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	City water.	I. N. Stone's well.	Missouri river.	Sioux river.	Manufactured ice.	Sioux river ice.
Total solids	505	450	562	526	94.	110.
Loss on ignition	....	90	....	....	6.	20
Chlorides	11.06	6.4	20.	6.47	7.3	4.5
Nitrogen as nitrates	.66	2.	.03	.07	.02	.01
Nitrogen as nitrites	None.	.011	None.	.0544	None.	None.
Nitrogen as free ammonia	None.	.00144	.009	.045	.039	.027
Nitrogen as albuminoid ammonia	.00054	.075	.171	.615	.01	.29
Oxygen consuming power	.1	.5	8.5	2.4	1.5	1 2

THE TOLEDO LOBE OF IOWAN DRIFT.

BY T. E. SAVAGE.

The southern margin of the main Iowan drift sheet extends in a sinuous line across the central portion of Tama county. From this border a tongue-shaped lobe, having an average width of about six miles, extends southward for a distance of eight or nine miles reaching one mile below the city of Toledo and within two miles of the Iowa river. This extension I have called the Toledo lobe of Iowan drift. It is bordered on the west from the point where it leaves the main Iowan drift sheet, about the middle of the south half of section 14 of Carlton township, down to near the middle of section 21 of Toledo township, by the hills which form the west bank of the valley of Deer creek. From the latter point the irregular ridges which mark the margin of the lobe trend to the southeast for one-half mile, and then eastward, continuing in an undulating line near the north side of sections 27, 26, and 25, of the township of Tama. They enter Otter Creek township not far from the southwest corner of section 19. From this point they trend in a northeasterly direction across the southern portion of section 19, and bending further to the north they cross the northwest corner of section 20. Otter creek passes through a gap in these hills near the southwest corner of section 17. From here the ridges extend in a general northerly direction, bending alternately eastward and westward, near the west side of sections 17, 8, and 5. They enter Carroll township near the southeast corner of section 31. Continuing northward with a slight inclination towards the west for a distance of five miles, they merge into the morainic hills of the proper Iowan drift plain near the southwest corner of section 6.

This Toledo lobe covers the greater portion of Howard township, a small corner of Carlton, a little more than the east half of the township of Toledo and a narrow strip from the west side of the townships of Otter Creek and Carroll. It is about four and one-half miles in width at the southern extremity, and nearly eight miles across at the north, where it leaves the main sheet. It embraces an area of over 31,000 acres.

Over the southern portion of this lobe the surface is that of a billowy prairie. The elevations seldom exceed twenty feet above the broad channels of the streams. A thin covering of Iowan drift occurs over the lower lands, and in places is found even on the tops of the subdued hills. This drift is of the typical Iowan character. It is yellowish brown in color. The iron which it contains is not fully oxidized, and the calcareous matter is not leached from the surface. It carries but few pebbles or small bowlders as compared with the Kansan, and of these there is but a small percentage of dark colored trap or green-stones.

Over this region the Iowan drift is usually concealed beneath a covering of loess, which varies from a foot or two to several feet in thickness. Such a loess-covered bed of Iowan drift is well exposed along the roadside between sections 18 and 19 of Otter Creek township, and again about the middle of the line which separates sections 33 and 26 of Howard township. The presence of loess overlying Iowan drift is not unique over the state, but this is not its usual mode of occurrence. In central and southern Iowa the deeper beds of loess are found covering Kansan drift at no great distance from the Iowan border. It seems probable that then, as now, loess materials were deposited on the leeward side of obstructions to dust-laden currents of air, or where, in the path of such winds, the soil was covered with vegetation which would serve to catch and retain the dust particles that fell upon it. However, the distribution of loess over this portion of the state would indicate that during the time when the Iowan ice prevailed the conditions were exceptionally favorable for its deposition, and that probably the source of much of the materials might have been the super-glacial silt from the Iowan ice sheet itself.

Very often the deposits of Iowan drift are found in the valleys while till of Kansan age covers the hills and emerges at the surface along the upper part of the slopes. Examples of hills with Kansan drift exposed at the top and having Iowan materials flanking the base, may be seen in the northern part of section 35 of Howard township and along the middle line of section 21 of the same township.

The Iowan ice which pushed down over this area carried quite a large number of light colored granite bowlders. These bowlders are usually from four to eight feet in diameter, but individuals ten to twelve feet in length are not rare, while one specimen was seen with a long diameter of about thirty feet. Bowlder strewn fields, some of the rocks of large size, may be seen about eighty rods south of the Toledo and Cedar Rapids road, one in the eastern part of section 23 and another in the western part of section 24, of Toledo township. Occasional bowlders dot the surface along all of the stream courses over this region. They are seldom found on the higher points, but seem to have been left during the process of the melting of the ice which carried them either on the lower flanks of the slopes or along the beds of the streams.

The topographic features of an area across the middle portion of this lobe are bolder. The tops of the hills stand, in many places, forty to fifty feet above the valleys. The contours are quite sharp and the slopes are steep. The irregular character of these sand or loess capped hills resembles very closely the ridges which are found around the margin of the Iowan drift plain. Even here, however, the stream channels, choked and clogged with aqueo-glacial debris, the occurrence of Iowan drift near the base of the hills, and the presence of large, light-colored granite bowlders along the valleys bear indubitable testimony to the former presence of the Iowan ice sheet. The axes of these hills are composed of Kansan drift, but their tops are usually crowned with sand or with loess, often to a depth of fifteen to thirty feet. A short distance south of the Monticello church, in section 33 of Howard township, the road has been cut through a bank of loess exposing a depth of about fifteen feet while in the valley a short distance away there may be seen a bed of Iowan drift. The loess at this place is very fossiliferous, containing numerous individuals of species of Polygyra, Succinea, Zonites and Pupa. Examples of sand covered hills over this area are numerous, but typical places have been already cited.

The peculiar topography of the Toledo lobe, the presence of loess overlying the Iowan drift, together with the very scant amount of material that the Iowan ice sheet left over its surface would seem to indicate an unusual episode in the history of the Iowan ice action. The phenomena which it presents lend themselves to the following interpretation. During the early stages of the extension of the Iowan glacier a narrow lobe of ice was pushed southward beyond the main body over the deeply eroded Kansan surface, covering the area outlined as the Toledo lobe. For some reason the pressure from behind soon became insufficient to keep up the movement over this lobe, and the ice which covered the region became dead and gradually melted where it came to rest. As the glacier moved slowly over the old Kansan surface, the stones which were held fast along the bottom of the ice would form instruments of attrition of the most effective kind. The materials on the tops of the hills, even though frozen solid, could not but yield rapidly to this grinding action of the ice. The debris worn off from the higher points would be pushed over into the valleys to the leeward of the advancing ice sheet. In this manner the surface inequalities would gradually be reduced, both by the constant wearing down of the greater elevations and by the no less constant filling of the valleys with the materials removed from the tops of the hills. Owing to the short period during which the flow of ice continued over this surface, the tops of the Kansan hills were not subjected to the powerful abrading action of great masses of moving ice for so long a period as were those where the flow continued for the whole time during which the Iowan ice prevailed. As a consequence the pre-Iowan surface here was not planed down to the same extent as it was over the area covered by the main sheet of the Iowan drift.

The generally smooth character of the Iowan drift surface is probably due more to the leveling action of thick masses of ice moving over the region than to the amount of materials transported from great distances which the ice left as it retreated. The Iowan ice did not generally carry such a large amount of drift and debris as the Kansan, as is witnessed by the comparatively thin sheet of materials which is usually found covering the Kansan drift over the main Iowan plain. However, it is probable that the small quantity of ice which melted over this lobe would be one good and sufficient reason for the unusually thin mantle of Iowan materials that is found over its surface.

The cause or causes which resulted in the early cessation of the flow of ice over this lobe did not produce their full effect at once. The movement probably ceased quite suddenly over the southern half of the area, but its withdrawal from the northern portion was accomplished much more slowly and at a much less uniform rate. A halting in the retreat of the ice near the central portion of the lobe, its line of lower limit receding but very slowly through a long period of time, would result in the accumulation around its margin of deposits of sand and loess by the overwash of materials liberated from the melting ice, and by the action of winds sweeping over the surface of the ice sheet and laying down their load to the leeward of its margin.

As a consequence of such deposition the Kansan hills immediately around the border, which had been leveled down to some extent by the ice moving over them, were built up to a height twenty to thirty feet above the more elevated points in the southern portion of the lobe. During this time, also, much of the fine-grained loess materials gathered up by the winds would be carried out for some distance beyond the margin of the ice, and thus the southern portion of the lobe would receive a mantle of loess above the Iowan drift which had been previously deposited over the area. When the ice melted there was left the belt of sand or loess-covered hills, one-half mile to a mile in width, which forms so conspicuous a feature across the north central portion of the lobe.

Some time before the entire withdrawal of the Iowan glacier from the county, the flow of ice ceased over the northern portion of the lobe, the margin retreated to about the same distance southward as that of the main body of Iowan ice. Along this border a new series of ridges was formed, but the width of this belt is less than that of the one which crosses the central portion of the lobe. The individual ridges are also lower and less conspicuous. Pleasant Hill church, situated about the middle of the south side of section 2 of Howard township, is located on one of the ridges of this moraine.

After the retreat of the ice from the Toledo lobe, and probably before the entire withdrawal of the Iowan sheet from this part of the state, a mantle of loess was deposited in places over the northern portion of the area under consideration.

With this deposit and the retreat of the ice the stage of the Iowan ice invasion was closed. From that time, so long ago when measured in years yet so recent from a geological point of view, the forces of weathering and erosion have modified but slightly the topographic forms of its surface, adding only the last touches to the features which the region presents to-day.

A POSSIBLE ORIGIN FOR THE LIGNITES OF NORTH DAKOTA.

BY FRANK A. WILDER.

The lignite of North Dakota occupies part of an area that is shared by the neighboring states of Montana, Wyoming, and South Dakota, and by Assiniboia on the north. The total area of this lignite field in the United States alone is 70,000 square miles, apportioned as follows:

North Dakota	31,500
Montana	25,000
Wyoming	9,000
South Dakota	4,500

It is probable that all of this field does not contain lignite beds of workable thickness, but studies carried on in North Dakota and Montana during the past summer indicate that thick beds are very general, and that often a series of four or five are separated by relatively thin strata of clay. Some of the beds are very thick, one which outcrops near the Little Missouri in southwestern North Dakota measuring forty feet, while twenty-foot beds are not uncommon.

Analyses of samples taken from more than sixty points in North Dakota show that, except for the high percentage of moisture that they contain, they might be ranked as semi-bituminous coal, since the amount of fixed carbon is unusually high for lignite. The average North Dakota lignite contains thirty-two per cent of moisture. When this is driven off by heating to 100 C., analyses show that the average lignite is composed of:

	Per cent.
Volatile matter	41.5
Fixed carbon	51.
Ash	7.5

The beds, as a rule, show no great lateral persistence. Mining operations have demonstrated that one bed in Ward county underlies fifty square miles of country, but this is believed to be much more extensive than the average. Observations along the Little Missouri and in the Bad Lands, where the lignite beds are often exposed along ravines and canyons for miles continuously, show that the floor on which they were laid down was often uneven, and that they are inclined to thicken or thin out rapidly. While one bed is thinning another may develop above or below it, so that the lignite is continuous through large areas, though there is diversity of beds.

All of the workable lignite beds of North Dakota are regarded as Laramie, though beds a few inches in thickness in the eastern part of the state occur in the Benton. Fossil shells which included three gasteropod and one pelecypod species, collected during the past summer at three points—the same species being found at each point—in clays intimately associated with the lignite, were identified by Mr. Charles Schuchert, of the Smithsonian Institution, who reports that while the range of the species is somewhat extensive, all are indicative of the Laramie. Similar determinations have been made in former years by members of the staff of the United States Geological Survey. As it exists in North Dakota the Laramie consists mainly of clays which are never fissile or shale-like in character. From fat and joint clays they may gradually become arenaceous till they pass into unconsolidated sand. This is locally hardened into solid beds. The most extensive sandstone in the state caps the high buttes in Billings county, and is fifty feet thick. Most of the sandstones are micaceous, the common mica being biotite. Strata which are widely separated laterally and in the vertical scale as well, often show great similarity in composition. They are commonly cross-bedded. The clay strata are marked by strong individuality in color, and display all shades of gray, brown, red, and yellow, producing effects in the canyons of the Bad Lands that are often exceedingly beautiful. Beds of high grade fire clay which have a fusing point above 3,500° F., are common. A series of clay strata may dip at an angle of ten degrees or more, while those above and below are horizontal. The effect to the eye is not unlike that of cross-bedding.

The lignite is commonly brown in color and exceedingly woody in structure. Tree trunks many feet long and from one to two feet in diameter are often found lying prone in the lignite bed. Unfortunately the bark is never preserved or other characteristics by which they can be identified without the microscope, and as yet microscopic studies have not been undertaken. Small masses of a rosinous-like substance are often distributed through the lignite. Leaf prints and delicate forms have not been found in the lignite itself, but in the associated clays they are well preserved. Specimens taken from a clay which lies between two lignite beds in Ward county were sent to the Smithsonian Institution for identification, and were determined to be:

Sequoia langsdorfii (Brongniart) Heer.
Sequoia brevifolia Lesq.
Sequoia angustifolia Lesq.

Sequoia cones, finely fossilized, were found in great abundance in Morton county. Leaf prints of *Viburnum* perfectly preserved in thin bands of clay-ironstone were found at a number of points.

Unusual opportunities to study the relations of the lignite to the under clay are given, since a great deal of mining is done by the strip-pit system, which leaves the clay bare and shows exactly the line of contact between clay and coal. The extensive exposures in the bluffs of the Bad Lands are instructive in the same way. The underlying clay is practically free from roots. It may contain limbs or trunks, which are scattered irregularly here and there, but these are not uncommon anywhere in the Laramie clays. In not a single instance was a stump found with roots in the clay under the coal, nor was a case reported by any of the miners interviewed. The clay floor is often uneven. It may dip as much as five degrees when the structure of the overlying clays shows that there has been no folding. It is dotted with low, broad mounds at times and is rarely level.

The purity of some beds is very constant, while the amount of ash in the lignite from others will increase ten per cent and even more in a lateral distance of two hundred yards. So great a change in quality, however, is unusual. Often the upper two or three feet, or even all of a thin bed seems to have decayed, as though after the woody matter had accumulated under water, the lake or swamp under which it was deposited had been partly drained and the lignite exposed to the air for a time before it was covered by silt. The ash in this "soft" lignite is often twenty per cent and it is worthless as fuel. This is as apt to be true of beds low in the Laramie as of those that are near the top.

It is difficult to formulate an hypothesis for the origin of the lignite that is in harmony with all of the facts cited. The ordinary explanation for coal deposits seems inadequate since nearly all of the phenomena on which it is based are absent in this field. There are no roots in, nor stumps rising out of the underlying clays; nor are there delicate leaf prints preserved in the body of the coal, indicating deposition in quiet water. Moreover, the flora of the Laramie, or at least those forms that have been collected from the lignite area and in close connection with the lignite, are of genera which to-day live on dry ground. Many of the beds seem to be made up entirely of wood, with no addition of leaves or the finer forms of vegetation. This wood has suffered so little decay that it is hard to think that the material that forms the upper part of the bed grew upon or derived nourishment from that below, and where the beds are twenty feet thick, not an uncommon occurrence, it is equally hard to conceive of trees growing on ten feet or more of fallen but undecayed trunks, and striking root down into the underlying clay.

In considering drift material deposited in deltas as an origin for coal deposits, the question arises whether sufficient stress has been laid on the probability that considerable quantities of silt and sand would be deposited with the vegetable matter. The conditions must have been unique under which drift timber sufficient to make twenty feet of lignite could accumulate, and yet so little silt be deposited with it that the ash of the lignite is but one or two per cent higher than the percentage of mineral matter in the wood. A second point that demands consideration is the origin of this vast amount of drift material.

The Laramie beds are regarded as accumulations in fresh water. The great fresh water lakes of the present do not seem to present conditions which, though operative for a long period of time, would give rise to similar deposits, for the amount of drift material that becomes waterlogged in them and sinks to the bottom far from the shore where it could accumulate without addition of silt, is probably small. Strong currents and winds either carry most of the drift wood out of the lake or crowd it to shore where it is buried in sand. In the smaller lakes of northern Michigan and Minnesota, located in the heart of the timber country, conditions are different. Vegetation is abundant to the water's edge and sand beaches are rare. Any one who has seen certain of them during logging time can readily believe that, if by natural conditions logs were poured into the lakes as they are yearly during the logging season and became waterlogged there, woody beds equal to those of the Laramie lignites would result. Perfectly natural conditions as they exist to-day, operating through a very long period of time, would doubtless contribute to one of these lakes enough material for a lignite bed, but as the time in which the accumulation takes place is increased, the probability of a large admixture of foreign matter is increased. It is true that the forest conditions that exist around these lakes prevent the carrying in of large quantities of sand and dust by wind, but tributary streams that are active enough to bring down considerable quantities of timber would contribute to the lake a good deal of silt as well. This would be deposited near the mouths of the streams for the most part. It is conceivable that many logs would drift beyond the zone of heavy silt deposit, and that a woody deposit highly mixed with silt near the stream delta, and growing purer with distance or other conditions that diminished current action, might arise. Nevertheless, it is plain that if conditions which would hasten the accumulation of woody matter may be assumed, the problem will be simplified.

The Rocky mountain uplift is generally credited to the Laramie, for Laramie strata are found well upon the mountain slopes. No evidence is at hand, however, to show that the late Laramie ever wholly covered the Rocky mountain area. If the uplift occurred all through the Laramie, the explanation that has been offered for the lignites receives material aid. The uplift, it may be conceived, began with the region that is now the heart of the Rockies, and continued till the region as far east as western Dakota was slightly affected. The effect of the earliest movement would be to quicken erosion in the region of uplift and increase deposition at its edge, in the central and eastern Montana country. Here the disturbance in the west would manifest itself in abnormal drainage conditions. Lakes would arise, fed by the streams coming from the west. Streams thus rapidly quickened in a forest country would carry much drift timber, for during the former period of relative inactivity forest conditions would have crept down close to the stream banks. Undercutting, with landslides, would throw into the valleys the giant redwoods, which the next flood would carry to the lakes. As the uplift continued and its axis widened, the region of deposition would be carried farther and farther east, and there would be a gradual shifting of the lake country in that direction. The Laramie strata to the west would be tilted and faulted as they are to-day, and those farther from the center of upward movement would lie practically horizontal.

Such an hypothesis seems to fit the nature of the Laramie clays and sandstones, as well as the peculiarities of the interbedded lignite. The cross-bedded sandstone which passes gradually into clay; the clay beds that are sometimes remarkably persistent in color and texture, and at other times extremely variable, passing abruptly into carbonaceous clay and on into lignite; the large tree trunks that are scattered through all of the clay beds; all suggest the former presence of shifting lakes fed by streams laden with silt and timber. In one instance stumps three and four feet in diameter and fifteen feet high, silicified, were found over an extensive area standing upright. They were not associated with a lignite bed, and seem to represent part of a forest that was silted under by the shifting of a lake bed.

This view of the origin of the lignites is admittedly hypothetical. It seems, however, to present a reasonable line for study, to form a working hypothesis, to use the admirable term of Professor Chamberlin. To prove or disprove it, additional study will be directed to the following points: To determine whether the Laramie of the mountains is older than that of the plains; to show whether in the main the wood from which the lignite was derived was of land growth and to determine the habitat of the species, and to see what light the fauna of the Laramie throws on the relation of land to water at that time.