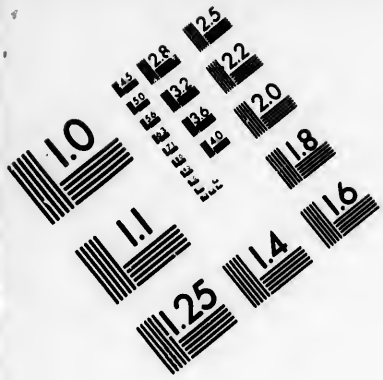

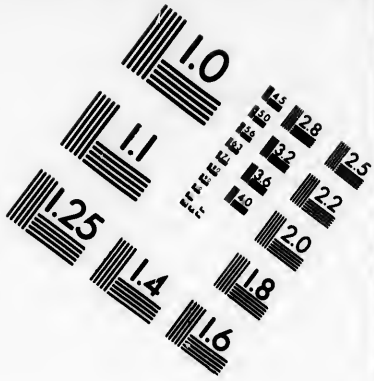

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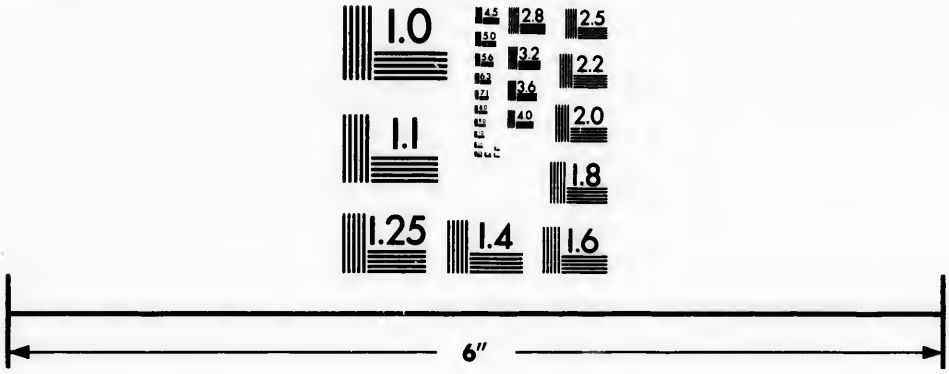

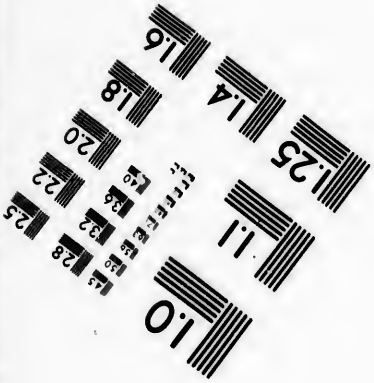

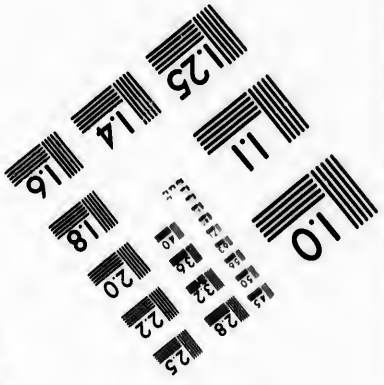

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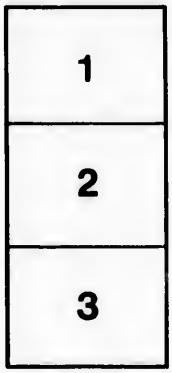

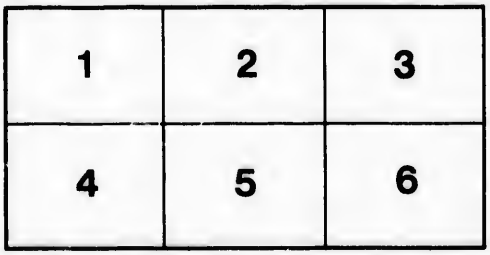

VII.—*On Certain Borings in Manitoba and the Northwest Territory.*

By GEORGE M. DAWSON.

(Read May 26, 1886.)

In Manitoba and in the Northwest generally, boring operations are likely each year, as settlement advances, to be undertaken with increasing frequency. The generally uniform character of the surface, coupled with the covering of drift deposits over large areas, due to the Glacial Period, renders boring necessary, whenever it is desired to ascertain the character of the underlying rocks. Most of the borings so far carried out have been for the purpose of obtaining water in localities where the surface supply is insufficient or unfit for use on account of dissolved salts. In a number of cases, the object in view has been attained, and it may be specially mentioned that a good supply of water for the City of Winnipeg has been secured, by wells sunk through the alluvium of the valley, at a comparatively moderate depth.

In too many instances, however, the strata passed through in these borings have not been noted with sufficient care to enable satisfactory sections to be given. The great importance attaching to such records, whether for the guidance of future sinkings for coal and lignite, natural gas or brine, and in explorations which may be attempted in search of petroleum, is my excuse for collecting in this paper such facts as I have been able to obtain and for discussing their bearings. Some of the results already arrived at are interesting from an economic point of view, as indicating the development in the near future of important industries; while, as will have been gathered from the remarks already made, all borings effected in Manitoba and the Northwest, the results of which are carefully recorded, possess a special value from a purely geological standpoint.

In addition to the borings now first reported on, and chiefly made by the Canadian Pacific Railway Company, several experimental borings, conducted under the auspices of the Geological Survey, are referred to in this paper. Details of these will be found in the Reports of Progress, as follows:—

Report of Progress, 1873-74, pp. 3, 12; 1874-75, p. 2, boring at Rat Creek, subsequently referred to; 1875-76, p. 281, boring at Carleton. This experimental boring was executed under the supervision of Mr. R. W. Ells, and was carried to a depth of 175 feet without passing through the drift deposits. 1875-76, p. 292, boring at Fort Pelly on the Assiniboine River. After passing through the drift, this boring penetrated the lower portion of the Pierre shales and ended at a depth of 500 feet in marly beds, evidently representing the Niobrara division of the Cretaceous (cf. Report of Progress, 1879-80, p. 1A.)

I.—Boring at Rosenfeld Station.

This station is situated on the South-Western Branch of the Canadian Pacific Railway, about fifteen miles north of the 49th parallel and ten miles west of the Red River, in the alluvial plain of the Red River valley. The boring was conducted by Mr. W. E. Swan, under instructions from the Canadian Pacific Railway Company. Through the kindness of Mr. W. C. Van Horne and Mr. J. M. Egan, I have been enabled to obtain from Mr. Swan, the logs of this and other borings made by him in the Northwest. Samples of the strata passed through in this well had been given by Mr. Swan to Mr. Acton Burrows, of Winnipeg, who was so obliging as to transmit them to Ottawa for my examination. The section given is, therefore, not precisely in the form of Mr. Swan's log, but is based also on my own examination of the materials obtained. The boring was made by means of an ordinary percussion drill, and was carried to a depth of 1,037 feet from the surface. The strong flow of brine met with in this well (a point subsequently referred to) is the most remarkable feature in connection with it.

In the subjoined section, the formations supposed to be represented are indicated in the column to the right:—

	Feet.	
1. Black soil	4	
2. Fine silt or clay	111	
3. Sand and gravel	10	
4. Boulder-clay ("hard-pan.")	12	
5. Boulders	6	
6. Grey shale	6 2	Maquoketa shales.
7. Limestone	15	
8. Red shale	5	
9. Grey shale	10	
10. Limestone	30	
11. Fine grey sandstone	40	
12. Chalky limestone	30	
13. Red shale	160	
14. Cream-coloured limestone	305	Galena limestone passing
15. Red shale	75	below into Trenton.
16. Soft sandstone	50	St. Peter sandstone.
17. Dark-red shale	50	Lower Magnesian limestone (?)
18. Reddish and greenish shale	25	
19. Bluish and grey shale	20	
20. Red shale	15	
21. "Granite."	2	Laurentian.
Total	1,037	

The soil, forming the first member of the above section, has the usual characters of that of the region, consisting of the underlying silts mingled with vegetable matter. The silts (described in the log as "blue clay") are those of the ancient lake which, about the close of the Glacial Period, occupied Red River valley, and which has been called "Lake Agassiz" by Mr. Upham. The coarser layers are composed of fine angular and subangular grains with formless argillaceous material; the finer become a blackish-grey plastic clay. The specimens secured of the sand and gravel deposit contained no fragments over three-

fourths of an inch in diameter. The gravel is well rounded, and consists of Laurentian and limestone pebbles not dissimilar from those usually found in a corresponding position in other parts of this district. The "hard pan," while evidently representing the boulder-clay, is unusually pale in colour, being apparently largely composed of limestone debris. The thickness of the boulder-clay is also much less than usual. Its microscopic character has already been described, in connection with that of other similar materials of the same age, in a paper presented to the Chicago Academy of Sciences.[1] The predominent mineral constituents which remain, after the finer clayey matter has been washed away, are rather coarse quartz grains, of which nearly one-half are perfectly rounded. Bottle-green fragments of hornblende are moderately abundant, as are also grains of felspar and limestone, but comminuted shaly materials are almost altogether wanting. It also contains a few specimens of foraminifera, which have been derived from some not far distant Cretaceous beds. These include a Textularia of the type of *T. globulosa*, with fragments of Rotalidæ and other forms.

Of the deposit described as "boulders" no specimens were obtained.

The beds underlying these superficial deposits, from No. 6 to No. 13 inclusive, are supposed to represent the Maquoketa shales. Their character is as follows :—

No. 6. This is a moderately firm greyish-green shale, with minute reddish laminæ and some thin films of pyrites parallel to the bedding. It is not calcareous, and under the microscope is found to contain a considerable proportion of partially rounded quartz grains, but no fragments were observed of hornblende or other green or dark minerals usually found in the boulder-clays and other drift deposits.

No. 7. This limestone is cream or buff coloured, and rather coarse. It effervesces freely in cold dilute acid. It is, apparently, easily friable, as the sample received was in the form of coarse sand.

No. 8. A soft shale of general reddish colour, but holding also purplish and greenish layers, and showing under the microscope much subangular grit.

No. 9. Resembles No. 6, and is a rather firm yellowish-grey shale, showing under the microscope a considerable proportion of partly-rounded, somewhat coarse quartz sand in a brownish argillaceous matrix.

No. 10. The specimen of this rock consisted largely of cream-coloured limestone in small fragments, but more than half of it is of coarse quartz sand. This might have been derived from the friction of the boring rods against the upper portion of the sides of the hole, but is unlike any met with in the overlying deposits. It is probably interbedded with the limestone, but no calcareous cement was observed to adhere to the grains. The sample included one small piece (about half an inch long) of coarsely granular whitish gypsum.

No. 11. This is a fine-grained calcareous sandstone or sandy shale, rather hard, and noticeably finer and more siliceous than No. 6. The only organic traces met with in these rocks were found in this layer. They consist of thin, dark-coloured corneous-looking laminæ seen on the surfaces of small fragments. Portions which were removed, and microscopically examined, showed occasional regularly disposed systems of bifurcating canals, closely resembling some of those figured and described by Bowerbank as occur-

[1] Bulletin, Chic. Acad. Sci., No. 6, Vol. i, 1885.

ring in the epidermis (*periostracum*) of *Solen vagina*. (Trans. Micro. Soc., London, 1844, Vol. I. p. 123.) They probably represent either the epidermis of some mollusc or portions of the test of a small crustacean.

No. 12. This material (described as "chalk" in the original log) consisted chiefly of coarse and fine calcareous granules, the latter under the microscope appearing rounded, and being probably concretionary in character. Small selenite crystals are rather abundant. The colour of the mass varies from white to pale greenish and reddish grey.

No. 13 is a soft, reddish shale, slightly calcareous, with small white spots of gypsum. The matrix also contains much subangular quartz, in grains which are very irregular in size, some being quite coarse.

Layer No. 14 (over 300 feet in thickness), which is supposed to be equivalent to the Galena limestone, and possibly at the base to include a portion of the Trenton, was represented by several specimens. It is cream or buff coloured, apparently uniform in character, generally free from detrital matter, and effervesces freely in cold dilute acid. It is rather coarsely granular in texture.

No. 15 is a reddish shale, scarcely calcareous, and with much quartz in subangular grains. It resembles No. 13, and contains small crystals of selenite.

No. 16 was represented by four specimens, of which those from the upper part of the bed were pale reddish in tint; these from the lower part nearly colorless transparent quartz sand. The reddish coloration is very probably due to admixture of small portions of the overlying red shale. The sand is coarse, clean, uncemented, with grains all beautifully rounded and polished by attrition, in a manner suggesting the action of wind rather than of water, and precisely resembling that of the St. Peter sandstone as seen near St. Paul, Minnesota.

No. 17 is a soft, non-calcareous, dark brownish-red shale with, in some places, very thin greenish-grey interlaminations. Under the microscope, it is found to include much fine and pretty well rounded quartz sand.

No. 18. A non-calcareous shale similar to last, but about one third of the fragments greenish, while portions of the remainder are a very dark purplish-red.

No. 19 is a bluish-grey, fine-grained shale or argillite, scarcely laminated and very slightly calcareous. A small concretionary pellet of gypsum was included with the sample, and was probably derived from the shale.

No. 20. This is a soft, dark reddish material, rather like a clay than a shale. It does not effervesce with acid, and, in addition to much fine and some coarse quartz sand, it contains half-rounded quartzose fragments as large as grains of wheat.

No. 21. The rock met with at the bottom of the boring, and said to have been penetrated for two feet, is described as granite. The specimens received, however, consisted almost entirely of "cavings" from the upper parts of the hole, mingled with which were some small angular flakes of granite or gneiss, chiefly composed of quartz and red felspar in rather small crystals.

While in the complete absence of palæontological evidence and of neighbouring outcrops to which reference may be made, the stratigraphical position of the beds passed through in this boring may be considered somewhat doubtful. I am, on careful consideration, disposed to believe that they represent that portion of the Cambro-Silurian between the Maquoketa shales (Cincinnati or Hudson Rivers) and the Lower Magnesian limestone

(Calciferous). The following are the grounds on which this correlation of the beds is made :—

Beds 6 to 13 inclusive are, as already stated, supposed to represent those named the "Maquoketa shales" by Dr. White in Iowa. In Iowa, the beds so named are about 75 feet in thickness, and consist of bluish and brownish shales with calcareous layers, which sometimes form a considerable part of the whole. In Wisconsin, the Maquoketa beds average about 200 feet in thickness and are composed of grey, green, blue, red, purple, buff and brown shales with thin limestones. These beds are also known in Minnesota, which, being much nearer to the locality now in question, would afford a better term of comparison, but there appears to be, unfortunately, an absence of complete sections. At Stony Mountain, however, fifty-eight miles north, in Manitoba, rocks determined by Mr. Whiteaves, on the evidence of fossils, to be of Hudson River age, occur, and so far as the section is there apparent, it corresponds pretty closely in general character with that in the Rosenfeld well. The beds at this place are as follows, in descending order:[1]—

	Feet.
1. Brownish-grey dolomitic limestone	40
2. Reddish-grey limestones, clayey partings	10
(Small gap in section.)	—
3. Limestone like No. 1	20
4. " in thin beds	4
5. "	2
6. Limestone, thin and broken	6
7. Yellowish rock	8
8. Reddish shales	10
9. Yellow and red shales	60
Total	160

These evidently nearly resemble those numbered 10 to 13 in the Rosenfeld boring.

The limestone numbered 14 in the section at Rosenfeld is supposed to represent the Galena limestone of the west, which it resembles in character. It probably, however, as already stated, may include layers at the base equivalent to the Trenton, to which latter formation the red shale, 75 feet in thickness, next underlying in the section, must be assigned. The Galena limestone of the west, which is nearly equivalent to the Utica of the New York series, is about 180 feet thick in Minnesota; 250 feet thick in Wisconsin; and from 100 to 250 feet thick in Iowa. The Trenton, in Minnesota, consists of flaggy limestones, with interbedded greenish shales, and is nearly 160 feet in thickness. In Iowa it consists of clayey shales and shaly and compact limestone, 200 feet in thickness. The reddish colours of the Rosenfeld shales and their apparently more complete separation from the limestone and want of interlamination with it, constitute the chief point of dissimilarity. The massive buff limestones of Selkirk and Stone Fort in Manitoba, resemble the Rosenfeld bed in character, and are known by the evidence of fossils to represent the Galena.

The sandstone, or rather unconsolidated sand-bed, which is the next underlying member of the section, has already been described as precisely resembling the typical St.

[1] From paper by J. H. Panton, Manitoba Hist. and Lit. Soc., Trans. 15, Session 1884-85.

Peter sandstones. Its thickness (50 feet) is somewhat less than that assigned to the same bed to the south. This in Minnesota is stated as 125 feet; in Iowa, 80 feet, and in Wisconsin, from 80 to 100 feet. The St. Peter sandstone has not elsewhere been recognized in Manitoba, and there is, therefore, no local term of comparison for this and the underlying Cambro-Silurian beds.

If the stratigraphical positions assigned to the foregoing beds are correct, beds 17 to 20 both inclusive, with an aggregate thickness of 110 feet, must occupy the position of the Lower Magnesian limestone, equivalent in age to the Calciferous of the New York section. This limestone in Iowa and Wisconsin, has a thickness of 65 to 250 feet. In Minnesota it is described as a cream-colored magnesian rock, but toward the top it is frequently sandy, and with beds of greenish shale. At Rosenfeld no limestone occurs, and we, apparently, have instead a littoral formation directly overlying the subjacent Laurentian, and marking the limit at this place of the Lower Magnesian Sea.

No sufficient supply of fresh water was met with in this well, but instead, a flow of brine was encountered. A small flow of brine was found below the limestone numbered 10 (30 feet in thickness), a second flow beneath the heavy limestone bed (No. 14) and when the St. Peter sandstone (No. 16) was reached, the supply increased four-fold, and formed a flowing well, which has, I believe, continued to give issue to large quantities of salt water ever since. Mr. Swan states that it rose in a pipe to a height of 18 feet above the surface of the ground, which is three feet below the level of the railway grade.

The most interesting feature in this connection is the great geological age of the rocks from which this brine comes. It appears not improbable that the shoaling of the Cambro-Silurian sea evidenced by the widespread littoral deposit known as the St. Peter sandstone resulted in the enclosure of salt lagoons in this portion of the interior basin, while it merely produced an increased land area further south in Iowa and Wisconsin.

The brine is of a quality well adapted for the manufacture of salt, and might be concentrated by solar evaporation and finally evaporated in pans. It has been examined and is reported on by Mr. G. C. Hoffmann, in the Annual Report of the Geological Survey for 1885 (p. 13 M). Mr. Hoffmann states that it contains but a small amount of deleterious salts, and gives the following as its composition for 1,000 parts by weight:—

Chloride of Potassium	0.4179
" Sodium	36.4971
" Calcium	0.3982
" Magnesium	1.7225
Sulphate of Lime	4.1511
Borate of Soda	traces.
Carbonate of Lime	0.0777
" Iron	traces.
Bromide of Magnesium	undt.
Iodide of Magnesium	undt.
Silica	0.0126

Another point of interest brought out by this boring is the comparatively thin covering of Palæozoic rocks which here overlaps the Archæan, and the very gradually shelving character of the surface of the latter westward. The slope of this surface, in a westward direction, from the last low Archæan exposures on the Lake of the Woods being

(on the supposition that it is uniform) not more than 11·5 feet to the mile. The Archæan surface at Rosenfeld is 265 feet below the present sea-level, that in the southern part of the Lake of the Woods is 1,060 feet above the same datum. A further remarkable fact in this connection is afforded by the boring conducted at Rat Creek in 1874, by the Geological Survey, details of which will be found in the Report for 1874-75 (p. 3). This place is about seventy miles north-west of Rosenfeld. Here, after penetrating the superficial deposits, the surface of a buff Silurian or Devonian limestone was reached at about 103 feet below the prairie-level. This limestone proved to be only forty-two feet in thickness, and beneath it a fine-grained grey crystalline rock (apparently a quartzite) was bored into for a depth of about eighty feet. This rock evidently belongs to the Archæan, and is either Laurentian or Huronian. The Archæan surface at this place must be nearly 700 feet above the present sea-level. The relative elevation of the Archæan surface at these three points (Rosenfeld, Lake of the Woods and Rat Creek) would indicate a direction of about W.N.W. by E.S.E., as that of a level line drawn upon it in this part of its extent.

II.—Boring at Solsgirth.

This is a station on the Manitoba and Northwestern Railway, in the north half of section 30, township 17, range 25, west of 1st principal meridian, elevation 1,757 feet. I am indebted for particulars concerning it to Mr. Reginald Baker, General Superintendant of the railway. The information was obtained partly from an excavated well and partly from a boring. The notes were accompanied by a suite of specimens, which has been carefully examined. The section is as follows:—

	Feet.
1. Loam	2
2. Hard blue clay and gravel	12
3. Hard blue clay and stones	10
4. Hard yellow "hard pan."	12
5. Softer bluish clay	16
6. " " "	74
7. Layer of sand [with water]	—
8. Blue clay with stones	136
9. Grey clay (shale?)	68
Total	360

The specimens received show the material to have been a hard grey boulder-clay in which small rounded fragments of fine grey Cretaceous shale, and of the white limestones of the Manitoba lake-region, are abundant. No. 9, of which one small specimen only was received, appears to be a grey, gritty, Cretaceous shale, resembling some parts of the Pierre shales, but it is not absolutely certain that it may not represent a laminated clay belonging to the drift. Excluding this lowest layer, however, the thickness of the glacial deposits is here rather remarkable, being no less than 292 feet.

From 76 feet below the surface, in the boulder-clay, a broken fragment, 1½ inches in diameter, of pale-grey, fine-grained, Cretaceous argillite, was brought up. Fragments of wood, for the most part soft and decayed, but not otherwise much changed, except from

the considerable compression they have suffered, were obtained from depths of 95, 107, 120 and 135 feet from the surface. They would appear to have been imbedded in the boulder-clay, and not to have occurred in any well marked interglacial deposit. Part of a specimen of wood from a depth of 135 feet was so well preserved as to admit of its identification under the microscope as a Taxus It is indistinguishable in structure from the wood of *Taxus baccata*. The supply of water met with in bed No. 7 rose to within 56 feet of the surface, in the hole, but was not copious.

III.—Boring at Grenfel Station.

This station is 279 miles west of Winnipeg, on the line of the Canadian Pacific Railway, and lies between the Weed Hills on the south, and Qu'Appelle River on the north, at an elevation of 1,933 feet above sea-level. The boring is 200 feet in depth, and is evidently entirely in the drift deposits. It is not stated whether a sufficient supply of water was obtained. The section is as follows:—

	Feet.
1. Loam	2
2. Yellow clay	18
3. Blue clay	75
4. Gravel and sand	5
5. Blue clay	90
6. Gravel and sand	10
Total	200

IV.—Boring at McLean Station.

This boring is on the line of the Canadian Pacific Railway, McLean being the next station west of Qu'Appelle Station, and twenty-four miles east of Regina. The well was begun at the same level with the adjoining track, or 2,248 feet above the sea-level. It was carried to a depth of 495 feet and then abandoned. The section, as given by Mr. W. E. Swan, is as follows:—

	Feet.
1. Black loam	1
2. Yellow clay	25
3. Blue clay	65
4. Gravel and sand	12
5. Blue clay and sand	85
6. Gravel and sand	10
7. Blue clay and gravel	98
8. Sand and gravel	52
9. Boulders	6
10. Blue clay and gravel	96
11. Gravel and sand	35
12. Boulders	5
13. Clay and sand	5
Total	495

No specimens from this boring were received, but it is pretty evident that it did not penetrate to the bottom of the boulder-clay and other drift deposits. The upper layers, 1 to 3 inclusive, aggregating 91 feet in thickness, are apparently the fine silty deposits, which form a mantle over an extensive region on both sides of Regina, and represent the sediments of a large later glacial lake. The remaining beds are referable, with little doubt, to the boulder-clay and associated deposits. These are here remarkably thick and must fill a deep pre-glacial hollow. It is instructive to compare this boring with two of those executed by Dr. Selwyn, in 1880, in the vicinity of the Souris River, and about 120 and 140 miles respectively south-east of McLean. The material passed through in the borings is very similar, consisting of alternating clays, gravels and sands. These borings are described in the Report of Progress of the Geological Survey for 1879-80, (pp. 8A to 10A). The first was on the Souris Plain, at a point west 10° south, from the mouth of Moose Mountain Creek, the surface being about 1,590 feet above sea-level, and the depth 155 feet. The second, 700 yards east of where the old Boundary Commission trail crosses North Antler Creek, at an estimated elevation of 1,595 feet, and was also 155 feet in depth. Neither penetrated to the bottom of the drift deposits, and though not nearly so deep as the well at McLean, the contrast between the depth of drift met with in them, and the shallow covering of superficial deposits found a short distance further west in the Souris region is sufficiently marked, and similar to that existing between the boring at McLean and that at Belle Plaine Station. This, with the trend of the water-courses in this region of the plains and that of the escarpment of the Missouri Côteau, would appear to indicate a wide and deep pre-glacial hollow, with a north-west and south-east direction which, though partly filled with drift deposits, has not been entirely obliterated by them, and still makes its influence apparent in the ruling surface features. It may probably have been occupied by a river or system of streams in pre-glacial times, though the probability of subsequent changes in relative level in the Northwest, leaves it uncertain in which direction the waters discharged.

Neither of the borings made by Dr. Selwyn, yielded much water, and the probable inference is, that the permeable layers included in the drift deposits, are not continuous, but rather lenticular in character, and that no important source of water is to be found in these deposits in this belt of country. It would appear, however, by no means improbable, that a more abundant supply of water and, possibly, flowing wells might be obtained by sinking to the bottom of the glacial deposits. The pre-glacial depression is likely to have gravelly or sandy layers still flooring it, which might be expected in such a position, to be charged with water.

V.—Wells at Regina.

In the vicinity of Regina, several borings have been made for water. The only one of these of which I have been able to obtain a description is one sunk by the Northwest Mounted Police, near their barracks, and for this I am indebted to Mr. A. L. Perry. It attained a depth of about 100 feet only, and is evidently entirely in alluvial and drift deposits. Water in limited quantities was obtained in layers 5 and 9, amounting, at the date at which Mr. Perry wrote (the spring of 1883) to about one barrel in three minutes. The water rose to within twenty feet of the surface.

The section is as follows :—

	Feet.
1. Clayey soil	3
2. Very dark, sticky clay	27
3. Sand, with small pebbles	10
4. Black, sticky clay	13
5. Sand, red to black	18
6. Black clay	10
7. Sand, dark, similar to No. 5	4
8. Reddish clay, with small pebbles	13
9. Sand, dark and fine	—
Total	98

VI.—Boring at Belle Plaine Station.

Belle Plaine Station is twenty-four miles west of Regina and forty-eight west of McLean, at an elevation of 1,877 feet. The boring was begun at a point three feet below the railway grade, and carried to a depth of 1,551 feet. Two specimens of the material from the lower part of the hole were sent to me by Mr. Swan, but not having had a suite of specimens from the various levels, I am able to give only the actual log, as follows :—

	Feet.	
1. Dark clay loam	3	
2. Yellow clay	11	94
3. Blue clay	80	
4. Blue shale	150	
5. Black shale	75	
6. Grey shale	125	800
7. Brown limestone	6	
8. Grey shale	444	
9. Reddish sand rock	20	
10. Grey shale	190	
11. Hard white sand rock	2	657
12. Grey shale, with thin layers of sand rock	200	
13. Grey, soft shale	175	
14. Black shale	70	
Total	1,551	

In this boring, Nos. 1, 2 and 3 are doubtless referable to the superficial deposits, but appear rather to represent the fine lake sediment before alluded to as covering the surface in this region than the boulder-clay, though part of layer 3 may be boulder-clay. Layers 4 and 5, with little doubt, represent the Pierre shales, which might, on other grounds, be expected to underlie this part of the country. It appears to me, indeed, highly probable that all the beds down to and including No. 8 are referable to the Pierre shales, and that No. 7, which Mr. Swan believed to be a boulder, may have been one of the large calcareous nodules frequently found in that formation. If this be so the Pierre would here have been passed through for a depth of 800 feet, which elsewhere in the Northwest is about its full thickness.

Numbers 9 to 13, inclusive, with a total thickness of 657 feet, evidently on either

hypothesis, represent beds below the Pierre, referable to the Belly River series or to the Niobrara. Not having at present any accurate knowledge of the character of the formation underlying the Pierre in this district, and in the unfortunate absence of specimens, we are are unable exactly to correlate it. A small specimen from layer 13 consists of buff or pale-grey shale, with small calcareous veins or intercalations. The lowest bed, of which also a specimen is to hand, was penetrated for a thickness of 70 feet, and is a dark, soft shale, or shaly clay, nearly black in colour, and quite plastic when wet. Under the microscope this material is found, besides flocculent argillaceous matter, to contain a considerable proportion of very fine, rather angular, quartz sand of uniform grain. It is not improbable that this represents the highest part of the Benton shales. Mr. Swan notes that no loose sand or gravel was met with in this well. In the sandstone No. 9, a flow of salt water was encountered. This is not described as being a brine, and may probably have been contaminated with sulphates, like most of the waters flowing from the Cretaceous rocks of the West. A small quantity of gas was met with under layer No. 11, but its nature is not stated.

VII.—Boring at Langevin Station.

This place is on the line of the Canadian Pacific Railway, thirty-five miles west of Medicine Hat, at an elevation of 2,471 feet above sea-level. No natural exposures occur in the immediate vicinity or nearer than those on the Bow River, but from a consideration of these, the relative elevations and other circumstances, the rocks underlying the drift at this place have been mapped[1] as those of the Belly River series, and are probably near the summit of the lower or yellowish and banded portion of this series. The boring would appear in fact to be near the summit of a wide, diffuse anticlinal which, with a general north-east and south-west direction, is here crossed by the line of railway. A depth of 1,400 feet was reached, and, as the lower rocks penetrated must belong to an horizon below that of any seen at the surface in the entire district, a good section would be of exceptional interest. Unfortunately, specimens of the rocks passed through were not preserved. Two borings were actually made, the first having been put down 1,155 feet in 1883, when it was abandoned in consequence of the ignition of a heavy flow of combustible gas, which resulted in the destruction of the derrick, etc., at the surface. In boring the second hole, the gas from the first was used to fire the boiler of the engine. The two wells were sunk by different men, and perhaps partly on account of carelessness in keeping the log, but largely, no doubt, from difference of nomenclature used in describing the materials, the records do not agree as closely as might be expected. It is often very difficult, even in natural exposures of the Belly River rocks, to decide, in measuring a section, where to draw the line between different layers—a circumstance arising from their close resemblance in texture and the blending in colours of one bed with another. It is therefore not remarkable that those in charge of the borings have differed so much in their nomenclature and the thickness assigned to the various strata. The section here given is that met with in the first hole, as obtained by Mr. R. G. McConnell of the Geological Survey, who visited Langevin spe-

[1] See geological map accompanying Report C, Report of Progress Geol. Survey, 1882-84.

cially in December, 1883, a short time before the accident above alluded to occurred. The terms employed are chiefly those of the borers' log, though in a few cases, where Mr. McConnell was able to ascertain accurately the nature of the material, it is described. The section is further supplemented by notes which I was so fortunate as to obtain from Mr. W. A. Simpson, who was foreman in charge of the second boring. He was able to give me a description of the general colours of the beds passed through, which affords an important clue in endeavouring to correlate them with the known Cretaceous deposits of the Northwest.

Taking all the facts into consideration, I am inclined to think that we have, first, 88 feet of drift deposits, with, underlying them, about 223 feet of the lower part of the Belly River series, the remaining 1,099 feet consisting of the "Lower Dark shales" of my Report,[1] but passing (as already stated) at the bottom into beds probably lower than any naturally exposed in the region, with the possible exception of those seen in the upturned strata surrounding the Sweet Grass Hills. I am uncertain whether to regard the upper part of the "Lower Dark shales" as constituting a basal portion of the Pierre separated by the Belly River series from the upper part of the Pierre, or as representing the lower part of the Niobrara, and passing below into the Benton. In either case, the lower beds met with in the boring are probably equivalent to the Benton, and some of those found in the last 400 feet of the boring closely resemble, in several characters, beds seen south of the Rocky Spring Ridge in northern Montana, while the beds above these, up to about the 900 feet level, compare closely with those in the escarpment of the same ridge, though they do not include the heavy sandstone bed there met with.[2]

The wells at this place did not yield any sufficient quantity of good water, though small flows were met with at several levels. They have, however, demonstrated the very important fact that a large supply of natural combustible gas exists in this district, at depths of 900 feet and over, in the sandy layers of the "Lower Dark shales." In consequence of the generally horizontal position and widespread uniformity in character of the rocks, it is probable that a similar supply will be met with over a great area of this part of the Northwest, and that it may become in the near future a factor of economic importance. The gas is doubtless derived from the decomposition of the organic matter of the dark carbonaceous shales occurring in the section. Mr. J. M. Egan, in a letter of late date (June 11, 1886), informs me that the flow of gas from this well has continued since without noticeable decrease.

It is unfortunate, for several reasons, that the boring at Langevin was not carried still deeper. Reasoning from analogy with other parts of the Western Territory, one would expect to meet with the Dakota sandstones or basal formation of the Cretaceous of the region at no great depth below that actually attained, and in these it is not improbable that a good supply of water might be found. There is, also, probably on the line of the railway no better place in which, by penetrating the Cretaceous series, to ascertain whether it is underlain by Devonian rocks like those of the Athabasca region, and whether these maintain their petroleum-bearing character so far south. The anticlinal structure already alluded to must, in the absence of contrary evidence, be assumed to

[1] Report of Progress Geological Survey, 1882-84.

[2] See Report of Progress Geological Survey, 1882-84, p. 42 c.

indicate that the covering of Cretaceous rocks is here thinner than in other parts of the region traversed by the railway line. The purely scientific interest attaching to the section, which a continuation of the boring of the lowest beds of the Cretaceous should yield, has already been adverted to. The section in this well, as ascertained in the manner above described, is as follows:—

Depth from Surface. Feet.		Description of Beds.	Thickness of Bed. Feet.	
37		Clay loam	30	Probably drift deposits.
49		Quicksand	7	
59		Clay	12	
68		Quicksand	10	
75		Clay and sand	9	
83		Quicksand	7	
88		Clays	8	
104		Quicksand	5	
113	General grey and pale tints, according to Mr. W. A. Simpson.	Sandstone	16	Probably lower part of Belly River series.
118		Soapstone (grey, fine-grained clay)	9	
126		Lime rock (fine calcareous sandstone) [small supply of water]	5	
133		Hard pan (dark shale)	8	
193		Coarse sand	7	
200		Soapstone (greyish clay)	60	
209		Lime rock (fine calcareous sandstone)	7	
227		Sandstone	9	
232		Small coal seam	—	
271		Soapstone	18	
322		Sandstone	5	
327		White clay	39	
464		Soapstone	50	
469		Lime rock	5	
474	Beds generally shales of dark to black tints.	Loose shaly soapstone	137	Probably "Lower Dark Shales" of Report 1882-84 passing down into Benton (?)
463		Brownish ferruginous clay	5	
524		Dark lime rock	5	
531		Small coal seam	—	
537		Soapstone	50	
541		Gravel [small supply of water]	7	
548		Sandstone	6	
558		Lime rock	4	
593		Sandstone	7	
943		Hard pan (dark shale)	10	
951		Clays	35	
1,041	Generally grey tints. One bed of very black shale about 30 thick at 1,000	Loose shaly soapstone (fine grey clay)	350	
1,061		Lime rock (fine calcareous sandstone)	8	
1,111	Fragment of a Baculite from about here.	Hard soapstone	90	
1,151		Sand and soapstone, with bands of hard-pan and supply of gas	20	
1,155	Generally dark to black tints.	Sandstone, with streaks of hard gravel	50	
1,426		Gravel and clay	40	
		Hard lime. Great flow of gas	5	
		Shales and "lime rock," (probably calcareous limestone) with layers of very dark, soft shale in second hole, to bottom	271	
		Total	1,426	

VIII.—Boring at Cassill's (8th Siding)

This station on the Canadian Pacific Railway is thirty-eight miles west of Langevin, at an elevation of 2,493 feet, or only 22 feet above Langevin, and here, as at that place, two holes were bored. Mr. R. G. McConnell obtained a section of the first to a depth of 700 feet in 1883. The second, put down under the superintendence of Mr. W. E. Swan, was carried to a depth of 1,000 feet. No specimens from either were examined, and as the names used to denote the strata, as obtained from the workmen, are very perplexing, and, moreover, as this section agrees very poorly with that furnished by Mr. Swan, I have adopted the latter, which is as follows (the boring was begun one foot below the level of the railway grade):—

	Feet.
1. Dark clay loam	2
2. Yellow clay	10
3. Blue clay	40
4. Blue shale	110
5. Grey shale	38
6. Drab sand rock	3
7. Blue shale	85
8. Brown shale	6
9. Coal	2
10. Grey shale	134
11. Brown sand rock	3
12. Black shale	257
13. Grey shale	135
14. Brown sand rock	5
15. Blue shale	85
16. Grey sandy shale	40
17. Grey shale	45
Total	1,000

Feeling that some uncertainty may attach to the above section, I do not propose to discuss it in detail. It may be sufficient to state that the first three beds are supposed to represent the drift deposits with a total thickness of 52 feet. Layers 4 to 8 inclusive, with a thickness of 142 feet, appear to represent the lower part of the Pierre, and correspond very well with its known character on the adjacent portion of the Bow River. The coal (No. 9) stated to be 2 feet in thickness, is given as 3 feet in the first-mentioned section and placed about 50 feet nearer the surface. It represents, with little doubt, the Grassy Island seam which, fourteen miles distant on the Bow River, is 4 feet 6 inches in thickness. The underlying beds, with a thickness of 706 feet, are supposed to represent the Belly River series though the great development of "black shale" represented by No. 12 is anomalous.

In layer 6, a small supply of water was met with, and in layer 14 a rather copious flow of combustible gas, which has since continued without perceptible diminution.

IX.—Boring at Gleichen Station (14th Siding).

This station is fifty-two miles west of the last, at an elevation of 2,926 feet above sea-level. It is known to be in the centre of a large area of Laramie rocks, which has a

general synclinal form. The section given was obtained by Mr. McConnell from the record kept during the work; but, as no specimens were examined, the precise meaning of some of the terms employed is rather doubtful. It is as follows:—

	Feet.
1. Sand and clay	8
2. Quicksand	20
3. Blue clay, with gravel and boulders	39
4. Black sand	11
5. Blue clays	22
6. Cement gravel	15
7. Soapstone	40
8. White sand (small flow of water)	5
9. Soapstone	94
10. Black sand	7
11. Loose soapstone	74
12. White lime	3
13. Black shale	40
14. Putty rock	12
15. Lime rock and loose shale	10
16. Soapstone	35
17. Sand rock	9
18. Black shale	20
19. Gravel soapstone (with sand and water)	38
Total	502

Layers 1 to 5 inclusive evidently belong to the drift deposits, and include a considerable thickness of boulder-clay. No. 6 is probably referable to the widespread pre-glacial gravel deposit, which is fully described in the report already several times referred to (Report of Progress Geological Survey, 1882-84).