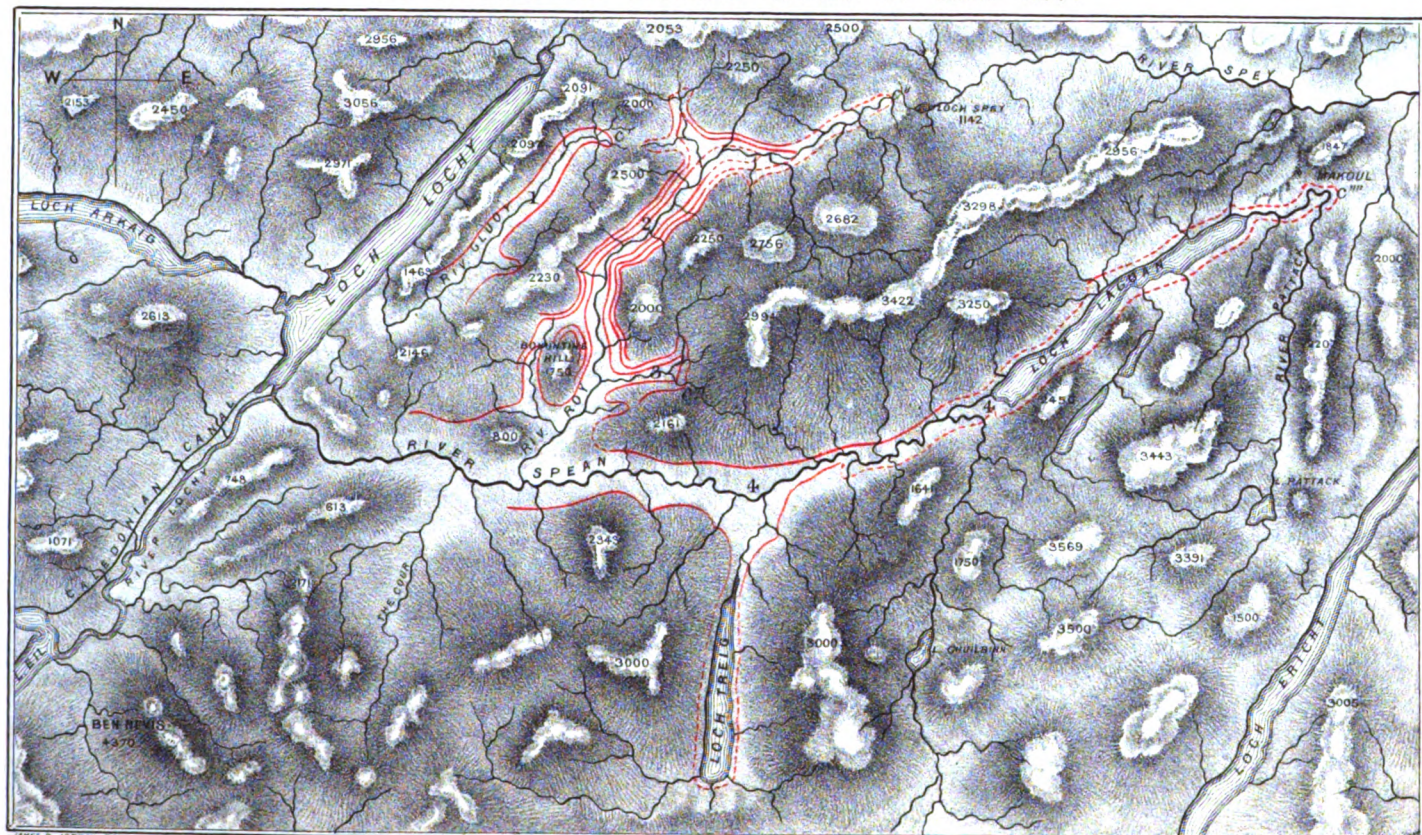


MAP SHEWING THE PARALLEL ROADS OF GLEN ROY.



MESSEY & JOHNSON, DES.

1. Glen Gluoy - 2. Glen Roy - 3. Glen Glaister - 4. Glen Spean
Heights marked in feet

Parallel roads shewn in red

0 1 2 3 4 5 6 7 8 9 10 Scale of Miles.

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WEEKLY EVENING MEETING,

Friday, June 9, 1876.

HIS MAJESTY THE KING OF HANOVER, K.G. in the Chair.

PROFESSOR TYNDALL, D.C.L. LL.D. F.R.S. &c.

The Parallel Roads of Glen Roy.

WHEN, after many months of assiduous work, I ventured to bring some of its fruits before you on the 21st of last January, I thought that my tribute to the Friday evening discourses of the present year had been fairly and honestly paid.* But your excellent Honorary Secretary seems to have thought otherwise when he marked me down for the concluding evening of the season. And considering all that our Honorary Secretary does for us here, I should feel ashamed to demur to any arrangement which he might think agreeable to the members, or otherwise conducive to the interests of the Institution. Nevertheless, Friday evening discourses are not to be developed out of consciousness at will, and my friend I fear must accept a portion of the responsibility, if the subject introduced to your attention to-night should appeal to some of you as a twice-told tale.

To some, but not perhaps to all. Once only has the subject been introduced here, in a discourse commended by a great charm of delivery, and a full report of which appears in the 'Proceedings' of this Institution.† To the views enunciated on that occasion I am unable to subscribe, and it is well that the readers of the 'Proceedings' should know that there are two sides to this question. This is one reason why I chose the subject. Another is that it is not yet considered to be settled, for a new communication regarding it has been recently laid before the Royal Society of Edinburgh by a very meritorious member of that body. Under the circumstances, it can hardly be considered inappropriate on the part of an old student of glacier action to state briefly the side he is disposed to take in the discussion.

The first published allusion to the Parallel Roads of Glen Roy occurs in the appendix to the third volume of Pennant's 'Tour in Scotland,' a work published in 1776. "In the face of these hills," says this writer, "both sides of the glen, there are three roads at small distances from each other and directly opposite on each side. These

* The work then described has been extended and confirmed in various ways since that time.

† Vol. iii. p. 841.

roads have been measured in the complete parts of them, and found to be 26 paces of a man 5 feet 10 inches high. The two highest are pretty near each other, about 50 yards, and the lowest double that distance from the nearest to it. They are carried along the sides of the glen with the utmost regularity, nearly as exact as drawn with a line of rule and compass."

The correct heights of the three roads of Glen Roy are respectively 1150, 1070, and 860 feet above the sea. Hence a vertical distance of 80 feet separates the two highest, while the lowest road is 210 feet below the middle one.

These "roads" are usually shelves or terraces formed in the yielding drift which here covers the slopes of the mountains. They are all sensibly horizontal and therefore parallel. Pennant accepted as reasonable the explanation of them given by the country people, who thought "they were designed for the chase, and that the terraces were made after the spots were cleared in lines from wood, in order to tempt the animals into the open paths after they were roused in order that they might come within reach of the bowmen who might conceal themselves in the woods above and below."

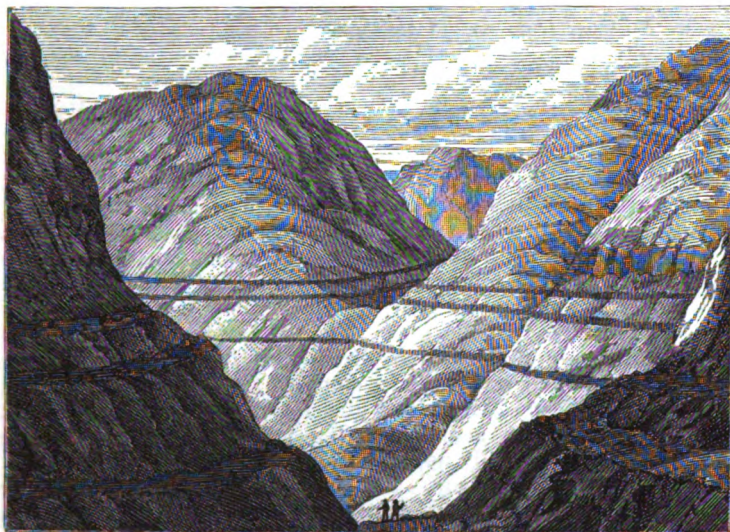
In these attempts of "the country people" we have an illustration of that impulse to which all scientific knowledge is due—the desire to know the causes of things; and it is a matter of surprise that in the case of the parallel roads, with their weird appearance challenging inquiry, this impulse did not make itself more rapidly and energetically felt. Their remoteness may perhaps account for the fact that until the year 1817 no systematic description of them, and no scientific attempt at an explanation of them, appeared. In that year Dr. MacCulloch, who was then President of the Geological Society, presented to that Society a memoir, in which the roads were discussed, and regarded as the margins of lakes once embosomed in Glen Roy.

To Dr. MacCulloch succeeded a man, possibly not so learned as a geologist, but obviously fitted by nature to grapple with her facts and to put them in their proper setting. I refer to Sir Thomas Dick-Lauder, who presented to the Royal Society of Edinburgh, on the 2nd of March, 1818, his paper on the Parallel Roads of Glen Roy. In looking over the literature of this subject, which is now copious, it is interesting to observe the differentiation of minds, and to single out those who went by a kind of instinct to the core of the question, from those who erred in it, or who learnedly occupied themselves with its analogies, adjuncts, and details. There is no man, in my opinion, connected with the history of the subject, who has shown, in relation to it, this spirit of penetration, this force of scientific insight, more conspicuously than Sir Thomas Dick-Lauder. Two distinct mental processes are involved in its treatment. Firstly, the faithful and sufficient observation of the data; and secondly, that higher mental process in which the constructive imagination comes into play, connecting the separate facts of observation with their common cause, and weaving

them into an organic whole. In neither of these requirements did Sir Thomas Dick-Lauder fail.

Adjacent to Glen Roy is a valley called Glen Gluoy, along the sides of which ran a single shelf, or terrace, formed obviously in the same manner as the parallel roads of Glen Roy. The two shelves on the opposing sides of the glen were at precisely the same level, and Dick-Lauder wished to see whether, and how, they became united at the head of the glen. He followed the shelves into the recesses of the mountains. The bottom of the valley, as it rose, came ever nearer to them, until finally, at the head of Glen Gluoy, he reached a col, or watershed, of precisely the same elevation as the road which swept round the glen.

The correct height of this col is 1170 feet above the sea. It is therefore 20 feet above the highest road in Glen Roy.



PARALLEL ROADS OF GLEN ROY.

After a Sketch by Sir Thomas Dick-Lauder.

From this col a lateral branch-valley led towards Glen Roy. Our explorer descended from the col to the highest road in that glen, and pursued it exactly as he had pursued the road in Glen Gluoy. For a time it belted the mountain sides at a considerable height above the bottom of the valley; but this rose as he proceeded, coming ever nearer to the highest shelf, until finally he reached a col, or watershed, looking into Glen Spey, and of precisely the same elevation as the highest parallel road of Glen Roy.

He then dropped down to the lowest of these roads, and followed

it towards the mouth of the glen. Its elevation above the bottom of the valley gradually increased; not because it rose, but because it remained level while the valley sloped downwards. He found this lowest road doubling round the hills at the mouth of Glen Roy, and running along the sides of the mountains which flank Glen Spean. He followed it eastwards. The Spean Valley, like the others, gradually rose, and therefore gradually approached the road on the adjacent mountain-side. He came to Loch Laggan, the surface of which rose almost to the level of the road, and beyond the head of this lake he found, as in the other two cases, a col, or watershed, of exactly the same level as the single road in Glen Spean, which, it will be remembered, is a continuation of the lowest road in Glen Roy.

Here we have a series of facts of obvious significance as regards the solution of this question. The effort of the mind to form a coherent image from such facts, might be compared with the effort of the eyes to cause the pictures of the stereoscope to coalesce. For a time we exercise a certain strain, the object remaining vague and indistinct. Suddenly its various parts seem to run together, the object starting forth in clear and definite relief. Such, I take it, was the effect of his ponderings upon the mind of Sir Thomas Dick-Lauder. His solution was this: Taking all their features into account, he was convinced that water only could have produced the terraces. He saw clearly that, supposing the mouth of Glen Gluoy to be stopped by a barrier, if the water from the mountains flanking the glen were allowed to collect, it would form behind the barrier a lake, the surface of which would gradually rise until it reached the level of the col at the head of the glen. The rising would then cease; the superfluous water of Glen Gluoy discharging itself over the col into Glen Roy. As long as the barrier stopping the mouth of Glen Gluoy continued, we should have in that glen a lake at the precise level of its shelf, which lake, acting upon the loose drift of the flanking mountains, would actually form the shelf revealed by observation.

So much for Glen Gluoy. But suppose the mouth of Glen Roy also stopped by a barrier sufficiently high. Behind it, the water from the adjacent mountains would collect. The surface of the lake thus formed would gradually rise, until it had reached the level of the col which divides Glen Roy from Glen Spey. Here the rising of the lake would cease; its superabundant water being poured over the col into the valley of the Spey. This state of things would continue as long as the barrier remained at the mouth of Glen Roy. The lake thus dammed in, with its surface at the level of the highest parallel road, would act, as in Glen Gluoy, upon the friable drift over-spreading the mountains, and would form the highest road or terrace of Glen Roy.

And now let us suppose the barrier to be so far removed from the mouth of Glen Roy as to establish a connection between it and the upper part of Glen Spean, while the lower part of the latter glen

continued blocked up. Upper Glen Spean and Glen Roy would then be occupied by a continuous lake, the level of which would obviously be determined by the col at the head of Loch Laggan. The water in Glen Roy would sink from the level it had previously maintained, to the level of its new place of escape. This new lake-surface would correspond exactly with the lowest parallel road, and it would form that road by its action upon the drift of the adjacent mountains.

In presence of the observed facts, this solution commends itself strongly to the scientific mind. The question next occurs, What was the character of the assumed barrier which stopped the glens? There are at the present moment vast masses of detritus in certain portions of Glen Spean, and of such detritus Sir Thomas Dick-Lauder imagined his barriers to have been formed. By some unknown convulsion, this detritus had been heaped up. But, once given, and once granted that it was subsequently removed, the single road of Glen Gluoy and the highest and lowest roads of Glen Roy would be explained in a satisfactory manner.

To account for the second or middle road of Glen Roy, Sir Thomas Dick-Lauder invoked a new agency. He supposed that at a certain point in the breaking down or waste of his dam, a halt occurred, the barrier holding its ground at a particular level sufficiently long to dam a lake rising to the height of, and forming the second road. This point of weakness was at once detected by Mr. Darwin, and adduced by him as proving that the levels of the cols did not constitute an essential feature in the phenomena of the parallel roads. Though not destroyed, Sir Thomas Dick-Lauder's theory was seriously shaken by this argument, and it became a point of capital importance, if the facts permitted, to remove such source of weakness. This was done in 1847 by Mr. David Milne, now Mr. Milne-Home. On walking up Glen Roy from Roy Bridge, we pass the mouth of a lateral glen, called Glen Glaster, running eastward from Glen Roy. There is nothing in this lateral glen to attract attention, or to suggest that it could have any conspicuous influence in the production of the parallel roads. Hence, I think, the failure of Sir Thomas Dick-Lauder to notice it. But Mr. Milne-Home entered this glen, on the northern side of which the middle and lowest roads are fairly shown. The principal stream running through the glen turns at a certain point northwards and loses itself among hills too high to offer any outlet. But another branch of the glen turns to the south-east; and, following up this branch, Mr. Milne-Home reached a col, or watershed, of the precise level of the second Glen Roy Road. When the barrier blocking the glens had been so far removed as to open this col, the water in Glen Roy would sink to the level of the second road. A new lake of diminished depth would be thus formed, the surplus water of which would escape over the Glen Glaster col into Glen Spean. The margin of this new lake, acting upon the detrital matter, would form the second road. The theory of Sir Thomas

Dick-Lauder, as regards the part played by the cols, was re-riveted by this new and unexpected discovery.

I have referred to Mr. Darwin, whose powerful mind swayed for a time the convictions of the scientific world in relation to this question. His notion was—and it is a notion which very naturally presents itself—that the parallel roads were formed by the sea; that this whole region was once submerged and subsequently upheaved; that there were pauses in the process of upheaval, during which these glens constituted so many fiords, on the sides of which the parallel terraces were formed. This theory will not bear close criticism; nor is it now maintained by Mr. Darwin himself. It would not account for the sea being 20 feet higher in Glen Gluoy than in Glen Roy. It would not account for the absence of the second and third Glen Roy roads from Glen Gluoy, where the mountain flanks are quite as impressionable as in Glen Roy. It would not account for the absence of the shelves from the other mountains in the neighbourhood, all of which would have been clasped by the sea had the sea been there. Here then, and no doubt elsewhere, Mr. Darwin has shown himself to be fallible; but here, as elsewhere, he has shown himself equal to that discipline of surrender to evidence which girds his intellect with unassailable moral strength.

But, granting the significance of Sir Thomas Dick-Lauder's facts, and the reasonableness, on the whole, of the views which he has founded on them, they will not bear examination in detail. No such barriers of detritus as he assumed could have existed without leaving traces behind them; but there is no trace left. There is detritus enough in Glen Spean, but not where it is wanted. The two highest parallel roads stop abruptly at different points near the mouth of Glen Roy, but no remnant of the barrier against which they abutted is to be seen. It might be urged that the subsequent invasion of the valley by glaciers has swept the detritus away; but there have been no glaciers in these valleys since the retreat of the lakes. Professor Geikie has favoured me with a drawing of the Glen Spean shelf near the entrance to Glen Triage. The shelf forms a belt round a great mound of detritus which, had a glacier followed the formation of the shelf, must have been cleared away. Taking all the circumstances into account, you may, I think, with safety dismiss the detrital barrier as incompetent to account for the present condition of Glen Gluoy and Glen Roy.

Hypotheses in science, though apparently transcending experience, are in reality experience modified by scientific thought and pushed into an ultra experiential region. At the time that he wrote, Sir Thomas Dick-Lauder could not possibly have assigned the cause subsequently assigned for the blockage of these glens. A knowledge of the action of ancient glaciers was the necessary antecedent to the new explanation, and experience of this nature was not possessed by the distinguished writer just mentioned. The extension of Swiss glaciers far beyond their present limits, was first made known by a Swiss

engineer named Venetz, who established, by the marks they had left behind, their former existence in places which they had long forsaken. The subject of glacier extension was subsequently followed up with distinguished success by Charpentier, Studer, and others. Agassiz grappled with it with characteristic vigour, extending his evidences far beyond the domain of Switzerland. He came to this country in 1840, and found in various places indubitable marks of ancient glacier action. England, Scotland, Wales, and Ireland he proved to have once given birth to glaciers. He visited Glen Roy, surveyed the surrounding neighbourhood, and pronounced, as a consequence of his investigation, the barriers which stopped the glens and produced the parallel roads to have been barriers of ice. To Mr. Jamieson, above all others, we are indebted for the thorough testing and confirmation of this theory.

And let me here say that Agassiz is only too likely to be misrated and misjudged by those who fail to grasp in their totality the motive powers invoked in scientific research. He lacked mechanical precision, but he abounded in that force and freshness of the scientific imagination which in some sciences, and probably in some stages of all sciences, are essential to the creator of knowledge. To Agassiz was given, not the art of the refiner, but the instinct of the discoverer, and the strength of the delver who brings ore from the recesses of the mine. That ore may contain its share of dross, but it also contains the precious metal which gives employment to the refiner, and without which his occupation would depart.

Let us dwell for a moment upon this subject of ancient glaciers. Under a flask containing water, in which a thermometer is immersed, is placed a Bunsen's lamp. The water is heated, reaches a temperature of 212° , and then begins to boil. The rise of the thermometer then ceases, although heat continues to be poured by the lamp into the water. What becomes of that heat? We know that it is consumed in the molecular work of vaporization. In the experiment here arranged, the steam passes from the flask through a tube into a second vessel kept at a low temperature. Here it is condensed, and indeed congealed to ice, the second vessel being plunged in a mixture cold enough to freeze the water. As a result of the process we obtain a mass of ice. That ice has an origin very antithetical to its own character. Though cold, it is the child of heat. If we removed the Bunsen lamp, there would be no steam, and if there were no steam there would be no ice. The mere cold of the mixture surrounding the second vessel would not produce ice. The cold must have the proper material to work upon; and this material—aqueous vapour—is, as we here see, the direct product of heat.

It is now, I suppose, fifteen or sixteen years since I found myself conversing with an illustrious philosopher regarding that glacial epoch which the researches of Agassiz and others had revealed. This profoundly thoughtful man was of opinion that, at a certain stage in the history of the solar system, the sun's radiation had suffered diminution,

the glacial epoch being a consequence of this central chill. The celebrated French mathematician Poisson had another theory. Astronomers have shown that the solar system moves through space, and the temperature of space is a familiar conception with scientific men. It was considered probable by Poisson that our system, during its motion, had traversed portions of space of different temperatures; and that, during its passage through one of the colder regions of the universe, the glacial epoch occurred. Notions such as these were more or less current not many years ago, and I therefore thought it worth while to show how incomplete they were. Suppose the temperature of our planet to be reduced, by the subsidence of solar heat, the cold of space, or any other cause, say one hundred degrees. Four-and-twenty hours of such a chill would bring down as snow nearly all the moisture of our atmosphere. But this would not produce a glacial epoch. Such an epoch would require the continuous generation of the material from which the ice of glaciers is derived. Mountain snow, the nutriment of glaciers, is derived from aqueous vapour raised mainly from the tropical ocean by the sun. The solar fire is as necessary a factor in the process as our Bunsen lamp in the experiment referred to a moment ago. Nothing is easier than to calculate the exact amount of heat expended by the sun in the production of a glacier. It would, as I have elsewhere shown,* raise a quantity of cast iron five times the weight of the glacier not only to a white heat, but to its point of fusion. If, as I have urged elsewhere, instead of being filled with ice, the valleys of the Alps were filled with white-hot metal, of quintuple the mass of the present glaciers, it is the heat, and not the cold, that would arrest our attention and solicit our explanation. The process of glacier making is obviously one of distillation, in which the fire of the sun which generates the vapour plays as essential a part as the cold of the mountains which condenses it.†

It was their ascription to glacier action that first gave the parallel roads of Glen Roy an interest in my eyes; and in 1867, with a view to self-instruction, I made a solitary pilgrimage to the place, and explored pretty thoroughly the roads of the principal glen. I traced the highest road to the col dividing Glen Roy from Glen Spey, and, thanks to the civility of an Ordnance surveyor, I was enabled to inspect some of the roads with a theodolite. As stated by Pennant, the width of the roads amounts sometimes to more than twenty yards; but near the head of Glen Roy the highest road ceases to have any width, for it runs along the face of a rock, the effect of the lapping of the water on

* 'Heat a Mode of Motion,' fifth edition, chap. vi.: Forms of Water, §§ 55 and 56.

† In Lyell's excellent 'Principles of Geology,' the remark occurs that "several writers have fallen into the strange error of supposing that the glacial period must have been one of higher mean temperature than usual." The really strange error was the forgetfulness of the fact that in the production of glaciers, heat played quite as important a part as cold.

the more friable portions of the rock being perfectly distinct to this hour. My knowledge of the region was, however, far from complete, and nine years had dimmed the memory even of the portion which I had thoroughly examined. Hence my desire to see the roads once more before venturing to talk to you about them. The Easter holidays were to be devoted to this purpose; but at the last moment a telegram from Roy Bridge informed me that the roads were snowed up. I was thus thrown back upon books and memories; but these proving only a poor substitute for the flavour of facts, I resolved subsequently to make another effort to see the roads. Accordingly on Thursday fortnight, after lecturing here, I packed up, and started (not this time alone) for the North. Next day at noon we found ourselves at Dalwhinnie, whence a drive of some five-and-thirty miles brought us to the excellent hostelry of Mr. Macintosh, at the mouth of Glen Roy.

We might have found the hills covered with mist, which would have wholly defeated us; but Nature was good-natured, and we had two successful working days among the hills. Guided by the excellent Ordnance map, on the Saturday morning we went up the glen, and on reaching the stream called Allt Bhreac Achaidh faced the hills to the west. At the watershed between Glen Roy and Glen Fintaig we bore northwards, struck the ridge above Glen Gluoy, came in view of its road, which we persistently followed as long as it continued visible. It is a feature of all the roads that they vanish before reaching the cols over which fell the waters of the lakes which formed them. One reason doubtless is that at their upper ends the lakes were shallow, and incompetent on this account to raise wavelets of any strength to act upon the mountain drift. A second reason is that they were land-locked in the higher portions and protected from the south-westerly winds, the stillness of their waters causing them to produce but a feeble impression upon the mountain sides. From Glen Gluoy we passed down Glen Turril to Glen Roy, and through it homewards, thus accomplishing two or three and twenty miles of rough and honest work.

Next day we thoroughly explored Glen Glaster, following its two roads as far as they were visible. We reached the col discovered by Mr. Milne-Home, and which stands at the level of the middle road of Glen Roy. Thence we crossed southwards over the mountain *Creag Dhubh*, and examined the erratic blocks upon its sides, and the ridges and mounds of moraine matter which cumber the lower flanks of the mountain. The observations of Mr. Jamieson upon this region, including the mouth of Glen Triage, are in the highest degree interesting. We entered Glen Spean, and continued a search begun on the evening of our arrival at Roy Bridge—the search, namely, for glacier polishings and markings. We did not find them copious, but they are indubitable. One of the proofs most convenient for reference, is a great rounded rock by the road side, 1000 yards east of the milestone marked three-quarters of a mile from Roy Bridge.

Farther east other cases occur, and they leave no doubt upon the mind that Glen Spean was at one time filled by a great glacier. To the disciplined eye the aspect of the mountains is perfectly conclusive on this point; and in no position can the observer more readily and thoroughly convince himself of this than at the head of Glen Glaster. The dominant hills here are all intensely glaciated.

But the great collecting ground of the glaciers which dammed the glens and produced the parallel roads, were the mountains south and west of Glen Spean. The monarch of these is Ben Nevis, 4370 feet high. The position of Ben Nevis and his colleagues, in reference to the vapour-laden winds of the Atlantic, is a point of the first importance. It is exactly similar to that of Carrantual and the Macgillicuddy Reeks in the south-west of Ireland. These mountains are, and were, the first to encounter the south-western Atlantic winds, and the precipitation, even at present, in the neighbourhood of Killarney, is enormous. The winds, robbed of their vapour, and charged with the heat set free by its precipitation, pursue their direction obliquely across Ireland; and the effect of the drying process may be understood by comparing the rainfall at Cahirciveen with that at Portarlinton. As found by Dr. Lloyd, the ratio is as 59 to 21—fifty-nine inches annually at Cahirciveen to twenty-one at Portarlinton. During the glacial epoch this vapour fell as snow, and the consequence was a system of glaciers which have left traces and evidences of the most impressive character in the region of the Killarney Lakes. I have referred in other places to the great glacier which, descending from the Reeks, moved through the Black Valley, took possession of the lake-basins, and left its traces on every rock and island emergent from the waters of the upper lake. They are all conspicuously glaciated. Not in Switzerland itself do we find clearer traces of ancient glacier action.

What the Macgillicuddy Reeks did in Ireland, Ben Nevis and the adjacent mountains did, and continue to do, in Scotland. We had an example of this on the morning we quitted Roy Bridge. From the bridge westward rain fell copiously, and the roads were wet; but the precipitation ceased near Loch Laggan, whence eastward the roads were dry. Measured by the gauge, the rainfall at Fort William is 86 inches, while at Laggan it is only 46 inches annually. The difference between west and east is forcibly brought out by observations at the two ends of the Caledonian Canal. Fort William at the south-western end has, as just stated, 86 inches, while Culloden, at its north-east end, has only 24. To the researches of that able and accomplished meteorologist, Mr. Buchan, we are indebted for these and other data of the most interesting and valuable kind.

Adhering to the facts now presented to us, it is not difficult to restore in idea the process by which the glaciers of Lochaber were produced and the glens dammed by ice. When the cold of the glacial epoch began to invade the Scottish hills, the sun at the same time acting with sufficient power upon the tropical ocean, the vapours raised and drifted on to these northern mountains were more and

more converted into snow. This slid down the slopes, and from every valley, strath, and corry south of Glen Spean, glaciers were poured into that glen. The two great factors here brought into play are the nutrition of the glaciers by the frozen material above, and their consumption in the milder air below. For a period supply exceeded consumption, and the ice extended, filling Glen Spean to an ever-increasing height, and abutting against the mountains to the north of that glen. But why, it may be asked, should the valleys south of Glen Spean be receptacles of ice at a time when those north of it were receptacles of water? The answer is to be found in the position and the greater elevation of the mountains south of Glen Spean. They first received the loads of moisture carried by the Atlantic winds, and not until they had been in part dried, and warmed by the liberation of their latent heat, did these winds touch the hills north of the Glen.

An instructive observation bearing upon this point is here to be noted. Had our visit been in the winter we should have found all the mountains covered; had it been in the summer we should have found the snow all gone. But happily it was at a season when the aspect of the mountains north and south of Glen Spean exhibited their relative powers as snow collectors. Scanning the former hills from many points of view, we were hardly able to detect a fleck of snow, while heavy swaths and patches loaded the latter. Were the glacial epoch to return, the relation indicated by this observation would cause Glen Spean to be filled with glaciers from the south, while the hills and valleys on the north, visited by milder and drier winds, would remain comparatively free from ice. This flow from the south would be reinforced from the west, and as long as the supply was in excess of the consumption the glaciers would extend, the dams closing the glens increasing in height. By-and-by supply and consumption becoming approximately equal, the height of the glacier barriers would remain constant. Then, as milder weather set in, consumption would be in excess, and a retreat of the ice would be the consequence. But for a long time the conflict between supply and consumption would continue, retarding indefinitely the disappearance of the barriers, and keeping the imprisoned lakes in the northern glens. But however slow its retreat, the ice in the long run would be forced to yield. The dam at the mouth of Glen Roy, which probably entered the glen sufficiently far to block up Glen Glaster, would gradually retreat. Glen Glaster and its col being opened, the subsidence of the lake 80 feet, from the level of the highest to that of the second parallel road, would follow as a consequence. I think this the most probable course of things, but it is also possible that Glen Glaster may have been blocked by a glacier from Glen Trieg. The ice dam continuing to retreat, at length permitted Glen Roy to connect itself with upper Glen Spean. A continuous lake then filled both glens, the level of which, as already explained, was determined by the col at Makul, above the head of Loch Laggan. The last

to yield was the portion of the glacier which derived nutrition from Ben Nevis, and probably also from the mountains north and south of Loch Arkaig. But it at length yielded, and the waters in the glens resumed the courses which they pursue to-day.

For the removal of the ice barriers no cataclysm is to be invoked; the gradual melting of the dam would produce the entire series of phenomena. In sinking from col to col the water would flow over a melting barrier, the surface of the imprisoned lake not remaining sufficiently long at any particular level to produce a shelf comparable to the parallel roads. By temporary halts in the process of melting due to atmospheric conditions or to the character of the dam itself, or through local softness in the drift, small pseudo-terraces would be formed which, to the perplexity of some observers, are seen upon the flanks of the glens to-day.

In presence then of the fact that the barriers which stopped these glens to a height, it may be, of 1500 feet above the bottom of Glen Spean, have dissolved and left not a wreck behind; in presence of the fact, insisted on by Professor Geikie, that barriers of detritus would undoubtedly have been able to maintain themselves had they ever been there; in presence of the fact that great glaciers once most certainly filled these valleys—that the whole region, as proved by Mr. Jamieson, is filled with the traces of their action; the theory which ascribes the parallel roads to lakes dammed by barriers of ice has, in my opinion, an amount of probability on its side which amounts to a practical demonstration of its truth.

Into the details of the terrace formation I do not enter. Mr. Darwin and Mr. Jamieson on the one side, and Sir John Lubbock on the other, deal with true causes. The terraces, no doubt, are due in part to the descending drift arrested by the water, and in part to the fretting of the wavelets, and the rearrangement of the stirred detritus, along the belts of contact of lake and hill. The descent of matter must have been frequent when the drift was unbound by the rootlets which hold it together now. In some cases, it may be remarked, the visibility of the roads is materially exalted by differences of vegetation. The grass upon the terraces is not always of the same character as that above and below them, while on heather-covered hills the absence of the dark shrub from the roads greatly enhances their conspicuousness.

Reviewing our work, we find three considerable steps to have marked the solution of the problem of the Parallel Roads of Glen Roy. The first of these was taken by Sir Thomas Dick-Lauder, the second was the pregnant conception of Agassiz regarding glacier action, and the third was the testing and verification of this conception by the very thorough researches of Mr. Jamieson.* To these may be added the

* No circumstance, or incident, connected with this discourse gives me greater pleasure than the recognition of the value of these researches. They are marked throughout by unflagging industry, by novelty and acuteness of observation, and

important observation of Mr. Milne-Home in Glen Glaster; with other remarks and reflections scattered through the literature of the subject, or suggested by the latest visit to the spot.

Thus ends our rapid survey of this brief episode in the physical history of the Scottish hills,—brief, that is to say, in comparison with the immeasurable lapses of time through which, to produce its varied structure and appearances, our planet must have passed. In the survey of such a field two things are specially worthy to be taken into account—the widening of the intellectual horizon and the reaction of expanding knowledge upon the intellectual organ itself. At first, as in the case of ancient glaciers, through sheer want of capacity, the mind refuses to take in revealed facts. But by degrees the steady contemplation of these facts so strengthens and expands the intellectual powers, that where truth once could not find an entrance it eventually finds a home.

[The formation, connection, successive subsidence, and final disappearance of the glacial lakes of Lochaber were illustrated in the discourse here reported, by a model constructed under the supervision of my assistant, Mr. John Cottrell. Glen Gluoy with its lake and road and the cataract over its col; Glen Roy and its three roads with their respective cataracts at the head of Glen Spey, Glen Glaster, and Glen Spean, were all represented. The successive shiftings of the barriers, which were formed of plate glass, brought each successive lake and its corresponding road into view, while the entire removal of the barriers caused the streams to flow down the glens of the model as they flow down the real glens of to-day. A map of the district, with the parallel roads shown in red, is annexed.]

[J. T.]

LITERATURE OF THE SUBJECT.

- THOMAS PENNANT.—A Tour in Scotland. Vol. iii. 1776, p. 394.
 JOHN MACCULLOCH.—On the Parallel Roads of Glen Roy. Geol. Soc. Trans. vol. iv. 1817, p. 314.
 THOMAS LAUDER DICK (afterwards SIR THOMAS DICK-LAUDER, Bart.).—On the Parallel Roads of Lochaber. Edin. Roy. Soc. Trans. 1818, vol. ix. p. 1.
 CHARLES DARWIN.—Observations on the Parallel Roads of Glen Roy, and of the other parts of Lochaber in Scotland, with an attempt to prove that they are of marine origin. Phil. Trans. 1839, vol. cxxix. p. 39.
 SIR CHARLES LYELL.—Elements of Geology. Second edition, 1841.
 LOUIS AGASSIZ.—The Glacial Theory and its Recent Progress—Parallel Terraces. Edin. New Phil. Journal, 1842, vol. xxxiii. p. 236.

by reasoning power of a high and varied kind. These pages had been returned "for press" when I learned that the relation of Ben Nevis and his colleagues to the vapour-laden winds of the Atlantic had not escaped Mr. Jamieson. To him obviously the exploration of Lochaber, and the development of the theory of the Parallel Roads, has been a labour of love.