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from the Author

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ON

THE ORIGIN

OF THE

PARALLEL ROADS

OF

GLEN ROY.

BY

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The general characters and appearance of these celebrated roads are so well known as scarcely to require to be mentioned. Running apparently with perfect horizontality and complete parallelism along the two sides of a long Highland glen, turning up every lateral valley and encircling every hill, they form a spectacle altogether unique in this country, and which, when once seen, can never be forgotten. Their mode of origin, on the other hand, still remains one of the open, undecided questions in Scottish geology. Various theories have been proposed, each enjoying popularity for a time, but no one permanently remaining master of the field. The horizontality, parallelism, and general character of the lines leave no doubt that they have been formed by water standing at the level of each line or road for a very considerable period, and then suddenly subsiding to the level of the next lower road. Thus far all recent observers seem agreed. But fresh water and salt—mountain loch and sea-firth—have still each their own supporters; and some who once advocated the one of these views, may now be found supporting the other. It is thus evident that no facts very decisively in favour of either theory have yet been adduced. But that such facts do exist I hope to be able to show in the following observations, and thus to contribute some evidence tending to decide this question.

As the general aspect and characters of these lines or roads are so well known, and have been so often and accurately described, I shall abstain from referring to them as far as possible. My remarks also have reference to the rival theories generally, and not to any special view or defence of them, and I have therefore avoided all reference to the writings of former observers, and all criticism or remark on their arguments. With very few (and these easily understood) exceptions, the facts stated are only such as I have personally verified during my repeated visits to the country where the lines occur.

Two rival theories as to the cause and origin of these lines at present prevail among scientific men. One party considers them ancient sea-margins, left behind as the land rose, or, as it may be otherwise expressed, when the sea retired. The other party ascribe them to fresh-water lakes which formerly filled the valleys and were drained at intervals, as the barriers, of ice or detritus, that shut in these lakes, were suddenly dissolved or broken down. I adopt the first or marine theory, and therefore am not much con-

cerned in the special arguments for or against the two varieties of the lake-theory.

Whatever view we may take of the origin of these lines, one great fact seems beyond dispute. Long before they originated, the country in which they lie must have had nearly its present form and outline—the same hills and mountains, the same glens and valleys, with nearly their present relative elevations. This fact we may, or rather must, assume in all our reasonings and speculations. This region has also been subjected to a very extensive glacial action. Wherever the rocks are newly exposed they are marked by grooves and striæ. The direction of these striæ and the form of the rounded rocks show that in a few cases the ice has come down some of the lateral valleys and moved towards the west. But other facts appear to me to indicate that here, as in other parts of the North of Scotland, the great ice-stream has flowed from the west, and probably from a lofty mountain-chain that then existed in that region.

Subsequent to this ice-period, but before the formation of the Glen-Roy lines, the whole region has been submerged in the sea. This is proved by the uniform coat of detritus covering the whole surface, in a thicker or thinner sheet according to the form of the ground. This coat is not the mere surface waste, but matter laid down by water, and is too widespread and general in its distribution, and too much mixed in its composition, to have been formed in any mere lake. Associated with it are numerous boulders of travelled stones, some of them imbedded in its mass, others lying on the surface. As examples of these I may mention some huge blocks of black granite and other smaller masses of red porphyry which occur within a few yards of the summit of Craig Dhu, a conical mountain of mica slate, that rises to more than 2000 feet above the sea, in the angle between the valleys of the Spean and Roy. One block must weigh about forty tons; and they are evidently ice-borne masses, floated probably far from the west in the ancient ocean.

It is in this detrital cover that the lines are cut; and the period and mode of its formation are thus of much importance. That it is a marine deposit seems beyond doubt. That it has been formed since the general glacial striation of the land is also proved by the fact that it spreads over the rocks marked in this manner. This is well seen in the Spean valley in very many places. More convincing, or at least more interesting, is the fact that in Glen Roy these striated rocks occur immediately under the lines. The old line or parallel road now passes over the rock-surface that in a former period was worn and striated by the glacier. There is thus the most direct proof that the period of general ice-striation was separated from that of the formation of the lines, by a period in which the land was submerged in the ocean and its general cover of detritus deposited.

This fact, however, does not decide the mode of formation of the lines, or even its relation to ice and glaciers. There is abundant evidence in many parts of Scotland that the great western glaciation

has been followed by more limited and local ice-action. Even on the same rock-surface two intersecting sets of striæ may be seen, the older set quite independent of the present outline of the country, the newer clearly determined by the existing mountain-valleys and glens. It is quite possible that, after the land emerged from the sea, ice may have again formed in the mountain-corries and flowed in vast rivers down the glens. There is, indeed, evidence that this has occurred, in at least the higher portions of the district. But we must ever be careful to avoid confusing these mere local and partial glaciers, very limited both in size and influence, with the far older and more universal ice-action of the first period. The earlier glaciers can have had no connexion with the origin of the lines; the later may.

When examining the lines on various occasions, I have ever been on the search for some fact or facts that might serve as a criterion of the truth or falsehood of the rival theories. At one time I thought the character of the shingle composing them, and the mode of its deposition, might serve this purpose. But I could find no character of this kind at all satisfactory. The shingle on the shores of our Highland fresh-water lakes and that on those of the inland salt-water lochs, are too similar in most respects to admit of accurate discrimination. At length one character did occur to me of a testing and discriminating kind, one point in which the two views were essentially different. Mr. Milne long ago pointed out the remarkable fact that the three best-marked lines corresponded nearly with cols or gorges between the hills, and showed that these gorges must have formed the outlets for the fresh-water lakes to which he ascribed the cutting out of the lines. Now of this there can be no doubt. If from any cause the water of the Spean was prevented from flowing off to the west till it rose to the height of the first or lower line, it would form a lake flowing off to the Spey by the pass of Maccoul; so also a barrier raising the waters of the Roy to the second line would cause them to overflow by Glen Glaister; and were this exit also shut, when they rose to the third or highest line they would then escape at the very top of Glen Roy into the Spey. How far the levels of the respective lines correspond exactly with these cols must be left to the Ordnance Survey to decide. The levels are either very near, or perhaps the lines in some cases a little higher; so that the supposed lakes would necessarily have overflowed at the points mentioned.

It is thus certain that, if the lines were formed by fresh-water lakes, each of these passes must have been the exit of a river of very considerable size and flowing in a narrow valley for a long period. If, on the other hand, they are of marine origin, then these same passes were sea-straits—narrow channels connecting one great bay with another. Here then was a marked difference in the two theories, a matter of fact which existing phenomena might enable us to decide. For this purpose I examined the various passes carefully, and found that whilst in none of them was there the slightest trace of an ancient river, in all there were distinct indications of the

former existence of a narrow sea-strait. Here, then, it appears to me we have undoubted proof that the lines have been formed by the sea, and not by lakes.

A few observations taken from notes made on the spot may render this statement plainer. The highest line is that in Glen Gloy. The valley by which the lake is assumed to have drained into Glen Roy is very narrow and encumbered with detritus from the hills on the sides. The summit-level is flat and marshy, and it appeared to me considerably below the level of the line. On the other hand, a line of stones, as if washed out of the detritus, appeared to show that the sea or loch had extended quite through the strait. I observed no indication of any stream of water larger than the present small rivulet having ever run here. But as the difference in height of this line from the upper line in Glen Roy is not great, and the erosive action of the river might thus have been limited, I shall not mention any other details.

The next pass is that from Glen Roy to the Spey. If a lake ever filled the valley of the Roy to the level of the upper line, a great river, fully equal to the Roy where it now joins the Spean, must have flowed through this pass. In time of floods, when swollen by the western rains and melting snows and glacier-ice, it ought to have left no uncertain mark of its passage over the watershed and down the valley of the Spey; but I looked in vain for any indication of the former presence of such a mighty stream. It has cut no notch in the ridge or on the sloping declivity to Loch Spey; it has formed no delta in this lonely tarn. The broad flat strath of the Spey shows only the narrow channel through which the present streamlet winds its way to the sea. No one who has ever studied the effects of running water in such situations could doubt that even in a few days or weeks such a river as the present Roy (and the old river at least could not have been smaller) would leave a groove in the soft alluvial hollow which centuries would fail to obliterate. The rapid running stream must have cut a deeper line on the low haugh than the mere wave-wash of a shut-in mountain-lake on the slope of the hill. Yet the one is distinctly visible for miles round and round; of the other there is not the faintest trace. It is a physical impossibility that the lake should have left such a deep and distinct line, and that the river should have flowed through the gorge and down the valley for the same time without leaving any mark of its presence.

On the other hand there are clear indications of the pass having once been a sea-strait. The bottom is broad and flat; a notch is cut horizontally along the side of the hill where the water once stood, and a distinct line of stones left where the water has washed away the detritus. In other words, there is an old wave-washed beach. Then a curious series of little rounded bare knolls rise up in the old channel. From a lateral corry below Loch Spey great masses of detritus project into the main valley, but these are spread out and levelled down; as if thrown into the sea, not as if heaped up in a river-valley. It is scarcely worth mentioning, though im-

portant in reference to the glacial form of the lake theory, that even in the end of August the snow was still lying unmelted in the corries to the south; hence any climatal conditions that would produce glaciers on Ben Nevis capable of damming up the valleys of the Roy and Spean, would have also sufficed to fill this lofty valley with an ice barrier. If ice prevented the water flowing west through the Spean, it ought also to have prevented its flowing east into the Spey.

The next point of assumed overflow, when the lake stood on the level of the second line, is the col at the top of Glen Glaister. This is very nearly on the level of the second line, as is easily seen even without instruments. The summit-level is a flat and marshy plain. A small stream that comes down to it from the hill on the south-west, after winding through it in almost stagnant pools, at length flows off to the Spean by the Rough Glen. The declivity here is very considerable, and the consequent rapidity and cutting-power of a river flowing down it must have been very great; yet no trace of such a river appears. There is only the narrow channel of the present small rivulet. A little below the watershed it crosses a ridge of low rocks; but even there no indication of a larger stream is visible. According to the lake theory, the Roy once ran down this glen, as it now runs in the bottom of its own glen. We have only to compare the deep, well-defined notch or gorge which the river has cut for itself from the mouth of Glen Glaister to the Spean with the unbroken outline of its so-called old course, to be convinced that no river has ever passed through the Glen-Glaister col. It is very remarkable that though there is no evidence of a former river, there is evidence of a shore-line on the level, not of the second, but of the higher line. A well-marked beach of washed stones can be traced along the side of the hill on the east quite through the pass. This shows that no barrier, damming up the water to the level of the higher line, existed in this place at the time when that line was forming.

It is evident from the distinctness of the lines that the fall of the water from the level of one to the level of the next lower, has been on the whole sudden. On the lake theory, the fall from the upper, Glen-Roy line to the second line was caused by the breaking down of the barrier of detritus or ice shutting up the Glen-Glaister col. But by removing that barrier, a depth of water of from 80 to 100 feet would be set free over the whole surface of the Glen-Roy lake, with an extent of ten miles in length by above one mile in width. All this enormous mass of water would be emptied out in a few hours, or, at most, days. With what rapidity and what results such a mass of water would escape may be imagined by any one who has read the accounts of the bursting of the far smaller ice-lake in the valley of the Dranse. If we wish for instances nearer home, the accounts of the bursting of the Bilberry reservoir in 1852, or of that of Dale Dike, near Sheffield, in 1864, will show the enormous devastation and erosion a far inferior mass of water suddenly let loose can occasion. A few sentences must be borrowed from the engineer's report on the latter:—"Everything solid which stood in the direct course

of the flood was swept away; huge rocks were torn up and were floated along, just as pine timber would have been floated in an ordinary waterway. One of these stones so floated weighs upwards of thirty tons, and is in dimensions not unlike one of the largest stones at Stonehenge. Hundreds of tons of smaller stones were torn up and swept along. Of the first mills encountered by the flood, not a vestige remains to show where they stood—the buildings, site, and subsoil (rock and shale) having been scooped out and swept away, as also the ground for a considerable distance around" . . . . .

If such results followed on the sudden drainage of a small reservoir, can we believe that the water in the upper Glen-Roy lake, to a greater depth and covering nearly a hundred times the extent of surface, all passed away down a steep and by no means wide valley, without leaving behind any trace of its passage?

The next point of supposed lake-drainage is the Pass of Macceoul, between Loch Laggan and the Spey. This pass is a narrow ravine with a flat bottom and a very slight declivity from the watershed either to Loch Laggan or the Spey. A river might thus have flowed through it without leaving any very deep trace behind. It is also much encumbered with peat, which hides and obscures the outline of the ground on which it rests. Hence though I observed no indications of an old river in this locality, I put less value on the negative evidence thus furnished. On the other hand it is curious that the river Puttaig, which falls into the pass from the south-west, and which would more naturally have flowed on to the Spey, turns sharply round and runs to Loch Laggan. Had a river from the lake flowed formerly in the other direction, we should have expected the present river to have continued its old course and not to have taken the reverse. The present channel, though not deep, is still well marked, and shows what we might have expected had a much larger river flowed in the other direction. On the other supposition of a sea-channel in this place with the western tidal currents setting through it, it is easy to see how the débris from this stream should be chiefly accumulated to the east, thus compelling the river, when the land rose out of the sea, to turn westwards to Loch Laggan. The evidence to be derived from the facts seen in this locality therefore appears to me altogether in favour of the marine theory; but, for the reasons mentioned, I do not insist on it. This, however, is not necessary. If there is, as I have endeavoured to show, undeniable proof that no lakes ever existed so as to form the higher lines, and that these therefore must have been formed by the sea, no person will seek to ascribe a lake-origin to the lowest of the series.

There seems to me no way of meeting the evidence for the marine origin of these lines, now adduced, except either to deny that rivers flowing in such places and conditions would form such distinct and well-marked channels as I have alleged, or to affirm that such channels and other marks of their existence would soon be obliterated by subsequent changes. But, after studying the action of running water for years, both in the south and north of Scotland, I

have no hesitation in affirming that it would be a physical impossibility for a river like the Roy to flow over and down such declivities and leave no notch behind. I have seen a stream which had during a flood changed its course, cut out in a few days a channel which centuries would fail to efface. In uncultivated ground such inequalities of surface are very slowly obliterated. In such places 1500 or 1600 years of neglect have done little to efface the old Roman roads or camps; the still older British hill-circles and vitrified forts are still distinctly marked; and there is no reason to believe these river-beds more perishable. The Glen-Roy lines are the best proof how durable such markings are in such conditions. In Glen Roy itself there is much curious evidence both of the effects of river-action and the durability of the marks it leaves. The delta-terraces formed where the streams fell into the old bays on the level of the lines, as at the entrance to Glen Turrit, were of course immediately cut into by the rivers when laid dry by the retiring of the waters. Many of these old watercourses, which had been cut out by the Turrit and other streams before they finally settled down into their present beds, are still easily seen. Some of these are nearly as old as the line they accompany, and older than the lower lines—and thus prove that there has been no surface-change here sufficient to obliterate the former river-channels, had they ever existed.

I might now leave the question to be decided on the evidence adduced; but there are a few other facts corroborating the same views that may be mentioned. And first, though these lines are in some respects unique in character, there are other indications of the former presence of the sea in this region. Thus in the valley of the Spean there is, as it were, a continuous series of terraces continuing the lines at intervals down to the sea-level. Such wide terraces, or shingle beaches, are well seen along the Spean from Roy Bridge downwards. Another similar terrace is seen at the mouth of Loch Treig on the level of the third or lower line. The sea has stood here for a long period, as the hills above this sheet of detritus are washed very bare, and in some places a well-marked shore-cliff has been cut immediately above it. The detritus here, however, has not come down Loch Treig, as might at first sight be imagined, but from the Corry Laire to the west, and has then been swept eastwards by the tidal currents, and even up into Loch Treig, on which it abuts with a bold, almost vertical end. In many other places in this part of Glen Spean there is similar evidence of a current from the west flowing up the valley. Thus the lower or western sides of the knolls and rocks are bare, and the detritus accumulated in long mounds or tails behind (that is, above them) to the east. This could not have occurred in an inland lake, where there are no currents, but must have taken place in a marine channel open from sea to sea.

Further, there is a vast amount of evidence of the former presence of the sea at various levels between the upper and lower Glen-Roy lines in all the surrounding region. This evidence also is specially distinct in the valley of the Spey, and thus on the other side of the watershed and in the very valleys into which the lakes

are said to have drained. This is most remarkably the case in the upper valley of the Spey above Laggan. I have already mentioned the great terrace-mound at the lower extremity of Loch Spey, and nearly on the level of the upper line in Glen Roy. Another very distinct terrace is seen near Garviemore, probably not far from the level of the second line. This terrace much resembles the one at Inverlaire near Loch Treig, but is on a different level. There is another similar flat mound near Glen-Shira Lodge, with a line of washed stones on the hillside, evidently marking a former beach-line.

Still lower down the main valley and in that of the Truim, followed by the Highland Railway, similar indications of the former presence of the sea are very striking. Kingussie, 762 feet above the sea, is about 80 feet under the lowest Glen-Roy line; whilst Dalwhinnie Inn, 1182 feet high, is 40 feet above the highest. In the space between, marks of horizontal lines and terraces are very conspicuous. Thus at the north end of Loch Ericht, a little below Dalwhinnie, and nearly on the level of the upper line, there is a great shingle-deposit of round water-worn stones, showing that the sea has long stood at this elevation. Singularly enough, this old beach forms the watershed between the Spey and Tay in this place. Another very strongly marked terrace is seen for miles on both sides of the Spey near Kingussie. It is about 820 feet above the sea, and thus rather lower than the third Glen-Roy line (about 30 feet). This difference of level is very small, considering that Kingussie is 30 miles from Glen Roy in a direct line, and 15 from Loch Laggan, where the lowest line terminates in the Spean valley. The breadth of this terrace, the flatness of the surface, broken from place to place by deep irregular hollows with pools of water at the bottom, and the distinct cliff where it meets the slope of the hill, prove that the sea has stood here for a long time. At Loch Gynac, a small lake in the valley behind Kingussie, there are three terraces quite similar to those in Glen Roy, but far inferior in extent. Two of them also, according to some aneroid observations I made, are nearly on the level of the second and third, or upper terraces in Glen Roy. There are other similar indications of the presence of the sea in this vicinity; but I shall only refer to some distinct traces of horizontal lines on the declivity of the hill forming the south side of the Laggan valley on the Spey. In regard to all these lines and terraces in this district, they appeared to me to show that the water had retired, or the land risen, by sudden starts, as it were, not by a slow, regular, and continuous process. In this they agree with the phenomena of Glen Roy, and thus confirm the view now given of the origin of its lines.

The exact coincidence of the lines with certain cols or passes between the valleys has to many appeared an almost insuperable difficulty in the way of the theory of their marine origin. It has been felt as a strong objection to this marine theory, that the sea in its descent should pause three or four times, just at the level of these three or four openings in the hills. It may lessen this difficulty if we consider that the currents from the west,

flowing through the old channels, would tend to cut them down to these levels; whilst the sudden rise of the land would stop the further continuation of the process. It is also important to remark that at all these points a stream enters the main valley from the side, or from a lateral valley, and thus, by the débris it would bring down and deposit at its mouth, would tend to fill up the main valley to the level of the line. This is very markedly the case with the pass of Maccoul and that of Glen Glaister. It may also be noted that such coincidences of the lines with hollows between the hills are seen in other places. Such is that already mentioned of the coincidence of the upper line with the level of Loch Ericht and the watershed between the basins of the Spey and the Tay.

But it must be remembered also that difficulties do not affect only this theory. Perhaps the combination of the various conditions needed to shut and open the lake-barriers exactly at the right time and in the proper order are not more probable. If these lake-barriers were formed of detritus, its collection and sudden removal is no less inexplicable. Ice-barriers may seem more manageable, but are subject to no less inexorable conditions of climate and elevation. A glacier that would fill the valley of the Spean and Roy with a mass of ice 800 or 1000 feet thick, and some miles in extent, would require an extent of feeding-ground that is not easily found in this region. I have never heard of a lake of such depth shut in by ice in any part of the earth at the present time. To form an embankment for a water reservoir of one-fourth the depth and one-tenth the extent of the supposed Glen-Roy lakes, with the best materials he can select, is no mean task for an engineer of the present day. What would he think of the task were he required to build the barrier of a material of less specific gravity than the water to be shut in, of a material which that water and the ground on which it rests were constantly corroding and wasting away, so that his barrier had to be incessantly moving forward from behind to compensate for what it lost in front? To form a permanent lake with a uniform level on such conditions has, I must confess, always appeared to me an almost impossible problem, far outweighing any difficulties that attach to the marine theory.

But all such considerations may be laid aside. The chief and fatal objection to the lake-theory is that it supposes rivers to have flowed in places where there is clear proof that no river has ever flowed,—that it assumes a great lake to have been suddenly drained by a narrow glen where it is undoubted no stream of water, larger or more rapid than the tiny rill gathered from the sides of the neighbouring mountain, has ever existed since the ocean laid down the loose soil spread over its smooth unbroken declivities. The theory not only fails to explain the phenomena, but is in direct contradiction to them, and therefore must be rejected.

Discussion.

Mr. Gwyn Jeffreys observed that no organic remains appear to have been found in these beaches, so as to prove their marine origin.

Mr. Evans agreed with the author as to the difficulties presented by the Lake theory in accounting for the terraces, especially those not in Glen Roy itself, but in the valley of the Spean. He called attention to the part which sheep and other animals had played in the preservation of the Parallel Roads, the vegetation on which, in consequence of their being more frequented by the animals, was of a different character from that on the other parts of the slope.

Mr. H. M. Jenkins objected to the supposition of the sudden alteration in the level of the water adopted by the author. He thought the gradual sinking of the water was quite compatible with the formation of the roads. He instanced the formation of terraces in gravel-pits filled with water.

Sir H. James announced that the Ordnance survey of the district in question was now complete.