sample shows blue-gray, calcareous, massive shale, 4.6', depth 1052.2'.

Sample missing, reported as sandy limestone, 3.1', depth 1055.3'.

Sample missing, reported as sandstone, gray, fine grained, 3.5', depth 1058.8'.

Sandstone, brownish red to yellowish, fine to medium grained, subangular, micaceous, argillaceous, 10', depth 1068.8'.

Dolomite, light gray, crystalline, vesicular, porous (may be out of place), 2', depth 1070.8'.

Shale, red, yellowish, and gray, with intermixed dolomitic sand and dolomite pebbles, 5.6', depth 1076.4'.

UNCONFORMITY: Lower part of Middle Carboniferous and most of Lower Carboniferous missing, due to non-deposition and erosion.

Lower Carboniferous (Mississippian) subseries, 20.7', elevation 83.6':

Dolomite, light gray to white, finely crystalline, sparkling, vesicular, porous, 19.7', depth 1096.1'.

Sample missing, reported as red shale, 1', depth 1097.1'.

UNCONFORMITY.

DEVONIAN SYSTEM, 86.9', elevation 62.9':

Dolomite, light gray, finely crystalline, dense, 1.7', depth 1098.8'.

Chert, medium light gray, finely granular, with stromatoporoids,<sup>3</sup> .3', depth 1099.1'.

Dolomite, medium gray, finely crystalline, dense, 1.8', depth 1100.9'.

In large part dolomite, medium light gray, finely crystalline, dense; in part sandstone, light gray, rounded and frosted quartz grains in a finely crystalline dolomite matrix, 83.1', depth 1184'.

UNCONFORMITY.

SILURIAN SYSTEM, 416'±, elevation -24':

Dolomite, light gray, sparkling, finely to moderately crystalline with common white, granular, tripolitic areas; in part light buff and rhombic with *Favosites*, light green shale in crevices, 34.5', depth 1218.5'.

Chert, white to yellowish, conchoidal, and dolomite, light gray, finely granular to crystalline, some crystalline quartz, 15', depth 1233.5'.

Sample missing, reported as "magnesian limestone, not differing in any marked degree from the bed above," 42.9', depth 1376.4'.

Dolomite, light gray to buff, rhombic, sparkling, in part vesicular, 51.3', depth 1427.7'.

Shale, light greenish, granular, dolomitic, massive, grading to reddish and yellowish mottled, 12.8', depth 1440.5'.

Dolomitic limestone, white, finely granular and sucrose, with dense, finely crystalline dolomite areas, 13.7', depth 1454.2'.

Dolomitic limestone, white, finely granular to finely crystalline, sucrose, 53.7', depth 1507.9'.

Dolomitic limestone, light gray to white, finely granular to finely crystalline, in lower part moderately dense and pink tinged, 37.7', depth 1545.6'.

Dolomite, light buff, rhombic, with areas of white granular tripolitic material; in part finely crystalline and dense dolomite, 13.8', depth 1559.4'.

Dolomite, light gray, finely crystalline, sparkling, 25.1', depth 1584.5'.

Dolomite, light gray to buff, rhombic, porous, with areas of white, granular, tripolitic material, 15.5'±, depth 1600'±. The exact depth of the base of this core could not be determined.

UNCONFORMITY: Upper part of the Ordovician missing.

<sup>3</sup> According to Dr. R. S. Bassler of the U. S. National Museum (personal communication), these stromatoporoids are of the Devonian type of structure.

ORDOVICIAN SYSTEM, 408'±, elevation -440'±:

Trenton group, 267.5':

Prosser dolomite formation, 213.2'±:

Dolomite, medium light gray, finely crystalline, dense, with some medium dark gray areas of rhombic dolomite, in part cavernous, 26.1'±, depth 1626.1'.

Dolomite, medium gray and medium dark gray mottled, crystalline and dense to porous and rhombic, with some medium gray quartzose chert with bryozoa replacements;<sup>4</sup> grades to medium light gray, dense dolomite, 56.1', depth 1682.2'.

Dolomitic limestone, light gray, finely crystalline to finely granular and sucrose, 27', depth 1709.2'.

Dolomitic limestone, medium light gray, finely to moderately crystalline, fairly dense, 22.1', depth 1731.3'.

Dolomite, medium dark brownish-gray, finely crystalline to finely rhombic, with areas of dull, light gray, speckled chert, in part weathered and granular, some *Rhinidictya* impressions,<sup>5</sup> 10.2', depth 1741.5'.

Dolomite, medium dark gray, rhombic, very vesicular, 29.2', depth 1770.7'.

Dolomite, medium dark gray to brownish, vesicular, with some finely crystalline, dense areas, 18.7, depth 1789.4'.

Dolomite, buff, finely rhombic, in part vesicular, with some dolomitized fossil casts, 23.8', depth 1813.2'.

Ion (?) shale formation, bluish gray, granular, massive, in part dolomitic, 34.3', depth 1847.5'.

Guttenberg (?) dolomite formation, medium dark gray, in part brownish with dark bands, finely crystalline to finely rhombic, 20', elevation -687.5', depth 1867.5'.

Black River group; limestone, brownish gray to tan, finely crystalline and dense to lithographic, very fossiliferous, with brachiopods; in part interbedded limestone, as above, and dark blue-gray shale; in part shale, blue-gray to dark, with limy seams and some phosphatic shell fragments, 80', elevation -707.5, depth 1947.5'.

Chazy group (St. Peter sandstone); sandstone, brownish gray, fine grained, with scattered grains of rounded and frosted sand (reported as moderately coarse and friable), 60.5', elevation -787.5', depth 2008'.

UNCONFORMITY.

CAMBRIAN OR ORDOVICIAN SYSTEM: Franconia (Bonnetterre) or Oneota dolomite, medium light gray to brownish, rhombic, in part vesicular, with much glauconite and some laminae of dark green glauconitic shale; residue shows much fine subangular sand, 113.2', elevation -848', depth 2121.2'.

CAMBRIAN OR PRE-CAMBRIAN SYSTEM: Red clastics: Sandstone, pink to red, quartz and weathered feldspar grains in a red, silty clay matrix, moderately friable, 71.6', elevation -961.2', depth 2192.8'.

UNCONFORMITY.

PRE-CAMBRIAN SYSTEM: Sioux formation, quartzite, pink to reddish; indurated red shales or pipestones; some granitic material which may be metamorphosed sandstone and conglomerate derived from granite; some chlorite schist; condition of core does not permit an interpretation of the relationship of the various types of lithology to each other, 270.2', elevation -1032.8', depth 2463'.

**Condition of Core.**—The entire footage of this core was not preserved, but representative parts of it were saved and the parts were labeled by Mr. Russell at the time of drilling. Consequently, the accuracy of our

correlation is in part dependent upon the accuracy of Mr. Russell's description and labeling. Where Mr. Russell's subdivisions are relatively thin the core has been well sampled but where his subdivisions are relatively thick and consist of more than one kind of lithology, it is not possible for us to locate contacts with more than approximate accuracy. Wash samples from the upper

<sup>4</sup> Dr. Bassler (personal communication) reports this to be a "stony bryozoa of the Upper Ordovician type" and that "it could very well be Trenton."

<sup>5</sup> Dr. Bassler (personal communication) identifies these fossils as "bifoliate ribbonlike bryozoa (*Rhinidictya*) which occur sparingly in the Trenton but more abundantly in the underlying Black River."

part of the hole, which was not core drilled, assisted in differentiating the upper formations.

**Carboniferous Strata.**—The upper and middle Carboniferous beds are correlated with satisfaction due to their persistent lithologic and faunal characteristics and because many representative samples were saved. However, the samples from the interval referred to the Friedrich-Dry shale formations (206.3'-273.2') do not show the thin limestone zones which are present in the outcrop and therefore this correlation is made with some hesitancy, there being some possibility that these strata may be largely equivalent to the Indian Cave sandstone formation of basal Permian age.

The Douglas-Pedee groups interval (660.8'-710.1') is readily correlated with the Platte valley outcrop section but further regional study will be necessary before the smaller subdivisions of these groups can be correlated with outcrops in adjacent states.

In the Kansas City group (775.8'-894.6'), the Wyandotte limestone formation is thinner than in the outcrop section of the Platte river valley but the Drum and Westerville limestones are thicker. The red shale zone in the middle of the Westerville in the core has no equivalent in the Platte valley section. However, the thickness of the Kansas City group in the core (118.8') is not much greater than the thickness of these beds in the Platte valley outcrops (about 103').

The Bronson group (894.6'-952.2') is typically developed in the core and the Bourbon group is relatively thin (about 9'), due to unconformity at its base.

Subdivisions of the Marmaton group (961.2'-1047.6') are correlated with difficulty because of lateral gradation from the outcrop areas. The 2-foot dolomite bed, cored from 1068.8 to 1070.8 feet, is lithologically similar to the Lower Carboniferous dolomite but it is underlain by typical basal Cherokee material. Therefore, it is concluded that this sample is either mislabeled or that it represents reworked material.

The Lower Carboniferous in this core is relatively thin (20.7'). It cannot now be correlated more specifically and is provisionally referred to the Lower Carboniferous because it differs from the overlying Cherokee and the underlying Devonian rocks.

**Pre-Carboniferous Strata.**—The interval drilled from 1097.1 to 1184 feet is classified as Devonian on the basis of stromatoporoids found at 1098.7 feet. Its base is marked by a zone of rounded and frosted sand grains embedded in dolomite which has been found in several other wells in eastern Nebraska. Apparently Russell did not note the change in lithology at 1184 feet but the cores are plainly labeled and there seems to be a sound basis for making a division here as typical Silurian fossils (*Favosites*) occur immediately below. Russell recorded sandstone from 1218.5 to 1233.5 feet but the only sample we have from this interval consists of chert and dolomite.

The Silurian-Ordovician contact is only approximated inasmuch as the samples labeled 1584.5 to 1626.1 feet appear to consist of two differing lithologic types, in part similar to the material above and in part similar to the underlying rocks which contain Ordovician fossils. Therefore, the contact is placed at approximately 1600 feet. The subdivisions of the Ordovician are based upon a study of the core and a comparison with the records of other wells where more detailed sampling was done.

The bed of dolomite drilled from 2008 to 2121.2 feet is referred to the Cambrian or Ordovician. It is impossible at this time to be sure whether it represents the lower bed of the Prairie du Chien group (*Oneota*) of the Lower Ordovician or the Franconia dolomite of Cambrian age. Its large percentage of glauconite is suggestive of Cambrian rather than Ordovician age, yet, upon acid treatment, the typical Franconia (*Bonnetterre*) residues are not found.

The red sandstone which occurs between the lower dolomite and the Sioux quartzite is classified as Cambrian or Pre-Cambrian. It seems probable, however, that this sandstone is Cambrian in age and that its red color is due to material reworked from the Sioux quartzite surface during Cambrian time.

The lowest division drilled (2192.8-2463') is referred to the Sioux formation of Pre-Cambrian age. Several types of lithology are represented here and it is apparent from the drillings studied in other places that the Sioux formation is only in part quartzite and contains interbeds of meta-

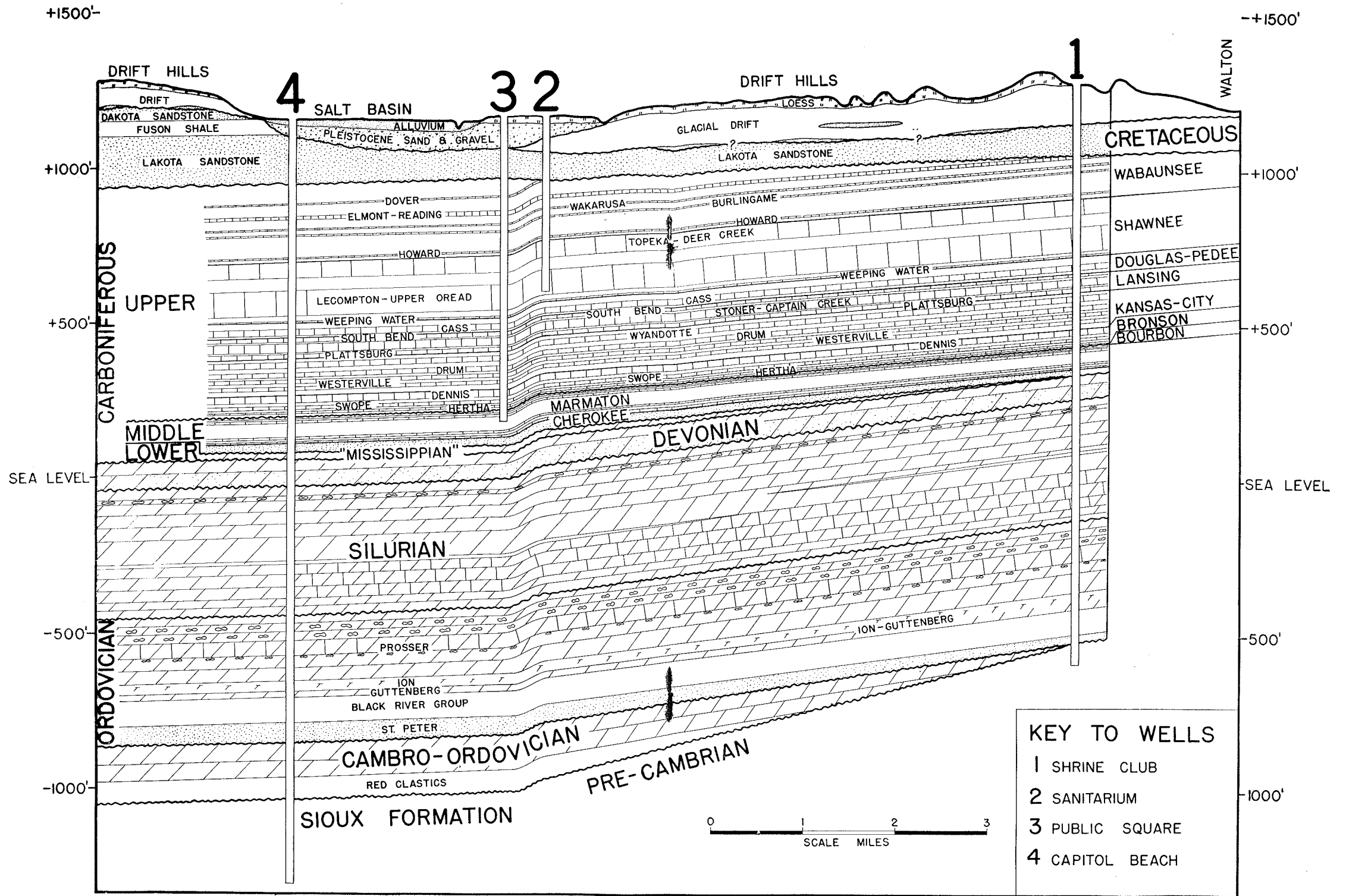


Fig. 2.—Profile section from Capitol Beach well to Shrine Club well.



Limestone, alternating with layers of shale, blue and green, with some chalky shale, about 41', depth 950'±.

Middle Carboniferous series (Des Moines subseries), about 36', elevation about 225':

Marmaton (?) group, described as limestone rock, alternating with layers of blue and green shale, with some chalky shale, 36', depth 986'.

**Salt Water Zones.**—The driller's log appears to be detailed down to 652 feet (base of Shawnee group), below which it is generalized. Strong brine was reported from a zone between 184 and 255 feet; artesian salt water was secured at about 560 feet, and a lower flow of salt water was reported but its depth was not given. According to the section of the Capitol Beach well, this salt zone should occur in the middle part of the Kansas City group, in the Public Square well at a depth of about 810 feet.

#### LINCOLN (EVERETT) SANITARIUM WELLS

Two wells, known as the Sanitarium wells, were drilled in 1891 at what is now the northwest corner of the block bounded

by L, M, 14th, and 15th streets. They are about 900 feet south of the north line and 50 feet east of the west line of sec. 25, T 10 N, R 6 E. The wells are about 30 feet apart; their curb elevations are about 1174 feet; their depths are 450 and 565 feet, and their diameters are 5 inches at the bottom. The shallower well was pumped and the deeper one flowed. Their water was used in the sulpho-saline baths and a large swimming pool was operated by the Everett Sanitarium. Now, however, both wells are abandoned.

The following correlation of the deeper well is modified after the log furnished the Geological Survey August 12, 1893, by the former Dr. M. H. Everett and Dr. J. O. Everett.

#### CORRELATION OF DEEPER SANITARIUM WELL

##### QUATERNARY SYSTEM, 134':

Soil and subsoil, 4'.  
 Peorian loess, 18', depth 22'.  
 Sand, gray, loose, with stony fragments, 3'.  
 Clay, yellowish, soft, 10'.  
 Clay, hard, stony, 9'.  
 Sand, compact, 24'.  
 Clay, dense, yellowish, 58'.  
 Gravel, cemented, 8', depth 134'.  
 UNCONFORMITY: Upper beds of the Dakota group removed by erosion.

##### CRETACEOUS SYSTEM, 72', elevation 1040':

Lakota formation, 72':  
 Sandstone and packed sand, with water-bearing streaks, 26'.  
 Gravel, cemented, 9'.  
 Sandstone, concretionary ("boulders"), 3'.  
 Sandstone, with streaks of sand, salt water bearing, 33'.  
 Conglomerate ("rock"), 1', depth 206'.  
 UNCONFORMITY: Younger beds of the Pennsylvanian and yet later formations removed by erosion.

##### CARBONIFEROUS SYSTEM, 359', elevation 968':

Upper Carboniferous (Upper Pennsylvanian) series, 359':

Virgil subseries, 359':

Wabaunsee group, 206':

Nemaha-Richardson subgroups, 124':

Dry-Table Creek-Willard formations, shale, dense, with streaks of soft limestone, 48', depth 254'.

Elmont-Reading formations, reported as lime rock, 11', elevation 920', depth 265'.

Auburn formation, 32'.

Shale, 4'.

Limestone, 6'.

- Shale, blue, 3'.
- Shale, red, .5'.
- Shale, yellow, 2'.
- Shale, red, 1.5'.
- Shale, yellow, 2'.
- Shale, blue, 3'.
- Shale, brown, 10', depth 297'.
- Wakarusa formation, reported as "lime rock", 3', elevation 877', depth 300'.
- Soldier Creek-Burlingame formations, reported as dark shale, 30', depth 330'.
- Sac-Fox subgroup, 82':
  - Cedarvale-White Cloud formations, 68', elevation 844':
    - Black shale, probably at horizon of Elmo coal, 1'.
    - Shale, 14'.
    - Shale, red, 12'.
    - Dark shale, 41', depth 398'.
  - Howard formation, reported as lime rock, 6', elevation 776', depth 404'.
  - Severy formation, reported as black shale, 8', elevation 770', depth 412'.
- Shawnee group, 153', elevation 762':
  - Upper and middle Topeka formation, 16':
    - Coal Creek limestone ("lime rock"), 4', depth 416'.
    - Holt shale, black, 1.5', depth 417.5'.
    - Du Bois limestone, 1.5', depth 419'.
    - Turner Creek shale, reported as reddish, 9', depth 428'.
  - Lower Topeka-Deer Creek formations, 37', elevation 746':
    - Lower Topeka-Ervine Creek-Haynies, reported as lime rock with shale streaks, 32', depth 460'.
    - Laresh shale, reported as black shale above and "red shale" below, 2', depth 462'.
    - Rock Bluff limestone, 3', depth 465'.
  - Tecumseh formation, 32', elevation 709':
    - Sandstone, gray, 10'.
    - Sandstone, red, 18'.
    - Shale, red, 4', depth 497'.
  - Lecompton-Oread formations, 68', elevation 677':
    - Limestone, hard, 10'.
    - Limestone, white, hard, 8', depth 515'.
    - Shale, black (may be Queen Hill), 9', depth 524'.
    - Limestone, soft, 4', elevation 650', depth 528'.
    - Limestone and shale, 22', depth 550'.
    - Limestone, magnesian (artesian flow of salty water reported), 15', elevation 624', depth 565'.

**Salt Water Zones.**—The salt water reported at about 565 feet in this well is thought to occur in the Plattsmouth limestone, i.e., in the same horizon as at the Public Square well. Although it has been claimed by some that the Sanitarium well was drilled to about 600 feet, the 565 feet given by the owners of the Sanitarium, who had the well drilled, is accepted as the correct depth.

#### SHRINE CLUB WELL

A much more recent well is located on the Drift Hills east of Lincoln, near the

southwest end of the old Shrine Club ground. It is 300 feet north of the south line and 300 feet east of the half-section line of sec. 26, T 10 N, R 7 E, about 1½ miles southeast of the United States Veterans Hospital, and was drilled by the Cass Petroleum Corporation in 1932, in search for oil and gas. The altitude of the curb is 1281 feet (determined by altimeter) and the depth of the well is 1870 feet. Cuttings of this well are stored at the State Geological Survey, and the results of their study by A. C. Hornady and E. C. Reed are the basis for the following correlation.

## CORRELATION OF THE SHRINE CLUB WELL

RECENT, PLEISTOCENE AND CRETACEOUS SYSTEMS (Dakota group) undifferentiated, 230':

Samples missing, depth 200'.

Sandstone, brownish gray and light gray, poorly sorted, pebbly, with some rounded pebbles of limestone, depth 230'.

UNCONFORMITY: Uppermost Carboniferous and lower Permian beds removed by erosion.

CARBONIFEROUS SYSTEM, 710', elevation 1051':

Upper Carboniferous series, 620':

Virgil subseries, 380':

Wabaunsee group, 120':

Nemaha subgroup, 57':

Elmont-Reading formations, limestone, bluish gray, medium light gray, argillaceous, 10', depth 240'.

Auburn formation; largely brownish gray sandstone, sample is, at least in part, cave from overlying Dakota group, 20', depth 260'.

Wakarusa formation, limestone, medium gray to greenish gray, finely granular, argillaceous, some green-gray, nodular shale, 10', depth 270'.

Soldier Creek formation, shale, blue-gray, calcareous, 10', depth 280'.

Burlingame formation, limestone, medium gray, finely granular, with some crinoid joints, some shale as above, 7', elevation 1001', depth 287'.

Sac-Fox subgroup (exclusive of Howard and Severy formations), shale, medium blue-gray to dark gray, micaceous to silty, in part calcareous, in part black and carbonaceous, 63', depth 350', elevation 994'.

Shawnee group (including basal Sac-Fox formations), 205', elevation 931':

Howard-Topeka formations, limestone, medium light gray, fine grained, finely micaceous, with many *Triticites*, *Rhombopora*, *Bairdia*, some dark gray to black shale, 20', depth 370'.

Lower Topeka-Calhoun formations, samples missing, 15', depth 385'.

Deer Creek formation, 35', elevation 896':

Limestone, light gray to white, oolitic, 15', depth 400'.

Limestone, light gray to white, saccharoidal, with some dark gray, fossiliferous areas, common *Triticites*, a little dark blue-gray shale, 10', depth 410'.

Limestone, medium to dark gray, finely granular, slightly micaceous, pyritic, in part platy, with common black fissile shale, 10', depth 420'.

Tecumseh formation, samples badly mixed, in part pinkish brown silt and green shale, 40', depth 460'.

Lecompton formation-Plattsmouth limestone (undifferentiated), 71', elevation 821'.

Limestone, medium light gray, fine grained, crystalline to granular, in part pyritic, with *Triticites*, *Rhombopora*, and brachiopods, some blue-gray, micaceous shale and a little black fissile shale, 40', depth 500'.

Limestone, light gray, fine grained, granular, with some blue-gray shale, 5', depth 505'.

Samples missing, 24', depth 529'.

Limestone, medium gray and light gray, granular, in part silty, with some blue-gray and red-brown shale, 2', depth 531'.

Heebner shale and Leavenworth limestone: shale, dark gray, with black, carbonaceous areas and limestone, medium gray, 4', depth 535'.

Snyderville shale, brownish red, silty, calcareous, with some greenish gray areas, 13', depth 548'.

Weeping Water limestone, medium light gray, fine grained, sharp fracture, 7', elevation 733', depth 555'.

Douglas-Pedee groups, 55', elevation 726':

Shale, brownish red with some mustard-yellow areas, silty, micaceous, 25', depth 580'.

Cass limestone, 20', elevation 701':

Limestone, medium to light gray, fine grained, sharp fracture, 10', depth 590'.

Limestone, medium dark gray, oolitic and shale, blue-gray to greenish gray, micaceous, 10', depth 600'.

- Lower Douglas-Pedee, shale, brownish red and blue-gray, micaceous, silty, 10', depth 610'.
- Missouri subseries, 240', elevation 671':
- Lansing group, 60':
- Lansing-Vilas-Plattsburg formations, 60':
- South Bend limestone, medium light gray, with small *Triticites*, 10', depth 620'.
- Rock Lake shale, brownish red and blue-gray, micaceous, silty, 8', depth 628'.
- Stoner-Plattsburg limestones, 42', elevation 653':
- Limestone, light gray, granular, and some blue-gray to dark gray shale, 12', depth 640'.
- Limestone, light gray, granular, with some white chert, 10', depth 650'.
- Limestone, light gray to white, finely crystalline, with *Triticites*, 20', depth 670'.
- Kansas City group, 110', elevation 611':
- Bonner Springs formation, shale, blue-gray, locally silty and very micaceous, locally argillaceous, 10', depth 680'.
- Wyandotte formation, 21', elevation 601':
- Limestone, medium gray to brown-gray, semicrystalline, and dark gray shale, 10', depth 690'.
- Limestone, medium light gray to brown-gray, semicrystalline, some small *Triticites*, 11', depth 701'.
- Lane-Iola-Chanute formations, 16':
- Shale, black, carbonaceous, fissile, and limestone, medium gray to dark gray, granular, 9', depth 710'.
- Shale, dark gray, carbonaceous, and blue-gray, silty, 7', depth 717'.
- Drum-Westerville formations, 56', elevation 564':
- Limestone, light gray, finely granular, with small *Triticites* and some white chert, 15', depth 732'.
- Limestone, light gray, semicrystalline, with some blue-gray and dark gray shale, 18', depth 750'.
- Shale, dark blue-gray to black, 10', depth 760'.
- Limestone, medium light gray, granular, platy to laminated, 10', depth 770'.
- Limestone, light gray and medium dark gray, granular, with fusulines, 3', depth 773'.
- Cherryvale formation, shale, dark gray, calcareous to black, carbonaceous, 7', depth 780'.
- Bronson group, 60', elevation 501':
- Dennis formation, 30':
- Limestone, medium light gray, finely crystalline to granular, 10', depth 790'.
- Limestone, light gray, fine grained, granular, with some dark gray shale, 20', depth 810'.
- Galesburg formation, shale, dark gray and black, carbonaceous, with some granular, silty limestone, 10', depth 820'.
- Swope-Hertha formations, limestone, light gray, granular to finely crystalline, 20', elevation 461', depth 840'.
- Bourbon group, shale, brownish red, silty, with some limestone, 10', elevation, 441', depth 850':  
UNCONFORMITY.
- Middle Carboniferous (Des Moines) series, 90', elevation 431':
- Marmaton group, undifferentiated, 70' or more:
- Shale, blue-gray, calcareous, cavings, 20', depth 870'.
- Shale, brownish red, silty to sandy, 10', depth 880'.
- Shale, as above, and sandstone, red-brown, very micaceous, some mustard-yellow shale, 20', depth 900'.
- As above, with some limestone, caving badly, 20', depth 920'.
- Cherokee group (?), samples missing, 20', elevation 361', depth 940'.
- UNCONFORMITY: Lower part of Middle Carboniferous missing; Lower Carboniferous largely or completely eroded.
- DEVONIAN SYSTEM (may or may not include some Lower Carboniferous at top), 80', elevation 341':
- Chert, white, conchoidal, with some dolomite, light gray to white, crystalline, moderately dense, with some crinoid joints; with some conglomerate of quartz sand, 10', depth 950'.

Chert and dolomite, as above, with abundant rounded and frosted sand, 10', depth 960'.

Chert, as above, with some dolomite and some rounded and frosted sand, 10', depth 970'.

Sample missing, 10', depth 980'.

Dolomite, medium light gray, crystalline, with common white chert and rounded and frosted sand, 10' depth 990'.

Dolomite, medium light gray, moderately coarsely crystalline, dense, with some chert and rounded and frosted sand, 10', depth 1000'.

Dolomite, medium light gray, crystalline, dense, with common rounded and frosted sand and a little chert, 20', depth 1020'.

UNCONFORMITY.

SILURIAN SYSTEM, 390', elevation 261':

Dolomite, light gray, crystalline, in part white and granular, and chert, white, conchoidal, with common crystalline quartz, 30', depth 1050'.

Dolomite, light gray to buff, crystalline to rhombic, with common chert, white, conchoidal, in part tripolitic, common crystalline quartz, 20', depth 1070'.

Chert, white, in part conchoidal, in part tripolitic, and dolomite, as above, some crystalline quartz, 35', depth 1105'.

Dolomite, buff, crystalline to rhombic, sparkling, in part sucrose, with some chert, as above, 25', depth 1130'.

Dolomite, as above, with fairly common chert, white, conchoidal and tripolitic, 10', depth 1140'.

Dolomite, light gray to buff, crystalline to rhombic, 35', depth 1175'.

Dolomite, buff, crystalline, dense, with common chert, white, tripolitic and conchoidal, 10', depth 1185'.

Shale, light green-gray, dolomitic, grades to granular dolomite, with much cave from above, 8', depth 1193'.

Dolomite, buff, finely crystalline, dense, with common conchoidal and tripolitic chert, 4', depth 1197'.

Limestone and dolomite, light gray, granular, in part medium light gray to buff, crystalline, 73', depth 1270'.

Dolomite, light gray to white, crystalline, rhombic, 30', depth 1300'.

Dolomitic limestone, light gray, moderately crystalline, dense, 20', depth 1320'.

Dolomite, light gray to white, in part buff, crystalline, rhombic, with some white chert, tripolitic, 40', depth 1360'.

Chert, white, conchoidal and tripolitic, and dolomite, as above, 40', depth 1400'.

Dolomite, light gray to buff, crystalline, rhombic, with chert, as above, 10', depth 1410'.

UNCONFORMITY: Upper part of Ordovician missing.

ORDOVICIAN SYSTEM, 395', elevation —129':

Trenton group, probably about 285':

Prosser dolomite formation, probably about 230':

Dolomite, light buff and medium dark gray mottled, crystalline, rhombic, pyritic, 65', depth 1475'.

Dolomite, as above, with common chert, light gray to white, in part finely speckled, 25', depth 1500'.

Chert and dolomite, as above, 20', depth 1520'.

Dolomite, medium light gray and dark gray mottled, crystalline, rhombic, pyritic with some chert, as above, 30', depth 1550'.

Dolomite, light buff to tan, finely crystalline, in part rhombic, sandy appearance in lower part, 41', depth 1591'.

Samples missing, 49', depth 1640' (?).

Ion-Guttenberg formation interval, samples missing, probably about 55', depth 1695' (?).

Black River group, samples missing, probably about 80', depth 1775'.

Chazyan group (St. Peter sandstone), 30', elevation —494':

Sandstone, light gray, friable, largely composed of medium coarse, rounded and frosted quartz sand grains, with some pyrite, much cave of green Spechts Ferry shale, 15', depth 1790'.

As above, with common conglomerate of rounded and frosted sand in a fine, argillaceous sandstone matrix, in part with pyrite cement, 15', depth 1805'.  
UNCONFORMITY: Lower Ordovician and Cambrian missing.

PRE-CAMBRIAN SYSTEM, 65', elevation -524':

Dolerite, dark gray to brownish black, ophitic; contains augite, feldspar, olivine, magnetite, and serpentine, 40', depth 1845'.

As above, with common quartzose material, 25', depth 1870'.

**Condition of Samples.**—Samples were not turned over to the Survey for two important intervals drilled in this well. These intervals are from the surface to 200 feet and from 1591 to 1775 feet. The upper missing interval probably includes some glacial drift resting upon the sandstones and shales of the Dakota group.

**Factors Affecting Correlation.**—The subdivisions of the Upper and Middle Carboniferous cannot be located as accurately here as in the Capitol Beach core because the depth range covered by many samples is too great to permit differentiation of the thinner zones. The Lower Carboniferous appears to be missing, probably having been completely removed by post-Lower Carboniferous erosion, and the Devonian is thinner than at Capitol Beach.

Formations present in the interval from 1591 to 1775 feet can be only approximated since neither samples nor a driller's record is available but the correlation, based on thicknesses measured in other wells in eastern Nebraska, is believed to be substantially correct.

The samples from 1775 to 1805 feet are typical of the St. Peter sandstone which here rests upon the Pre-Cambrian, with the Lower Ordovician and Cambrian formations missing.

The lower part of the well (1805'-1870') is certainly Pre-Cambrian in age and is probably correlative with the Sioux formation even though most of the material drilled is dolerite of igneous origin. It is thought that the dolerite has been intruded into the Sioux quartzite.

#### BURNHAM WELL

In 1906 and 1907 the Burnham well was drilled as a test for oil and gas. Its location is southwest of the Yankee Hill brick yard and south of Pioneer park, in sec. 4, T 9 N, R 6 E, about 150 feet north of the south

line of the section and 100 feet east of the west line. The altitude of the curb is 1168 feet.

The well was drilled on leases taken by the Yankee Hill Development Company of which Mr. S. W. Burnham and Dr. A. P. Furgason, both of Lincoln, were president and secretary-treasurer, respectively. Public-spirited citizens of Lincoln supplied most of the funds for this test. Our files contain very little information on the Burnham well, but Dr. Furgason, Mr. Frank G. Burnham of York, and others have supplied considerable data. According to the data collected, the diameter of the well was 12 or 14 inches at the top and about 6 inches at the bottom. The depth of the well is 2465 feet according to Mr. Burnham (from memory) and about 2615 feet according to Dr. Furgason. Mr. Burnham reports that artesian water was struck at a depth of 590 feet, which probably is the upper artesian horizon reported at the Public Square and Capitol Beach wells.

The Burnham well is thought to have penetrated about the same formations that were drilled at the Capitol Beach well. However, it may be drilled farther into the Sioux quartzite. Slight showings of oil and gas were reported at depths of 1160 and 1440 feet. This well has flowed a diminishing quantity of brackish water since it was drilled. Discharge is weak now, and passes into small stock ponds.

**Driller's Log.**—The driller's log of this well, which was secured from Dr. Furgason, April 27, 1939, is as follows:

No record, 855', depth 855'.

Shale, with hard lime shells, 21', depth 876'.

Lime, white, 19', depth 895'.

Shale, dark 10', depth 905'.

Shale, red, 11', depth 916'.

Lime, white, hard, 8', depth 924'.

Shale, dark, soft, 4', depth 928'.

Lime, white, 27', depth, 955'.

Shale, blue, 8', depth 963'.

Lime, white, with water, 7', depth 970'.

Lime, broken, 20', depth 990'.

Shale, red and blue, 43', depth 1033'.

Lime, white, 7', depth 1040'.

Shale, red, 30', depth 1070'.

"Mississippi lime," 300', depth 1370', with hard flint, contains crevices and small seams of red shale which caves, with good showing of oil at 1160'-1170'.

Shale, white, plastic, 10' depth 1380'.

Lime, white, 40', depth 1420'.

Shale, pink, 10', depth 1430' or to "top of Upper Silurian."

Lime, white, 383', depth 1813', good show of oil at 1440'-1446'.

Shale, blue, 6', depth 1819'.

Lime, blue, hard, 33', depth 1852'.

Shale, blue, 22', depth 1874', logged as "top of Trenton."

Lime, hard, 12', depth 1886'.

Shale, blue, 44', depth 1930'.

Lime, hard, 12', depth 1942'.

Shale, brown, 10', depth 1952'.

Lime, hard, 48', depth 2000'.

Shale, blue, 20', depth 2020'.

Lime, hard, 10', depth 2030'.

Lime, sandy, 25', depth 2055'.

Lime, hard, 27', depth 2082'.

Sand, crystal 14', depth 2096'.

St. Peter sand, with fresh water.

Total depth, 2600' or 2665'.

**Interpretation of Log.**—It is unfortunate that a record of the upper part of the Burnham well was not saved. Mr. Frank Burnham reports that, in his memory, shale was reached at 147 feet. A test hole, recently drilled by the Nebraska Survey on the floor of the Yankee Hill clay pit northeast of the deep well at an elevation about 8 feet lower reached the base of the Fuson shale and top of the Lakota sandstone at about 20 feet, and drilled Lakota sandstone to 150.6 feet where the well was abandoned in hard rock, probably a Permian or Upper Carboniferous limestone. Therefore we conclude that the top of the Permo-Carboniferous in the Burnham well is 147 feet.

The artesian flow of water reported at a depth of 590 feet (578 feet above sea level) appears to correspond with the flow reported in the Plattsmouth limestone in the Capitol Beach core at 600 feet (560 feet above sea level).

The limestone and shale section logged from 876 to 955 feet in the Burnham well is probably the Bronson group and the base of the Bourbon is probably at 963 feet. The rocks drilled from 963 to 1040 feet are probably correlative with the Marmaton group and the red shale from 1040 to 1070 feet appears to be the Cherokee shale. Therefore, the top of the Lower Carboniferous is 98 feet above sea level and 14.4 feet higher than at Capitol Beach.

It is difficult to classify the pre-Carboniferous section from a study of the log without samples. The show of oil reported at 1160 to 1170 feet may be in the dolomitic sandstone which occurs in the lower part of the Devonian of the Capitol Beach core (1100.9-1184'). The pink shale, logged between 1430 and 1440 feet in the Burnham well, seems to correlate with the shale zone of the Silurian which was drilled at Capitol Beach from 1427.7 to 1440.5 feet.

The blue shale, logged from 1852 to 1874 feet, appears to be the Ion shale and the "hard lime" from 1874 to 1886 feet probably is the Guttenberg limestone at the base of the Trenton group.

If the St. Peter sandstone, logged from 2082 to 2096 feet, is correctly correlated, the interval from 1886 to 2082 feet is probably correlative with the Black River group. This interval appears to be too thick, there being only 80 feet of Black River group in the Capitol Beach core.

Very probably, Lower Ordovician or Cambrian dolomites were drilled below the St. Peter and it is expected that the drilling penetrated the Sioux formation for several hundred feet before reaching the total depth of about 2600 feet. The thicknesses of the lower formations cannot be estimated accurately because no record was kept of the drilling below 2096 feet.

#### ECONOMIC INFORMATION RESULTING FROM DRILLING THE TEST WELLS

**Salt Water.**—The saline springs located near Lincoln were a natural source of salt supply for the Indians, and for the early settlers from 1855 to about 1871. For several years thereafter, the brines of the playa-like flats were evaporated by solar and artificial heat, making salt in small commercial quantities.

Table 1.—Quantitative Analysis of Artesian Well Water, Public Square Well, Lincoln.\*

CONSTITUENT	PER CENT	GRAINS PER U. S. GALLON
Ferrous Oxide	0.0162	0.33
Alumic Oxide	0.0542	1.09
Sulphuric Anhydride	10.2487	205.36
Calcium Oxide	0.9647	19.33
Magnesium Oxide	0.9790	19.61
Chlorine	49.7580	997.05
Silica	0.1299	2.60
Carbonic Anhydride	0.8867	17.77
Sodium	32.2790	81.12
Potassium	trace	trace
TOTAL	99.3645	1991.07

\* By Professor H. H. Nicholson, formerly chairman of the department of chemistry, University of Nebraska.

The West Lincoln, Public Square, and Capitol Beach wells were sunk in the hope of discovering rich brine or thick deposits of rock salt, but failure to find these resulted in abandonment. The Public Square well and the Everett Sanitarium wells, however, were used beneficially for several years in connection with bathing and sanitarium purposes and thus added to the early history and growth of the city.

**Salt Water Horizons.**—The logs of the Lincoln wells show that there are three principal salt water horizons in the vicinity of the city. The upper one of these occurs in the Pleistocene sands and the Lakota sandstone of the Salt Basin, at a depth of 200 feet or less. Next below this are two artesian salt water horizons in the Upper Carboniferous formations. The upper artesian zone is in the Plattsmouth limestone at a depth of about 555 feet in the deeper Sanitarium well, 560 feet in the Public Square well, and 600 feet under the Salt Basin. The third zone, or second artesian salt water, at the Salt Basin probably occurs in the Drum limestone at a depth of about 828 feet. This zone seems to lie at a depth of about 790 feet in the Public Square well.

According to Russell (1888), the per cent of salt content is greatest in zone 1, second in zone 3, and weakest in zone 2. The flows from the Capitol Beach and Public Square wells, however, came from both zones 2 and 3 and were the blended waters of these horizons.

Table 2 shows Professor Nicholson's comparison of three salt waters.

Table 2.—Comparison of Ocean and Artesian Water.

SALT WATERS	GRAINS PER U. S. GALLON
Ocean water	2139.93
Public Square well	2003.80
Capitol Beach well	1920.20

**Origin of Salt Water.**—There has been much speculation regarding the origin of the salt springs and salt water horizons located near Lincoln. Some hold that the saline springs of the Salt Basin issue from deeply buried rock salt and others claim that they are brines escaping from zones in the Carboniferous rocks. Also, a few people claim that the salt on the flats was dissolved from the soil and subsoil of the hilly uplands and deposited on the poorly drained bottomlands, by evaporation. None of these suppositions, however, is an acceptable explanation of the origin of the salt.

Much has been written on the origin of the saline flats in Oklahoma, Kansas, and Nebraska, where, in most cases, they occur on bottomlands located at a level just below the outcrops of the Fuson shale, which is the middle formation of the Dakota group, lying next above the Lakota sandstone. And, it is now known that saline springs issue from a sandy zone near the base of the Fuson and carry much salt water onto the saline flats and to the Lakota sandstone, as at Lincoln and other places similarly located. A source of salt water in the Fuson shale seems to be the best explanation for the presence of the Salt Basin at Lincoln and the occurrence of salt water in the Lakota sandstone in the Lincoln wells.

The artesian salt waters of zones 2 and 3 at Lincoln are separated from zone 1 by thick, impervious beds, and probably do not escape to the surface except where they are tapped by wells. Consequently, the salt of these zones is not the natural and primary source of the salines of the springs which recharge zone 1. Also, it seems now that the salt of zones 2 and 3 is original marine water not yet leached from the formation or that it has been formed by the basinward concentration of salts carried



downward from structurally higher areas. The first of these probable origins seems to be the more likely.

**Fresh-water Horizons.**—The fresh-water aquifers in the vicinity of Lincoln are the alluvial sands, terrace sands, Aftonian sands, subglacial sands, Dakota sandstone, Lakota sandstone, and some of the Carboniferous, Silurian and Ordovician formations. Farm wells of the area tap the alluvial, terrace, glacial and Dakota sands. East and southeast of the city the Dakota and Lakota sandstones overlap the formations of the Upper Carboniferous and Permian systems and are recharged with fresh water from that direction, whereas to the west of Lincoln saline water stands quite high in the Lakota sandstone. Formerly much of the Lincoln water supply came from the Dakota and Lakota formations in Antelope valley, but heavy draft at the wells located there caused the salt water zone to encroach eastward upon this fresh-water storage ground, making it necessary for the city to locate elsewhere a dependable source of supplemental water.

Evidently the limited supply, the rather unfavorable composition and the high cost of production will make it infeasible for the city to pump water from the St. Peter sandstone and the Ordovician and Silurian dolomites which lie at considerable depths. Production of water from these sources would also be expensive and hazardous. All told, the deep wells at Lincoln have contributed much of value in locating and developing a dependable water supply for the city but have not revealed reliable and readily available supplies of good quality water.

**Coal, Petroleum, and Gas.**—The Capitol Beach, Burnham, and Shrine Club wells were drilled deep enough to test the mineral fuel possibilities at Lincoln. Although coal was reported to occur at certain depths in these wells, we now know that the coals encountered are very thin and that in some cases black shales were mistaken for coal.

Only small showings of gas and some residues of petroleum were found. Consequently, these deep wells show that natural gas and petroleum do not underlie Lincoln in commercial quantities, but that

the wells do not condemn the oil and gas possibilities of Nebraska generally.

**Brick-making Materials.**—One of the largest brick and tile manufacturing plants of the state is located at Yankee Hill, southwest of Lincoln. It uses the varicolored clays of the Fuson formation and the loess in making brick and tile for use in Lincoln and shipment to other parts of the state. Various natural outcrops and the wells drilled in and near the city show that the brickmaking materials occur quite widely here.

**Stone, Gypsum, and Rock Salt.**—No beds of gypsum and rock salt were found in the Lincoln wells. Thick limestones and dolomites were penetrated, however, and are now available for mining if that becomes feasible, as in some other states.

#### TOPOGRAPHIC AND STRUCTURAL RELATIONSHIPS

Three types of land forms are represented in the vicinity of Lincoln: the floodplain of Salt Creek and its tributaries; the terrace land which borders the floodplain and consists of a well-defined lower terrace situated about 15 to 20 feet above the floodplain level, and a poorly-defined high terrace which occurs only as scattered remnants along the edges of the valley; and finally, the drift hills which form the higher rolling upland on both sides of the Salt creek valley, fig. 1. All of these land forms, with exception of the higher terrace, are crossed by the profile section, fig. 2.

The drift hills have been developed on boulder clay deposited by the Nebraskan and Kansan glaciers during early Pleistocene time. At many places this glacial drift is mantled by the Loveland and Peorian loesses. Intertill (Aftonian) sand and gravel often occurs near the middle of the boulder clay deposits and a subglacial sand and gravel is intermittently present at the base of the boulder clay, both of these sandy horizons yielding water to some farm wells. The boulder clay and its associated sand and gravel deposits rest upon the eroded top of the sandstones and shales of the Dakota group.

The terraces represent the floodplain levels of streams that removed all or most

of the glacial drift and some of the underlying bedrock locally in forming their valley and then filled these channels with sands, gravels, and silts. The Peorian loess mantles these relatively level sand and gravel plains and, in places, the drift hills.

The floodplain of Salt Creek has been formed by recent erosion of a channel through the terrace land to a level below that of the present bottom land and the partial filling of this channel with silt and clay washed down from the surrounding upland. The sands and gravels which underlie the terraces and floodplains rest on remnants of glacial drift locally but more generally occur above the Fuson shale and Lakota sandstone bedrock.

The Pleistocene mantlerock (glacial drift, Loveland formation and Peorian loess) has been completely eroded from the valley-sides at many places in and around Lincoln, exposing the bedrock which consists of Dakota sandstone at the higher

elevations and Fuson shale in the lower slopes. The Dakota sandstone, Fuson shale and Lakota sandstone formations dip gently westward and rest with considerable erosional and structural unconformity upon the Upper Carboniferous shales and limestones, fig. 2.

The regional westward dip of the Upper Carboniferous, as determined from the study of the deep wells of the vicinity, is markedly greater than that of the overlying Cretaceous. Sea level elevations of the tops of the Upper and Middle Carboniferous limestone formations (table 3) show that these beds lower westward about 150 feet in a distance of  $5\frac{3}{4}$  miles from the Shrine Club well to the Sanitarium well or at the rate of about 26 feet per mile. The westward dip of these limestones from the Sanitarium well to the Public Square well is unusually high or else the rocks are downfaulted to the west, for the beds lower about 40 feet within a distance of about

Table 3.—Sea level elevations (top) of geologic subdivisions in Lincoln wells.

	SHRINE	SANITARIUM	PUBLIC SQUARE	BURNHAM	CAPITOL BEACH
Elevation of curb	1281	1174	1175	1168	1160
Base of Lakota sandstone	1051	968	975	1021 ?	953.7
Top of Dover limestone			920		886.8
Top of Elmont limestone	1051	920			847.7
Top of Wakarusa limestone	1021	877			807.7
Top of Burlingame limestone	1001	849±	805		785.5
Top of Howard limestone	931	776	741		710.3
Top of Deer Creek limestone	916±	762	724		697.2
Top of Lecompton limestone	821	677	630		615.3
Top of Douglas shale	726		523		499.2
Top of Cass limestone	701				478.6
Top of Lansing group	671		480		449.9
Top of Kansas City group	611		415		384.2
Top of Bronson group	501		292	292 ?	265.4
Top of Marmaton group	431		225±	205 ?	198.9
Top of Cherokee shale	361			128	112.4
Top of "Mississippian system"				98	83.6
Top of Devonian system	341			78	62.9
Top of Silurian system	261			-8 ?	-24
Top of Ordovician system	-129			-424 ?	-440
Top of Ion shale	-359 ?			-684 ?	-653.2
Top of Black River group	-414			-718	-707.5
				-762	
Top of St. Peter	-494 ?			-862	-787.5
				-914	
Top of Cambro-Ordovician dolomite				-928	-848
				or +	
Top of Sioux quartzite	-524				-1032.8

one-half mile, which is at the rate of 80 feet per mile. The westward dip of the Upper Carboniferous from the Public Square well to the Capitol Beach well is relatively gentle, the beds lowering about 26 feet in a distance of about 2.3 miles, or at the rate of about 11 feet per mile. There is a gentle southward rise of the Upper Carboniferous limestones from Capitol Beach well to the Burnham well amounting to about 18 feet in  $3\frac{1}{2}$  miles (rate of about 5 feet per mile).

Comparison of the elevations of the Upper Carboniferous limestones in the Capitol Beach, Public Square, and Burnham wells indicates that the true amount of dip in the area encompassed by these wells is about  $12\frac{1}{2}$  feet per mile and that the true direction of dip is about north  $60^\circ$  west. Therefore, the strike of the beds in this part of the area is about north  $30^\circ$  east.

The Lower Carboniferous limestone is relatively thin in the Capitol Beach well and was probably present in the Burnham well but apparently has been removed by erosion from the structurally higher area near the Shrine Club well. The erosional unconformity at the base of the Middle Carboniferous in the Capitol Beach well is 257 feet below the same horizon in the Shrine Club well, whereas the structural difference between these two wells on the Upper and Middle Carboniferous is only 216 feet. Comparison between the Capitol Beach and Burnham wells on the base of the Middle Carboniferous, however, shows that the Burnham well is only about 15 feet higher, whereas the Upper Carboniferous limestones rise 18 feet in this distance.

The top of the Devonian lowers 278 feet from the Shrine Club well to the Capitol Beach well; the top of the Silurian lowers 285 feet; the top of the Ordovician lowers about 271 feet; the top of the St. Peter sandstone lowers about 293 feet; and the top of the Pre-Cambrian about 509 feet. Thus, in general, we find progressive increase in dip in succeeding older formations.

The pre-Carboniferous formations in the Burnham well cannot be differentiated with much satisfaction but there is sufficient control to indicate that these formations, instead of lowering northward, as is the case of the Upper Carboniferous limestones, actually lower southward in the Ordovician

formations, the top of the Ion shale being about 31 feet lower at the Burnham well than at Capitol Beach while the top of the St. Peter sandstone appears to be 75 to 126 feet lower. Thus we find sufficient divergence between the upper and lower part of the sedimentary section drilled in the Capitol Beach and Burnham wells to reverse the gentle north dip in the Upper Carboniferous to a marked south dip on the top of the St. Peter sandstone.

Figure 2 also shows that the dolomites of Lower Ordovician or Cambrian age and the underlying Red clastics were either not deposited in the vicinity of the Shrine Club well or have been removed by pre-St. Peter erosion so that we have an eastward overlap of the St. Peter on successively older rocks.

The structural conditions immediately east of the Shrine Club well are not yet clearly understood. There may be some reversal of dip in an eastward direction here or the beds may continue to rise northeastward to the axis of the Richfield uplift.

#### CONCLUSIONS

Study of the records of the deep wells located in and near Lincoln has furnished much diversified information which emphasizes the importance of knowing the constitution of the land. The information secured is partly of immediate economic importance and partly of future economic importance while helping to reduce speculation as to what may or may not be found at depth in this vicinity.

Although practically all of the ventures which resulted in the drilling of these wells failed to accomplish their immediate objectives, they have contributed much to our knowledge. The following conclusions are based upon the study of these wells:

- (1) The city of Lincoln and vicinity is underlain by rocks of Pleistocene, Cretaceous, Carboniferous, Devonian, Silurian, Ordovician, Cambrian and Pre-Cambrian ages in the order given, and the lithologic subdivisions may be traced through the area by means of the records and samples of deep wells.

- (2) The strata dip generally westward but the rate of dip is not constant, being greater in the eastern part of the region and

less toward the west. The Cretaceous formations dip gently westward, the dip of the Carboniferous formations is markedly greater than that of the Cretaceous, and the rate of dip appears to increase in successively older systems of rocks.

(3) There is a marked uplift of the pre-Cretaceous formations in the eastern part of the area, i.e., in the vicinity of the Shrine Club well. The attitude of the strata east of the Shrine Club well is not known. The bedrock is either downfolded east of the well or continues to rise gently northeastwardly to the Richfield uplift.

(4) A number of unconformities in the section were penetrated in drilling, the most important ones being at the base of the Cretaceous, at the base of the Middle Carboniferous, at the top of the Ordovician, at the base of the St. Peter sandstone, and at the top of the Pre-Cambrian.

(5) The water-bearing formations are as follows: the Recent alluvium of the Salt Creek bottomland; Aftonian and subglacial sands of Pleistocene age which underlie the drift hills; the Pleistocene sands and gravels below the terraces; the Dakota and Lakota sandstones of the Cretaceous; the Plattsmouth and Drum limestones and locally other horizons in the Upper Carboniferous; the Middle Carboniferous dolomite; the Silurian and Ordovician dolomites and the St. Peter sandstone. The hydrostatic pressure of the water in the Carboniferous and older aquifers is usually sufficient to cause a surface flow at the lower elevations.

(6) The water in the Pleistocene formations and the Dakota sandstone is generally of good quality except where these formations are directly in contact with salt water horizons or are fed by salt springs; the Lakota sandstone carries salt water in the central and western part of the area; the waters of the Upper Carboniferous aquifers are less salty than the more concentrated salt-bearing Lakota water yet too highly mineralized for domestic use; and the water in the Lower Carboniferous and older horizons is believed to be of better quality than the Upper Carboniferous zones yet may

contain many undesirable mineral constituents.

(7) No deposits of rock salt were noted in the drilling of the wells and the concentration of salt in the various salt water horizons seems to be too small to permit economic production of salt by evaporation at this time.

(8) Several thin coals are present in the Carboniferous rocks but these are too deep and too thin to be mined commercially.

(9) Limestones occur at depth but the production of stone from them by mining is not feasible under present conditions.

(10) Clays and shales of the Fuson formation and the loess occur favorably for brick and tile manufacture. Moreover, they are found at or near the surface in a number of places near Lincoln.

(11) The Dakota and Lakota sandstones, although used to some extent for building purposes, are generally too friable and irregular in quality for good building stone. The Pleistocene sands and gravels have been produced from time to time for use in road-surfacing and concrete admixture.

(12) Although two small shows of oil were reported in the Burnham well, our studies do not indicate that oil or gas in commercial quantities occur in the rocks which underlie Lincoln.

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