South Dakota
Geological and Natural History Survey
Freeman Ward, State Geologist

CIRCULAR 18

Well Log in Northern Ziebach County

by
W. L. Russell

The Fossil Content

by
T. W. Stanton
U. S. Geological Survey

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EXPLANATION

The Survey issues two series of publications as follows:

BULLETINS.—Some subjects have been investigated a longer time, full data have been gathered, such preparatory or experimental work as was necessary has been entirely or nearly completed. In other words, the study of the subject is actually completed or so nearly so that the results can be relied on and published with a degree of confidence as to their value; and the treatment is full and thorough. In such case the matter is published as a bulletin.

CIRCULARS.—But often during the progress of the work enough information is at hand to be of value to those interested, yet not enough for a complete treatise. A part of a county or a part of a certain subject may be finished, perhaps, and publication waiting for the complete investigation of the whole county or the whole subject. There may be a demand for statistical matter, or lists of references, or current information, etc., which would hardly do for a formal bulletin. Such partial reports, summary reports, reports of progress, lists, or unit fragments of larger subjects, etc., are handled in circulars.

It is planned to publish the circulars frequently and the bulletins at longer intervals. With this arrangement much information will reach the public with a minimum of delay.

Inquiries may be addressed to the State Geologist, Vermillion, S. D.

The Log

W. L. Russell

LOCATION AND ACKNOWLEDGMENTS

After the completion of the field work on which Circular 13[1] is based, the citizens of Isabel organized the Irish Creek Oil Company to drill the most prominent structure found in the area examined. The well is located in the S. E. ¼ of Sec. 17, T. 15 N., R. 20 E. A diamond drill with a single core barrel was selected for the test. After a depth of 1,550 feet had been reached, an unsuccessful fishing job caused the abandonment of the first hole. But another was begun a few feet away, and at present (September, 1925) the bottom of the hole is at 2,049 feet. Very generously the Irish Creek Oil Company donated the core to the State Geological Survey for examination. The samples from 80 to 1,550 feet are from the first hole. The log of the well is hereby published by permission of the Irish Creek Oil Company.

As there are no deep wells in this part of South Dakota between the Black Hills, 120 miles southwest, and the Standing Butte well, northwest of Pierre, about 80 miles southeast, and as the diamond drill core gives an excellent record of the character of the formations, further drilling on this well should be awaited with great interest.

THE LOG

The log of the well is given below. The boundaries of the formations are determined by the lithologic characteristics and not by the fossil content.

FOX HILLS FORMATION

0-80. Fish tail bit used—no core obtained.

80-89. Alternate bands of bluish gray shale and soft, very fine grained, grayish or yellowish gray sandstone or silt. The sandstone bands vary in width from four inches to 0.1 inch, and the sandstone is all extremely fine grained, shaly, often silty. The boundaries between the sandstone and shale layers are abrupt and not gradational. The minute laminae of the sandstone or silt bands are often cross bedded, being in some cases inclined 10 degrees to the main band. The thickness of the same band may often be observed to vary from one part of the core to the other, and the amount of shaly material in the bands varies also from one part of the same band to another. The upper surfaces of the sandstone bands are irregular, possibly owing to ripple marks. The amount of sandstone from 80-89 is slightly less than the amount of shale.

[1] Roy A. Wilson and Freeman Ward—The Possibilities of Oil in Northern Ziebach County: South Dakota Geol. and Nat. Hist. Survey, Circular No. 13, April, 1923.

89-139. Shale and silt bands as above, with the shale greatly predominating. Limestone and pyrite concretions. The shale from 80-139 is lighter in color than the shale from 400-550, which is darker than the shale in the lower part of the Pierre shale.

All of the strata in the Fox Hills formation, including the shaly sandstone and silt, will effervesce with hot hydrochloric acid, most of them briskly. These strata, with the exception of the concretions, will effervesce but slightly with cold hydrochloric acid. At 139 is a slickensided surface inclined to the core at an angle of 50 degrees.

PIERRE SHALE

139-180. Bluish gray clay shale, silty, especially near the top, but without distinct bedding or lamination.

180-220. Bluish gray shale, with occasional light colored streaks containing silt, and numerous lumps and slabs of silt, which suggest an intraformational conglomerate.

220-260. Bluish gray shale, without much lamination, and with a few sandy or silty streaks, and numerous thin fragments of sandstone or silt.

260-335. Very fine grained, shaly, greenish gray sandstone, with numerous shale bands and also particles of sandstone embedded in shale, and shale in sandstone. The shale predominates in the core, but in the original rock the sandstone probably predominates, for the sandstone, during coring, wastes away much more rapidly than the shale. Strata of relatively pure sandstone several feet thick at 260, 305, 317 and 329 feet, but even these contain some shaly streaks and shaly material.

335-396. Grayish blue shale with a few silty streaks and innumerable lingulae.

460-522. Dark gray, calcareous shale, with little or no silt, which contains numerous white specks and is rather chalky in certain layers. Numerous lingulae in certain strata. Laminae frequently inclined about 10 degrees.

522-587. Dark gray, non-calcareous shale, which will not effervesce with cold hydrochloric acid, containing numerous thin laminae and streaks of silt, 1-20 to 1-10 inch thick and on average about 1-5 inch apart. A few layers containing numerous lingulae. No chalk.

587-589. Dark gray, calcareous shale stratum or concretion, containing lingulae.

589-599. Dark gray, clay shale, in part slightly calcareous, with occasional streaks of silt, but in general much less silt than preceding. Lingulae present at 594 only.

599-612. Light bluish gray shale, in part slightly limy with numerous streaks of silt, especially a fine, greenish gray silt or sandstone.

Practically no lingulae are present below 594 in the Pierre shale. A few are present in the Niobrara, but the shells of these are lighter in color than those in the Pierre above 594. All formations from 139 to 612 are dolomitic.

612-1,445. Light bluish gray, dolomitic shale, lighter below, with practically no slit. Dolomitic and occasionally slightly calcareous. Fossiliferous in lower part. Upper part badly checked. No lingulae. Baculites in lower part.

1,075-1,085. Numerous slickensided surfaces, one of which has been mineralized by calcite and another developed parallel to it ¼ inch away. Dips of slickensided surfaces generally 30-80 degrees. Indications of dip at this horizon also.

From 1,085 down to 1,445 there are numerous fragments of shells which have a fibrous structure, the fibers being arranged at right angles to the surface of the shell. These bits of shell are scattered very irregularly through the strata and are probably *Inoceramus*.

From 1,050 on down to 1,445, there are numerous strata of light bluish gray, clay shale, that when immersed in water will swell to many times their original volume, turning to a soft, plastic mud. In the 200 feet from 1,245-1,445 nearly all the strata are of this character.

From 1,360-1,410 the dip is generally at a high angle, in some cases as high as 25 degrees, as indicated by the way the core breaks, by the indistinct laminations and by the inclined fossils.

1,445-1,585. Very dark gray shale, from which oil may be distilled. Crumbles up to a soft mud when placed in water. Parts of it are slightly dolomitic. Contains fish scales, spines, bones and vertebrae.

NIOBRARA FORMATION

1,585-1,880. Bluish gray shale, much lighter than the preceding, but darker than the shale from 612-1,445. A small amount of oil may be distilled from it. Most of this shale is dolomitic; portions of it are calcareous and chalky; and it contains very few fossils except a few cylindrical tubes.

1,680-1,865. Medium dark, bluish gray shale, calcareous and more or less chalky, containing fish scales, spines, bones and vertebrae, like the shale from 1,445-1,585. Oil may be distilled from the darker layers.

1,865-1,885. Hard, gray, impure chalk.

1,885-1,925. Dark bluish gray shale, and light bluish gray shale, all calcareous, especially the latter, interbedded with a dark bluish gray, mottled rock. The mottling is due to the presence of lighter particles of shale and shells in the dark shale. Pieces of the darker shale also occur embedded in the lighter shale. These features apparently represent an intraformational conglomerate. A few lingulae are found in the lighter layers but they are lighter in color than those of the Pierre shale.

1,925-1,960. Bluish gray, calcareous shale and shaly limestone, chalky in certain layers, from the darker layers of which oil may be distilled.

CARLILE SHALE

1,960-2,049. Bluish gray, clay shale, slightly dolomitic, but much less so than the Pierre shale. A trace of oil may be distilled from it.

Bottom of hole at 2,049.

NOTES

POSSIBLE ERRORS

The depths of the fossils and other features in the core were estimated by distributing the loss due to grinding between the portions on which the depths were marked. As, however, the core does not grind away at the same rate, an uncertainty of 5 or 10 feet is sometimes involved. In a few cases it was found that fossils fitted into fragments 5 or 10 feet lower down. This was apparently due to the cores being inverted as they were inserted in the core boxes.

POROSITY TESTS ON SANDSTONE FROM 250 TO 335.

Depth in ft.	Size of sample in cu. in.	Porosity
300.	0.324	36.7
300.	0.424	34.2
320.	0.233	36.7
266.5	0.395	32.9
266.5	0.448	33.7
266.5	0.292	35.3

These determinations were made by measuring the volume directly with acetylene tetrachloride.

TENDENCY OF THE FORMATION TO CAVE

With the exception of the chalk from 1,965-1,995 and a few of the limy layers and concretions, all of the strata will soften up and fal into pieces when placed in water. Most of these strata, including practically all of the Fox Hills formation and the Pierre and the Carlile, will swell up and change to a very soft mud when placed in water. This is especially true of the light gray shales near the base of the Pierre, which will swell to many times their original volume, becoming a light gray mud with an unctuous or soapy feeling. This indicates that these formations in the well, with the exception of the chalk, will cave when the well is allowed to stand with water in it; consequently the drill should be followed closely by the casing.

STRUCTURAL FEATURES

At several points the core exhibits steep dips and zones containing many slickensided surfaces. The dip is not constant throughout the core, but changes several times. Throughout most of the core it is nearly horizontal, where it can be determined, but at several points it exhibits dips of from 5 to 10 degrees and in one case 25 degrees. There is no sign of any marked dip below the top of the dark shale encountered at 1,445 feet, though a few slickensides were noted in the Niobrara formation. In much of the rock penetrated, especially in the lower part of the Pierre, it is impossible to determine the dip, as there is no visible lamination or stratification.

The inclination of the strata is probably not due to oblique lamination or cross-bedding, for it is often continuous for many feet at the same angle and is associated with the slickensides. The nature of the formation—very fine shales—is such as to render it unlikely that they would be cross-bedded at angles as high as 25 degrees. The dips and fractures are probably due to the crumbling of the shales in certain zones. Such a condition is common in the outcrops to the southwest of the well.

The content of dolomite in the shales must be present in the form of minute crystals or grain and not as a cement, for otherwise the rocks would be more resistant.

FOSSILS

During the examination of the core, samples of all the well preserved fossils were taken, and these were examined by Mr. T. W. Stanton of the United States Geological Survey, whose report follows in the second part of this circular.

The Fossils

T. W. Stanton

According to the labels accompanying the specimens the collection ranges in depth from 138 feet to 2,019 feet, but as would be expected the fossils are not uniformly distributed. There are three intervals of 100 feet or more and five intervals of nearly 50 feet or more not represented by fossils in the collection submitted for examination.

There are several facts which tend to make it difficult to determine formation boundaries in this well from paleontologic evidence alone. In the first place the critical zones may be unfossiliferous or so nearly so that the narrow core does not contain any fossils where they would be most useful. Again the boundaries of the paleontologic zones do not coincide exactly with the lithologic boundaries of the formations. This is especially true of the Fox Hills sandstone and the Pierre shale. The genus *Sphenodiscus* and the various *Scaphites* species of the section *Discoscaphites* are essentially guide fossils for the Fox Hills sandstone, and yet in South Dakota and Wyoming they are all found in the upper 200 feet of the Pierre shale. Nearly all the other forms that are specifically identified in the following list, except *Inoceramus fibrosus*, are found both in the Fox Hills and the upper part of the Pierre. The characteristic species of *Inoceramus*, *Baculites*, and *Scaphites* are largely depended upon for distinguishing between Pierre and older Cretaceous faunas, but in this well core *Baculites* and *Scaphites* are absent from the lower depths, and the fragments of the large species of *Inoceramus* are not big enough to permit specific determination.

Since neither *Baculites* nor *Inoceramus* is known to occur in the Fox Hills sandstone, the first occurrence of either of these genera is taken as positive evidence that the drill has passed below the Fox Hills. The first recognized fragment of *Inoceramus fibrosus*, an upper Pierre species, ranges from 545 to 598 feet. The first *Baculites* were found at 590 feet. The paleontologic evidence therefore justifies the statement that the top of the Pierre is not much more than 400 feet below the surface and may be less than that.

Baculites were recognized in samples from many depths from 590 to 1,402 feet, and although most of the specimens were either such young individuals or so fragmentary that they could not be specifically identified it is reasonably certain that each belongs to one or another of the three Pierre species, *B. compressus* and *B. grandis*, as usually recognized. One specimen from the depth of 1,746 feet is less certain than most of the others because it is only a fragment and badly crushed. It is worthy of note that several of the specimens of young *Baculites* show the initial coiled portion of the shell.

It is reasonably certain the fragments of large species of *Inoceramus* from depths down to 1,396 feet belong to Pierre shale species. Fragments of large *Inoceramus* were again obtained at 2,000 feet and at 2,018. These are not distinctive. They might belong to either Pierre or Niobrara or older species.

No distinctively pre-Pierre species of any kind were recognized in the entire collection. This negative evidence of course would be of no value against definite Niobrara lithology which may be recognized in samples not submitted with the fossils. It is somewhat surprising that an interval of more than 500 feet at depths between 1,448 and 2,000 feet yielded numerous fish scales and bones and very few other fossils. In surface outcrops occasional fish remains are found throughout the marine Cretaceous, and they are perhaps somewhat more common in the Niobrara, but they are seldom obviously abundant except in the Mowry shale. While two or three of the fish scales in this collection suggest relationship with species described from the Mowry shale it is not believed that that formation is represented in the drill core samples.

The forms recognized in each sample are listed below, arranged according to the depths as recorded on the labels.

No.	Ft.	
1	138	Scaphites sp. Imprint of small fragment. Pelecypod. Small fragment.
2		
3	139.5	Anchura ? sp.
4		
11, 12	139.5	*Yoldia scitula* M. and H. Cucullaea ? sp.
6	144	Small pelecypod.
8	150	*Yoldia scitula* M. and H. This first No. 12 labeled 139.5.
9	170	Small pelecypod.
13a, 13b	181.5	*Yoldia evansi* M. and H.
13	245	Pecten ? sp. Small, smooth cast.
14	265	*Dentalium pauperculum* M. and H? Fragment.
15	265.5	*Yoldia scitula* M. and H.
22	266	Fragment of pelecypod.
23		
24	266	*Nucula cancellata* M. and H.
25		
17	269	*Scaphites mandanensis* (Morton)? Young shells.
31	275	*Dentalium pauperculum* M. and H.
19	282	*Yoldia evansi* M. and H.
18	306	*Fascoilaria buccinoides* M. and H. Young shell.
20	316	*Dentalium pauperculum* M. and H. Nucula sp. Fragment.
21	317	*Nucula cancellata* M. and H.
26	318	

27	320	*Dentalium pauperculum* M. and H.
28	321	*Nucula cancellata* M. and H.
29	327	*Nucula cancellata* M. and H.
32	331	*Nucula cancellata* M. and H.
33		
34		
35	333	*Nucula cancellata* M. and H.
30	344	Fish scales?
46	345	*Lingula subspatulata* Hall and Meek?
		Lucina? sp.
		Scaphites sp. Possibly *S. mandanensis* (Morton).
36	355	*Yoldia evansi* M. and H.
37	360	Scaphites sp. Possibly *S. cheyennensis* (Owen).
37	374	Yoldia? sp.
38	374	Canthorus? sp. Young shell.
39	374.5	*Nucula subplana* M. and H.?
40	379	*Lingula subspatulata* Hall and Meek?
41	396	*Lingulu subspatulata* Hall and Meek?
42	399	*Lucina occidentalis* (Morton).
43	427	Inoceramus sp.
		Lucina ? sp.
44	428	Anchura ? sp.
45	436	Scaphites sp. Young shell.
48	466	Fish scale.
49	466.5	Plicatula ? sp.
49	476	Thracia sp.
50	482	Lucina ? sp. Fragment.
		Undetermined slender branching organism.
51	500	Fish scale and teeth.
52	506	*Lingula subspatulata* Hall and Meek?
		Fish scales.
53	508	Ostrea sp.
		Fish bone.
		Cristellaria sp.
55	511	Fish scales.
55	545	*Inoceramus* (*Actinoceramus*) *fibrosus* (M. and H.)
56	548	*Lingula nitida* M. and H.
		Inoceramus (*Actinoceramus*) *fibrosus* M. and H.
57	548.5	Same fossils as in 56.
58A	550	Same fossils as in 56.
58B	550	Same fossils as in 56.
59	555	Same fossils as in 56.
60	556	Same fossils as in 56.
62	564	Inoceramus sp. Fragment.
61	565	*Inoceramus* (*Actinoceramus*) *fibrosus* (M. and H.)
63	576	*Inoceramus* (*Actinoceramus*) *fibrosus* (M. and H.)
64	582	*Inoceramus* (*Actinoceramus*) *fibrosus* (M. and H.)

65	586	*Inoceramus* (*Actinoceramus*) *fibrosus* (M. and H.)
67A&B	590	Baculites sp. Probably either *B. ovatus* or *B. grandis.*
68	591	Baculites sp.
69	598	*Inoceramus* (*Actinoceramus*) sp.
70	598.5	Baculites sp.
71	599.5	Nodosaria sp.
		Cinulia sp. May be young specimen of *C. concinna* (H. and M.)
72	600	Inoceramus sp. Small, probably undescribed species.
73	605	Baculites sp. Fragments.
74	606	Baculites sp. Fragments.
75	606.5	Ammonoid fragments.
76A&B	607	*Yoldia scitula* M. and H.
		Baculites sp. Fragments.
77	608	Scaphites ? sp. Fragment.
78A&B	609	Baculites sp.
79	609	*Inoceramus* (*Actinoceramus*) *fibrosus* M. and H.
80	612	*Inoceramus* (*Actinoceramus*) *fibrosus* M. and H.
		Baculites sp.
81	613	Fragments of Baculites and of small pelecypod.
82	614	Lucina ? sp. Fragment.
81	618	Anchura sp.
84	651	*Yoldia evansi* M. and H.
86	657	*Yoldia evansi* M. and H.
87	658	Young shells of Lunatia and Baculites with initial coiled part of shell.
88	659	Fragments of Baculites and of undermined small pelecypods.
89	667	Scaphites sp. Young shell probably of *S. conradi* or a related species of the Discoscaphites section.
83	670	Dentalium ? sp.
		Anchura sp.
		Pelecypod fragment.
91	743	Macteon ? sp.
90	790	*Protocardia subquadrata* (E. and S.)
92	847	Baculites sp.
96	954	Baculites sp. Young specimens with initial coiled portion.
96	955	*Syncyclonema rigida* (Hall and Meek). Immature specimens.
97	957	Baculites sp. Fragment.
98	958	Baculites sp. Fragments. The large oval imprint which simulates a Pecten or Inoceramus is probably not a fossil.
100	960	Fish scale.
101	973	Baculites sp. Fragments.
		Fish scales.
102A&B	974	Pholadomya n. sp.?

103	975	Undetermined small pelecypod.
		Baculites. Fragments.
		Fish scale.
104	976	Undetermined small pelecypod.
		Inoceramus. Fragment.
		Baculites. Fragments.
105A&B	977	*Syncyclonema rigida* (H. and M.)?
		Pteria nebrascana (E. and S.)?
		Dentalium sp.
		Undetermined gastropod.
		Baculites sp.
107A&B	982	Lucina sp. Young shell.
		Baculites sp. Fragments.
108	983	*Syncyclonema rigida* (H. and M.)?
		Inoceramus sp. Fragment.
		Lucina sp. Young shell.
		Baculites sp.
110	982	*Pteria nebrascana* (E. and S.) Fragment.
		Baculites sp. Young shells and fragments.
109	985	Ostrea ? sp. Very small shell.
		Baculites sp.
		Fish bones and scales.
111	985	*Dentalium pauperculum* M. and H.?
112	996	Inoceramus sp. Fragments showing prismatic fibrous layer of shell and one with the pearly layer.
113	1,002	Baculites. Fragments of young shell.
114	1,004	Nucula sp.
		Baculites sp. Young shell.
		Scaphites sp. Young shell.
115	1,007	Nothing determinable.
116	1,007	Baculites sp.
117	1,009	Baculites sp.
119	1,014	Inoceramus sp.
		Baculites sp.
120	1,030	Baculites sp. Young shell.
121	1,030	Lunatia ? sp.
122	1,030	Baculites sp.
123	1,032	Baculites sp.
124	1,033	Baculites sp.
125	1,034	Baculites sp.
126	1,048	Baculites sp.
127	1,061	Baculites sp.
128	1,077	Scaphites sp. Fragment.
132	Depth not given.	Inoceramus sp. Fragment of large specimen.
135	1,080	Fish scale.
130	1,111	Inoceramus sp. Fragment of a large shell.
131	1,115	Undetermined shell fragment.
133	1,136	Inoceramus sp. Fragments.

138	1,264	Baculites sp. Young shell with initial coiled portion.
139	1,272	*Yoldia scitula* M. and H.?
139	1,280	Scaphites ? sp. Crushed fragment.
140	1,300	Baculites sp. Young shell with initial coil.
141	1,304	Baculites sp.
142	1,305	Cinulia ? sp. Fragment.
142	1,309	*Yoldia evansi* M. and H.
143	1,318	Inoceramus sp. Fragment of a large coarse ribbed species.
144	1,327	Lucina sp.
145	1,341	Inoceramus sp. Fragments.
146	1,341	Inoceramus sp. Fragments.
147	1,361	*Baculites ovatus* Say. Initial coil.
		Pachydiscus complexus (Hall and Meek) ? Possibly very young shell of this species.
160	1,370	Inoceramus sp. Large fragments possibly of
		I. Sagesis or *barabini.*
		Baculites sp.
150	1,374	Inoceramus sp.
148	1,375	Baculites sp.
149	1,375	Baculites sp.
151	1,380	Baculites sp.
153	1,383	Baculites sp.
154	1,386	*Lingula nitida* M. and H.
156	1,390	
	1,391	Inoceramus sp.
157	1,393	
155	1,396	Inoceramus sp.
158	1,402	Baculites sp. Fragment.
159	1,448	Fish scales and bones.
160	1,454	Fish bones and teeth or spines.
161	1,455	Fish scales and bones.
161	1,456	Fish scales and bones.
162	1,490	Fish scale and vertebra.
163	1,492	Fish scales and bones.
165	1,540	Fish scales, possibly Hypsodon.
166	1,550	Fish vertebra.
166	1,630	Undetermined stains and imprints.
167	1,635	Undetermined stains and imprints.
168	1,722	Fish scales and bones.
169	1,730	Fish vertebra.
170	1,735	Fish scale.
171	1,746	Baculites sp. Flattened species with maximum width of ¾ in.
172	1,768	Fish scale.
171	1,775	Fish scales and bones.
173	1,775	Fish scales and bones.

174	1,780	Fish scae. Probably Holcolepis.
172	1,880	*Lingula subspatulata* Hall and Meek ?
173	1,886	*Lingula subspatulata* Hall and Meek ?
175	1,890	Fish bone.
176	1,890	Fish scale or bone.
178	1,890	Ostrea sp. Fragment. Fish scale or bone.
179	1,890	Ostrea sp. Fish bones.
177	1,895	Fish scales and bones.
179	1,897	Fish bones.
185	1,897	Fish bones.
182	1,903	Fish scales and bone fragments.
183	1,903	Orbiculoidea ? sp. Bone fragments.
184	1,903	*Lingula subspatulata* Hall and Meek? Fish scales and bone fragments. Scale suggests *Leucichthyops vagans* Cockerell.
186	1,908	Fish bone.
187	1,909	*Lingula subspatulata* Hall and Meek? Orbiculoidea ? sp.
188	1,910	Ostrea sp. Fish vertebra and other bones.
188	1,930	Fish bone.
189	1,931	Fish bone and scale.
190	1,932	Fish bones and scales.
191	1,932	Fish bones and scales.
192	1,960	Fish bones.
193	1,965	Fish scale.
202	2,000	Inoceramus sp. Fragments of large shell. Nucula ? sp.
194	2,007	Inoceramus sp. Young shells. Fish scale.
195	2,007	Inoceramus sp. Young shells.
199	2,018	Inoceramus sp. Fragments of large species.
200	2,019	Inoceramus sp. Fragment. Yoldia sp.