II.—THE RELATION OF CHANGES OF LEVEL TO INTERGLACIAL PERIODS.

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THE interesting paper on "The Connection of the Glacial Period with Oscillation of the Land," by Dr. Holst,¹ while reinforcing the quite probable theory that areas loaded with glacial ice sink under the burden, and after the ice has been thawed rise again, goes out of its way to deny the existence of Interglacial periods, probably with the idea that there was only one important sinking and rising in the Pleistocene, and hence no opportunity for Interglacial times. However that may be in Sweden, the evidence in favour of at least one important Interglacial period in North America is too strong to be set aside for any mere theory.

At the Meeting of the British Association in Toronto in 1897, a number of British geologists had an opportunity of seeing sections of the drift in the Don valley and at Scarboro' Heights near Toronto, which show a very extensive series of sediments, rich in fossils, lying between two well-defined sheets of Boulder-clay.

A committee was appointed to work out in detail the relationships of these Interglacial beds, and the secretary of the committee, the present writer, aided by generous grants from the Association, carried on a series of explorations the results of which were reported at the three following meetings. A detailed summing up of the facts observed, giving sections and lists of about 180 species of plants and animals, chiefly forest trees, fresh-water shellfish, and beetles, but including elephants, bison, and caribou, was published last Summer in the *Journal of Geology*.²

In a few words the general character of the facts observed may be given here, so that the strength of the evidence may be appreciated; and lest there should be any doubt as to the reality of the Interglacial position of the beds in question, it may be stated that they have been visited by numbers of glacialists from the United States as well as the Old World, some of them strongly opposed to the idea of Interglacial periods; but all have admitted that they are really Interglacial, though there have been differences of opinion as to whether the ice-sheet completely vanished during the time of their deposition, or merely withdrew to a greater or less distance and then advanced again.

The Interglacial beds consist mainly of a series of lake deposits, sands and clays, probably formed as a delta at the mouth of a large river. They are more than 186 feet in thickness at some points, and at least 18½ miles wide along the shore of Lake Ontario; while they have been traced inland more than 6 miles, beyond which they are buried under glacial materials.

At the base of the series, resting on an eroded surface of Boulder-clay, are 41 feet of the Don beds, containing, according to Professor

¹ Translation by Dr. F. A. Bather: *GEOL. MAG.*, May, 1901, pp. 205–216.

² "Glacial and Interglacial Beds near Toronto": *Journ. Geol.*, vol. ix, No. 4, pp. 285–310.

Penhallow, an assemblage of forest trees like that of Ohio or Pennsylvania, some of them reaching their northern limit to the south of Toronto, others still growing in southern Ontario. One of them, *Acer pleistocenicum*, is extinct. Tree trunks 18 inches across are found at various levels in the Don beds, generally too much flattened by the pressure of the later ice-sheet to permit of counting their annual rings, though one that was better preserved than usual was found to have 120 rings in a width of 4 inches, and must have been 7 inches in radius when complete, i.e. 200 years old. These trees occur at the very bottom of the beds as well as at several levels above, and must represent different generations of forest. The upper or Scarboro' beds contain trees and other plants as well as beetles, of a cool temperate climate, like that of the north shore of Lake Superior, according to Dr. Macoun and Dr. Scudder. There are no Arctic nor sub-Arctic forms among them, and no glaciated pebbles nor ice-transported boulders; and the stratified clay is more ferruginous and less calcareous than any of our stratified glacial clays, burning to red brick instead of grey brick like the latter. The large river which formed the delta must have drained the upper lakes by a direct channel from Georgian Bay on Lake Huron to Scarboro' on Lake Ontario, and could not have drawn its waters from glacial sources.

It may be noted that at the very beginning of these Interglacial beds trees, such as three species of oak, an elm, the red cedar, and the pawpaw, were growing in the Don valley, showing that the climate was already warm, the last tree indicating a dry and hot Summer like that of Ohio. The isotherms evidently ran 150 miles north of their present position in eastern America.

Let us now turn to another side of the evidence. At the beginning of the deposits the water in the Ontario basin stood no higher than at present, perhaps lower, for streams eroded their channels through the Boulder-clay, and even 16 feet into the solid rock beneath, as shown in one of the Don sections. Afterwards the water in the basin rose to 60 feet above Lake Ontario at the end of the Don beds, and to 152 feet or more above that level before the close of the Scarboro' beds. There is no doubt about this point, for the deposits may be followed for miles with fine and even stratification, and could not have been formed by glacial rivers on a sloping land surface, as suggested by Mr. Warren Upham.¹

Afterwards there was a fall in the level of the water to a point much below that of Ontario, and rivers had time to cut valleys more than 150 feet deep and from a mile to five miles in width through the Interglacial clay and sand. We have, therefore, an interval of erosion with low water after the retreat of the earlier ice-sheet before the warm-climate beds were laid down; and a very long stage of erosion with still lower water after the cold-temperate-climate beds were deposited; while there was a stage of high water between. How shall we account for these changes in the Interglacial water-levels?

¹ Amer. Geol., vol. xxviii, No. 5, p. 315.

Only two explanations have been suggested, an ice dam at the outlet of Lake Ontario, or an epeirogenic uplift of the region to the north-east, like that proved by Dr. Gilbert to be now going on in the Great Lakes region, followed by a sinking of the land again.

It seems incredible that after centuries, if not thousands, of years of hot summers like those of Pennsylvania the ice-sheet should still be lingering at the Thousand Islands, and should even advance 50 miles to the south, forming a wall of ice 200 or more feet thick across the powerful Interglacial St. Lawrence river. If the ice could thus advance during the warm climate epoch, why did it withdraw again after the climate had become cooler?

The improbabilities of the ice-dam theory are too great, and we must turn to the other theory of an uplift to the north-east followed by a depression for a satisfactory solution of the problem. Here a point of interest in connection with Dr. Holst's thesis makes its appearance. If during the warm Interglacial period there was a great differential uplift toward the north-east, was it not due to the thawing of the Labradorean ice-sheet, supposed to have been a mile or even two miles thick, and the resulting relief from pressure?

The supposition seems probable; and, since the water was ponded back to a height more than 150 feet above the present level, may we not suppose that Labrador toward the end of the time of deposit stood hundreds and possibly thousands of feet higher than now? Such an elevation towards the north-east would have rendered the climate of Labrador much colder; and, perhaps aided by changes in the constitution of the atmosphere or other causes, may have started a fresh accumulation of ice, which as it thickened pressed down the region and thus drained off the Interglacial lake and allowed rivers to cut their valleys.

Finally, the last ice-sheet, after advancing over the whole region, thawed, and the slow elevation toward the north-east began again. The distortion of the old Iroquois beach, as shown by the work of Drs. Spencer and Gilbert, gives an idea of how much elevation has been regained, and Dr. Gilbert's work in connection with lake-levels proves that the process is still going on; though the last vestige of the Labradorean ice-sheet long ago disappeared.

Apparently these changes of level are very much in arrears of the changes of load, and it may take even thousands of years for the earth's crust to readjust itself after a burden has been removed. We must not think of the solid rock or lithosphere as a thin crust resting on a molten layer, but as merging downwards into a plastic layer—Dr. Murray's tectosphere—which can yield to long-applied pressure and flow sluggishly to each side. After the pressure is removed, it returns in an equally sluggish way. If this conception of earth-movements is correct, the idea of motions due to the elasticity of the crust, like a pendulum set free, as suggested by Dr. Holst, must be abandoned. The rocks forming the lithosphere are not appreciably elastic, nor is the tectosphere a fluid that responds quickly to changes by successive waves slowly dying out. The

surface cannot rebound beyond the level appropriate to its specific gravity, but is likely through friction to halt somewhat below that point.

It is probable that the return of the plastic substratum after the load has been removed is not at a uniform rate, perhaps because of halts in the recession of the ice or even of temporary advances during the time of general retreat; and thus the successive marine terraces found, for instance, on the lower St. Lawrence would be accounted for.

One other point seems worthy of discussion, as to whether the pre-Glacial and Interglacial elevation of the north-east of America was sufficient to account for an Ice Age without other aid. The evidence of the submerged channels of the St. Lawrence and other rivers points to a former elevation of about 3,000 feet above the present level. It is doubtful if that would place Labrador above snow-line under existing climatic conditions, since the present level of the country is not more than one or two thousand feet. Snow-line in the Rocky Mountains and Selkirks at the same latitude ranges from 9,000 to 7,500 feet; and even with the difference due to cold oceanic currents, 4,000 or 5,000 feet seems too low an average level for perpetual snow in central Labrador.

The elevation of Scandinavia, where there are now mountains 8,000 feet high, with numerous snowfields 3,000 or 5,000 feet higher, would no doubt under present conditions produce a great extension of the ice, perhaps covering most of the land; but would it push ice-sheets across the Baltic and North Sea to Germany and England? This seems very improbable; and some supplemental cause should perhaps be sought for, but a discussion of such wide questions would lead us too far.

III.—ON AN *Alveolina*-LIMESTONE AND NUMMULITIC LIMESTONES FROM EGYPT.

By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

PART I.

THE following description of Egyptian foraminiferal limestones is based on a series of specimens transmitted to me by Dr. H. Woodward, F.R.S., on behalf of Captain H. G. Lyons, F.G.S.

The series comprises specimens from the Eocene and Miocene of the eastern side of the Red Sea Hills, collected by Mr. Thomas Barron, F.G.S.; and specimens from the Eocene of the east side of the Nile, between Assiut and Qena, and from the Baharia and Farafra Oases, collected by Mr. H. J. L. Beadnell, F.G.S. A great amount of interest attaches to these rocks, both as regards their general character and preservation, and also with respect to their microzoic contents.

The present series of rock-specimens may be described as follows:—