NORTH DAKOTA GEOLOGICAL SURVEY

WILSON M. LAIRD, *Director*

Bulletin 21

PART I

The Keene Dome, Northeast McKenzie County, North Dakota

By
CHARLES NEVIN

PART II

The Subsurface Stratigraphy of The Nesson Anticline

By
WILSON M. LAIRD

Grand Forks, North Dakota, 1946

CONTENTS

PART I

The Keene Dome, Northeast McKenzie County, North Dakota

ILLUSTRATIONS

PART II

The Subsurface Stratigraphy of the Nesson Anticline

PART I

The Keene Dome, Northeast McKenzie County, North Dakota

By

CHARLES NEVIN

PART I.

The Keene Dome, Northeast McKenzie County, North Dakota

— by —

CHARLES NEVIN[1]

INTRODUCTION

Abstract

The stratigraphy and structure of northeast McKenzie County are discussed. A large surface structure, the Keene dome, is mapped with a contour interval of 20 feet. It is predicted that the closure of this structure will increase with depth, and drilling tests for oil and gas are recommended.

Preliminary Statement

As part of a program, by the North Dakota Geological Survey, to map the geology of McKenvie County, the writer examined the structure of an area south and west of the Missouri River and north of the Little Missouri River, during the summer of 1945. Specifically the area is located in Townships 149 and 154 North and Ranges 93 to 99 West inclusive.

Ordinarily, before publication, additional structural data would be obtained by extending the mapping northward, across the Missouri River, into Williams County. Although admittedly incomplete, a general summary and discussion of the field work is presented at this time because of widespread interest in the possible commercial occurrence of oil and gas in western North Dakota.

Previous Geological Work

The rock formations of western North Dakota lie nearly flat, and the tendency has been to consider the structure as quite simple. The earlier reports generally described the structure in a single paragraph.

In 1917, a United States Geological Survey party mapped in detail the outcrops of the lignite beds in the Ray quadrangle, and discovered a fairly well marked anticline or dome. This was named the Nesson anticline by Collier,[2] and its general character was shown on a map drawn to a scale of approximately three miles to the inch.

Since some of Collier's data was of a reconnaissance character, additional field work on the east side of the Nesson anticline was undertaken by Dove.[3] Unfortunately this work was not carried southward across the Missouri River into McKenzie County.

---

[1] Professor of Geology, Cornell University, Ithaca, New York.
[2] Collier, A. J., The Nesson anticline, Williams County, North Dakota: U. S. Geol. Survey Bull. 691-G, pp. 211-217, 1918.
[3] Dove, L. P., The geology and structure of the east side of the Nesson anticline: North Dakota Univ. Quart. Jour., vol. 12, No. 3, pp. 240-249, 1922.

During 1911 and 1912 the United States Geological Survey mapped in detail the outcrops of lignite beds in the western part of the Fort Berthold Indian Reservation. Since this examination was undertaken primarily to obtain data for classifying the land on the basis of lignite content, no elevations were shown on the published map of the lignite outcrops; and only one paragraph in the report was devoted to the geological structure.

Beginning about 1937, a large number of oil and gas leases were taken in western North Dakota by both major oil companies and independent operators. As a result of this activity, several reconnaissance surveys and at least one seismograph survey were made, by commercial interests, of the area covered by this report. None of this material was available to the writer.

During the field seasons of 1940, 1941 and 1942, Hennen[5] made a reconnaissance survey in southwestern North Dakota of a large area, approximately 10,000 square miles in extent, which included the area of this report. His published map is drawn to a scale of about 25 miles to the inch.

Method of Field Work

The Soil Survey Map of McKenzie County (1933), drawn to a scale of one inch to the mile, was found to be quite accurate and it was used as a base map for this report. All observations were located directly on this map while in the field. The soil survey did not include the Fort Berthold Indian Reservation and no accurate base map of this area was available.

Primary bench marks were scarce and it was necessary to run rather extended net-works of secondary elevation points. These were carefully checked to make certain that no cumulative errors were present.

All elevations were determined by two Paulin altimeters. A control altimeter was stationed in the area that was being worked, and an observer recorded hourly readings. The other altimeter was read at the outcrops. Corrections for temperature and diurnal variation were applied to all readings. The resulting elevation data were quite satisfactory except for the occasional loss of a day's work because of inexperience of the observer at the control altimeter.

Acknowledgments

The writer is very grateful to Director W. E. Wrather of the U. S. Geological Survey for permission to use the original plane-table sheets from the lignite survey of the western part of the Fort Berthold Indian Reservation. Although this material was not received until after leaving the field, by integrating the data with that already

[4] Bauer, C. M. and Herald, F. A., Lignite in the western part of the Fort Berthold Indian Reservation south of the Missouri River: U. S. Geol. Survey Bull. 726-D, pp. 109-172, 1921.

[5] Hennen, R. V., Tertiary geology and oil and gas prospects in Dakota basin of North Dakota: Am. Assoc. Petroleum Geologists Bull., vol. 27, pp. 1567-1594, 1943.

secured in the field, it was possible to complete the contouring of the structure in Townships 150 and 151 North, Range 94 West. The twelve elevations used are marked by an encircled dot, so as to distinguish them from data secured by the writer.

STRATIGRAPHY

Introduction

There has been considerable controversy regarding the age and nomenclature of the geological formations of western North Dakota. Recent discussions by Ballard,[6] by Kline,[7] by Seager,[8] and by Hennen,[9] review the previous lierature and add much new information.

The stratigraphy of the subsurface rocks will be discussed in a later section by Dr. Laird. Following is the classification used in this report for the surface rocks:

Cenozoic
- Tertiary system
  - Oligocene series
    - White River group
  - Eocene series
    - Wasatch group
      - Unnamed formation
      - Sentinel Butte formation
  - Paleocene series
    - Fort Union group
      - Tongue River formation

Recent Alluvium and Stream Deposits

The region as a whole is a dissected upland plain with an average elevation of about 2100 feet above sea level. In this plain, the Missouri River is entrenched to a depth of about 400 feet, and the tributary streams have also cut deep valleys. Flood plains and terraces are well developed and the underlying bed rock is usually covered in all of the major stream valleys. Along the valley of the Missouri River the flood plain may be as wide as two miles and, in places, the alluvial deposits are 50 feet or more thick. In the valley of Tobacco Garden Creek alluvial deposits are also extensive, although probably not as thick. The alluvium consists of fine sand, silt and clay, and represents recent deposits of the streams and the river.

Pleistocene Glacial Deposits

With the melting and retreat of the continental glacier a tremendous quantity of debris, both sorted and unsorted, was left behind

[6] Ballard Norval, Regional geology of the Dakota basin: Am. Assoc. Petroleum Geologists Bull., vol. 26, pp. 1557-1584, 1942.

[7] Kline, V. A., Stratigraphy of North Dakota: Am. Assoc. Petroleum Geologists Bull., vol. 26, pp. 336-379, 1942.

[8] Seager, O. A., et al, Discussion—Stratigraphy of North Dakota: Am. Assoc. Petroleum Geologists Bull., vol. 26 pp. 1414-1423, 1942.

[9] op. cit.

by the ice. A very large part of the upland plain area has been covered by a thin veneer of these glacial deposits. As a result, the soil is usually unlike the underlying bed rock. Tracing of key beds is consequently very difficult, and in fact is often impossible, except where the streams have stripped away the glacial deposits.

A majority of the glacial debris is till and boulder clay, although some water sorted material is also present. Usually the thickness is small, 10 feet or so on the average, but even so the covering of the bed rock is surprisingly efficient.

White River Group

In an area south and west of Keene, half a dozen buttes rise abruptly from the average elevation of the upland plain. These buttes are capped with remnants of a former extensive deposit of continental White River beds. A resistant sandstone, which is a prominent member of these beds, is responsible for the presence of the buttes. The White River group lies unconformably upon the upper part of the Tongue River, and effectively conceals the underlying geologic structure.

Sentinel Butte Formation

The upper or unnamed member of the Wasatch group is too high stratigraphically to appear in the area. The lower or Sentinel Butte formation outcrops southwest of Schafer, and is well exposed along the Little Missouri River, outside the area farther to the south, in North Roosevelt National Park.

Although the Sentinel Butte is conformable with the underlying Tongue River, and although the environment of sedimentation was very similar for both formations, it is possible to map them separately. The Sentinel Butte is characterized by somber, dark-colored clays and bentonitic clays. Lignite beds and sands, although present, are usually neither thick nor numerous. Because of the common predminance of clays and a scarcity of sands, the Sentinel Butte weathers in a typical "mud-butte' type of topography.

Contact of Sentinel Butte and Tongue River Formations

Since the contact of the Sentinel Butte and Tongue River is completely graduational, some arbitrary horizon must be seelcted for the boundary. Seager[10] states that a lignite or a burned clinker bed marks the contact in many places. Hennen[11] places the contact at the top of lignite 22, a bed 20 feet thick, that is being mined on the north face of Sentinel Butte. If no mistake has been made in correlation, this horizon is equivalent to JK in the stratigraphic section, figured in this report. The selection of this horizon as the contact would place in the Sentinel Butte the upper part of a thick section that is dominantly sand and typically Tongue River.

It is suggested, therefore, that a more logical contact would be

[10] op. cit. p. 1417.
[11] op. cit. p. 1569.

the top of the thick sand member, at the horizon marked L in the stratigraphic section.

Tongue River Formation

The Tongue River formation of the Fort Union group extends over the entire area, with the exception of a minor amount of Sentinel Butte southwest of Schafer. Small areas of Tongue River are covered in the Blue Buttes region, west and south of Keene, by remnants of the White River formation; larger areas are covered by recent alluvial deposits in the major stream and river valleys; and very extensive areas in the upland plains are covered by Pleistocene glacial deposits. The best exposures occur, therefore, in the hillsides and bad-lands, between the upland plain and the valley levels.

The name Tongue River was given by Taff[12] to a lignite bearing formation exposed along the Tongue River in Wyoming and Montana. These lignites are a part of the Fort Union group, as described by Meek and Hayden.[13] A type section is exposed at Old Fort Union near the mouth of the Yellowstone River, and the eastward extension of these beds into the area mapped is unquestioned. Farther south, the Tongue River is underlain by the Cannonball and Ludlow formations. These formations do not apparently extend northward into this area.

Geologic Age

The Tongue River formation occurs in a transition zone between overlying beds that are Eocene and underlying beds that are Cretaceous. Fossil plants and fossil fresh water shells were collected during the survey of the lignites of the Fort Berthold Indian Reservation,[14] and were referred to the early Tertiary or Fort Union by Stanton in the report of Bauer and Herald. Later regional studies by Thom and Dobbin[15] placed the overlying Sentinel Butte formation in the Wasatch group of Eocene age. Earlier studies by Leonard[16] showed that the Fort Union overlies beds of Cretaceous age.

The present tendency is to place the Fort Union in the Paleocene as suggested by Seager[17] and Laird and Mitchell.[18] However, Ballard,[19] as recently as 1942, considered the Fort Union to be Eocene in age, and reserved the Paleocene for beds that are older.

[12] Taff, J. A., The Sheridan coal field, Wyoming: U. S. Geol. Survey Bull. 341, p. 129, 1909.
[13] Meek, F. B., and Hayden, F. V., Descriptions of new Lower Silurian, Jurassic, Cretaceous and Tertiary fossils collected in Nebraska, by Capt. Wm. F. Reynolds, U. S. Top. Eng.; with some remarks on the rocks from which they were obtained: Proc. Phila. Acad. Nat. Sci., vol. 13, p. 433, 1861.
[14] Bauer, C. M. and Herald, F. A., Lignite in the western part of the Fort Berthold Indian Reservation south of the Missouri River: U. S. Geol. Survey Bull. 726-D, p. 116, 1921.
[15] Thom, W. T. and Dobbin, C. E., Stratigraphy of the Cretaceous-Eocene transition beds in eastern Montana and Dakota: Geol. Soc. America Bull., vol. 35, pp. 481-506, 1924.
[16] Leonard, A. G., The Cretaceous and Teritary formations in western North Dakota and eastern Montana: Jour Geol., vol. 19, p. 535, 1911.
[17] op. cit. p. 1416-1417.
[18] Laird, W. M., and Mitchell, R. H., The geology of the southern part of Morton County, North Dakota: North Dakota Geol. Survey Bull. 14, p. 16, 1942.
[19] op. cit. p. 1583.

Lithology

The Tongue River is essentially a clay and sand formation. There is a continual interfingering of clays, sandy clays, silts, fine sands and coarse sands throughout the section. Here and there, thin lenses of rather pure limestone appear. Concretionary masses and lenses of silt and sand are common in the clays, as well as numerous concretions and thin bands of limonite. The most distinctive feature, however, is the frequent occurrence of lignite beds of varying thickness and purity. The total thickness of Tongue River is greater than 700 feet. A composite stratigraphic section is shown in Figure 1.

On a fresh surface, the predominant color of the sands, clays and limestone is a light gray. Weathering gives various shades of buff. Bands of lighter color may be traced for some distance, but they are not persistent and usually disappear, or rise and fall in the stratigraphic section.

Most of the lignites break down readily and slack on exposure to weathering agents. Where unweathered, the lignites are dark brown to black in color. The texture is dense to woody, the bids are usually laminated, and vertical jointing is well developed. Partly silicified stumps and silicified fragments of wood are found in practically all the lignite beds. The commonest impurities are gypsum, pyrite and marcasite.

Every lignite bed varies considerably in thickness from place to place, and, in fact, may completely disappear, to be found again in another area. The greatest thickness was found to be about 20 feet, but from 2 to 5 feet is more usual. Clay partings within a lignite bed are not uncommon, and these partings may enlarge until the lignite is split by several feet of clay.

The Tongue River formation weathers and erodes readily except where the sands have been cemented locally into sandstones. On the other hand, where the sands are not cemented, the beds break down even more rapidly than the clays and very easily may be overlooked.

Clinker or Scoria Beds

Baked and partly fused rocks of various shades of brown and red have been formed wherever the lignite has been afire at the outcrop. This so-called scoria or clinker is wide-spread throughout the area, and is not restricted to the burning of any one lignite. Under favorable conditions any of the lignites will form scoria, although it appears that certain of the lignites have produced the more extensive scoria zones. Ignition of the lignites may have resulted from prairie fires or, more probably, from spontaneous combustion caused by rapid oxidation.

The scoria or clinker is formed mostly above the burning lignite, so that the bottom of the scoria represents approximately the former position of the lignite. The thickness of the scoria and the degree of fusion is, to some extent, a reflection of the thickness of the

lignite and the character of the overlying beds, whether sand or clay.

Environment of Deposition

Fossil remains of plants and fresh water shells indicate a continental environment during the deposition of the Tongue River formation. The presence of lignite beds at frequent intervals denote shallow water, swampy conditions for at least a considerable part of the depositional cycle. The climate was probably temperate rather than tropical.

The clays, which make up a majority of the Tongue River formation, usually have good bedding and the waters in which they were deposited must have been relatively quiet. However, since many of the clays are sandy or silty, the transporting currents must have had sufficient velocity to bring in this type of material.

Although a considerable amount of iron is present, as shown by the buff colors produced by weathering and by the various shades of red and brown in the scoria, the beds are gray in color. This means that sufficient organic matter was present to keep the iron in a reduced condition. Furthermore, lack of oxidation of the iron is against the formation of these beds as part of a flood plain. Shallow water lakes and swamps appear to be a reasonable environment of deposition for a majority of the Tongue River beds.

That depositional conditions fluctuated is a certainty because of the continual interfingering of the clays, silts and sands. That such fluctuations were of only minor magnitude is proven by the repeated appearance of the swamps in which the lignites were formed. Undoubtedly, these swamps were not completely connected, at any one time, and conditions for accumulation and preservation of organic matter were better in some areas than in others. Thus, it would be logical to expect considerable local variation in the thickness of a lignite bed, and even its disappearance and reappearance in nearby areas.

Toward the close of the Tongue River cycle, fine sands, and later, coarse sands became dominant. A quickening of the transporting currents and by-passing of the muds is indicated. Whether this was brought about by upwarping of the land or by a change of climate is not known, but it is obvious that the change was not of large magnitude since the overlying Sentinel Butte formation was deposited in an environment essentially similar to that of the Tongue River.

STRUCTURAL GEOLOGY

Introduction

Western North Dakota is structurally a large, gently sloping trough, to which the name Dakota basin (Williston basin) has been given. The Keene dome, which is shown on Plate 1, lies almost in the center of this geosyncline, being a little to the north and east of the deepest part of the basin.

Correlation of Beds

Whether this structure has been mapped correctly or not depends entirely on how successfully the beds have been correlated.

Collier,[20] in his original map of the Nesson anticline, questioned all of his correlations on the east side of the structure. In the published map of the lignite beds of the western part of the Fort Berthold Reservation,[21] no correlations of any lignites were attempted unless they appeared as continuous outcrops along the hillsides and coulees, even though some uncorrelated outcrops were less than two miles from continuous exposures.

The fact of the matter is, all the lignite beds in the section tend to look alike, and on the upland plain too much of the area is covered with a veneer of glacial deposits. At first it was thought that, with so much variation in the sands and clays, and with so much similarity in the lignites, detailed mapping of the structure was impossible. However, continued field work and more familiarity with the beds showed that reasonable correlations were possible in most of the area. Of course, the lack of good outcrops in the upland areas could not be overcome, and for this reason the final structural map is not entirely satisfactory.

On Plate 1 the actual correlation used at each station is shown by a bed letter, which in turn refers to the stratigraphic section of Figure 1. Thus, anyone can check the correlation that was used.

Regarding the correlation of the stratigraphic section, **Figure 1,** with lignite beds of other investigators, the following approximations can be made. Collier's[22] bed 2 is equivalent to bed D, and his Williston bed is the same as bed H. Herald's[23] bed E in the Fort Berthold Indian Reservation corresponds to bed E in this area. Leonard's[24] bed 2 in Sec 35, T. 153 N., R. 98 W., is bed H, his bed 4 in the Banks Section is bed H, his coal bed 2 in the Tobacco Garden Section is bed F, and his bed 3 in the North Branch Section is bed H. Hennen's[25] lignite 22 is equivalent to bed J and horizon JK.

Using a contour interval of 20 feet, the structural details of the Keene dome are shown on Plate 1. The contours are drawn on bed E and the intervals, that should be added or subtracted to bring the beds to the contour horizon, are shown for each observation.

Elevations were usually run on the bottom contacts of the lignites. Where the lignites had burned out, forming scoria, the bottom contact could usually be determined only approximately. Even so, this approximation is far better than any guess would have been as to the top of the lignite, as already explained under the discussion of the

[20] op. cit. Plate 26.
[21] op. cit. Plate 27.
[22] op. cit. Plate 26.
[23] op. cit. Plate 26.
[24] Leonard, A. G., Babcock, E. J. and Dove, L. P., The lignite deposits of North Dakota: North Dakota Geol. Survey Bull. 4, 240 pp., 1925.
[25] op. cit. p. 1569.

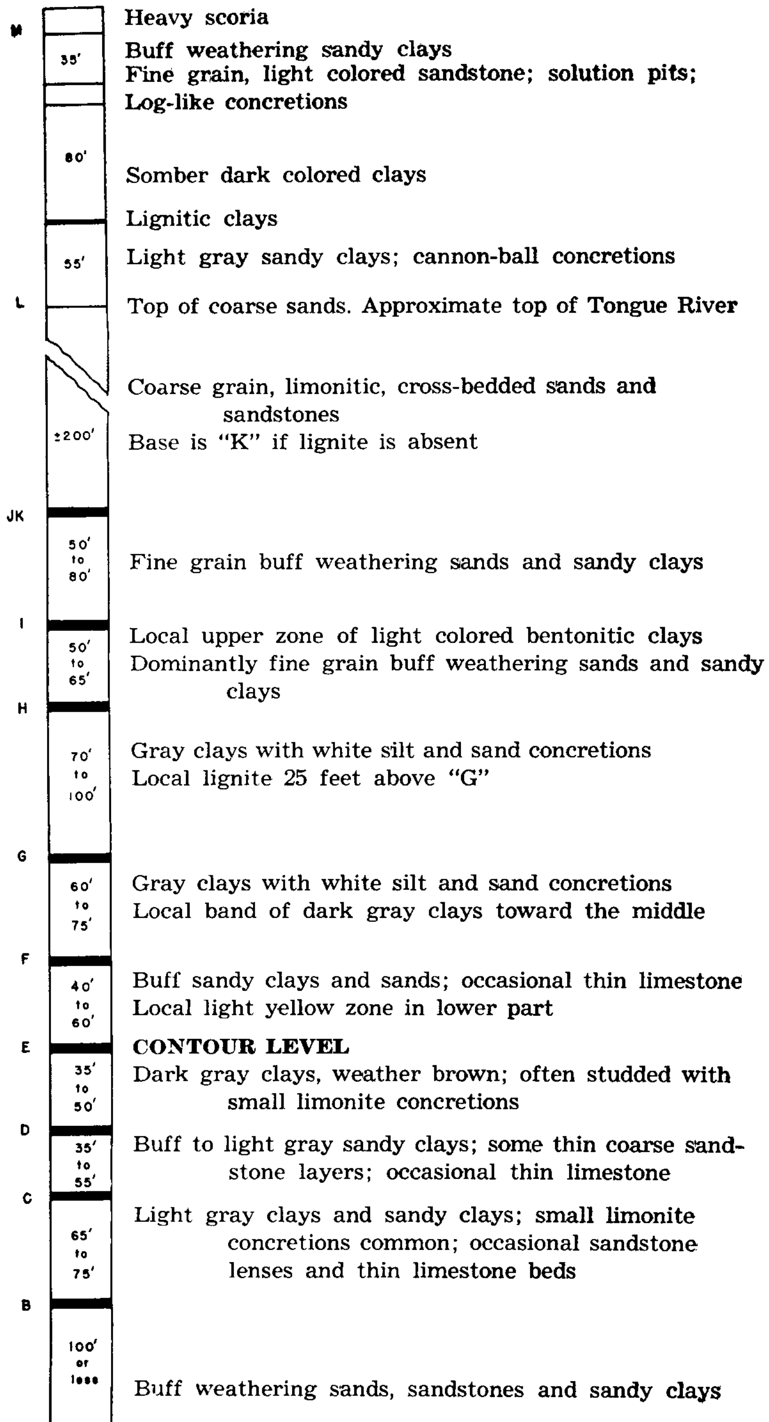


FIGURE 1 Columnar section of the surface stratigraphy of the Tongue River formation

scoria beds. Also, the bottom contact of a lignite is often marked by springs, even though the lignite may be mostly covered.

Slumping of the lignite is rather common and, unless recognized, gives erroneous elevation data. In the bad-lands, large scale slumping occurs with surprisingly little distortion or tilting of the beds. Also, wherever the sand section is thick and uncemeted, slumping invariably occurs. Burning of the lignites may cause local slumping on a much smaller scale.

Closure

The amount of closure could not be accurately determined. This was partly because of scarcity of outcrops on the top of the dome. Of more importance, lack of time prevented mapping the structure north of the Missouri River, where additional closure may be found.

Collier[26] showed the Nesson anticline as plunging south toward McKenzie County. The writer's field work in McKenzie County does not support this, but rather agrees with Hennen's[27] mapping of the structure. Whether the Keene dome is merely the southward extension of the Nesson anticline, or whether it is actually the major part of that anticline, cannot be determined until further detailed mapping is carried on north of the Missouri River.

The possibility of increased closure below the surface should not be ignored. Considering the character of the structure, and its probable origin, the writer is of the opinion that closure will increase with depth.

Faulting

No evidence of faulting, such as shearing and distortion of the beds, was apparent in the vicinity of Schafer. However, unless a mistake has been made in correlation, the only reasonable interpretation of the attitude of the beds in that area is displacement by fauling. Unfortunately, much of the critical area is covered by river alluvium. Until further field work is undertaken the faulting shown at Schafer should be regarded as questionable.

RECOMMENDATIONS

The Keene dome is the largest local structure so far found in western North Dakota. Its location near the center of the Dakota basin is advantageous, although this results in deeper drilling. The Keene dome is an excellent structural trap and merits thorough testing for oil and gas. Before a test is drilled, a seismograph survey should be made to determine the attitude of the deeper formations and the best location of the well.

[26] op. cit. Plate 26.
[27] op. cit. Fig 2.

PART II

The Subsurface Stratigraphy of The Nesson Anticline

By

WILSON M. LAIRD

PART II.

The Subsurface Stratigraphy of the Nesson Anticline

— by —

WILSON M. LAIRD[1]

INTRODUCTION

Abstract

The cuttings of the California Kamp well have been restudied and the stratigraphy is reviewed. Pertinent data concerning the coring and abandonment procedure is published for the first time.

Preliminary Statement

The Nesson anticline is without question the major feature in the Dakota structural basin within the boundaries of North Dakota. It has been long known but only two tests, located very closely together, have been drilled. One, the Big Viking Oil Company well located in the SW¼ of the NE¼ of Sec. 3, T. 154 N., R. 96 W. was drilled to a total depth of only 4642 feet before abandonment and the other, the California Company Kamp Number 1 well, discussed below, was drilled to a depth of 10,281 feet before abandonment. Both were dry holes.

The cuttings have been reexamined by the writer and the following log is based on his interpretations of the cuttings on file in the office of the North Dakota Geological Survey. Any one familier with the literature cited in the footnotes of this report will realize that there are many interpretations of the stratigraphy of this well.

CLASSIFIED LOG OF THE CALIFORNIA KAMP WELL

Depth in Feet	
	TERTIARY
0- 800	TONGUE RIVER FORMATION Interfingering clays, fine and coarse sandstone and silts. Frequent beds of lignite are common. Concretionary masses of limonite and lenses of silt and clay common in the sands.
	CRETACEOUS
800- 910	HELL CREEK FORMATION Gray fine-grained sandstone with some gray shale and lignite. Lignites constitute very minor portion of the section.
910-1010	FOX HILLS FORMATION Gray to buff angular quartz sandstone with some lime cement. Some glauconite present.
1010-4220	PIERRE, NIOBRARA, BENTON FORMATIONS Medium to dark gray shale, some slightly sandy and soft. Pyrite present. Foraminifera are present in Niobara and below and in some places *Globigerina* is so abundant it makes up considerable portions of the rock.
4220-4620	DAKOTA GROUP Clean white to dirty gray quartz sandstone, occasionally tinged red. Sandstone is composed of angular to rounded and pitted quartz grains and some small amounts of mica. Much gray and black shale interbedded.

---

[1] State Geologist and Associate Professor of Geology, University of North Dakota.

JURASSIC

4620-4880 MORRISON FORMATION

Yellow green, green, medium to dark gray to black shale with some gray and green sandstone.

4880-5520 SUNDANCE FORMATION

Gray medium-grained glauconitic sandstone. 4880-5040. Medium gray shale with green tint, green splintery shale with some few gray calcareous sandstones 5040-5210. Dark gray medium-grained quartz sandstone with some red and gray shale 5210-5380. White dense dolomite and red and gray shale interbedded 5380-5520. Questionable pyritized Belemnite mold at 5510.

TRIASSIC

5520-6490 SPEARFISH FORMATION

Contact with overlying Sundance appears to be gradational. Contact picked where red is predominant color of shale. Formation consists of brick red, medium to fine-grained silty angular to subgrounded quartz sandstones, red and gray silty shale and some gray shale.

MISSISSIPPIAN

6490-6740 AMSDEN FORMATION

Red fine-grained silty sandstone, red and purple shale, white dolomitic dense limestone, some white coarse-grained sandstone, and green shale.

6740-8130 BIG SNOWY GROUP

6740-7020 *Heath and Otter formations* — Black carbonaceous splintery shale, purple and green shale and gray shale. Minor amounts of gray dense limestone, sandstone and siltstone.

7020-7320 *Kibbey formation*—Red and white micaceous poorly sorted, limy, fine to medium-grained sandstone. Some white anhydrite and brown dense cavernous limestone.

7320-8130 *Charles formation*—Gray and white with salt hopper cavities. red shaly siltstone and some white and pink fine to coarse-grained sandstone. Gray and dense cavernous limestone. Top of salt on basis of salinity of drilling fluid is at 7330. Base of salt part of section at 7710′.

8130-9540 MADISON GROUP

8130-8660 *Mission Canyon formation*—Upper part dark brown dense and sparsely fragmental limestone with very little dark gray chert 8130-8310. Lower part coarsely fragmental limestone containing small amounts of pyrite with some dark brown dense limestone interbedded 8310-8660.

8660-9540 *Lodgepole formation*—Medium to dark brown dense limestone with minor amounts of sparsely fragmental limestone in upper part. Limestone is slightly darker below 9330.

9540-9650 KINDERHOOK

Black fissile, carbonaceous slickensided shale. At base is about 20 feet of gray calcareous fine to medium-grained sandstone.

9650-10281 DEVONIAN

9650-9810 *Unit A*—Dark brown to light green to slightly pink dense and somewhat silty dolomite. Some pink calcareous siltstone.

9810-10,150 *Unit B*—Medium to dark dense limestone with some medium brown saccharoidal limestone near base of unit.

10,150-10,281 *Unit C*—Dark brown coarsely saccharoidal dolomite. Some dark strain present which does not cut with alcohol.

STRATIGRAPHY

Tertiary

Paleocene

Fort Union group

Tongue River formation

The Tongue River formation has been described by Dr. Nevin in the preceding section of this report and need not be repeated here. In the southern and southwestern parts of the state the Tongue River is underlain by the Cannonball-Ludlow formation. These latter formations are known to thin in a northern and eastern direction and were not identified in the cuttings from this well.

Cretaceous

Hell Creek formation

The Hell Creek formation consists of gray, fine to medium-grained sandstones and silty and lignitic shales. In the Kamp well it is 110 feet thick but thickens south and westward. Ballard[2] gives its maximum thickness at 600 feet.

Fox Hills formation

The Fox Hills formation consists of lime cemented gray to buff angular glauconitic quartz sandstone. On the surface numerous limonitic concretions are present. Heavy minerals are present and a recent study was made of them[3]. The Fox Hills also thickens in a southerly direction.

Pierre, Niobara and Benton formations

No attempt was made to study this extensive shale section in detail. The section is 3210 feet thick and consists of medium to dark gray shales with some sandy and limy members.

In a letter to the author, dated March 21, 1941, J. G. Mitchell notes that rough correlations in this Cretaceous shale section might be made by the use of the foraminifera. Above the Niobara the foraminifera are present although rare and are of the **Ammodiscus** and **Anomalina** (?) types. Through the Niobara many genera are present with **Globigerina** becoming most abundant. In the lower section about the Greenhorn lime horizon only **Globigerina** seems to be present, and here it is so abundant that the tests make up a considerable portion of the rock.

Apparently none of the gas producing sandstones (the Eagle and Judith River) present in the upper part of the Cretaceous shale section farther west extend this far east into the deeper part of the basin.

Undoubtedly these shales do contain minor amounts of hydrocarbons as the gas found in small quantities in the Bottineau area may

[2] Ballard, Norval, Regional geology of Dakota basin: Am. Assoc. Petroleum Geologists Bull. vol. no. 10, p. 1560, 1942.

[3] Lindberg, M. L., Heavy mineral correlation of the Fox Hills, Hell Creek and Cannonball sediments, Morton and Sioux counties, North Dakota: Jour. Sedimentary Petrology, vol. 14, No. 3, pp. 131-143, 1944. Also published as Bulletin 19 of the North Dakota Geological Survey.

have had its source in these beds.[4] It is also reported that oil shows were encountered in the Pierre section in the Des Lacs Western Oil Company well No. 1 in the SW¼ of Section 4, T. 155 N., R. 85 W., Ward County, North Dakota.[5]

Dakota group

The Dakota sandstone consists in this well of clean white to dirty gray quartz sandstone. The grains are angular to rounded and pitted. Some mica is also present. A faint reddish tinge is found in some of the sandstones. The sandstones are apparently interbedded with much gray shale.

The Dakota group is the source of much artesian water in southeastern and eastern North Dakota. Small amounts of gas are present but no oil in commercial quantities has ever been found in the Dakota sandstone in North Dakota. It is likely that if it ever were present that the powerful artesian circulation may have flushed it out.

Jurassic

Morrison formation

The Morrison formation is a yellow green to green, gray to black shale with some gray to green sandstone. The formation is 260 feet thick in this well but areally the thickness of this formation is erratic due to the overlying unconformity. Probably the thickness given for the Kamp well is larger than that found in many other areas of the Northern Great Plains due to its location near the center of the Williston structural basin.

Sundance formation

The Sundance formation in the Kamp well is divisable into an upper gray medium-grained calcareous poorly cemented sandstone, a middle unit consisting of a medium gray shale with a green tint and green splintery shales with some few calcareous sandstones, and a lower dark gray, medium-grained quartz sandstone with some red and gray shale and white dense dolomite interbedded.

The gray green shale resembles the appearance of the Ellis shales on the outcrop and it is probably in part at least an equivalent. The shales might prove to be possible source beds and the sandstones in the upper part of the section are porous enough to make an adequate reservoir if the oil were present.

Triassic

Spearfish formation

The Spearfish formation appears to be in gradational contact with the overlying Sundance formation. The Spearfish is predominantly a brick red medium to fine-grained silty sandstone consisting of angular to subrounded quartz fragments. Gray and red shale are also present but in minor amounts. There appears to be little porosity

[4] Barry, John G., The Bottineau gas field: North Dakota Geol. Survey, Fifth Bienn. Rept., p. 251, 1908.
[5] Laird, Wilson M., Selected deep well records: North Dakota Geol. Survey Bull. 12, p. 7, 1941.

in the silty sandstone. R. A. Carmody[6] places the "Minnelusa-Tensleep" between 6465-6485 in this section, but this unit is included here as the basal part of the Spearfish formation, as no lithologic basis for such a distinction could be seen in the cuttings examined.

Mississippian

Amsden formation

The portion of the stratigraphic section in the Kamp well herein being termed the Amsden formation is one of the most controversial parts of the whole section. The formation consists of 250 feet of white dense dolomitic limestone, red fine-grained silty sandstone, red and purple shale, some white coarse-grained sandstone and a little limy green shale. The writer follows the usage of O. A. Seager et al[7] in terming this stratigraphic unit the Amsden formation.

The lithology of the unit fits that observed by the writer on the outcrop in west-central Montana and fits the description given by Scott[8] for the Amsden formation of south central Montana.

Ballard[9] not only places the Permian Minnekahta and probably the Opeche formations in this interval but also the Pennsylvanian Minnelusa formation. This latter formation he says is represented in the Kamp well by non-porous red sandy shale and evaporites. This lithology was not observed in the samples studied by the writer.

Big Snowy group

Heath and Otter formations

These two formations cannot be separated in the subsurface although on the outcrop the Heath usually consists of black splintery thin bedded shale and thin dense white to gray limestones while the Otter is a characteristically bright green shale. In the Kamp well this unit consists mainly of black and green or purple shale with a few gray dense limestones and siltstones.

Kibbey formation

The Kibbey consists mainly of poorly sorted silty red sandstone and some evaporites. Some brown cavernous limestone is present from 7180-7220 but the sandstones are so impure they would make poor reservoir rocks. However, some oil has been produced from what is thought by Ballard[10] to be the Big Snowy group in the Baker Glendive anticline.

Charles formation

This formation consisted of gray and white anhydrite and salt, some siltstone, and some white to pink coarse-grained sandstone. Gray dense cavernous limestones are also present. This formation has

[6] Carmody, R. A., Guide Book Kansas Geol. Soc., 14th Annual Field Conference, p. 137, 1940.
[7] Seager, O. A. et al, Discussion, Stratigraphy of North Dakota: Am. Assoc. Petroleum Geologists Bull. vol. 26, No. 8, p. 1419, 1942.
[8] Scott, H. W., Some Carboniferous stratigraphy in Montana and northwestern Wyoming: Jour. Geol. vol. 43, No. 8, pp. 1020-1023, 1935.
[9] Ballard, Norval, Regional geology of the Dakota basin: Am. Assoc. Petroleum Geologists Bull., vol. 26, No. 10, p. 1563-1564, 1942.
[10] op. cit. p. 1582.

been placed in the Big Snowy group by Perry and Sloss[11], although it clearly is gradational in the subsurface with the underlying Madison limestone. It is probably genetically more closely related to the Madison than the overlying Kibbey which appears to be a phase of a transgressing sea.

The Charles has never been observed on the outcrop and it is probable that its place is taken by other formations of different lithology. Possibly the upper part of the Hannan formation of Deiss[12] or the basal part of the Brazer of the main geosynclinal area further west may be the representative of the Charles. Correlation with the middle part of the Rundle limestone of Alberta is also suggested.[13]

Madison group

Mission Canyon formation

The Mission Canyon consists of dark brown dense limestone and coarsely fragmental limestone. The coarsely fragmental limestone is composed in large part of recrystallized and unrecrystallized crinoid stem fragments. Very little chert is present in the cuttings. The gradational contact with the Charles has been noted above. The contact with the underlying Lodgepole is also gradational in the subsurface.

Lodgepole formation

The Lodgepole formation is mainly a dense, medium to dark brown limestone with very small amounts of chert in the Kamp well. Below 9330 in the Lodgepole formation, the color is somewhat darker. On the outcrop the basal part of the Lodgepole is a dark gray to black chert-bearing member termed the Paine formation. In the Kamp well little chert appears to be present in the cuttings studied.

Kinderhook

The beds herein assigned to the Kinderhook are probably the same as those called the Englewood formation by Ehlers[14] in the E. L. Semling well.

The formation consists of fissile, black, carbonaceous shale with some gray calcareous fine to medium-grained quartz sandstone at the base. This shale is similar in stratigraphic position to the Exshaw shale of Alberta but Warren[15] states that the type of the Exshaw shale is Upper Devonian. On the Sweetgrass Arch the lower portion of a unit similar to what is herein termed Kinderhook is also a sandy limestone or limy sandstone.[16]

[11] Perry, E. S., Sloss, L. L., Big Snowy group: Lithology and correlation in the northern Great Plains: Am. Assoc. Petroleum Geologists Bull., vol. 27, No. 10, pp. 1299-1301, 1943.
[12] Deiss, Charles, Stratigraphy and structure of southwest Saypo quadrangle, Montana: Geol. Soc. America Bull., vol. 54, pp. 228-231, 1943.
[13] See also Sloss, L. L., Laird, W. M., Mississippian and Devonian stratigraphy of northwestern Montana: U. S. Geol. Survey Oil and Gas Invest. Prelim. Chart 15, 1945.
[14] Ehlers, Allen, Williston basin wildcat test, Oliver County, North Dakota: Am. Assoc. Petroleum Geologists Bull., vol. 27, No. 12, pp. 1618-1632, 1943.
[15] Warren, P. S., Age of the Exshaw shale in the Canadian Rockies: Am. Jour. Sci., 5th ser., vol. 33, pp. 454-457, 1937.
[16] See Sloss, L. L., and Laird, W. M., op. cit.

This shale where observed in the Sawtooth Range in western Montana contained considerable hydrocarbon especially on Cabin Creek located in Section 25, T. 23 N., R. 10. W. If this shale were present in any thickness it should provide an excellent source rock.

Devonian

The rocks assigned to the Devonian in the Kamp well can be divided into three units arbitrarily designated Units A, B, and C. Unit A is a dark brown, green to slightly pink dense silty dolomite. Unit B is a medium to dark brown dense limestone and Unit C is brown coarsely saccharoidal dolomite. The three units designated above appear to correspond to the Amaranth, Manitoba and Winnipegosan formations described by Ehlers [17] as occurring in the Semling well.

Not all who have studied these cuttings agree that the well bottomed in the Devonian. Jones[18] places the base of the Devonian at 10,145 and places the remainder of the hole in the Ordovician. Carmondy[19] states that be believes it doubtful if rocks of Osage age were reached.

Hennen[20] places the base of the Devonian at 10,050 putting the remainder of the hole in the Ordovician. Seager et al[21] believes that the drill was in the Devonian when the hole was abandoned.

Hennen[22] notes oil showings in what he classifies as Ordovician from 10,050 to 10,245. His information is based on a personal communication from Thomas Leach.

Pre-Devonian Rocks

As is indicated above, it is the belief of the writer that pre-Devonian rocks were not entered by the drill in the Kamp well. Hennen also reports that geophone tests at the bottom of the hole made prior to the time the drill stem stuck indicate that there are approximately 2,000 feet of sedimentary strata which are as yet untested present above the basement rock. On the basis of information obtained in the Semling well, it is highly probable that these rocks are largely Ordovician in age. There are some, however, who would place some Silurian beds in both wells.

In the Semling well the Ordovician consists of limestone, dolomite, shale, sandstone, and conglomerate. Hennen[23] calls attention to the series of porous dolomites found in the Semling well at 7180-7372, the sandy phase at 7495-7545, and the sand series from 8476-8831. This

[17] op. cit. p. 1620.
[18] Jones, C. T., Contribution to stratigraphy of northern Great Plains area: Kansas Geol. Sec. 14th Ann. Field Conference, p. 130, 1940.
[19] Carmody, R. A., Kansas Geol. Soc. 14th Ann. Field Conference, p. 137, 1940.
[20] Hennen, R. V., Tertiary geology and oil and gas prospects in Dakota basin of North Dakota: Am. Assoc. Petroleum Geologists Bull., vol. 27, No. 12, pp. 1588-1589, 1943.
[21] Seager et al, op. cit. p. 1421.
[22] op. cit. p. 1588.
[23] op. cit. p. 1589.

lower sand probably represents the Winnipeg formation as given by Ehlers[24] in his description of the Semling well.

A similar sand section totalling approximately 290 feet in thickness in the basal Ordovician was also encountered in the Northern Ordnance Inc. Franklin Investment Co. number 1 well located in the C. of the NW¼ of the SW¼ of Section 35, T. 133 N., R. 75 W., Emmons County, North Dakota.

Thus it would appear that the Ordovician offers excellent possibilities for a reservoir rock on the Nesson anticline if the wells are drilled deep enough. The sandstone section is very porous and quite thick. What the chances of oil being there are, of course, impossible to say at the present time. The structure certainly merits another deep test. With the drilling equipment now available, it should be possible, even though admittedly expensive, to reach these sandstones easily. Hennen also suggests that the structure is greatly accentuated at depth.

THE CALIFORNIA KAMP WELL

Pertinent Data

Name: California Company Nels Kamp No. 1.

Location: C of the NW of the NE¼ of Section 3, T. 154 N., R. 96 W., Williams County, North Dakota.

Operation started September 28, 1937.

Operation completed August 15, 1938.

Elevation: 1918 A. T. surface, 1926 rotary table.

Core Record

The following record of the cores taken has been in the file of the North Dakota Geological Survey for some time. Through the courtesy of Mr. N. H. Hickey of the California Company this information has been released. The numbers in some instances are not consecutive, but this is the fashion that the data is recorded. Numbers 1 and 13 appear to be missing. This is probably due more to misnumbering than actual loss or non-recording.

No. 2. 4165-4180. Recovery 15 feet. Dark green laminated to massive shale.

No. 3 4231-4236. Grayish sandy shale with very thin fine-grained sandy inclusions.

No. 4 4525-4541. Recovery 13 feet. Two feet brownish black brittle shale. 10′ 6″ slate-gray soft shale and hard bluish gray sandy shale.

No. 5 4922-4937. Recovery 15 feet. Alternating thin beds of hard grayish calcareous sandy shale and light green brittle flaky shale.

No. 6 6254-6264. Recovery 8 feet. Hard, brittle, bright red shale with a considerable number of salt-filled fissures 1/8″ to 1/5″ wide. Much salt is disseminated through the red shale. In places where the salt has been removed by solution, a honeycomb structure is present in the shale. This red shale is calcareous in spots.

[24] op. cit. p. 1620.

No. 7 6651-6671. Recovery a few fragments up to egg size. Fairly hard, splintery non-limy massive deep maroon shale with conchoidal fracture. Fairly hard, laminated and mottled splintery non-limy brick red shale. Fairly hard, laminated light to dark purple shale, locally with light crystalline limestone. White, medium grained, quartz sandstone with angular grains. Fairly soft, laminated black shale with deep green cast. Hard massive non-calcareous gray shale. Light limy sandstone with a green cast. Abundant pryite disseminated in hard massive dark shale. Hard, massive, light greenish-gray and light green shale. Hard, massive, very fine-grained dark gray sandstone.

No. 8 6671-6679. Recovery 15 inches.

Top: Fairly hard, laminated purple shale, interbedded with thin streaks of very deep purplish well-rounded, frosted and pitted sand, and hard light gray to very light violet colored shale.

Miscellaneous: Same as above plus white to dark brown and reddish, fine-grained sand. The grains are mostly angular, but elliptical and subelliptical grains are also present.

Bottom: Fairly hard, laminated, purple and light gray shale, interbedded with thin streaks of dark purplish, well-rounded sand. In this shale, there are sand-filled fissures.

No. 9 6679-6693. Recovery 2½ feet. Fairly hard, light to dark purple, laminated shale interbedded with thin layers of deep purplish, well-rounded sand. Some deep well-rounded sand with lime cement. At bottom of core is a white, fairly hard, compact sand with some well-rounded but mostly angular quartz grains.

No. 10 6693-6703. Recovery 1½ feet. Fairly hard, compact white sandstone with angular grains. Hard, compact, deep red sandstone with some lime cement; the grains are well-rounded. Hard, deep red non-limy laminated shale.

No. 11 6703-6710. Recovery none. Descriptions based on cuttings. Mostly bright red, limy, vuggy, fine-grained sandstone with smaller amounts of deep red laminated splintery shale. Light to purplish sandstone and light green limy shale. Very small amounts of gray to brown, limy, medium-grained sand, light to greenish fine-grained sand and dark green to black shale and dark green, limy shale. Traces of lime and dolomite.

No. 12 6715-6726. Recovery 7 feet. Finely laminated shale with a light to dark purple color showing some brittle splintery fracture as will as some conchoidal fracture. Good cleavage parallel to bedding and evidence of joints or fractures normal to bedding also present. Small fragments of fossil plants.

No. 14 6736-6746. Recovery 8½ feet. Fairly hard, calcareous and non-calcareous black shale. Some of the shale has vuggy openings to ½" lined with calcite crystals. Some pyrite as replacement in the shale.

No. 15 6988-7006. Recovery 14 feet.

Top .4"—gray limy shale, 10" red limy shale—shows mottling and contains included anhydrite; 1' massive grayish green shale; 11" gray limy shale grading into: 14½" red mottled shale containing included anhydrite—sharp break—10" gray, slightly limy, shale—grades into 17½" (3") deep red mottled shale and (14") of red shale containing much included anhydrite— contact below is sharp; 23½" gray, slightly limy—shale—somewhat mottled with green—grades into purplish shale—contact below sharp with 31½" gray mottled shale grading into gray mottled red shale (at 19½") sharp contact; 12½" mottled red shale containing much included anhydrite; 19" gray and grayish green shale—disconformable contact below; 15" red shale and gray shale with included red shale with 2" anhydrite at base.

No. 16 7070-7088. Recovery 14.66 feet.

Top 27¼"—fine red limy sand

38"—fine red limy sand and red sandy shale. With very small amounts of muscovite

36"—fine red limy sand and included red shale—stringers of purple shale and some red shale — salt disseminated throughout

1"—deep purple shale; ¼" bright green shale

49"—medium-grained white, pink and red sand, grains fairly well-rounded

8¼"—red, limy, sandy shale containing included anhydrite

No. 17 7088-7106. Recovery 39".

Top Fragments of pink and white, medium-grained, limy sand

limy, sandy red shale

limy, medium-grained red sand with small amounts of included anhydrite

No. 18 7106-7115. Recovery 8' 3".

37½"—slightly limy, red sandy shale with thin beds of laminated purple shale and green shale

8"—red, limy and sandy shale

15½"—medium-grained, white limy sand

38"—red, sandy and limy shale, with red shale inclusions

No. 19 7124-7133. Recovery 41".

A few fragments of black shale and hard concretionary material

9"—medium-grained, limy, pink sand

7"—medium-grained, pink and white, limy sand

16"—deep red shale—interbedded with very thin layers of green shale—lower portion somewhat sandy and limy

9"—deep red, limy, medium-grained sand with some included anhydrite

No. 20 7133-7142. Recovery 52".

18"—red limy sand with some included anhydrite—some of the sand is mottled

23½"—sandy red shale—limy in places

10½"—red and white medium-grained, limy sand

No. 21 7200-7209. Recovery 59". Soft and hard, brown limestone containing much salt.

No. 22 7238-7246. Recovery 7'.

19"—very hard, buff to pink, slightly limy sandy shale—some anhydrite

1"—white, limy, fine-grained sand, very hard

11"—deep red, slightly limy, sandy shale with much included anhydrite

31"—white and buff, fine, limy, interstratified sand containing much included anhydrite

22"—pink and red sand and sandy shale—limy and very hard

No. 23 7246-7252. Recovery 5' 2".

Very slightly limy, red sandy shale with some included red shale and some included anhydrite; red shale

Some limy buff sand

No. 24 7296-7304. Recovery 3 small pieces.

No. 25 7304-7305. No recovery.

No. 26 7307-7309. No recovery.

No. 27 7309-7310. No recovery. At 7310, found about 4 feet of core wedged in first joint of drill pipe indicating inner barrel was not seated.

No. 28 7354-7363. Recovery 1 foot. Transparent, crystalline salt, with some included red shale.

No. 29 7380-7389. Recovery 3 feet of transparent, crystalline salt with a little included red shale.

No. 30 7545-7554. Recovery 7'. Red and gray shale interbedded with and included in transparent crystalline salt.

No. 31 7696-7705. Recovery 37". Transparent, crystalline salt with some included soft gray clay.

No. 32 7737-7746. Recovery a few fragments of anhydrite.

No. 32-A 7746-7748. Recovery 18½"—oolitic very salty, brown limestone.

No. 33 7748-7756. Recovery 50"—oolitic very salty, brown limestone; gray clay; light brown, dense lime; anhydrite.

No. 34 8052-8057. Recovery two small pieces of very dense, translucent, brownish and white anhydrite, with and included in dense brown dolomite.

No. 35 8206-8211. Recovery 51" of dark gray and brown limestone, containing many brachiopods, and small masses of crystalline calcite and anhydrite. Gives a strong odor of H_2S when broken.

No. 36—8231-8240. Recovery 31" of light, gray to tan, rather dense limestone, containing small included masses of crystalline calcite. Surface stained black. Dense grayish-brown lime at base.

No. 37 8418-8421. Recovery 21" of hard very dark brown and gray limestone containing small masses of calcite and included white anhydrite. H_2S odor in fresh fracture.

No. 38 8636-8637¾ Recovery — several fragments of fairly hard, light tan to gray, highly crystalline lime. One piece of hard, black cherty lime at base. Fossil crinoids and brachiopods. H_2S odor.

No. 39 8645½-7648½. Recovery 2½'.

No. 40 9544-9561. Recovery 2½'.

2' of broken, fairly hard, non-calcareous, fossiliferous, black shale—pyrite and calcite

6" of fairly hard, light gray, fossiliferous lime

No. 41 9891-9909. Recovery 7' 2".

No. 42 9980-9998. Recovery 3 feet.

No. 43 10076-10094. Recovery 4' 6".

10076-85 Hard medium and dark brown dense and very finely crystalline lime.

10085-94 Small amount of black filling (showing flow?) in hard fractured gray dolomitic shale somewhat mottled with brownish shale—contains fine stringers of transparent crystalline anhydrite and small amounts of pyrite; a few fragments of very dark brown lime and anhydrite; hard bluish gray dolomitic shale.

No. 44 10201-10213. Recovery 10" in bottom of barrel, the remainder being mud. Several large pieces of dense laminated finely crystalline dolomitic lime, several pieces of dense massive finely crystalline dolomitic lime.

No. 45 10213-10219 Recovery 2'. Brown finely crystalline dolomitic lime; some anhydrite; a few fragments of dense laminated finely crystaline dolomitic lime; two pieces of red dolomitic shale (probably contamination).

Abandonment Procedure

The following paragraphs are quoted from a letter dated February 27, 1939 addressed to Dr. Frank C. Foley, then State Geologist, from Mr. J. M. Kirby of the California Company.[25] The information contained therein is pertinent in that there have been numerous requests for this information from interested parties.

"The well had reached a total depth of 10,281' on August 14, 1938. While rotating to bottom, the drill pipe stuck at 10,280'. Circulation was free, and the pipe was worked to 10,281', but could not be recovered. On August 14, 1938, we washed the hole with 1500 gallons of 15% hydro-chloric acid, the pipe being worked at frequent intervals during this process. On August 18, 1938, all acid was circulated from the hole and on the following day we pumped in 220 barrels of fuel oil, moving same up the hole in stages, and working the pipe intermittently. All the oil was circulated from the hole on August 21. Another charge of 3000 gallons of 15% hydro-chloric acid was pumped in and moved up the hole in stages, working the drill pipe frequently. On August 24, all the acid was circulted out of the well but the drill pipe would not move.

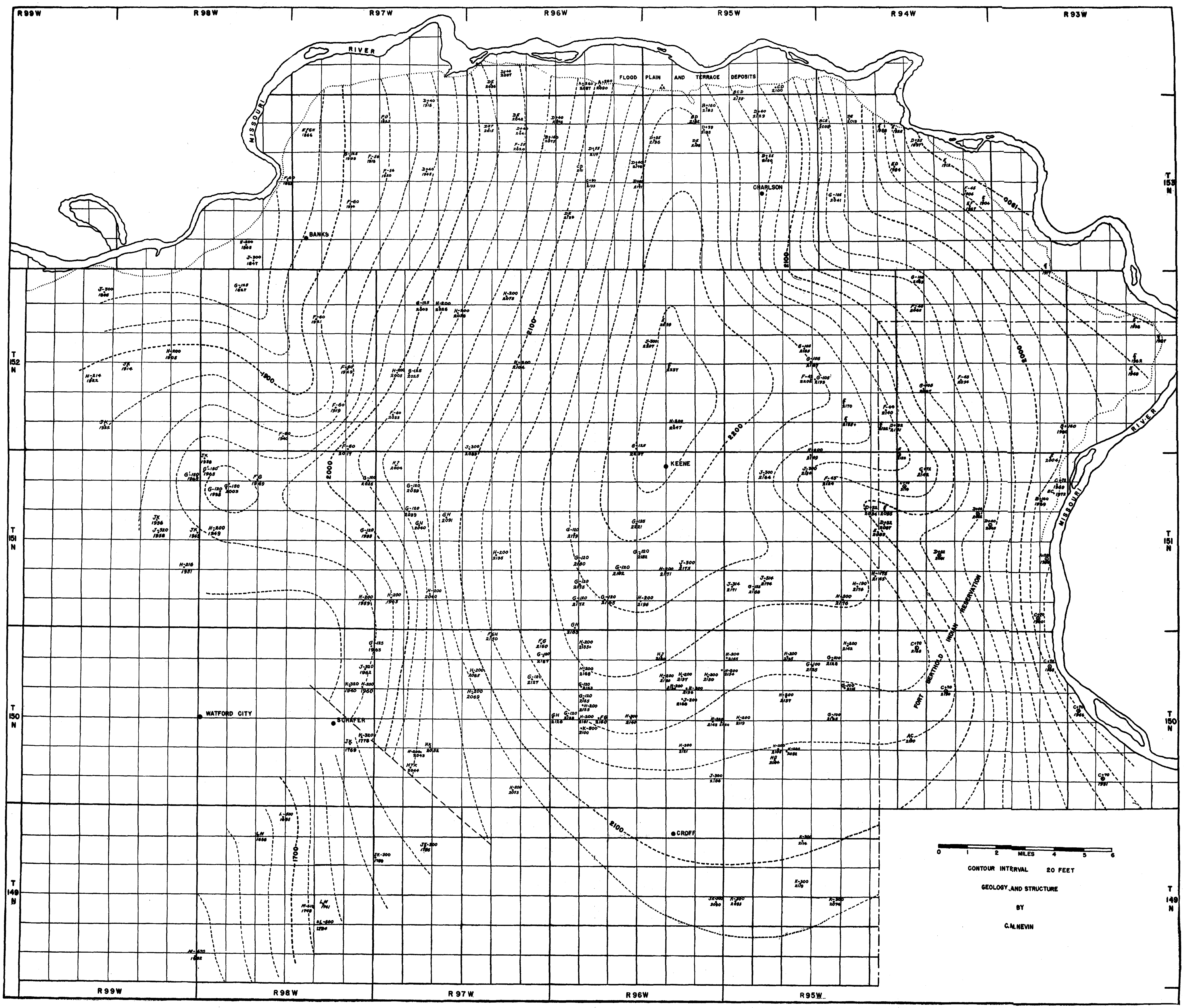
[25] Letters on file with the North Dakota Geological Survey.

On August 29 we began shooting the drill pipe to recover as much as possible. After 5 shots, placed at various depths, the pipe was finally shot off at 7511' and this amount recovered.

On September 3 we bagan operations to remove the 9⅝" casing. The casing was shot five times at various depths, and finally came loose at 4000 feet and this amount was recovered.

On September 5 we ran 4000 feet of drill pipe into the hole and pumped out 10 sacks of cement. The drill pipe was pulled up to 3940', and 15 sacks of cement were spotted at this point. Drill pipe was then pulled up to 1570', and 44 sacks of cement spotted at this depth. The top of this cement plug was later located at 1500'. At this stage of abandonment proceedings, 850' of 13⅜" casing still remained cemented in the hole, leaving the hole open from 850' to 1500'.

At the lessor's request a reducer and valve were placed in the top of the 13⅜" casing to provide him with a water well. Final abandonment of the hole was completed on September 16, 1938, and the work of tearing down surface equipment began."


R99W
R98W
R97W
R96W
R95W
R94W
R93W
MISSOURI
RIVER
FLOOD PLAIN AND TERRACE DEPOSITS
CHARLSON
BANKS
KEENE
WATFORD CITY
SCHAFER
CROFF
FORT BERTHOLD INDIAN RESERVATION
T 153 N
T 152 N
T 151 N
T 150 N
T 149 N
1900
2000
2100
2200
1700
0 1 2 MILES 4 5 6
CONTOUR INTERVAL 20 FEET
GEOLOGY AND STRUCTURE
BY
C.N. NEVIN