

XV.—*On the Parallel Roads of Lochaber.* By JAMES
MELVIN, *Vice-President.* (Plates v. and vi.)

(Read 3rd December 1885.)

SINCE Agassiz, forty-five years ago, pointed out striæ and surface shapings over various parts of Scotland as proof of an ice-sheet having once covered much of the country, my attention has been drawn to such evidence wherever it was my fortune to meet with it; and I have long held that ice and water, and not water alone, has had much to do in shaping the river valleys and forming those terraces which contain no marine remains, met with both on the east and west watersheds of Scotland; and that the Parallel Roads of Lochaber in place of being "merely contour lines etched on the sides of the valleys by long continued but slight agitation of the margin of the water which filled the glens to various depths in succession, as the barriers which dammed it up were at intervals broken down,"¹ are sea beaches, river terraces, or ancient roads, formed as the margins of the ice filled the glens when the last great glaciation was slowly passing away. Before entering on this discussion, it is well to bear in mind, that though ice is a solid rigid substance, it has many of the properties of a liquid, and from its viscosity fits itself to the valley. When the glaciation was greatest, ice covered much of Scotland, and filled the valleys of Lochaber to a much greater height than the levels of the roads, as shown by the markings, striæ, and boulders far above them. Including the lines forming the roads, consisting of four main terraces, there are enumerated by Mr Robert Chambers twenty-five shelves or surface markings attributed to the action of the sea by that writer. These, so far as I was able to trace them, seemed to be the result of the ice shaping of the surface, the four main terraces already referred to being the best preserved and most complete. It is to the lowest of these, the one in Glen Spean, continued, however, into Glen Roy, that I chiefly confine my remarks. I may say, however, that the terrace in Glen Gluoy is at an altitude of from 1162 feet above the sea to 1173 feet. There are three more or less continuous in Glen Roy, and two distinct portions of another. The lowest road is on a similar level as the terrace in Glen Spean. These roads or lines, before the Ordnance Survey of the district was taken, were supposed to be rigidly parallel and truly horizontal. The Survey, however, showed

¹ "Properties of Matter," by Professor Tait, 1885.

this not to be the case. It is found that the Glen Gluoy road is 11 feet higher in parts than in others. The Glen Roy roads are also uneven, viz., 11, 13, and 12 feet respectively, while in Glen Spean the level of the terrace, as shown on the six-inch Survey map, varies. And the opposite sides in the same valley are not always on the same level. In Glen Spean, where the River Treig flows out of Loch Treig, the Surveyors show the terrace on the left side looking down the glen to vary from 877 to 891 and 896 feet. On the opposite side of the Spean, two and a quarter miles distant, the road there is marked 856 feet above the sea. These differences in level the Lake theorists have not, as yet, accounted for, and seemingly find it impossible to account for even "by a long continued slight agitation of the margin of water which filled the glen," or by the action in more robust form of the waves of the sea; and the officers of the Survey, after a re-survey had been made, are discredited in the performance of their work, for the sole reason seemingly that it does not confirm the Glacier Lake theory.¹ The objection to the Sea theory is the entire absence of any vestiges of its presence where the roads are traced. In none of the accumulations of debris is there any shells to be seen. To this it is replied, the period when the sea was there was so remote that the shells have all decayed. If so, however, why have the shells remained along the shores of the Linhe Loch in the 40 feet beach, as pointed out by Mr Jamieson in his paper "on the roads," in the *Geological Magazine*, and why have the roads not also disappeared? They are traced in glacial sub-soils, subject to change by winters' frost and rain, though added to by the vegetation and animals that lived and died on them. There they remain, so also do the striæ, planings, and groovings of the rocks. When newly exposed, many of the dressings are as fresh as if the ice had traced them yesterday. The make-up of the roads also in no manner resembles an ocean beach, or even a lake margin. So far as I have examined them they resemble neither the one nor the other, and equally unlike is the surface-covering of the hills below their level, to that of the sub-soils of drained lakes. The Rev. Mr Brown's description points also to glacial debris. Again as to lakes held in by detrital dams (the most simple and natural barrier of all), one of these, if not two, would have been required for Glen Gluoy, other three for Glen Roy, and a fourth common to Glen Roy and Glen Spean, as well as dams for other shelves. No surface remains of such dams are visible where they ought to have been found, the sub-soils are everywhere similar above and below the line where dams should have been.

¹ Mr Jolly, "Trans. Geol. Soc. of Glasgow," 1836, page 83.

I must ask for more proof before believing in such an hypothesis. If detrital dams had ever blocked up the water in the valleys, part of the wreckage would remain. Then as to ice dams, which at present receive attention, I do not believe glacier ice can permanently hold water. The great one in Glen Spean must have crossed over the valley from below Coire-an-Eoin to the Odhar Burn, a distance of about four miles at a height above the sea of 900 feet, and with a breadth sufficient to withstand the pressure of a lake along Glen Spean to Makoul, and throughout Glen Roy (where the "roads" run) to a length of forty miles, with a width of water varying from four miles to several hundred yards. This ice dam, they say, was fed on the south side by a glacier. The entire draining area or gathering ground for snow and névé to collect does not exceed twelve square miles, its highest point of land being 4059 feet, the ice from Ben Nevis entering the valley six miles away, while on the other side the ice from the Great Glen is supposed to abut on the Spean Valley to complete the barrier. The strength of such a barrier to resist the pressure of so great a sheet of water, seems very doubtful. The fact that every glacier melts, slowly perhaps, but still melts during summer, lessens its powers of resistance. It seems to me, however, that the necessity which exists of first shrinking up all the other glaciers above Coire-Eoin that once fed and filled Glen Spean with ice to overflowing, in order that water might fill that Glen and Glen Roy, and demand the Coire-an-Eoin Glacier to continue, is inconsistent with the usual order of nature, as similar causes would produce like effects in the same glen. Before water could have permanently filled Glen Spean all the glaciers entering the glen would shrink out of it, or float as do icebergs. If the snowfields and névés from which they were fed retained their altitude, no such occurrence would take place. But no change of level is apparent in the district save that of the 40 feet beach. The first glacier that would require to shrink up from entering Glen Spean is that of Glen Treig. Mr Jamieson's description of what this Great Glacier had been is the most interesting of his valuable paper. That glacier, the draining area or gathering-ground of which coming from mountains reaching from 1250 feet at the lowest to 3658 feet, and several not much lower, with snow fields or gathering ground of about forty-five square miles of surface, and if the Laire Valley is added, other eight square miles, with its hill top also 3500 feet,—this ice, when glaciation was intense, spread enormous mounds of glacial debris over fifteen square miles of the surface of Glen Spean, carrying the Syenitic Rocks from the mouth of the Treig high five miles up the glen, and on to the hills on the opposite side to the height of 1400 feet. The lateral moraine to the right for half-a-mile after issuing from the gorge of the Treig being of gigantic size, blocks of Syenite,

of more than 100 tons weight, are scattered over the glen with fan-shaped lines of moraines spreading outwards, the debris of this great glacier. In order that the formation of the lower road in Glen Spean and Glen Roy may be accounted for by a lake, this glacier, the visible effects of whose potency when glaciation was at its height, is evident, must be obliterated, or shrunk up. The glacier also which flowed down the Ghulbin Valley from fifty square miles of mountain country must also disappear. In fact, more than a hundred square miles of mountains must have a warm climate, and twelve miles adjoining an arctic climate. This seems to me incredible. What then does account for these roads? The district of Lochaber has not its counterpart in Britain in its surface formation. The drainage outlet, where the roads are situated, is at sea-level at Corran Ferry. Seven hundred and fifty square miles of the most mountainous land in Scotland sends its surplus waters to the ocean there, and so the ice would go during the periods of glaciation, as the passage, sixty miles long, north-eastward to the sea, at 100 feet of elevation, would be blocked in the Great Glen, and westwards by Glenmoidart, while at Makoul the outflow only could take place at its level of 848 feet. The only outflow of ice below that level would be by Corran Ferry, until the glens filled up to the level of the Pass of Makoul, when a portion would escape to the Spey. The outlet at Corran Ferry is restricted at sea-level to a passage 330 yards wide, and the hills gradually narrow it landwards. The quantity of ice which would discharge itself seawards here may be estimated from the present rainfall in the districts (assuming no more rain fell during the Glacial period than does now),—viz., 50 inches per annum at Roy Bridge, 70 inches at Fort William, and $145\frac{1}{4}$ on Ben Nevis,—an average of 88 inches. Allow half during the Glacial period to evaporate, sink into the ground beneath the ice, or run off in water seawards below the ice. The other half would freeze into one yard and one fourth of a yard of ice per yard of surface, or 6453 yards per acre. Rendu in his work on glaciers, says such a depth forms on Mont Blanc. The 750 square miles referred to would yield 2,919,000,000 square yards of ice yearly. At Corran Ferry the outlet below the level of 900 feet is 4000 yards in length, and the average depth 600 feet or 200 yards. Thus 800,000 cubic yards of ice could pass out, and at the rate of ten yards a day, the whole of the 2,919,000,000 would do so in the year. The rate of motion of the Glaciers of the Alps is nothing like this, but that of the ice in the valleys of Greenland is stated to far exceed that of the Alps. The passage at Corran Ferry being so narrow, the ice would be restricted until it rose on the hills on both sides, and as the ice of Greenland is said to be almost stationary during winter, so it would be in Glen

Spean, and it would accumulate until the passage at the head of that glen would afford an outlet at the height of 848 feet. The stricture at Corran Ferry would reverse the flow of a portion of the ice in Glen Spean, and proof is required that such has been the case. A close observation of the district shows that the striæ and groovings on the unmoved rocks point to the ice having gone in the direction of Makoul. Taking a stand at the mouth of Glen Treig, the moraines from that glacier carrying the syenite boulders, referred to by Mr Jamieson, are seen spreading out fan-shaped up the glen close on five miles; while others, as already stated, have been carried across at a high elevation to the opposite side, two miles and a half away, and deposited at a height of from 800 to 1400 or more feet on the hill sides. The ice thus having gone up the valley, the mouth or opening into the glen from the Treig is more or less filled with Glacial debris, part of which is due also to the glacier which issued from the Lairé, assisted by the water which issues from all glaciers, shewing that the ice which removed that debris up the glen had done so under the resistance from the lower part of Glen Spean forcing upwards the ice against the outflow from the Lairé and the Treig. The moraines of boulders of syenite alluded to from the mouth of Glen Treig stop before reaching Loch Laggan. This had been brought about by the Great Glacier (the accumulation, as already noted, of some fifty square miles of mountainous country, the peaks rising to 3433 feet), which flowed down the Ghulbin Valley. The ice there gathered had carried away the debris of the softer rocks, and accumulated it in a moraine at the west end of Loch Laggan. The ice from the Ghulbin helped to fill that hollow in its progress to the North Sea. After the intense cold which produced so much ice began to be mitigated, and greater warmth caused greater melting and evaporation, the upflow over Makoul would cease. The opening at Corran Ferry would allow of a greater, but still retarded, escape for the ice and water. Then the reversal of the motion of the ice in Glen Spean would take place, and the continued but gently diminished inflow into the glen from the Ghulbin, the Treig, the Lairé, and the Coire-an-Eoin, would supply enough from the Rough Burn downwards, to maintain the ice in Glen Spean for a considerable period, and the lowest "road" would be traced, while the narrower and more contracted Valley of the Roy would have sufficient feeding ground to maintain its corresponding glacier, and also form the road there, the outlet into Glen Spean being, then, its only mode of escape. With a rigid yet plastic substance such as ice shows itself to be, the difference of level of the "roads" or margins (unexplainable by the lake theory) can be understood with an ice margin origin.

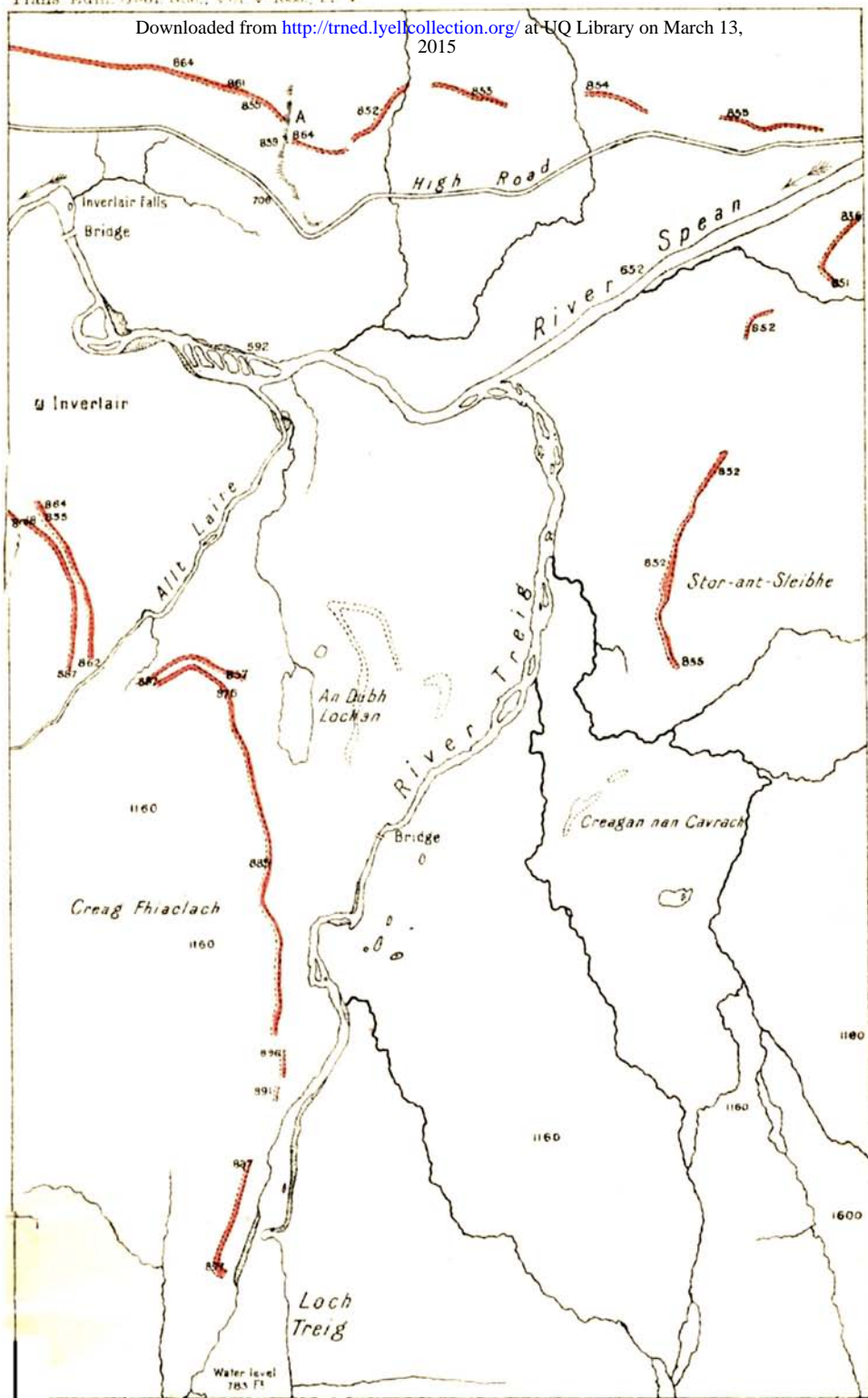
The want of a continuously level margin in the same line in a valley, fatal to the lake origin, is seen to be possible as the result of ice. In Glen Treig, on the left, looking out, the surveyors show road lines on the 6-inch Ordnance Map, at 877 feet ; further along on the same side and line, 896 feet ; while across the Valley of the Spean the highest are 848 and 856 feet. Thus, on the same road, from the lowest portion in the Spean Valley to the highest between the mouth of Glen Treig and the Laire, there is a difference of 48 feet in the height of the "road" on the one side and the opposite. Thus, while water issuing from Loch Treig and the Laire could not have raised the level of the margin higher on the side from which it came, ice could, and the lateral matter from the side of the glacier remains to this day to testify to its origin by the glacier, as many terraces may have been formed. The retardation of the outflow of ice from Glen Spean and the Fort William valley at sea-level receives support also from the fact that the two upper "roads" and part of a third in Glen Roy are absent from the mouth of that glen. If the water of lakes had formed them, roads should have shown there, or left some wreckage of dams at their termini. The Ordnance Survey Map, as well as the land when examined, gives no indication of the "road" higher up Glen Spean than the Rough Burn. If a lake had formed it, it would have been shown up to the Col at Makoul and round Loch Laggan. There seems nothing in the local formation of the land on the hillsides to have obliterated the lines, neither would the glacier rest there long enough to form a road. It is not likely it would have sufficient pressure from the Pattach, which also had its glacier, to maintain one level for any length of time from the Col at Makoul until joined by the ice from the Ghulbin, the Treig, and the Laire. Thus, then, the resting of the glacier or its slower motion in the valley at a certain level, would allow the "roads" to form, by the deposits from the edges of the glacier, and slight runnage from the hills above from summer melting. This would take place in Glen Gluoy after the ice ceased to flow over into Glen Roy. The highest road in Glen Roy, and several other terrace-looking shelves, noted by Chambers, and in the work by Sir H. James on the "roads," would be formed after the ice ceased to flow into Glen Roy ; the next in Glen Roy after the ice ceased to flow from that glen into the Spey ; and the lower Glen Roy road, when no more ice flowed into Glen Spean by Glen Glaister, as well as the portions of another "road" at the height of 975 feet in Glen Roy, and several other shelves. That terraces may be formed as margins is evidenced by Mr Green, in his book on the "High Alps of New Zealand." He speaks of portions of the terrace-formations, so characteristic of the scenery in the South Island, as being possibly so formed. The

accompanying sketch ¹ from his book shows the terraces formed and forming. Von Haast, the geologist of the Canterbury province in that island, says, in his book on its geology, at page 148, "That the main Valley of the Waimakarriri for many miles shows numerous slightly sloping terraces along both banks, often as high as 3000 feet above the river bed." Having had opportunities years ago of examining many of these terraces in Otago, I concluded that several of them owed their existence to the ice which had filled the valley. These terraces usually slope slightly. None of them I saw had strictures in their way seawards; but in the case of the Lochaber roads the structural arrangement of the country is somewhat different, yet the same causes would operate so far in both. I hold, then, that the roads have been traced on the mountain sides by the agency of ice and water. That the only climatic change that has taken place in the locality since they were so formed, is an increase of the solar heat. I therefore entirely agree with Prof. Prestwich in his pamphlet on the roads (1879), "that ice could not hold in water long enough to form them," but disagree with him in believing that the hillsides slipped down when temporary lakes were drained, and that the water-run debris, which had given rise in his mind to the idea of general slips, was caused by summer melting of the snow on the hillsides washing down portions of the glacial stuff until it was caught by the ice at the level of the roads. Without the check the ice supplied, the rush of the debris would have been continued to the bottom of the valleys, as in many places the incline is steeper below than above the level of the roads.

After careful examination of the make-up of the terraces, the depth of vegetable soil covering them, the hillsides, valleys, and the nature of the rock debris of the hillsides' stuff, it appears to me no long period has elapsed since they were formed.

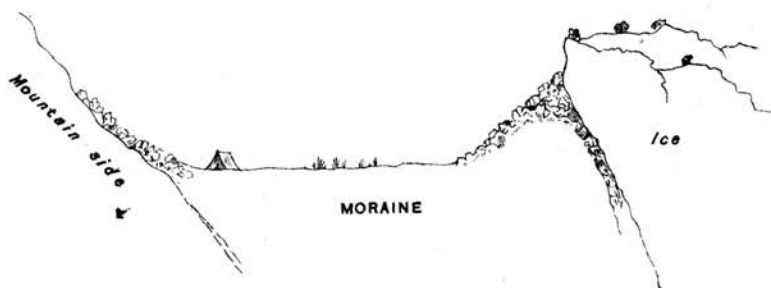
Many earth-works made during the Roman invasion are little more distinct, and the only time-measurer which can be referred to, viz., the depth of vegetable soil which has formed on them since vegetation covered the country, does not indicate an age of many thousand years. In fact, the ice which filled these valleys grooved and moulded the surface of the roads, strewed the hillsides with boulders, and the finer debris does not appear to have departed more than twenty thousand years or so. When more attention is given to the growth of vegetable soil under various conditions in nature, the possibilities of counting recent geological time will be more thought of, though all such estimates must be approximate, as there is yet no record of the time taken by vegetation to coat the surface, and no vegetable soil could form until plant and insect life had taken possession of the country.

¹ See Plate vi.



The Parallel Roads are coloured Red, and the numbers are the heights in feet above sea-level from the Six-inch Ordnance Map.

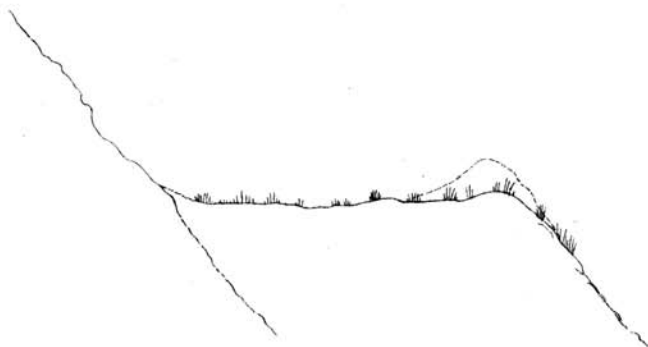
NO. 1—TASMAN VALLEY, MOUNT COOK, SECTION OF MORaine NOW FORMING.



SECTION OF MORaine VALLEY,

"Method by which the Glacier forms Terraces somewhat similar, perhaps exactly similar, to those of the lower Tasman, as shewn in No. 2."

Green's High Alps of New Zealand, page 200.



NO. 2—SECTION OF TERRACE IN LOWER TASMAN VALLEY, LONG SINCE FORMED.