until the Cretaceous period when heavy deposits of shale were laid down east of the mountains. These deposits terminated for the most part just west of this district, and we find no shale stratifications underlying Winnipeg.

Later we have the period of the great glacial drift, at which time a blanket of ice with its accumulated rock and sediment moved down from the north, over practically the whole of this immense basin. This blanket was thousands of feet thick, and its tremendous pressure, as it moved southward, doubtless created a grinding action on the surface of the limestone, so that in some localities this rock surface has been badly broken up and displaced. I have seen cases where the rock has been shattered much the same as though it had come from a rock crusher. In other places the surface was not disturbed in the same manner, but is seamy, as though having been cracked by the heavy pressure of the overlying mass. This difference in action to the surface of the rock may be accounted for by the glacier having deposited a protective layer over those sections where we find the limestone practically undisturbed. Consequently we find deposits overlying the limestone in one place of sand, gravel and boulders; in another a composite of shattered or broken-up limestone firmly cemented together with marle, and covered with a grayish-white clay and gravel; in another place we find this deposit in the form of hardpan. This so-called hardpan is usually composed of gravel, sand, small boulders and a tough, brownish clay, and is frequently called boulder clay. I have seen small quantities of the blue clay of this district close to the rock and intermingled with gravel and hardpan. This stratification resulted mostly from glacial drift passing southward over the surface of the limestone. It varies in thickness from 6 or 7 feet to 10 or 12 feet, and is water-bearing.

The glacial drift was followed by another period of rest, at which time much of this glacier melted, forming a lake which covered this district to a depth of some 500 feet. It was inevitable during this period that much of the sediment and rocks which had been carried down with the glacier would settle to the bed of this lake. Also that the stream action over the higher grounds to the west would move large quantities of clay and sediment down into this basin, from the shale beds to the west. And so we find in this district a layer of clay from 30 to 40 feet in depth, which we term blue clay. It is more or less homogeneous in texture, strongly alkaline and soapy in character, and practically impervious to the flow of water. It contains near its underside a sprinkling of boulders of various sizes.

Above this blue clay is a stratification of yellow clay, about 8 to 12 feet thick, and above this in turn a surface loam, a few inches to several feet in thickness. These last two stratifications have doubtless been deposited by streams. They are also water-bearing and carry surface drainage.

To summarize, we have the following stratifications overlying the rock. Beginning at the surface and working in the direction an excavation would be made they are as follows:—

First: A layer of loam being from a few inches to several feet in thickness.

Second: A layer of yellowish clay from 8 to 12 feet in thickness.

Third: A body of blue or slatish colored clay from 30 to 40 feet in depth, with a sprinkling of boulders toward the bottom.

Fourth: A conglomerate stratification of sand, clay and gravel; boulder clay or hardpan; grayish clay and gravel, overlying shattered limestone cemented together with marle. This stratification is from 6 to 12 feet in thickness. These different materials do not necessarily occur together, although at times several of the different substances are intermingled.

Bearing Capacities and Peculiarities of the Stratifications.—Before taking up the description of the different types of foundations we will consider the bearing capacities of the different stratifications, as well as some of the peculiarities which they exhibit when subjected to heavy pressure.

The surface stratifications of loam and yellowish clay are water-bearing and are ordinarily too shallow for the foundations of large buildings. Consequently, it is needless to discuss them. If used for foundations they should be most carefully drained.

Below these is the thick bed of blue or slatish colored clay which is practically impervious to water, and yet 15 semi-liquid in its action when subjected to pressure. This is the clay which has been used in the past for supporting most of the buildings in this district. It is a well-known fact that in almost every instance where a building of any material weight has been founded on this clay the building has shown signs of settlement. In some cases it is more marked than in others. In several instances the settlement has been so serious as to have forced the owners into underpinning the structure from bed-rock, by means of concrete piers. In the case of the better finished buildings and dwellings the settlement has been a source of annoyance and expense to the owners, in having to renew the decorations more frequently In industrial than would otherwise be necessary. buildings settlement is usually the source of the difficulty in keeping shafting in alignment and machinery level. This condition of the clay is due to the presence of a shaly material which has largely destroyed its frictional value. I have noted some marked instances of this sort when removing old piling from excavations. variably the piles had a film of clay adhering to them, and the pockets left after removing the piles were as smooth as glass. The outside of the clay film adhering to the piles being just as glossy.

I will note another instance of this condition which has come under my observation. At one stage in the righting of the C.P.R. North Transcona elevator a rather peculiar lateral movement of the entire building set up. This movement was caused by a slip in the clay bank on the low side of the building. The movement was only controlled and finally stopped after elaborate and extremely heavy shoring had been placed against the opposite side of the building. An examination at different points under the mattress disclosed a bed of blue clay an inch or two thick adhering to the under-face of the concrete, the lower surface of the clay, as well as the surface of the larger bed underneath it, had the same smooth and glossy appearance referred to in the case of the old piles which had been removed.

Still another instance of the apparent lack of frictional value is frequently evident when a vertical face of the clay is exposed without being retained by sheeting. I have seen chunks a cubic yard or more in volume drop out suddenly, without the least forewarning of their coming. Here again the exposed faces of the cavity, as well as the broken faces of the fallen chunk, have this same glossy appearance.

There are cases in this district where the railroads have made heavy fills for their tracks and the weight of th

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