THE FORMATION OF SOILS AND OTHER SUPERFICIAL DEPOSITS.

In the Southern and Southwestern parts of Indiana the soils, when not alluvial, or lacustrine, are residuary, formed by the disintegration of stratified rocks either sandstone or limestone. In the Drift region proper there is no residuary soil, the glacial deposits showing superficial loams, modified loëss, vegetable mold and peaty formations.

Most of our black prairie soil, which is so deep and so remarkably fertile, has had its origin at the bottom of shallow sheets of fresh water, in which sphagnous growths and vast masses of aquatic grasses and weeds have decayed year after year for centuries. In many places this soil is so peaty that in very dry weather it will burn with a slow, hidden fire. I have seen wells that showed a section of nearly twelve feet of this almost jet black deposit. Deep drainage and careful tillage give the best possible results with this land, especially in corn and grass. It has been a question, much discussed, how the carbonate of lime, in which much of the prairie soil is very rich, has been deposited throughout the mass. Upon examination I have found that where the soil approaches a black loam in consistency, the lime is in the form of marl or chalk blended with very fine sand, like the deposits often found at the bottom of shallow ponds fed by surface drainage from calcareous drift. Areas of this description usually are partly or wholly surrounded by what is called "barrens;" that is a region of low clayey or sandy knobs, overgrown by stunted oak trees. It is from the "barrens" that the sand and lime have come down to the lower surface, in cases of this sort; but where we find a calcareous loam covering a wide prairie which has no barrens, we are left without our argument. I have concluded that all the extensive shallow lakes, once so common on our drift surface, were subject to violent storms, since they were without any surroundings tending to break the force of winds, and that consequently the sediment of vegetable matter constantly accumulating was often stirred up and suspended in the water, which, as it was dashed about, took up portions of the clay basin in which it was inclosed, and thus disseminated the sand, gravel and lime through the vegetable matter. This action may be observed

now, in the windy season, by any one who will take the trouble to note the changes in the bottom of a shallow pond after each gale. Doubtless the wind storms during the period between the final retreat of the glaciers and the return of vegetation of the larger kinds to the drift area, were much more frequent and powerful than now.

The action of rain-water upon limestone is well known; as the rock is disintegrated the lime is taken up and held in suspension until it is precipitated in the form of chalk, or "marl," as it is popularly called. The bowlder clay in which all the lakes and ponds have had their basins, is calcareous, in a greater or less degree, and from it the carbonate of lime has been taken up by surface water and borne into the reservoirs where it has finally found its way into the silt and vegetable deposits at the bottom. The more peat-like soils have very little calcareous matter in them, and, consequently, are less fertile.

Oxide of iron, in various forms, is plentifully distributed throughout the black prairie soils; in some places it is found as bog ore which has been deposited by water, surcharged with salts of iron, welling up from the clays beneath. What are called "spouty" places, where chalybeate springs come to the surface, are often rich in bog ore; the iron salts solved in the water are oxidized upon coming in contact with the air and are precipitated in the form of oxide of iron, which gradually accumulates in concretionary bodies of a dark brown color sometimes covering many acres. In the region of the Kankakee River these iron deposits are quite frequently observed.

What has been said of the mode of formation of the black prairie soils may also apply to the black soils of our timbered lands. The most casual observer will note that in our burr-oak swamps there are low knobs and swells of white or bluish clay breaking through the black earth; upon these clay swells the white oaks grow, while down in the little "mucky" baisins grow the burr oaks. The black soil in these burr-oak basins and swales has been formed by the deposit of vegetable matter. All the leaves and mold of the forests are washed by rain and blown by wind down from the highest to the lowest places, where in time they form the black muck-like soil. When well-drained the burr-oak swamps of Indiana are incomparably fertile.

What has been named by some of our geologists "modified loëss" is a grayish brown or reddish gray soil capping the higher and dryer areas of our drift. I do not recognize this as a true lacustral formation; indeed, it is doubtful whether lake water ever had anything whatever to do with its deposit. It would be better to name it modified drift matter, and to refer its origin to broad and gentle currents of water flowing away from the retreating glaciers. Everywhere I have found huge bowlders stranded on these deposits, as if dumped there by icebergs. The assorting power of water is capable of modifying the drift substance in so many ways that

it can not be deemed that it may have produced the so-called loëss. Doubtless where fresh water shells are found in the body of the deposit we must refer it to lacustral or fluviatile origin; but I have not yet been able to find any such organisms in the "modified loëss" of middle and northern Indiana.

The red and brown clays of the drift resemble very closely the residuary clays of Kentucky and Tennessee, but upon examination they are found to be a modification of the blue bowlder clay chiefly by oxidation and the action of rains and frost. Wherever the surface clays of the drift have been highly charged with comminuted limestone, there has followed a disintegration, the carbonate of lime being freed by the action of rain water and the iron being solved by oxidation, from which has resulted a fine, light loam-like soil colored by the oxide of iron. Under this soil in many instances we find heavy deposits of gravel and sand, and the timber growth upon it is usually tulip (poplar) and white walnut, sugar-tree and black walnut, indicating warmth and perfect under drainage.

Where the face of the ground is rolling the flow of surface water controls the deposition of soil, the deeper and richer formations lying always in the lower areas, while the higher surfaces are more or less denuded of vegetable fertilizers. These washed lands are usually looked upon as unfertile, but an intelligent application of the tile drain to the stiff, dead clay soil will aerate it, oxidize the limestone contained in it and soon render it very productive. Thus the very lands which appear to be best drained by nature most need artificial drainage. Indeed, there is scarcely an acre of land, high or low, in all Indiana, which would not be benefited by a system of under drainage. The two words *aeration* and *oxidation* should be familiar to all farmers. The soil must have air and the mineral and vegetable substances in the soil must have a chance to oxidize. Deep and many drains and deep and frequent plowing are the means of attaining to this end. There can not be too many drains, there can not be too deep or too frequent plowing.

The superficial deposit, locally known as "lime marl," which is found in basins of the drift, has puzzled geologists not a little, its peculiar structure and order of formation offering the following questions:

1st. Whence came the lime?

2d. How was it transported?

3d. What caused its deposition?

4th. Why is it so free from vegetable matter and other foreign substances?

I have given the matter careful investigation, and without going at this time into any minute details of discussion, it seems to me that I can answer the questions seriatim as follows:

1. The lime has come from the body of the drift mass.
2. It has been transported by water in motion.

3. Its deposition has been by simple precipitation, or sediment action, after the water has become still in a basin.

4. It is free from vegetable matter because there was no vegetable matter near by where it was deposited.

Now when I say that the lime has been transported by running water, I do not mean *surface* water; but I do mean water percolating through the drift substance and rising in the basins where it is to let fall its surcharge of carbonate of lime.

Most of the small lakes now existing in Northern Indiana are fed mostly by springs whose water brings up a large amount of lime. Subsequent evaporation causes the precipitation of the carbonate. Analysis shows that these chalk or lime deposits carry a considerable quantity of free silica in the form of very fine sand which has been brought up by the spring streams. In one of the gas wells at Lebanon, in Boone county, the drill at a depth of about two hundred feet in the drift struck a deposit of white silicious clay nearly two hundred feet in thickness, which bore in its composition twenty per cent. of the carbonate of lime. At Lake Maxinkuckee a flowing well brought up a milky-looking fluid which proved to be a thick solution of a kindred clay. I mention these facts to show how easy it is for springs arising out of calcareous deposits to bring up the substance which, when precipitated, will form clean beds of chalk. Calcareous tufa is deposited in the same way by water seeping out of limestone formations.

Superficial mounds and ridges of gravel and sand have been formed by one or the other of two forces: water-currents and floating ice-bergs. When the former have been the force no large bowlders will be found in or upon the mass; but when the latter have acted there may be immense bowlders lying high and dry on the very highest points of the formation. A careful examination will rarely fail to disclose the agent to which any particular deposit is clearly referable. In cases where water-currents have assorted and heaped up the gravel the direction of the flow may be detected by the relative positions of the coarse and the fine material, the former always lying up stream from the latter, from the fact that light material is moved farther than heavy, the same current acting upon each. Where a huge iceberg, loaded with bowlders, gravel and sand, has stranded and melted, its burden will be found laid down in a heap, the mass unassorted. But it is only in favored spots that this last-named feature is observable; for the action of winds, rains and frost has destroyed the strongest outlines of the drift wherever it has been afforded free application to the mass. Here and there, however, a fine example remains. One a little east of Crawfordsville, in Montgomery County, on the south side of the I., B. & W. Railroad, shows its origin perfectly.

Indeed, when once we admit that our drift mass is due to glacial action, we are forced to the conclusion that many curious effects are due to

floating icebergs borne along by currents flowing away from the melting glaciers. Of course the highest parts of the moraines would form the most effective barrier to this current, and it would be there that the icebergs would strand and finally melt. Hence it is that most of the peculiar gravel knobs and ridges are located on the highest points of our drift areas, while the presence of immense bowlders lying quite upon the surface of these apices can be accounted for on no other hypothesis than that they have been transported by ancient ice-ships whose cargoes fell where the vessels melted. Some of these icebergs must have been of almost unimaginable size in order to bear the tremendous loads cast down by them all over the drift area.

The gravel mounds, often mistaken for ancient Indian works, which are found on the terraces and in the bottom lands of our rivers and rivulets, are not glacial formations, but owe their origin to a time when the streams upon whose banks they rest were much larger than now, and when thei currents had power to heap up these curious deposits.

Over large areas in the northern part of the State vast bodies of sand, very fine and of a light buff color, heaped in hillocks and ridges, are due to the action of wind. The sand has been thrown ashore by Lake Michigan, at a time when its waters covered a far larger surface than now, and thence it has been transported by the prevailing winds southward and eastward to its present situation. There is reason to believe, and I venture to assume provisionally, that the result of a careful survey of the region north of the Kankakee River will show that at a very recent geological date Lake Michigan had an inlet or large estuary reaching southeastwardly from its present southern boundary, and covering a considerable portion of Northern Indiana.