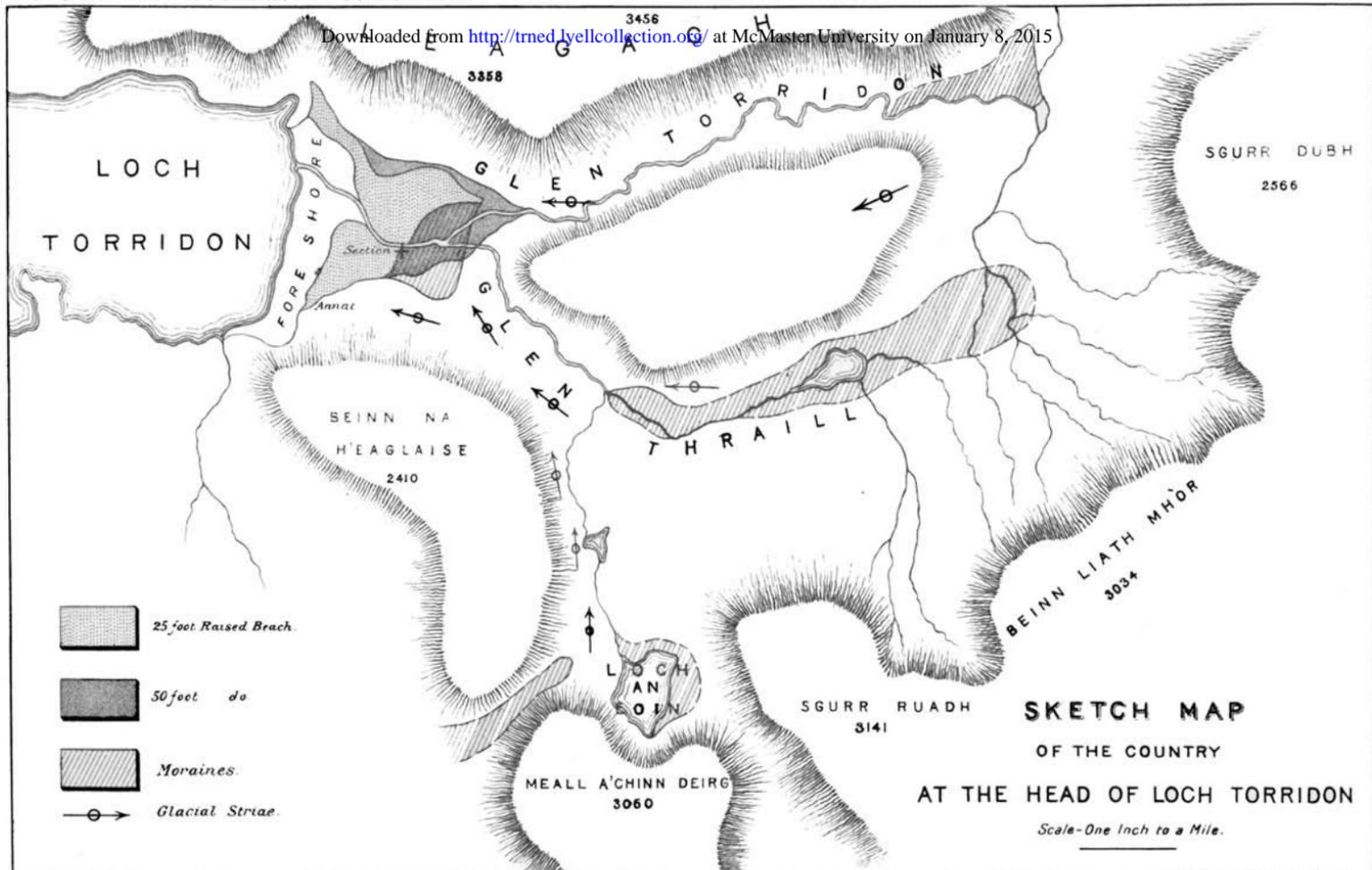


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XXX.—*On the Occurrence of Moraines later than the 50-foot Beach in the North-West Highlands.* By LIONEL W. HINXMAN, B.A., of H.M. Geological Survey of Scotland.

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(Read 21st April 1892.)

ROUND the head of Loch Torridon, an arm of the sea which penetrates for more than ten miles into the mountains of West Ross, are grouped the bare and rugged peaks of the Torridon, Coulin, and Ben Damph forests, most of which reach or exceed a height of 3000 feet above sea-level, Leagach, the highest, rising 3400 feet directly from the water's edge.

These ranges may be described as forming roughly a triangle, of which the head of the loch is the apex, Leagach and Beinn na h' Eaglaise are respectively the northern and southern sides, while the base is represented by the western front of the hills known collectively as the "Grey Heads," and individually as Sgurr Dubh, Beinn Liath Mhór, Sgurr Ruadh, and Meall a' Chinn Deirg. They are composed for the most part of red and purple grits and sandstones, lately proved to be of pre-Cambrian age, and to which the name of Torridonian has been given, from this region, in which they are most characteristically developed. Outliers of Cambrian Quartzite also occur, either capping the highest peaks, or in lenticular and wedge-shaped masses repeated by thrusts at various horizons in the Torridonian.

This triangular area is intersected by two main valleys—Glen Torridon and the valley of the Amhainn Thrail—which converge at a point three-quarters of a mile from the head of the loch. Glen Torridon is straight, narrow, and trench-like, with rocky precipitous sides, and—except at the head—no tributary glens. Glen Thrail is wider, especially in the upper part, where it bifurcates, the northern branch running up to the foot of Beinn Liath Mhór, and only separated by a low drift and moraine-covered *col* from the head-waters of the Torridon river. The southern branch is bare and rocky, and descends steeply from the great corrie at the foot of Meall a' Chinn Deirg, in which lies Loch an Eoin. This corrie may be regarded as the probable gathering-ground of the glacier whose moraines are here under consideration.

At the head of Loch Torridon the 25 and 50 feet raised beaches form a plateau of considerable extent, the latter extending for more than a mile up Glen Torridon as a narrow fringe

to the rocky sides of the valley. Just below the confluence of the Torridon and Thrail rivers, a fan of well-formed moraines, pouring out of Glen Thrail, streams down upon the flat surface of the 50 feet beach, and at the side of the road leading to Annat, and immediately to the south of the bridge, an opening made for road-metal in the face of one of these moraines gives a clear section of the moraine and underlying terrace of marine alluvium. The section shows six feet of loose earthy moraine-stuff, filled with large angular blocks of Torridon sandstone, together with a few smaller fragments of Cambrian quartzite, all derived from, and agreeing in lithological character with, the rocks of the catchment-basin. This moraine-stuff rests immediately upon the raised beach deposits, which consist of alternating layers of horizontally-bedded sand and rolled shingle.

Nor is the superposition of the moraines upon the raised beach the only evidence of their later origin. An examination of the pebbles that compose these beaches shows that a large proportion—sometimes as much as 60 per cent.—consists of fragments of quartz-schist and flaggy gneiss, derived from the rocks known by the Survey as the "Eastern Schists."

These rocks do not occur *in situ* within the watershed of the streams flowing into Loch Torridon, the nearest point where they are found being on the east side of the Coulin Glen.

It is therefore evident that the raised beaches must have been formed from the detritus brought down by the streams at a time when the valleys through which they flowed were more or less filled with boulder clay and morainic deposits of earlier date than those with which we are now dealing. Traces of this older drift are still to be found over the cols and on the hill-sides at the heads of the valleys; but the bottoms of the glens have been swept completely bare by the latest phase of the valley-glaciers, so that in the lower part of Glen Thrail the moraines rest directly upon the smoothed and striated rock-floor, and a fragment of the "Eastern Schists," derived from the earlier drift, is hard to find.

Professor Geikie has shown that the genial period which followed the close of the great ice-age was succeeded by a recrudescence of colder conditions, during which the great forests that covered the country perished, and were overwhelmed in the peat mosses in which their remains are now found.¹ And that there were further oscillations of climate is evident from the alternations of peat and forest growth seen in the deeper mosses.

It therefore seems probable that, after the appearance of

¹ "Prehistoric Europe," chap. xvii.

Neolithic Man in Scotland, the glens and corries of West Ross were again occupied by local glaciers that descended to sea-level, and left those striae and moraines whose wonderfully fresh appearance has always made it difficult to believe that their origin must be referred back to the remote ages of the Glacial Period.

Nor do we need to invoke any great change of climate to produce the conditions necessary for the existence of these glaciers. Round Loch Torridon, as on many other sea lochs of the West Coast, the mountains rise directly from the shore to heights of upwards of 3000 feet. The snow-line under present conditions would be found in this latitude at a height not greater than 5500 feet above the sea, and a very slight lowering of the mean annual temperature, in this region of great precipitation, would be sufficient to produce permanent snowfields on the mountain tops, with glaciers in the valleys descending to the sea.*

We are thus led to the conclusion that the terminal moraines of the Glen Thraill glacier were laid down subsequently to, and probably at a considerable interval after, the formation of the 500 feet beach on this part of the West Coast of Scotland.

At the head of Loch Erribol, in North Sutherland, as has been pointed out by Sir Archibald Geikie,† and as my friends and colleagues, Messrs Peach and Horne, have shown by detailed mapping, similar phenomena occur, though in that locality satisfactory sections, such as those described above, are wanting.

Nor are these isolated instances. In various parts of the Continent "post-glacial moraines" have lately been described, as by Dr Penck in the Pyrenees, Dr Kerner in the valley of the Stubai near Innsbruck, and by Dr Brückner in the Salzach region.

* A fall of 7° or 8° in the mean annual temperature would bring the line of perpetual snow below the tops of the mountains of West Ross-shire, but an additional diminution of at least 4° would probably be necessary to produce glaciers descending to sea-level.

† "Scenery of Scotland," 2nd ed., 1887, p. 272.