ART. XI.—*Observations upon the Glacial Drift beneath the bed of Lake Michigan, as seen in the Chicago Tunnel*; by E. ANDREWS, A.M., M.D., Prof. of Surgery in Chicago Medical College.

IN the November number of this Journal there is an article from E. W. Hilgard, State Geologist of Mississippi, which contains serious errors respecting the Drift formation in Illinois. The mistakes occurred, doubtless, because the distinguished author had not an opportunity for personal observation here, and was obliged to rely on the information of others less competent than himself.

He remarks that the erratic blocks are nearly all well water-worn, and that the drift "is more or less irregularly, but distinctly, stratified," and that "no glacier scorings are mentioned either on the pebbles or on the adjacent rocks."

The truth is this. The drift of Illinois, Indiana, Michigan and Wisconsin consists of two distinct formations, one above the other. The lower is the well known "glacial drift" of authors. It is a heterogeneous mass, full of boulders and pebbles, which are only imperfectly rounded and sometimes quite sharp at the edges. Vast multitudes of the larger blocks are scratched and polished on one side by unmistakable glacier action. In a large part of the formation it is extremely difficult to discover any traces of stratification, though it can be noticed by great care.

The second formation always overlies the former, and consists of sand and gravel distinctly stratified, and filled with well rounded and water-worn pebbles. The two deposits are so unlike each other that there is no possibility of confounding them. Their relation to each other is best shown in the numerous railroad cuts which traverse them. It is there seen that at a distance from the valleys of streams, the old glacial drift usually comes to the surface, and often rises into considerable eminences. In Illinois, at least, the closest scrutiny generally fails to discover in it any stratification. As we approach the streams, however, the glacial drift sinks out of sight, and is overlaid by perfectly well stratified sand and gravel. The latter exists in enormous quantities, sometimes bordering the valley miles in width, and by its thick masses fully maintains the general height of the country. At the border of the valleys of the streams the sand and gravel suddenly cease, terminating in an abrupt descent; or perhaps the lower strata may continue beneath the alluvium of the bottom lands.

The Chicago tunnel is excavated for two miles in the glacial drift beneath the bed of Lake Michigan. It has been closely watched by a committee of the Chicago Academy of Sciences, as well as by Mr. Chesborough the city engineer, Mr. Kroeshell the

inspector, and Mr. Gowan the contractor. From my own personal observation, and from those of the above-mentioned gentlemen, I derive the following facts. The tunnel is to supply the city with fresh water drawn from the lake at a distance of two miles from the shore. For this purpose a coffer dam was erected in the lake, two miles from the land, and within it a shaft was excavated in the clay to the depth of about seventy-five feet below the surface of the water. A similar shaft was sunk at the shore end, and from the bottoms the workmen drifted horizontally until they met beneath the lake.

The shaft at the shore end descended first through beach sand and then through tough clay, mostly free from boulders, and apparently a deposit from the lake. At the depth of about sixty-two feet the workmen came suddenly upon the hard glacial drift, containing glacier-scratched boulders, and in every way very different from the clay above it. The material appeared to be a soft comminuted shale reduced to a clay by the same means which transported it from its original strata. Every cubic yard of it contained millions of broken and scarcely rounded little fragments of the shale. These were accompanied with larger blocks of it, mixed with glacier-scratched boulders of limestone, sandstone, granite, syenite, and every other kind of rock which exists in the regions north of us. In this and similar material the whole of the rest of the shaft and the entire two miles of the horizontal part of the tunnel was excavated. Some extremely interesting facts were observed. For instance, this hard clay showed no trace of stratification when any particular part of it was inspected, yet it was so intercalated with other beds as to clearly prove its right to be called a stratum. After sinking eleven feet through it the workmen came to a thin bed of clay free from boulders, and beneath that to a stratum of sand, six inches in thickness, with another layer of hard clay beneath that. This stratum of sand was traced horizontally for over a thousand feet, when it ascended and disappeared through the roof of the excavation. Several hundred feet farther on another thin stratum of sand was struck whose upper surface clearly showed *ripple marks*. It was singular to observe that the clay resting upon it preserved a perfect cast of the ripple marks after the sand was removed from beneath it. This stratum extended only about fifty feet, when it thinned out and disappeared. About six thousand feet from the shore a stratum of softer clay entered the roof of the excavation, resting upon the hardpan beneath. Both formations contained boulders. These two strata followed so exactly the level of the tunnel that their junction was traced for four thousand feet farther, and was only lost at the outer extremity of the work, two miles from shore. It would seem therefore that in spite of the absence of minute

layers in the clay, the stratified character of the whole mass is clearly made out.

The most surprising phenomenon discovered, was the existence all through the glacial drift, of numerous isolated "pockets" or cavities filled with stratified gravel. These "pockets," as the workmen called them, lay in all imaginable positions, sometimes with their strata set up at high angles. They were generally from a few inches to a few feet in diameter, and terminated abruptly on all sides in the solid impermeable clay. The gravel was water-worn, and often so clean that it would scarcely soil a handkerchief. Its interstices commonly contained a few gallons of water at the lower part, and some air or gas at the upper. The gas in many instances was inflammable, and was doubtless derived from the numerous boulders of highly bituminous limestone found in the clay. That the pockets were perfectly isolated is shown by the fact that though nearly eighty feet beneath the surface of the lake, they scarcely leaked a drop of water after they were once emptied. The existence of these masses of gravel is very surprising. The cavities, when emptied, looked exactly in many instances like the casts of rounded boulders. I can only account for them by the theory that they were deposited as frozen masses of gravel, and thawed after they were well imbedded in the clay, leaving their strata in whatever position they happened to be put while frozen.

After getting beneath the deposits made by the lake itself, the excavations furnished not the slightest traces of any organic remains.

Along the west shore of Lake Michigan, for a distance of over a hundred miles north of this place, the glacial drift rises some eighty feet above the water in precipitous bluffs. In many places the bluffs are eroded by the waves, and show fine sections. To one standing close by it is often extremely difficult to notice any stratification, but to an observer stationed in a boat a hundred yards distant, dim but evident traces of a horizontal arrangement appear. The strata are best seen by noting the level bands where the springs ooze out.

The more recent formation may frequently be noticed as a well stratified deposit filling the hollows or valleys of the older drift, and rising to nearly the same height above the lake. It perhaps belongs to the Champlain epoch. It is greatly to be desired that some geologist should thoroughly examine the recent geology around Lake Michigan, as there are problems of great interest to be solved in connection with it; but as yet it is an unexplored field.

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