through the tunnel, and in the clay near the zone of the "*Cyræna* bed." This, although in the same deposit, would be at a higher level than that of the skull already mentioned, and, therefore, cannot be supposed to have belonged to it. The deposit is rich in remains of Mammalia, both of extinct and still existing species; the teeth and bones of Elephants, Oxen, Deer, and the Horse predominating; those of the Rhinoceros (three species), although frequent, are far less common; whilst the remains of Carnivora are rare.

Whether these brick-earths are Pre-glacial, as Prof. Dawkins supposes them to be, or, as more generally considered by geologists, belong to a later period than the true Glacial epoch, they contain, curiously commingled, the *débris* of animals which were respectively inhabitants of temperate and of rigorous climes. The species, excluding the Invertebrata, whose remains are recorded as having been found at Crayford, are the following:—

Ursus ferox, Linn.
 " *arctos*, Linn.
Felis spelæa, Goldf.
Hyæna spelæa, Goldf.
Canis lupus, Linn.
Bison priscus, Ow.
Bos primigenius, Boj.
Oribos moschatus, Blainv.
Megaceros Hibernicus, Ow.

Cervus elaphus, Linn.
Elephas antiquus, Falc.
 " *primigenius*, Blum.
Equus fossilis, Mey.
Rhinoceros tichorhinus, Cuv.
 " *leptorhinus*, Ow.
 " *megarhinus*, Christ.
Arvicola amphibius, Desm.
Spermophilus erythrogenoides, Falc.

The fossil remains of the Musk-ox are as equally rare in the Upper Tertiaries of the European continent as in England. Prof. Dawkins cites three localities in France, and four in Germany, where its remains have been discovered. They have also been found in three places in Siberia; and also in the frozen mud cliffs of Eschscholtz Bay, on the coast of Arctic America, but nowhere abundantly; and only in one instance, and that a single tooth, "in the gravel of the Oise," near Chauny, France, have the teeth, previously to those here described, been found. It is assumed, on account of the paucity of its remains in Europe, that it was only an occasional wanderer so far south of its usual habitats.

The distribution of the existing Musk-ox is at present limited to the barren lands of Polar America, between the 60th and 83rd parallels of latitude. During the late Arctic Expedition a fine bull was shot near the coast of Grinnell Land, in latitude 82° 27'; the stuffed skin of which is exhibited in the National Collection.

IV.—THE GLACIAL PERIOD IN EASTERN AMERICA.

By Prof. C. H. HITCHCOCK.

RECENT studies of the glacial phenomena as exhibited in the State of New Hampshire and adjoining regions enable us to maintain the following propositions.

1. The ice-sheet at the time of its maximum development passed south-easterly over all New England, New Brunswick and Nova Scotia. It came from the St. Lawrence Valley, where all the

observed striation is at right angles to this south-east course, and travelled directly over the highest ridges and summits towards the sea. I find upon the summit of Mount Washington boulders weighing 90 lbs. that have travelled certainly ten miles and ascended as much as 4000 feet above their source. I also find striæ and 'till' there. Heretofore the top of this mountain, 6291 feet above the sea, has been regarded as a glacial island.

2. In the decline of the ice period local glaciers radiated from the White and Green Mountains. Those passing southerly were the most conspicuous. Their traces consist partly of striæ, and, in their absence, of transported material. Careful preliminary studies of the position of the several formations has made such identification possible.

3. The till consists of two parts, called lower and upper, and believed to be the equivalents of the corresponding parts of the till of the British Islands. The lower consists of bluish compact earth containing small striated and far-travelled boulders, with occasional lenticular gravel sheets. Its iron oxide is mostly ferrous, the same as that of the rocks before transportation. The upper till is universal; is a reddish-brown loose material with imbedded and overlying rough blocks of large size which have usually travelled a short distance. The iron oxide is hydrous ferric. The description of the common varieties of the Scottish till, by James Geikie, in the *Great Ice Age*, second edition, p. 116, seems to agree with this. All these facts, especially the condition of the iron oxide, necessitates the belief that our lower till is the proper ground moraine, while the upper till consists of all the ice-borne materials (lateral, median and much of the terminal moraines with imbedded detritus), which fell upon the subjacent hard face when the ice melted. The upper till would therefore cover the lower deposit uniformly and universally, save where enormously accumulated in the terminal or frontal moraines; and the original anhydrous ferrous oxides would absorb water and oxygen by exposure to air and water during the melting process. Careful analyses confirm our impression of this diverse nature of the iron oxides.

4. No facts seen confirm the theory of the presence of a universal interglacial warmer period. The few marine beds lying between the two tills contain boreal fossils, or the remains of such animals as now flourish in Greenland, and they are covered only by our upper till. A true ground moraine never overlies the interglacial beds. An excellent case may be seen at Portland, Maine, where we find, first, enormous deposits of lower till; second, marine beds (called Champlain) containing 121 species of fossils, reaching to 100 feet above the present sea-level, thus indicating a submergence of that amount; third, deposits of upper till, 25 feet thick, covering uniformly both the lower till and the marine beds. Recent excavations made in grading the streets show these facts incontestably. Hence it seems plain that for a brief period the glacier retreated a short distance, allowing the marine beds to accumulate just as they do now in Greenland; then the ice re-advanced so as to cover the

fossiliferous deposit, bringing a load of coarse ferric material, but no ground moraine. The ice soon melted, and thus the upper till was precipitated upon the previously formed floor. In the Champlain and St. Lawrence valleys no occurrence of till overlying the marine beds has yet been observed; so that the recurring glacial conditions were too insignificant to cause a re-advance of the ice-sheet less than 200 miles to the north of Portland.

5. All the facts of striation and drift dispersion from the Gulf of St. Lawrence to the Rocky Mountains are best explained by the existence of a central *mer de glace* in the Labrador peninsula, or somewhat farther west. Torell and Dana have maintained that the starting-point of the glacier was in Greenland; but we find (a) the glacial movements from the Labrador peninsula have been *towards* Greenland instead of away from it; (b) the Greenland ice must have been twenty-two miles high to flow to the Saskatchewan region; (c) the bridging of Davis Straits could be hardly possible.

6. The Labrador plateau is lower than the New England hills. To overcome this difficulty Professor Dana supposed there had been an elevation of the northern Laurentian watershed, sufficiently gigantic to allow of a south-east sliding of the ice. There is no evidence of such elevation of the land beyond the requirements of the theory. It will be easier to accept Dr. Croll's view that the ice-sheet itself became miles in thickness, by the gradual retention of frozen moisture, and moved then as readily as if a less amount capped high mountains. It first moved south-westerly as far as Manitoba, Dakota, and Missouri; then when the St. Lawrence Valley became filled to the brim, the surplusage moved towards the Atlantic in a south-east direction. Either of these theories is extreme; but there seems to be no escape from accepting one of the two horns of the dilemma.

7. The south edge of the American ice-sheet is well marked by the presence of enormous terminal moraines, coupled with extensive sand and gravel plains washed from the glacial debris by the waters derived from the melting ice. The eastern extremity is at Cape Cod, Massachusetts, and Long Island, New York. These long drift hills, consisting largely of gravel and sand, are isolated from all present appearance of connexion with any possible higher land from whence the depositing waters could have flowed. By supposing that they formed the front of the glacier just before its decadence, it is easy to understand both how an immense supply of drift material was furnished, and the origin of the freshwater streams which formed plains and hummocks of stratified sand far above the present water-level. A study of the writings of all the State geological reports enables us to discover more than one continuous moraine line, from Massachusetts to the Red River country west of Manitoba, save in a portion of Pennsylvania, which needs further study.