ART. XLV.—*Dall's Observations on Arctic Ice, and the bearing of the facts on Glacial phenomena in Minnesota*; by N. H. WINCHELL.

MR. DALL'S observations on the existing perennial ice in northern Alaska are highly interesting and valuable* at this point in the history and progress of glacial theory. He describes the region about Eschscholtz Bay as made of gneissoid rock and volcanic breccia, but without attaining anywhere in the vicinity any greater height than three or four hundred feet above the sea. He also states that the formation of the surrounding country shows no high land or rocky hills suited for the production of a glacier. In this respect it is like the interior of North America, throughout the Western and Northwestern States where there is proof, now rarely questioned, of the former existence of vast fields of glacier ice; and it is highly probable that the field explored by Mr. Dall is an epitome, under peculiar and somewhat inexplicable circumstances of the vaster field which extended from the Rocky Mountains on the west to the Alleghanies on the east, during the latest epoch of continental ice, the only important exception being that over the Continent the southern termination of the ice sheet was everywhere invisible, and abutted nowhere (in the interior) on the ocean shore so as to reveal its existence. The surface covering of the ice was the surface of the country, and over many miles north from its actual termination, it supported a varied and even rank vegetation. Mr. Dall's observations on the "fossil glacier" extending west from Point Barrow and south as far as Kotzebue Sound, seem to prove that the northern slopes of Alaska are now glacier-covered; throughout the most of which distance the margin of the ice is but occasionally revealed by reason of the wave action on the overlying drift.

* This Journal, xx, p. 335 and xxi, p. 104.

In numerous places it seems that the ice is so far attenuated that the drift which it brings forward is the barrier against the ocean, and in other places the ice itself, underlying the drift, is brought into contact with the water of the Arctic Ocean. Without a just conception of the action of the vast continental glacier of glacial times, it is difficult to conceive of this ice in motion, and Mr. Dall believes it has no motion, adducing, however, only the unbroken condition of the mosses and peats on its surface to prove it. It is to be hoped that inland exploration may be made of the glacier at Elephant's Point, in order to ascertain if it is derived from some mountain source. It is almost certain, if our ideas of glacier ice be correct, to have such a source, though its connection unbroken from the coast to the mountains, may be hid from sight for miles, in the same manner as its east and west flanks are hid by the accumulations on its surface. It is also highly probable that it will be found to come in various ways into contact with running water, some of which will bring upon it the fine tough clay described by Mr. Dall, and in other places will precipitate upon it, in stronger current, the gravel and sand, and even some of the stones which he mentions as covering it near Point Barrow.

The facts reported by Mr. Dall throw great light on the manner of formation and deposit of the till, which has been the source of much difference of opinion among glacialists. Some have imagined a *moraine profonde*, pushed out from the front margin of the ice-sheet in its retreat, left as a continuous terminal moraine from north to south after the ice had entirely disappeared. Others contend that it *was not only deposited at the ice-foot but also was formed there*. However satisfactory these theories may be to those who understand them, it is true that to some they are wholly beyond comprehension, and seem to be mythical. Another theory asserts that the ice *died out gradually, and imperceptibly beneath its burden of clay and stone*, and that the till is not a terminal moraine, but instead a surface moraine (to employ a new term) resulting from the same causes, whatever they may be, which bring the drift on to the surface of the ice in northern Alaska and which so frequently hide the surface of the small glaciers that have been described in the Rocky Mountains.

These observations also throw light on the cause and manner of formation of kames. Kames are gravel-ridges, lying in till-covered countries, and occupying the lower portions. They are generally coincident in direction with the direction of the present surface drainage, and often on either side of a kame, which may be several miles in length, there is a swamp or low spot, parallel with the kame, while on the right and left, outside of this valley, the unbroken till spreads out indefinitely.

The gravel of which the kame consists is of the same material as the gravel and stones found in the till that adjoins it, and was undoubtedly brought there at the same time that the till was—but necessarily by some other agent. The kame also sometimes becomes broken up, and fades out, by becoming hummocky and clayey, into the till itself. Now on the supposition that the till before its deposit lay on the surface of the ice, it is plain that surface drainage gathering into small streams and even rivers, would produce deep channels or gorges in the ice-sheet. In the bottom of the stream would be gathered such gravel, stones and sand as the stream had not current enough to carry away. The warmth imparted to it by the water would cause it to sink deeper and deeper into the ice, and in many places to lie on the rocky floor itself, especially in the southerly portions of the gorge where the ice would be thinner. It is easy to see that on the entire withdrawal of the ice, such a kame would lie undisturbed, in its beautiful stratification, where the river produced it; while on either side would be, first, the comparatively low or swampy belt caused by the withdrawal, during the existence of the river, of the clay of the till, and the concentration of its stones and gravel in the bottom of the stream by the sloping sides of the gorge, and secondly, outside of this swampy belt, the unmodified till itself. On the supposition that the stream was sub-glacial, not only can the circumstances not be imagined in accord with the known operations of gravity and momentum; but, if once so formed, the subsequent movements of the ice would inevitably have destroyed the stratification of the kame, and mixed it with the till. On the supposition that the kame was formed by such streams outside the area of the ice, on their debouchure from it, such steep ridges can hardly be explained. Gravel and sand so deposited are spread out more like "alluvial fans," and probably such are the superficial gravels and sands over southern Ohio and Indiana, south of the ice-margin at the time of the last glacial epoch.

University of Minnesota, Feb. 5, 1881.