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THE LIGNITE FORMATIONS OF THE WEST.

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The true Carboniferous formation and that with which the greater part of the valuable coals of the world are associated, and which is so largely developed in the eastern half of the American continent, from Nova Scotia southward, does not appear in the western prairie region. Its north-western border lies in the eastern part of the Territory of Nebraska and in Iowa, where the thickly wooded country of the east has already passed into the prairie land of the west. Here, however, this formation, depended on for fuel in so many parts of the world, to a great extent loses its coal-bearing character. In Nebraska it has now been pretty thoroughly explored, both by surface examination and by boring, and yet has only yielded coal in very sparing quantities. Coal seams of 18 inches and 2 feet are described, and one which has been pretty extensively worked in the vicinity of Nebraska city, is not more than 8 inches in thickness. Such coal beds as these would not be workable in England or on the continent of Europe, with all the cheap and skilled labour there at command, and in a new country like Nebraska are only rendered so by the extreme scarcity of wood for fuel, the coal, such as it is, being sold at prices ranging from about 40c. to 80c. per bushel.

Hayden and other United States geologists, who have examined this region, consider it to be upon the western lip or margin of the true coal formation. Even in the State of Iowa the coal beds are of comparatively small importance. The formation is

thin and irregular, and the coals themselves contain an excess of moisture and much ash and sulphur. In this western country the sandstones and mud rocks, usually associated with coal, are gradually replaced by limestones, indicating deeper water and conditions unfavourable to the formation of coal beds, as pointed out by Professor Hall.

Poor as these western coal-bearing rocks are, they labour under the additional disadvantage of being in great part covered by a newer formation, the Cretaceous; and where the Carboniferous formation again comes to the surface along the Rocky Mountain region of uplift, to the west of the great plains, it has not been found to contain so much as a single seam of coal, but is represented by massive limestones, shewing deposit in deep ocean water, and so far removed from land that it is rare to find in them even a fragment of any of the plants which were growing so luxuriantly in the swamps and deltas of the eastern half of the continent at the same time. Just where the coal of the recognized formation fails, the luxuriant growth of timber of the east also comes to an end, and the country assumes that prairie character which persists with scarcely a break to the foot of the Rocky Mountains. The bare rolling grassy hills and plains, though in many places eminently suited for agriculture, seldom yield wood for fuel or construction. Trees as a rule are only found fringing the deep river valleys, and in steep-edged gullies, where they are protected from the sweep of the prairie fires, and find a permanent supply of moisture.

In the western portion of the Dominion, in Manitoba and the Red River country, the Carboniferous formation is not found at all, but the Cretaceous rocks already alluded to, overlap the limestones of the older Silurian period. The true coal formation can only be supposed to exist there below a great thickness of Cretaceous rocks, and even if accessible the probability of coal of any value being found in it is, from analogy with the regions already mentioned, exceedingly small.

Neither do the Cretaceous rocks of the eastern portion of the plains yield, so far as known, any fuel of economic value in their great stretch from the borders of Mexico to the northern part of the British North-West. They consist almost entirely of clay rocks and sandstones, with one interesting zone of limestone and marl, which forms part of Hayden's group 3, or *Niobrara Division*, and which appears to be recognizable in Manitoba at Pembina mountain.

The lower part of this formation, however, in Nebraska, and on the Missouri river, seems to show an attempt at the production of beds of fuel. Beds of "impure lignite" of small thickness and of "carbonaceous clays" are met with there, especially in Hayden's lowest, or *Dakota Group*. Fossil leaves and stems are also found associated with these beds, and one lignite occurring in beds believed to be transitional between the *Dakota Group* and the *Fort Benton Group*, next above it, is even stated to have been worked to a small extent, and to have been "used by blacksmiths with some success."

There is therefore a possibility that the eastern edge of the Cretaceous in some regions may yet give a supply of fuel; and in Manitoba, the lower beds, and those in which the deposits above mentioned occur further south, probably lie east of the escarpment of Pembina mountain, and further east than the Cretaceous formation is made to extend in Hind's Geological Map, which has hitherto been the authority for the region. These lower beds, if they still exist beneath the alluvium of the Red River valley, are nowhere exposed, and cannot be explored except by boring operations. The possibility of the existence of fuel in the representative of the *Dakota Group* in Manitoba is much increased if the coal beds of the Upper Saskatchewan, examined last summer by Mr. Selwyn, are, as he supposes, of Lower Cretaceous age also, for in this case there would appear to be a tendency in the Lower Cretaceous formation east of the Rocky Mountains to become coal-bearing northwards.

Dr. Hector, many years ago, referred lignite beds observed by him in this region, to the same period. In view of these facts the position and character of the Cretaceous rocks occurring in Manitoba and the neighbouring country, becomes an interesting and important subject of inquiry.

Fortunately, however, the advance of settlement and civilization on the Western plains need not wait for the development of these possibilities, or for the tedious process of the planting and growth of trees suitable for fuel. A great deposit of fossil fuel, of still later age than the Cretaceous, has of late years been prominently brought to notice in the Western States, and the northern extension of this lignite formation of Tertiary age is largely developed in the Canadian Northwest. The existence of these fuels on the eastern side of the Rocky Mountains has long been known in a general way. Sir Alexander Mackenzie, the explorer

of the river of the same name, in his account of his voyages of discovery prosecuted during the years 1789 to 1793, says that along the eastern side of the mountains there exists "a narrow strip of very marshy, boggy, and uneven ground, the outer edge of which produces coal and bitumen; these I saw on the banks of the Mackenzie River, as far north as Lat. 66°. I also discovered them in my second journey at the commencement of the Rocky Mountains, in 56° N. Lat.; 120 W. Long.; and the same was observed by Mr. Fiddler, one of the servants of the H. B. Company, at the source of the South branch of the Saskatchewan, in about Lat. 52; Long. 112° 30'." He also describes near the Peace River, "several chasms in the earth which emitted heat and smoke which diffused a strong sulphurous stench,"—probably a case of the spontaneous combustion of a lignite bed comparable with those observed in other localities. Sir John Franklin in his second journey to the Polar Sea, noticed what he calls beds of lignite or tertiary pitch-coal at Garry's Island, off the mouth of the Mackenzie River, and also an extensive deposit near the Babbage River, on the coast of the Arctic Sea, opposite the termination of the Richardson chain of the Rocky Mountains. Sir J. Richardson, who accompanied Franklin in the expedition just referred to, was one of those engaged in the search for him in subsequent years, and mentions in his account of a boat voyage on the Mackenzie and in the vicinity of Great Bear River, a species of coal which when recently extracted is massive but shows woody structure, the beds appearing to be made up of pretty large trunks, the fibre of which is contorted. He says that when this coal is exposed a short time to air it splits into rhomboidal fragments, which again separate into thin layers, and much of it eventually falls into a coarse powder. When exposed to moist air, it takes fire and burns with a fetid smell, but with little smoke or flame. Some varieties resemble charcoal, and others are conchoidal like cannel coal. Amber is also noticed to occur, and the beds of coal are often destroyed as exposed by their spontaneous inflammability. This description and the account given of the associated clays and shales might almost as well apply to some localities in the southern part of British America or to the lignite tertiary formation of the Missouri River.

In the United States the first observers of this formation appear to have been Lewis and Clarke, who, in the narrative of

their expedition on the Missouri in 1804, mention somewhat fully the occurrence and distribution of the rocks of this formation. Many other explorers have since that time noticed the occurrence of this lignite formation even as far south as the Arkansas River, but till the inception of the trans-continental railway, it was thought of as lying too far west to be useful. The explorations connected with the railway and its construction, and the simultaneous growth of an important gold and silver mining region in Nevada and other western territories, with the explorations of Hayden and other geologists, have brought the great Lignite Tertiary Basin of these regions to notice in a manner commensurate with its importance. The lignite coals of this formation are now very extensively worked in several places near the line of the Union Pacific, and are found to subserve all the ordinary purposes of the more perfect coals of the true Carboniferous formation. They are used on the railways, and also for the metallurgical treatment of ores.

The region examined by me during the latter part of last summer, lies for the most part immediately north of the International Boundary, which crosses the continent from the Lake of the Woods to the Pacific Ocean, on the 49th parallel of latitude. Of the country through which the line passes, about 300 miles from East to West, have remained unknown even geographically until explored by the Boundary Survey during last summer, and the Lignite Tertiary formation described in this paper lies almost entirely in this hitherto unvisited region.

In proceeding westward from Red River, the Cretaceous beds already mentioned are met with in the region of the escarpment called Pembina Mountain, and in the streams which flow down over it, and occasional exposures of these rocks are found for a distance of about 45 miles. Beyond this, for about 150 miles, no rock exposures whatever are to be seen in the vicinity of the Line, the whole surface of the plains being composed of drift materials and marly sands and gravels. The river valleys are deep and broad, but the banks are grassed from top to bottom, and though very generally strewn with boulders belonging to the drift formation, do not show any sections of the underlying rocks.

At about 240 miles west of Red River, the boundary line strikes the Lignite Tertiary formation; the prairie level rises at the same place by a gentle step, which may be considered as

the first elevation towards the Coteau de Missouri, or region of high and broken ground which separates the waters draining by the Souris and Saskatchewan Rivers to Hudson's Bay, from those forming the northern tributaries of the Missouri River, and falling at last into the Gulf of Mexico. Here also the river valley of the Souris, which is the largest stream in proximity to the line, undergoes a remarkable change, its banks become scarped and bare, and are seen to be composed of stratified sands, clays and sandstones belonging to the Lignite formation. The beds here represented are probably among the lowest of the Lignite group, and near their base is a remarkable nodularly hardened sandstone, which has been formed by the action of the weather where it outcrops in the valley into a group of extremely picturesque and castellated rocks, known collectively by the half-breeds as the *Roche Percée*. The lower part of this sandstone is grey, and so soft that it may be cut and scraped away with a knife. The upper part is divided into thinner beds and is hardened by calcareous cement. Both layers show false bedded structure in great perfection, and the lower has been pierced by window-like openings, due to weathering along lines of jointage.

These rocks have been probably from time immemorial objects of superstition to the Indians inhabiting this region of the plains, and chiefly belonging to the Cree and Assineboin tribes. They have covered the lower soft part of the sandstone with rude carvings, some representing human figures on foot or on horseback, others various animals of the chase, and many merely resembling strings and necklaces of beads. These sandstones closely resemble those described in Wyoming and elsewhere to the south at the base of the Lignite tertiary, and which there weather into similar fantastic forms, to which names such as "Fairy's Caves," "Hermit's Caves," &c., have been applied.

For about 15 miles westward along the Souris Valley, many banks showing good exposures of the Lignite Tertiary rocks occur. The strata there represented probably overlie those of the Roche Percée, and contain many beds of lignite, which those seen immediately underlying the sandstone do not.

The beds in association with which the lignites occur are mostly arenaceous clays, sometimes changing into moderately coarse sands or soft sandstones, but generally more resembling a true clay of a hard character, and frequently passing into a species of clay-shale. The colours of the beds are very varied, much

more so than their texture, and a bank which from a distance frequently shows a perfectly banded appearance from top to bottom in shades of drab, yellowish, light brown and purple-grey, when approached more closely, loses all distinctness, and it is almost impossible to draw well defined lines between the layers in a measured section. The formation, though showing some slight undulations on a small scale, does not appear to have any definite direction of dip, and it is therefore difficult to correlate the beds seen in different places.

Many seams of lignite coal crop out in this part of the Souris Valley, the thickest observed was 7 feet 3 inches, and from this they show all intermediate degrees of thickness down to layers of a few inches only.

The following is one of many sections seen in this locality, and may be taken as an illustration of the manner of alternation of the deposits. The beds are arranged in descending order:

	Prairie Sod	– –
1.	Mixed Shale and Drift	7 to 8 feet.
2	Lignite	6 feet 6 in.
3.	Greyish Sandy Shale	4 " 0
4.	Lignite	1 " 6
5.	Fine sand and shaly clays, greyish and yellowish, well stratified	14 " 0
6.	Ironstone (nodular)	2 to 4 in.
7.	Greyish and whitish clay	2 feet 0 in.
8.	Carbonaceous shale	1 " 0
9.	Grey soft sandstone	1 " 8
10.	Lignite	1 " 0
11.	Laminated sandy clay, grey and yellowish	5 " 0
12.	Ironstone (nodular)	0 " 3
13.	Lignite	1 " 7
14.	Carbonaceous shale	1 " 6
15.	Lignite	2 " 2
16.	Grey sandy clay	2 " 0
17.	Lignite	1 " 5
18.	Sandy under clay, with large and small roots, poorly preserved	1 " 6
19.	Lignite	3 " 2
20.	Greyish soft sandy clay	– –
		About 58 0

The upper lignite lies so near the surface that it is penetrated by the roots of shrubs and small trees growing above, and where exposed is soft and rotten. The lower lignites though not of

great thickness are excellent in quality. Bed No. 18 is one of the very few instances where a well characterized underclay was found to lie below a bed of lignite.

Few recognizable remains of plants are found in this part of the region in connection with the lignites. Some beds, however, and often those in close association with the lignites, yield molluscan remains, representing two species of *Paludina* or *Vivipara* at least two of *Melania*, one *Corbula* and several *Unio*-like bivalves. All these resemble those described by Meek and Hayden, from the Lignite Tertiary further South, and the *Corbula* is probably identical with their *C. mactriformis*, and indicates that brackish as well as fresh waters took part in the deposition of the lower beds of this formation.

Another peculiar feature in connection with the lignite deposits is their tendency to burn away *in situ*, and below the surface of the ground. The beds become ignited by some prairie fire, or the camp-fire of some Indian or trader, or it may be spontaneously (though this seems improbable, as iron pyrites, the general agent of spontaneous combustion in coals, is absent in these lignites); and smoulder away for years, producing breaks in the edges of the bank by the caving in of superior beds, and giving rise to a material which is plentiful in many places, and resembles a scoriaceous lava, but is really a species of clinker produced by the fusion of the ashes of the lignite.

In continuing westward, and after having crossed the region of drift hills already mentioned as the Coteau de Missouri, the Lignite formation is again represented in all the valleys and gullies of the streams which now run southward, and form the upper parts of the North Western tributaries of the Missouri. Specially good exhibitions of the rocks are to be seen in the first of these large valleys, at a distance of 345 miles west of Red River, and also in another a few miles further west, which has been called Pyramid Creek, from a remarkable pyramidal hill formed by the wearing away of the softer beds of the formation from below a layer of harder sandstone, a block of which has formed the capping of the hill. The beds are everywhere nearly horizontal, showing merely local dips, and it does not appear that a great thickness is represented by the whole of the sections examined. One locality is remarkable as showing the greatest development of the lignite beds, and also for the abundance of remains of plants in moderately good preservation. This is nearly 400

miles west of Red River, and the chief exposure is something less than a mile south of the line, and in the Territory of Montana. A seam of lignite coal no less than 18 feet thick there crops out. The section, including this lignite, is as follows, in descending order:

1.	Surface soil	1 foot	0 in.
2.	Drift (quartzite pebbles)	1 "	6
3.	Yellowish and grey stratified sandy clays	9 "	0
4.	Lignite	0 "	9
5.	Brown, banded clays, with plants and some crystalline gypsum	5 "	0
6.	Lignite (weathering soft)	10 "	0
7.	Lignite (hard and compact)	8 "	0
8.	Soft grey sandstone	5 "	0
		40	3

The laminated clays of bed 5 when first exposed show plant remains in great perfection; even the delicate fronds of ferns, which are here unusually common, showing every detail of their form. On drying, however, the clay becomes cracked and fissured, and it is with difficulty that the impressions can be preserved. The association of selenite crystals, isolated or in groups, with the clays and arenaceous clays holding plant remains, is very constant.

The upper part of the lignite bed weathers soft and forms a steep slope. The lower part is hard, and being divided by vertical jointage planes, like many true coals, falls into the stream in great rectangular blocks, and presents a vertical face.

The plants associated with the lignite beds are very numerous in species, but have not yet been fully examined. Many *flag* and *sedge*-like leaves occur. At least two kinds of Ferns are represented—a *Sphenopteris* and an *Onoclea* apparently identical with *O. sensibilis*, a form still living. There are also twigs of several coniferous trees, including a cedar, *Thuja interrupta* of Newberry, and apparently species of *Sequoia* and *Taxus*; and from the microscopic structure of the lignites it would appear that most of them are made up of woods of this kind. Leaves of a great many species of *deciduous* trees also occur, and are generally full grown, and appear to have fallen in the order of nature, and at the change of the season, and floated quietly out into the great lakes, in the fine silty deposits of which they have been preserved. *Populus*, *Salix*, *Ulmus*, *Platanus*, and

probably *Rubus* and *Hedera* are among the genera represented; and it is not the least remarkable of the facts indicated by these deposits that they thus prove that in a comparatively modern period the region now so entirely destitute of trees was covered by a dense growth of forest.

Though it must not be supposed that the lignites of this region are comparable with true coal as fuel, they are still of considerable value, and will play a very important part in the settlement of a country so destitute of wood, not only as fuel for ordinary use, but in the manufacture of bricks for constructive purposes from the abundant clays. Most of the samples obtained were necessarily merely outcrop ones, and these fuels deteriorate rapidly under the action of the weather; still the average of fixed carbon in 13 samples from widely separated localities was over 40 per cent, and the ash in nearly every case very small in amount and light in colour, indicating the absence of iron pyrites.

As examples of the composition, two analyses of lignites from good compact seams, where the bank had recently fallen away and exposed a fresh surface, are here given. The first is from a bed 7 feet 3 inches thick on the Souris; the second from the lower part of the 18 foot bed included in the last section, and at a distance from the other of considerably over 100 miles.

Souris R. Valley, 7 ft. 3 in. seam.		*Porcupine Creek, 18 ft. seam.*	
Water	15.11	Water	12.05
Fixed Carbon	45.57	Carbon	46.18
Volatile matter	32.76	Volatile matter	35.12
Ash	4.56	Ash	6.65

These lignites, therefore, while superior to many which are used in other parts of the world, are somewhat inferior to the best class of lignite coals found on the line of the Union Pacific Railway, some of which contain from 45 to 53 per cent. of fixed carbon. These occur in detached basins of this formation, but probably in lower beds than those now described, and have also been improved by metamorphism connected with the elevation of the mountains with which they are in proximity, and with the contortion of the strata containing them, the lignites being in some cases actually on edge, and frequently inclined at high angles. Similar flexures will probably be found to affect the formation north of the 49th parallel, when traced towards the mountains, and the lignites may improve in quality in the same way. The deposits here described, however, gain much by their

horizontal attitude and easy accessibility, and could probably be mined by a system similar to that known as *long wall*, at the expense of a comparatively small amount of mine timber, which in these woodless regions would be a great advantage. The iron-stones, though occurring frequently in proximity to the coals, have not yet been observed in workable quantity, but it is highly probable that further explorations may bring such localities to light. The ores are among the best of their kind, both as to percentage of iron and freedom from sulphur and phosphorus. None of the lignites yet discovered yield however a coherent coke suitable for the smelting of iron in the blast furnace.*

The conditions implied by the nature of these deposits are marshes, lakes and estuaries, on a grand scale, and from which the sea was for the greater part of the time excluded. The previous deposits of Cretaceous age show that at that time the whole western part of the continent was covered by a sea of some depth, in which during a long time before the advent of the lignite period, fine silty and muddy sediments were laid slowly down, and included the remains of *Cephalopoda* and *Lamellibranchiata* peculiar to that age. Then came on a period of emergence, coarser sediments were carried by the waters, and at last the sea was entirely shut off from the area in question and replaced by great lakes of fresh water, with wide swampy margins, where the lignites were slowly formed by the growth of trees and peaty moss.

Much question has lately arisen with regard to the true age of the representatives of these deposits in the Western States. The plants as compared with those of European formations, have a comparatively modern aspect, and were originally referred on good authority to the Miocene. The molluscous fossils occurring in marine beds connected with the base of the formation on its western margin, show Cretaceous affinities. Cope maintains that the Cretaceous age of the greater part, if not the whole of the formation, is proved by the existence in it of a few relics of Dinosaurian reptiles. It would seem indeed that in the regular passage of beds of well marked Cretaceous age upwards into the Lignite Tertiary formation, we have a case of the blending of

* Mr. Miller, in some remarks made after the reading of this paper, mentioned the successful employment of charcoal made from similar lignites in Germany, in iron smelting.

two geological periods, but complicated by a simultaneous change over the area in question from marine to estuarine and fresh-water conditions. It seems certain that the formation of lignites began in the Rocky Mountain region before the salt waters had entirely left the area, and consequently while forms generally known as Cretaceous were still living there. The evidence does not appear to show that the Cretaceous species were of themselves becoming rapidly extinct, but that over the Western region, now forming part of this continent, the physical conditions changing drove the Cretaceous marine animals to other regions, and it is impossible at present to tell how long they may have endured in oceanic areas in other parts of the world. This being so, and in view of the evidence of the preponderant animal and vegetable forms, it seems reasonable to take the well marked base of the Lignite series as that of the lowest Tertiary, at least at present. The formation described belongs to this lowest Tertiary, being in fact an extension of Hayden's *Fort Union group*, and from analogy may be called *Eocene*. Judging from Hayden's descriptions this Northern extension would appear to be richer in lignite beds than that portion represented on the Missouri River, and therefore to show a tendency in the lignites to increase in importance northwards as they do southwards of that region.

NOTE ON THE OCCURRENCE OF FORAMINIFERA, COCCOLITHS, &c., IN THE CRETACEOUS ROCKS OF MANITOBA.

By G. M. Dawson, As. R. S. M., &c.

A great portion of the Cretaceous division in England and on the Continent of Europe, is composed of typical chalk, a substance which must have been formed in the tranquil depths of the ocean, far removed from land, as it contains but a very small proportion of any earthy impurity. It consists in great part of the calcareous shells of Foraminifera, and the still more minute calcareous bodies known as Coccoliths. The remains of the larger Molluscs and of Echinoderms occur but rarely. The American representative of this formation contains no beds of true chalk, but is made up for the most part of deposits of sand

and clay, indicating comparatively shallow-water conditions, and the proximity of land. The nearest approach to chalk is found in the interior continental basin, especially where the Cretaceous rocks are finely exposed along the Msssouri River, and where in Hayden's third group or Niobrara division a soft white shelly limestone occurs. It forms bold bluffs on some parts of the river, and the name "chalk" is popularly applied to it, and is justified by the fact that it contains large numbers of Foraminifera, some of which from the Cretaceous of the Missouri and Mississippi have been described by Ehrenberg.

In Manitoba, the rocks of the Cretaceous Series are much masked by drift material, and do not in any place I have seen yield fossils in any quantity. Through the kindness of Mr. A. T. Russel, I have however received specimens from a locality about twenty miles north of the 49th parallel, on the escarpment called Pembina Mountain, which exactly resemble the so-called "chalk" of Nebraska, and contain interesting organic remains.

The greater part of this rock is composed of shells of Inocerami and oysters, the latter probably identical with *Ostrea congesta*, characteristic of the Niobrara division further south. These shells are imbedded in a soft whitish earthy matrix, which on microscopic examination proved to be rich in Foraminifera, Coccoliths, and allied organisms.

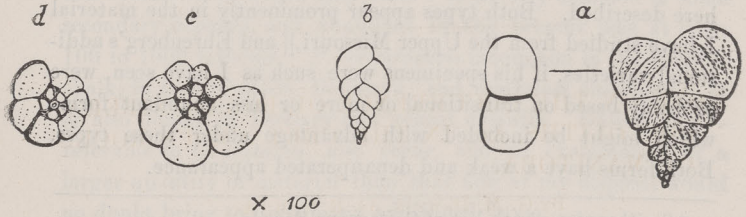

Fig. 1. Foraminifera from the Cretaceous of Manitoba.
(*a*) Textularia globulosa. (*b*) T. pygmæa. (*c*) Discorbina globularis. (*d*) Planorbulina Ariminensis.

The commonest foraminifers belong to the genus *Textularia*, and represent two of its varieties. Of these the predominant is a stout form with globose chambers rapidly increasing in size at each addition, and sometimes even as broad as long. The primordial chamber, and those next it, are often bent away several degrees from the axis of symmetry of the larger part of the shell. The surfaces of the chambers are marked with extremely minute

diagonal interrupted ridges or wrinkles, which may also be seen in specimens from the English chalk. This form is doubtless identical with *T. globulosa* * of Ehrenberg, noted as being in cretaceous material from Dakota and Nebraska, and falls under D'Orbigny's species *T. gibbosa*.† *T. globulosa* was found by Ehrenberg in the Brighton and Gravesend chalk, and is one of the commonest forms in the latter. It also occurrs in the Meudon chalk of France, and is still living in the Mediterranean and elsewhere, in depths of from 50 to 100 fathoms.‡

The second Textularine form is usually smaller and more delicate than the last. It is longer in proportion, considerably flattened, and with more elongated chambers. It is comparatively rare. Not unfrequently the first two or three chambers are very small, and arranged almost in a linear series. This may be equivalent to *T. Missouriensis*, or one of the other forms recognized by Ehrenberg, but according to the revised nomenclature may be included under *T. agglutinans*, variety *pygmœa*, D'Orbigny. This form is closely allied to if not identical with one found in the English chalk, and is common at the present day in the North Atlantic and elsewhere, becoming, however, rare and small at great depths, and appears to be most at home in about 90 fathoms in the latitude of England.§

Both of these Textulariæ are small and frequently deformed, and there are forms more or less intermediate between the types here described. Both types appear prominently in the material I have studied from the Upper Missouri,|| and Ehrenberg's additional varieties, if his specimens were such as I have seen, were probably based on transitional or more or less abundant forms which might be included with advantage under these types. Both forms have a weak and depauperated appearance.

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* Smithsonian check list of Cretaceous Fossils.

† See Parker and Jones, Geol. Mag. Vol. viii. No. 11.

‡ The same species or a variety of it seems to be named *T. Americana* by Bailey, in Silliman's Journal, vol. 46. In any case, a comparison of specimens shows that the common species at Pembina Mountain is even varietally identical with one common in the English chalk.

§ Parker and Jones on North Atlantic and Arctic Foraminifera.

|| Specimens presented by the Smithsonian Institution to the Museum of McGill College, from "Eau qui Court," on the Niobrara River, about 500 miles South of Pembina Mountain, are very similar to those from the latter place, containing the same Foraminifera and abundant Coccoliths and Rhabdoliths, with *Ostrea congesta*.

The common spiral Foraminifer in the Pembina Mountain specimens, is *Discorbina* (*Rotalia*) *globularis*, D'Orb. sp., and is probably identical with *Rotalina* (*Rotalia*) *globularis*, characteristic of and very common in the upper and lower chalk of England. This form is also common in the specimens from Nebraska, and must be the same as *Planorbulina globulosa*, recognized by Parker and Jones from Ehrenberg's figures as occurring in the Mississippi Cretaceous.* These authors there remark that *Planorbulina globulosa*, Ehr. sp. "must not be regarded as worth much, being a very minute Rotaline, and such a form as several species might present in their earliest stage of growth." It forms, however, a well marked type in the Manitoba and Nebraska deposits, and as no larger examples occur, must be regarded as an adult though depauperated variety. It is common everywhere at the present day. In the North Atlantic it is best developed from the shore down to 50 or 70 fathoms. It becomes flatter at greater depths. The specimens from Manitoba are considerably flattened.

A second Rotaline, smaller and flatter than the rest, and with more delicate chambers and more in a whorl, is referable to *Planorbulina* (*Planulina*) *ariminensis*, D'Orb. sp., included under *P. farcta* by Messrs. Parker and Jones, and belongs to the series of small quasi Rotalian and Nautiloid forms, more or less symmetrical, which they state † to be very common in some secondary deposits, and abundant in the present seas at from 100 to 1000 fathoms. *P. ariminensis* is common in the English chalk, in that of Möen, Denmark, and doubtless elsewhere. It is also found in Tertiary and recent deposits. *Globigerinæ*—referable to *G. cretacea*, also occur, and an examination of a larger quantity of material than that now at my disposal would no doubt bring to light many additional forms.

The general facies of the foraminiferal fauna of these Cretaceous rocks of Manitoba and Nebraska singularly resembles that of the ordinary English chalk. Both abound in Textularine and Rotaline forms of similar types, the most abundant in both being the form with globose chambers, and each having its rarer analogue with chambers flattened and more delicate.

To the bodies now included under the general name *Coccoliths*, attention has only been prominently drawn of late years. Ehren-

* Quart. Jour. Geol. Soc. 1872.

† Memoir on Atlantic and Arctic Forams.