

Geological Society of London, History of Geology Group

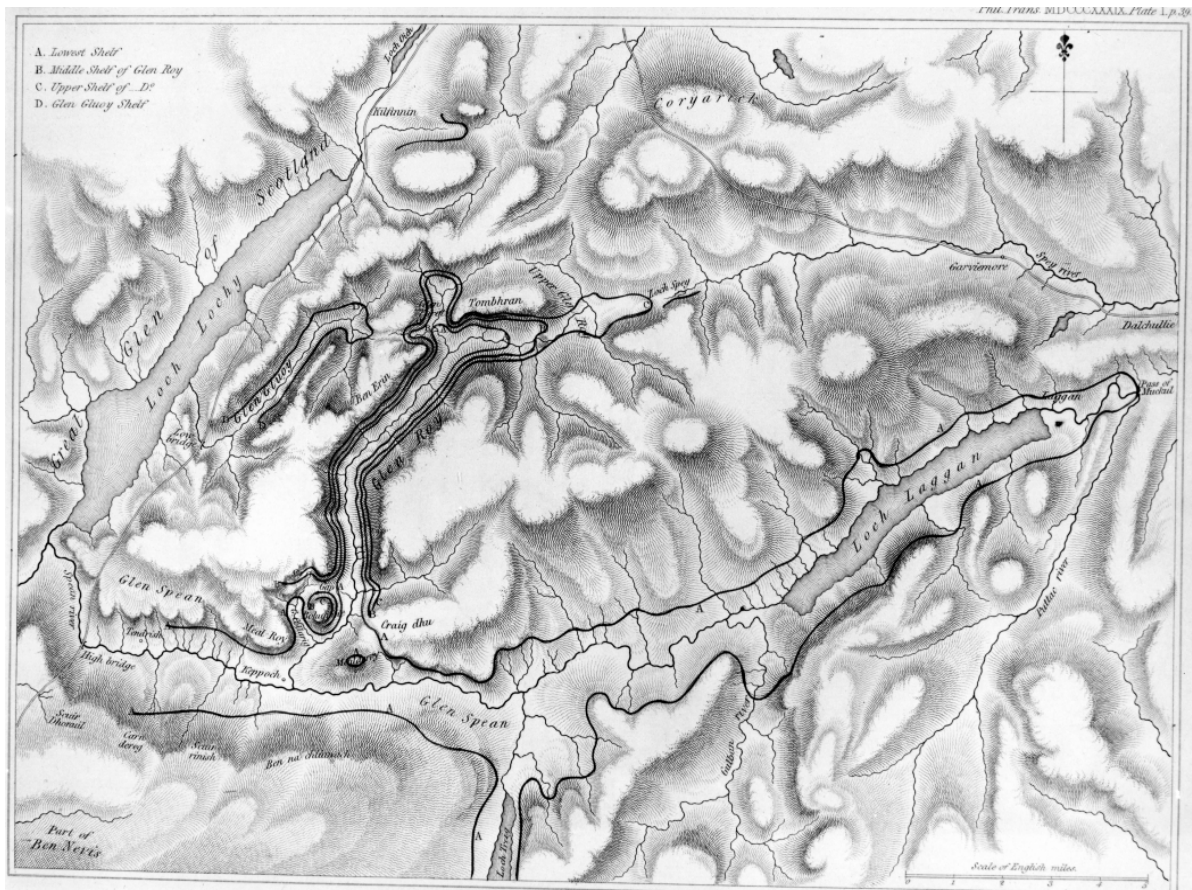
THE PARALLEL ROADS OF GLEN ROY: IN THE FOOTSTEPS OF CHARLES DARWIN

A FIELD GUIDE

by

Martin Rudwick

Based on the Guide prepared for the field trip in Lochaber (Scotland), 26-29 June 2009, led by Martin Rudwick (University of Cambridge) and Adrian Palmer (Royal Holloway, University of London), to mark the bicentenary of the birth of Charles Darwin; and revised to make it usable by anyone wishing to follow our itinerary on their own.



Darwin's paper 1839: map of the "Roads" in Lochaber
(the Roads were largely copied from Lauder's paper [1821] but on a better base map).

INTRODUCTION

“I must premise once for all, that this minuteness of description, however superfluous it may at first sight appear, is absolutely required, as the circumstances thus dwelt on will be of essential use in investigating the cause of the appearances under discussion. It is by an attention to circumstances which at first glance appear trivial, that abstruse truths are often discovered.”

John MacCulloch, “Parallel Roads”, 1817



Darwin’s paper 1839: View up Glen Roy from above “Viewpoint” with the three horizontal “Parallel Roads”, drawn from the lowest Road R3 (note its alignment on both sides of the valley).

Darwin returned from the *Beagle* voyage identifying himself as a *geologist*, and was accepted as such by the leaders of the Geological Society in London. His papers to the Society interpreted what he had seen in terms of a global tectonic theory modelled on that of his older mentor Charles Lyell. The most substantial piece of *fieldwork* that Darwin undertook after his return was designed to strengthen this theory by harnessing in its support a well-known but extremely puzzling geological feature, the “Parallel Roads” in Glen Roy and adjacent valleys in the Lochaber region of the Scottish Highlands. This fieldwork (1838) led to Darwin’s first substantial published scientific paper (1839), which helped earn him his FRS. But soon afterwards Louis Agassiz proposed an alternative explanation of the “Roads”, in terms of vanished glaciers, which implied that Darwin’s might be radically mistaken. Yet Darwin clung to his interpretation for about twenty years, in the face of mounting evidence in favour of the alternative, and only abandoned it with great reluctance, eventually conceding that it had been “a great failure” and “one long gigantic blunder”. Yet even the “blunder” of an outstanding scientist can throw instructive light on the relation between observation and interpretation, and also perhaps – in Darwin’s case – between his public theorising about global tectonics and his concurrent private theorising about speciation.

DRAMATIS PERSONAE [CAST LIST]

some major figures in the Glen Roy debates, in order of birth-year

John **MacCULLOCH** (1773-1835), Scottish geologist based in London; did extensive fieldwork in Scotland; in Lochaber in 1815; his paper on Roads read at Geological Society 1817, published in *Transactions of the Geological Society* 1817.

(Sir) Thomas Dick **LAUDER** [or Lauder **DICK**] (1784-1848), Scottish country gentleman (baronet from 1820), historical novelist, amateur geologist; did fieldwork in Lochaber 1816 and 1817; his paper on Roads read at Royal Society of Edinburgh 1817-18, published in *Transactions of the Royal Society of Edinburgh* 1821.

William **BUCKLAND** (1784-1856), English geologist based at Oxford, prominent from 1819 as a “diluvial” theorist; studied Alpine glaciers 1838; did fieldwork in the Highlands (including Lochaber) with Agassiz in 1840, and was converted to the glacial theory as applied to Britain.

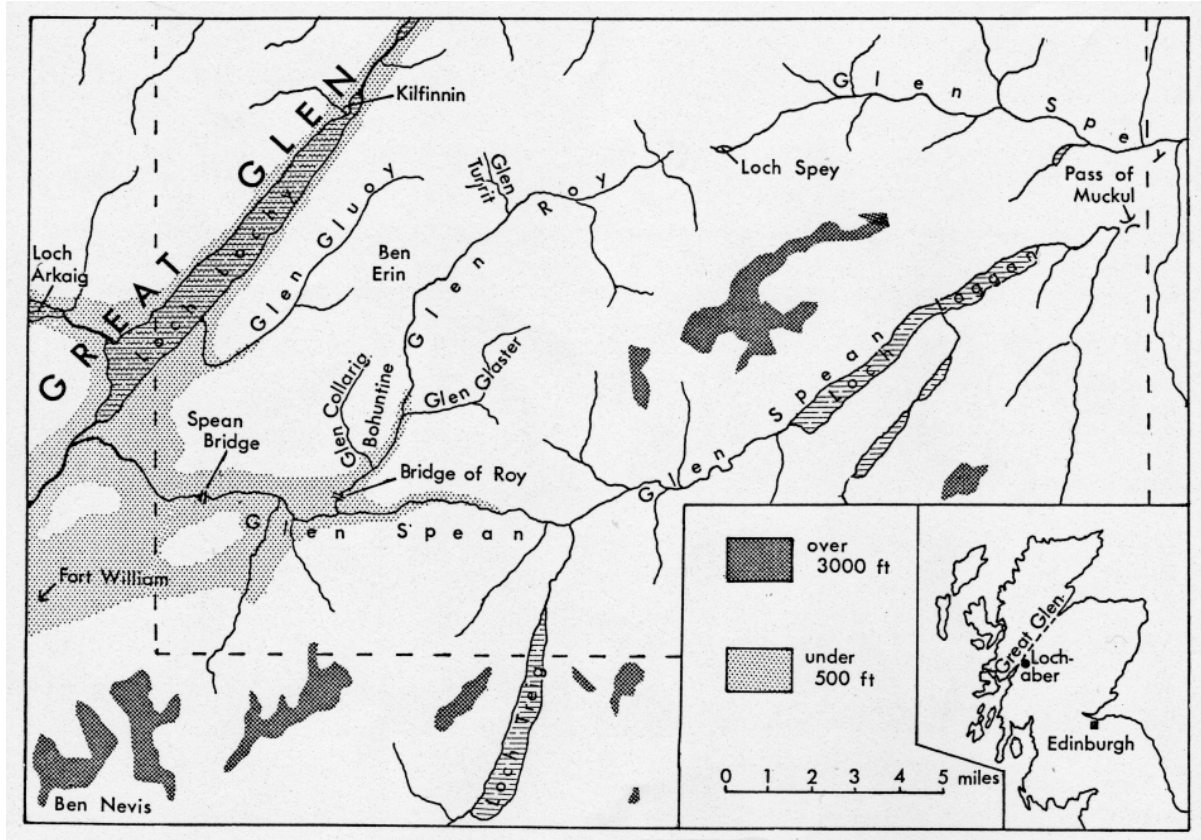
Charles **LYELL** (1797-1875), Anglo-Scottish geologist based in London; author of *Principles of Geology* (first ed. 1830-33), rejecting any diluvial theory; was converted to Agassiz’s glacial theory after fieldwork in Forfarshire in 1840, but soon retreated to a weaker version.

David **MILNE** [later, Milne **HUME**] (1805-1890), Scottish country gentleman, lawyer, amateur geologist; did fieldwork in Lochaber 1845 and 1846, his paper read at Royal Society of Edinburgh and published in its *Transactions* 1847.

Louis **AGASSIZ** (1807-1873), Swiss naturalist based at Neuchâtel; expert on fossil fish; proposed geologically recent “Ice Age” [a Pleistocene “Snowball Earth”] Neuchâtel 1837, and expounded it at Geological Society (London) and British Association (in Glasgow) 1840; fieldwork in Highlands (including Lochaber) with Buckland 1840; papers read at Geological Society and elsewhere, from 1840, applying glacial theory to Britain.

Charles **DARWIN** (1809-1882), English geologist; unofficial naturalist on *Beagle* 1831-36; based in London 1837-42, thereafter in Kent; papers on South America and global tectonic theory read at Geological Society 1837-38 [compiled private notebooks on speciation and “Man” 1837-39]; did fieldwork in Lochaber 1838, his paper on Roads read at Royal Society (London) 1839, published in *Philosophical Transactions of the Royal Society* 1839; [his species theory first sketched privately 1842, published as *On the Origin of Species* 1859].

Thomas **JAMIESON** (1829-1913), Scottish agricultural scientist, amateur geologist; did fieldwork in Lochaber (suggested by Lyell and Darwin) 1861 and 1862; his paper on Roads read at Geological Society 1863, published in *Quarterly Journal of the Geological Society* 1863.



Outline topographical map of Lochaber (from Rudwick 1974/2005)
with 19th-century anglicised place names
[the smaller rectangle defines the area of the interpretative maps, below].

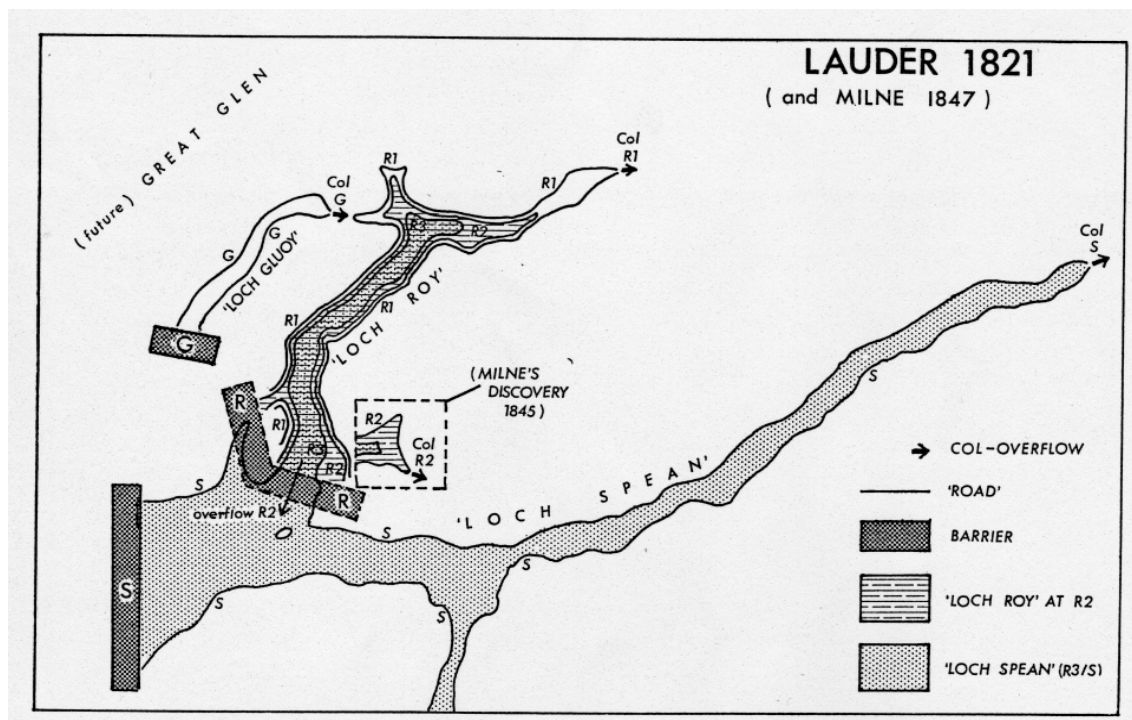
A BRIEF HISTORY OF THE PROBLEM

In the 18th century the “Parallel Roads of Glen Roy” became a celebrated feature of the remote Lochaber region; they were called “Roads” because they were initially thought to be ancient human constructions; but by the early 19th century most visitors agreed that they must be natural in origin. In Glen Roy itself there are three narrow horizontal terraces, high up on both steep sides of the valley; the lowest terrace extends out into Glen Spean and up into Glen Treig. There is also one terrace high up in Glen Gloy to the west of Glen Roy.

MacCULLOCH and **LAUDER** visited Lochaber independently around the same time (1815-17), surveyed the Roads in detail, and came to similar conclusions. Both interpreted the Roads as **lake beaches** formed at some remote time when Glen Roy and some adjacent valleys were filled with freshwater lakes at three or four successively lower levels. But this generated the problem of explaining the absence of any obvious trace of the barriers that must have impounded these lakes, most probably situated where the Roads faded away at the mouths of the valleys. **MacCulloch** considered briefly the alternative possibility that the

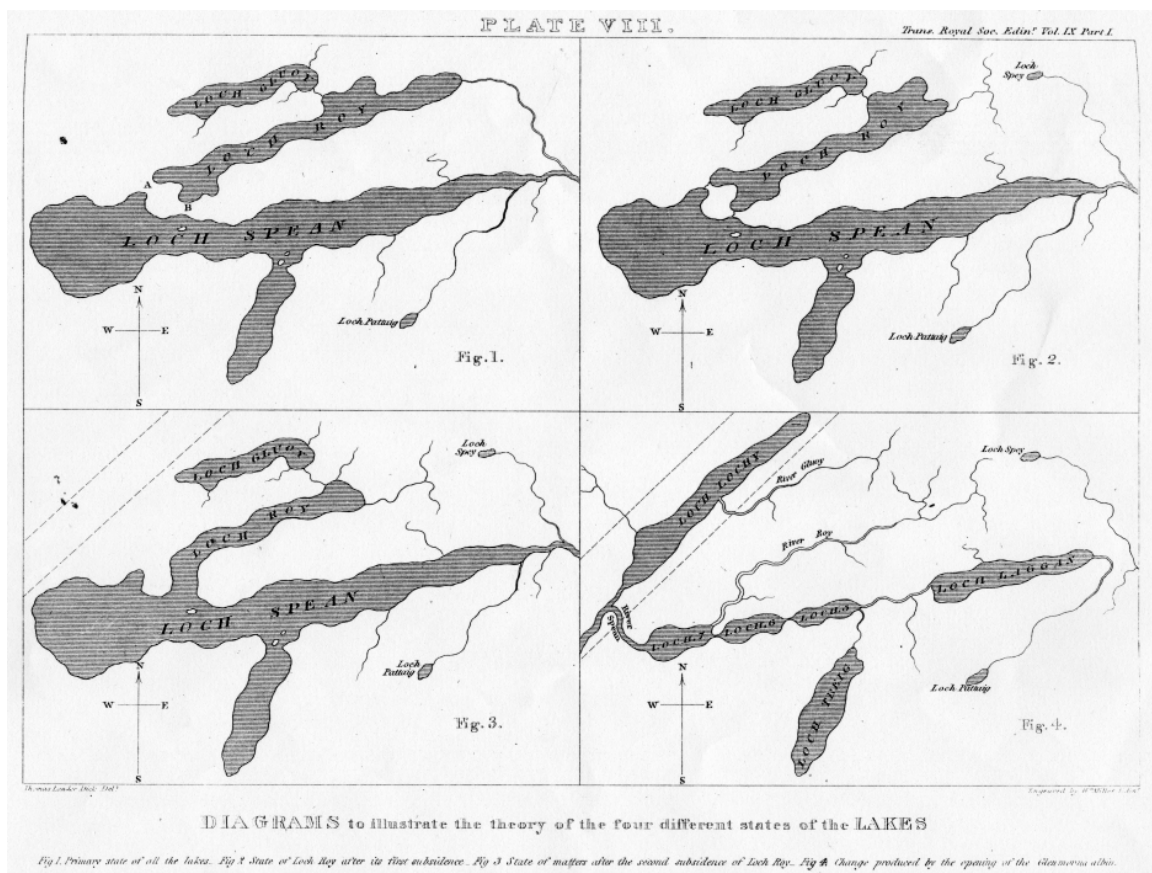
Roads were sea beaches, dating from a time of much higher sea level; but he rejected it because the Roads were confined to these specific valleys, and because there was no trace of marine debris such as sea shells anywhere on the terraces.

Lauder proposed an interpretation similar to MacCulloch's, but improved it on three important points, thanks to more accurate levelling by his surveyor. This survey showed, first, that the one and only definite Road in Glen Gloy ("Road G" in my nomenclature) is exactly level with the pass or col ("Col G") at its head; this could therefore have been the outlet of a putative "Loch Gloy", overflowing into the adjacent Glen Roy, where the highest of three Roads ("Road R1") is slightly but distinctly lower (rather than being at the same level as Road G, as MacCulloch thought). Second, that this Road R1 in turn is on a level with the pass or col ("Col R1") at the head of Glen Roy, which therefore could have been an outlet for a former "Loch Roy", overflowing into Glen Spey to the east (MacCulloch had thought it was higher than the col). Third, that the lowest of the three Roads in Glen Roy ("Road R3") - which unlike the others extends out into the much larger Glen Spean (as "Road S") - is on a level with the Pass of Muckul ("Col S") at the head of that valley, which could have been the overflow of a large "Loch Spean". This left the middle Road ("R2") of the three in Glen Roy as an anomaly, since there seemed to be no col that could have acted as an overflow while "Loch Roy" was at that intermediate level. Lauder therefore had to infer that its overflow at that stage was across the vanished barrier at the mouth of Glen Roy, although he (like MacCulloch) inferred that this must have been composed of loose gravelly material subsequently washed away, and was unlikely to have remained at exactly the same level long enough for a terrace to be formed as in the other cases.



Map to illustrate Lauder's lake theory (from Rudwick 1974/2005)
(and also its improvement by Milne in 1847).

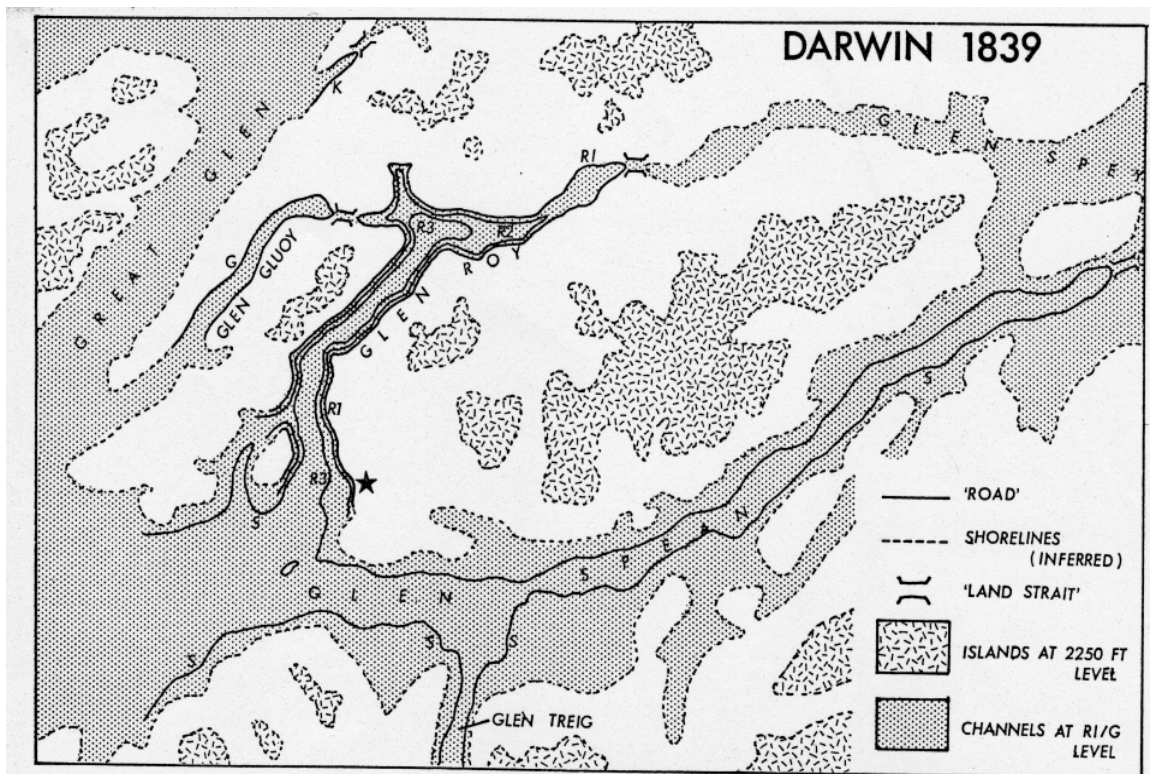
MacCulloch's and Lauder's **LAKE THEORY** was accepted by most other geologists at the time, and in subsequent years, as the best explanation available, despite the unresolved puzzle of the vanished lake barriers. Neither author was cramped for geological time: the whole sequence of lakes in Lochaber was tacitly assumed to have been extremely remote and probably pre-human, although very recent in terms of total Earth-history. And both authors were as actualistic (“the present is the key to the past”) in their reasoning as they could be, citing analogous cases of former beaches above various modern lakes. Lauder invoked a “catastrophe” only where he thought there was no alternative: he explained the final disappearance of the huge putative barrier at the mouth of Glen Spean as possibly the result of a sudden opening-up of the Great Glen beyond it (to the north-west).



Lauder's paper 1821: Reconstructions of lakes at four successive periods:
1 , at R1 level; **2** , at R2 level; **3** , at R3/S level;
4 , after “catastrophic” opening of Great Glen
 (at which point three small lakes remained in Glen Spean, since filled in).

Two decades later, in 1838, **DARWIN** interrupted the most creative phase of his private theorising about speciation in order to visit Lochaber, because he regarded its Roads as valuable potential evidence for his global tectonic theory - inspired by Lyell's - of crustal plates slowly oscillating up and down in a perpetually balanced steady state (which in turn was an important substrate for Darwin's theorising at this time about speciation). With the

terraces he had seen at Coquimbo in Chile as a relevant analogue, he hoped to prove that Scotland was part of a slowly but intermittently *rising* crustal plate like South America (his famous explanation of Indo-Pacific coral reefs and atolls made them corresponding indicators of slowly *subsiding* plates). This entailed adopting the **MARINE THEORY** that MacCulloch had considered but rejected. Darwin's manuscript agenda, written after he studied MacCulloch's and Lauder's papers but before his own visit to Lochaber, proves that he intended to look specifically for evidence that the Roads were indeed **sea beaches** and that their localised distribution could be "explained away" in terms of differential preservation. In the field, he duly convinced himself, although he failed to find any marine debris at all, and had to re-interpret Lauder's overflow cols as "*land-straits*" and explain them away as mere "coincidences" of level. He wrote up his work as his first major scientific paper, and gave it – such was its importance to him – not to the Geological but to the Royal Society (1839).

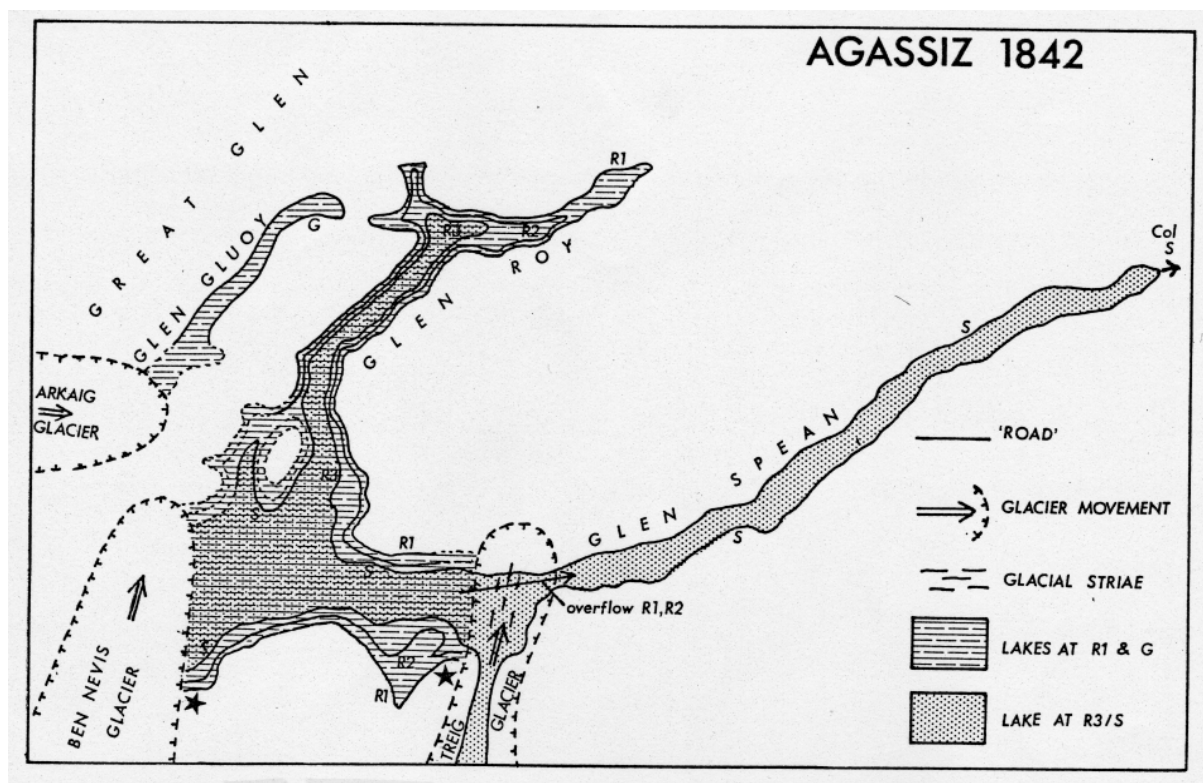


Map to illustrate Darwin's marine theory (from Rudwick 1974/2005)

This illustrates the former topography of islands, channels and fiords that he reconstructed (1) for an early phase in the uplift of the crust, when icebergs drifting among scattered islands might have deposited the highest of the erratic blocks now found on some of the hills; and (2) for a later phase when the sea was confined to a network of channels which, he thought, would have been like the Beagle Channel and others around Tierra del Fuego.

The following year **AGASSIZ**, while visiting Britain primarily for his research on fossil fish, expounded his sensational "Ice Age" theory in London and Glasgow (in outline it was already well known to British geologists, including Darwin). He argued that in the final

waning phase of this geologically recent “Snowball-Earth” episode there would have been extensive valley glaciers in many upland regions. Agassiz and Buckland (the latter a new convert to Agassiz’s Ice Age theory) then toured the Highlands and duly found widespread glacial traces (scratched bedrock [*striae*], moraines, erratic blocks etc). A brief visit to Lochaber convinced them that the Roads were traces of successive levels of a **glacial lake** impounded by glaciers, like ones that had been, or would be, produced by analogous extensions of present Alpine glaciers (the actualistic method again, as usual). This **GLACIAL THEORY** of the Roads purported to solve both the puzzle of the vanished barriers on the (non-glacial) lake theory – they had left no trace because they had simply melted away - and also the curiously limited extent of the Roads, which was such a puzzle on the marine theory.



Map to illustrate Agassiz’s glacial theory (from Rudwick 1974/2005)

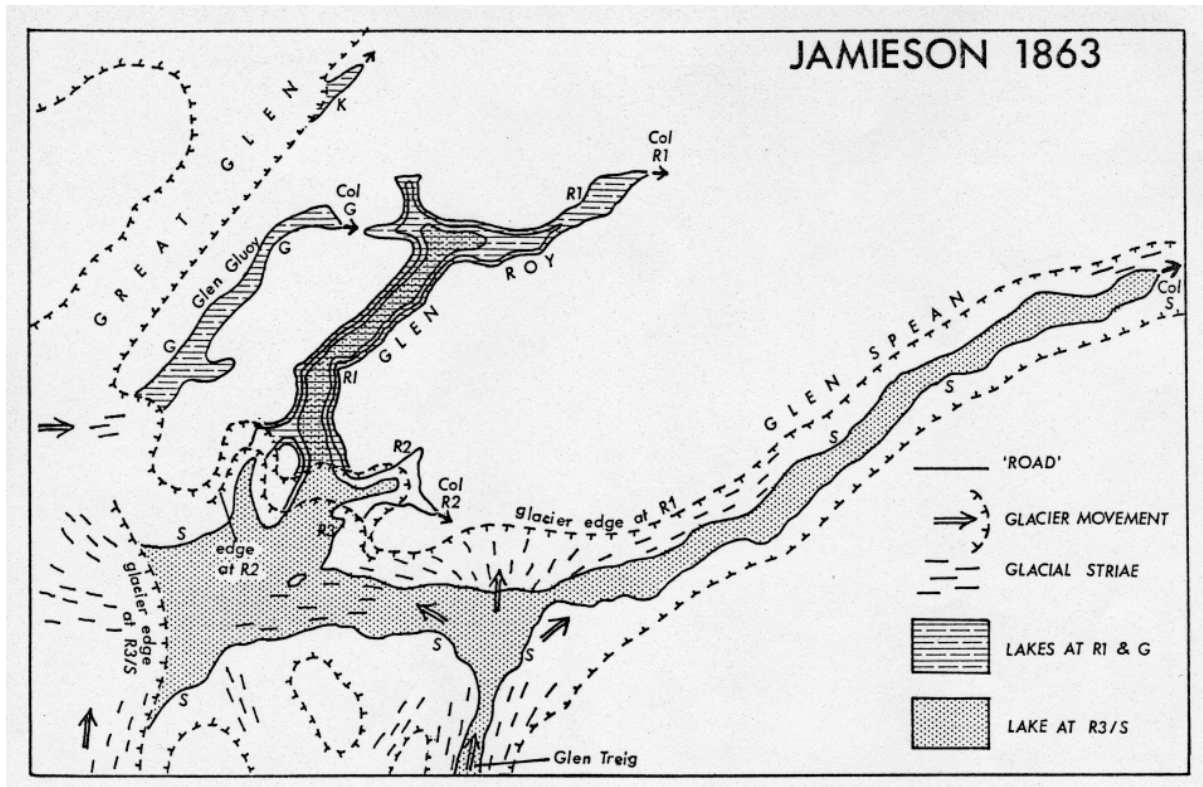
This reconstruction required that the upper Roads in Glen Roy should extend on to the south side of Glen Spean (between the asterisks), where no one else had reported seeing them (see, above, the map for Lauder’s interpretation).

But Agassiz’s full-blown (Snowball-Earth) Ice Age theory had been rejected outright – and with good reason - by most geologists other than Buckland, and even its more limited version (of vanished upland valley glaciers) was therefore treated with caution. In Lochaber, specifically, Agassiz’s reconstruction of two glaciers acting as lake dams implied a distribution of Roads that did not match what others had seen on the spot. So the (non-

glacial) lake theory, and Darwin's marine theory, each continued to enjoy some support among geologists; both were seen to have defects, but they seemed rather evenly matched.

A few years later, in 1845, **MILNE** visited Lochaber, convinced beforehand that Darwin's marine theory was correct and the (non-glacial) lake theory untenable; he was also unconvinced by the glacial interpretation, arguing that some of Agassiz's putative moraines were in fact relics of former barriers of loose gravelly material. However, in the field Milne changed his mind, and then (1847) published an improved version of Lauder's lake theory (see the map, above, for Lauder's theory). Most importantly, he resolved its major anomaly, by discovering a previously unnoticed pass or col ("Col R2") on the level of Road R2 in Glen Roy, and clear evidence that it had indeed been an overflow from "Loch Roy" into "Loch Spean" at that phase. He also confirmed Lauder's interpretation of the Pass of Muckul (Col S) as the overflow channel from "Loch Spean" into Glen Spey to the east, with evidence that was inexplicable on Darwin's marine theory.

The coup-de-grace for Darwin's theory (and also for that of non-glacial lakes) came a decade and a half later, in 1861, when **JAMIESON** applied to Lochaber the much improved understanding of glacial flow (that ice *en masse* acts as a viscous fluid) that Alpine geologists had meanwhile been developing. He made a new and more thorough survey of the Roads and other features, particularly scratched bedrock surfaces, moraines and erratics, which enabled him to reconstruct former glaciers that could have dammed the vanished "Loch Gloy", "Loch Roy" and "Loch Spean" in a complex sequence of phases that accounted for all classes of evidence: Roads, overflow cols, scratched bedrock, moraines etc (1863). Darwin then abandoned his marine explanation, though with great reluctance. But by this time his species theory had long overtaken his global tectonic theory as the focus of his research, and anyway the former no longer required the biogeographical model that had in part motivated the latter.



Map to illustrate Jamieson's improved glacial theory (from Rudwick 1974/2005).

Subsequent research in Lochaber, in the rest of the 19th century and through the 20th into the 21st, has elaborated Jamieson's sequence, reconstructed it with much greater precision, and set it in a wider context of Pleistocene glaciations, both locally and globally. But this research was, and still is, based on what was so fruitfully observed, sketched, mapped and argued about in the half-century stretching from Jamieson's fieldwork back to Lauder's and MacCulloch's. Darwin was surely too self-critical when in retrospect he condemned his own contribution as “a great failure” and “one long gigantic blunder”. Even if he got his fingers burnt, it was invaluable training in how to observe in the field and how to reason about his observations; and even, perhaps, a useful dry run for *On the Origin of Species*. His error, if it was one, was to have been over-committed to his tectonic theory, and to have rejected the lake theory on inadequate grounds, even before the glacial theory introduced a new range of possibilities into the puzzle. The episode as a whole is a neat illustration of a widespread pattern in scientific argument. Of two incompatible initial alternatives - the lake and marine theories for the Roads – the first was progressively improved by further fieldwork and its anomalies resolved, whereas the second was reduced to explaining *away* its anomalies. In the end, the first was decisively improved and indeed transformed by the introduction of a new explanatory resource (glacial action) unforeseen on either of the earlier theories.

ITINERARY, AND PRIMARY SOURCES

The field trip in 2009 was based at Spean Bridge (about 10 miles northeast of Fort William), where plenty of accommodation is available, and which is accessible by rail from Glasgow or by road via Stirling and Crianlarich or via Perth and Dalwhinnie. Large vehicles such as coaches are forbidden in Glen Roy and impracticable on other narrow lanes. The itinerary described below involves, at some points, climbing steep hillsides and walking over rough and/or boggy ground; stout footwear is essential, as is clothing suitable for the often unsettled Highland weather. In the summer months, protection against the notorious Highland midges is also essential. In the itinerary that follows, grid references can be located on Ordnance Survey “Explorer” (1:25000) maps 392, 393, 400 and 401. In the quotations from primary sources, significant place names are highlighted in **bold**, to aid their use in the field; editorial notes are within [square brackets]; the original authors' own later insertions are in <angled brackets>. Field directions are given in *italics*.

BEFORE ARRIVAL IN LOCHABER

Lyell, *Principles of Geology*, 1833 [1st ed. read by Darwin in South America; reprinted unchanged though 5th ed., 1837]:

“*Parallel Roads of Coquimbo* [Chile]. . . . These [three] roads, or shelves, occur in a valley six or seven miles long, which descends from the Andes to the Pacific. . . . Each resembles a shingle beach, being formed entirely of loose materials, principally water-worn rounded stones. . .

. . . The theory proposed by Captain [Basil] Hall [son of Hutton's friend James Hall] to explain these appearances is the same as that which had been adopted to account for the analogous parallel roads of Glen Roy in Scotland [references here to MacCulloch's and Lauder's papers, and to Hall's *Travels* (1829)]. . . . As I did not feel satisfied with this explanation, I applied to my friend Captain Hall for additional details, and he immediately sent me his original manuscript notes, requesting me to make free use of them. In them I find the following interesting passage, omitted from his printed account:

The valley is completely open towards the sea; if the roads, therefore, are the beaches of an ancient lake, it is difficult to imagine a catastrophe sufficiently violent to carry away the barrier, which should not at the same time obliterate all traces of the beaches. I find it difficult also to account for the water-worn character of all the stones. . . . They are in immense quantity too, and *seem more properly to belong to the ocean*.

I had entertained a strong suspicion, before reading these notes, that the beaches were formed by the waves of the Pacific, and not by the waters of any lake; in other words, that they bear testimony to the successive rise of the land, not to the repeated fall of the waters of a lake."

If travelling to Lochaber by road on the A84/A85 from Stirling and the South, stop at the roadside after passing Loch Dochart (on right), about 2 miles before Crianlarich, to view a "terrace" high up on the left (south), which Darwin interpreted as a probably marine beach. This was his first field note relevant to the Parallel Roads problem, and shows that in advance he was applying the marine interpretation he had adopted for the Coquimbo Roads.

Darwin's notebook 1838 [notes en route to Lochaber]

"On side of hill South of upper end of **Loch Dochart** [near **Crianlarich**], buttresses of Alluvium . . . [forming] vestige of irregular terrace perhaps 300 ft above Loch . . . Rivers could not have deposited it. Barrier of lake very lofty, & no trace of it; to the Sea more probable. I did not look carefully for Marine remains."

After driving over Rannoch Moor and down Glencoe on the A82, at the roundabout just before the road bridge over Loch Leven, deviate on the A828 (towards Oban), pass under the bridge and park just beyond, to view the terraces (raised beaches) on the far side of this sea-loch or fiord. Darwin's field note shows him grappling with the problem of the local non-preservation of such marine terracing.

"[In **Glencoe** and near **Fort William** are] two terraces perhaps upper one 100 ft & other one 40 [ft above sea level] - traces of them all along Glencoe - towards Fort William yet in Glencoe in parts no trace of them - Mem. [i.e. recall] Coast of Chile - ?is not Mica Slate too hard & uneven to be impressed [i.e. eroded into a incised terrace]."

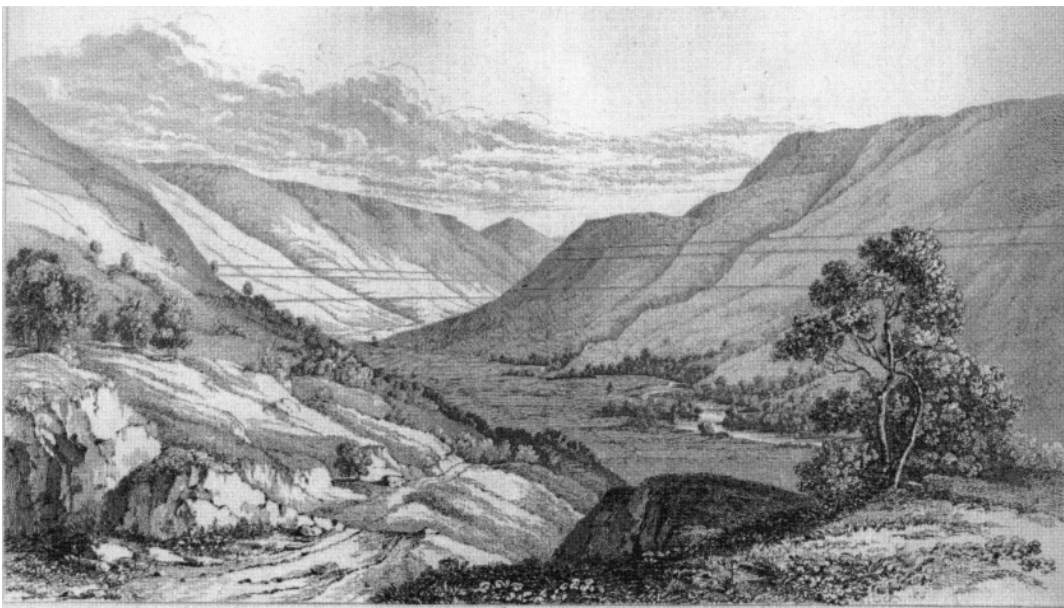
If travelling to Lochaber by rail, note the striking scenery as the train climbs over Rannoch Moor and then descends into Glen Treig and along the shore of Loch Treig [see Day Two below], which Jamieson identified as the site of a major glacier.

DAY ONE

From Spean Bridge, drive east on A86 to Roybridge, then turn left up the lane into Glen Roy; park at “Viewpoint” [298853] on the east flank of Bohuntine Hill. (An information plaque in the parking area gives a good brief summary of the modern interpretation of the Roads as glacial-lake shorelines.)

LOWER GLEN ROY: BOHUNTINE

Looking up Glen Roy, view the classic panorama of three Roads on each side of the valley. Note how your altitude in relation to them can be checked by their alignment (or non-alignment) on the spurs. Compare MacCulloch’s picture with Darwin’s closely similar one: in some important respects the “facts” of the Glen Roy puzzle were not in contention. Note the striking uniformity of the three Roads, although formed – on Darwin’s interpretation – at vastly different times, as the Highlands crustal block rose slowly and intermittently.



MacCulloch’s paper 1817: View up Glen Roy (accurate but for the conventional vertical exaggeration): this drawing was made – judging by the non-alignment of the Roads - from the “Viewpoint” on the flank of Bohuntine hill, *below* the lowest Road R3.

Darwin's Agenda 1838 [before travelling to Lochaber]

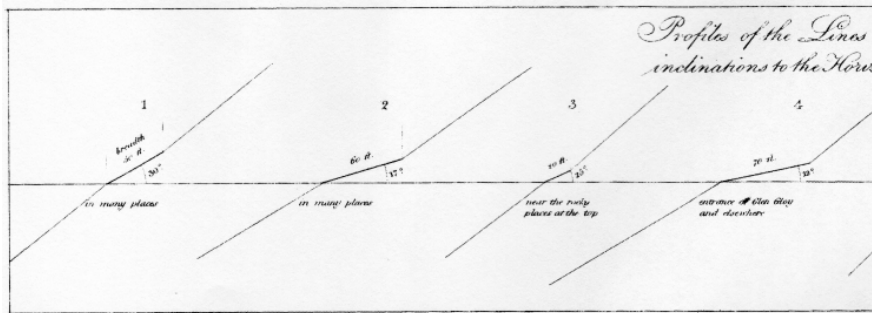
“11th. The relative preservation of the shelves [i.e. in proportion to their putative ages]. . .

15. Form of valleys of **Glen Roy** and **Glouy**, and of Hill of **Bohuntine**.”

Darwin to Lyell 9 August [1838] [shortly after returning from his field trip]

“Here [in Lochaber] I enjoyed five days of the most beautiful weather, with gorgeous sunsets, & all nature looking as happy, as I felt. . . It is far the most remarkable area I ever examined.”

Climb westwards, up the east flank of Bohuntine Hill, **to Road R3** (check by its alignment with R3 further up the valley). Looking south, note its profile seen against the distant hills, with a gentle outward slope of the terrace itself and perhaps a slight steepening above and below it (due, respectively, to erosion and deposition of the loose rubbly material – not rounded cobbles - exposed here and there). Is this like the shore of a present-day Highland lake, or like a sea shore with tidal action?



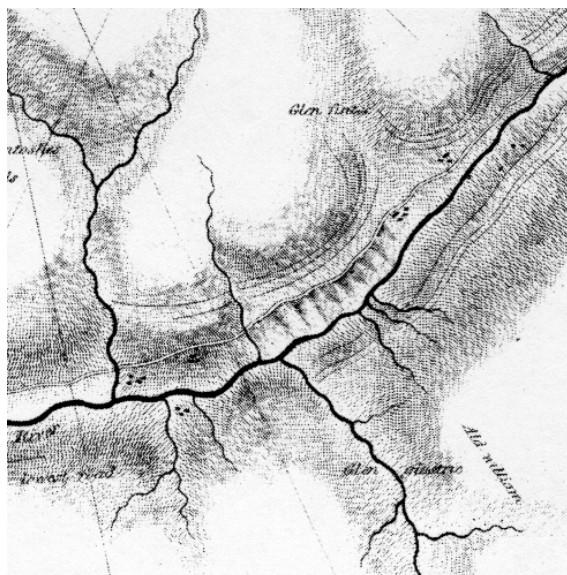
MacCulloch's paper 1817: typical measured profiles of Roads as terraces sloping outwards.

Darwin's Agenda 1838 [before travelling to Lochaber]

"1st. Nature of shelves. with respect to foundation [i.e. solid bedrock or loose materials]."

Climb to Road R2 (here marked distinctively, in summer months, as a terrace of heather flanked by hillsides of bracken). Check its alignment with R2 further up the valley. **Walk south** (left) along it for about 300m, to a point where it is quite broad; but view its profile further on, visible against the edge of a conifer plantation, where it has become ill-defined; all authors agreed that it disappears completely, a little further round the flank of Bohuntine.

Look directly across Glen Roy. Roads R1 and R2 can be seen on the opposite hillside, and each makes a clear nick against the edge of the large conifer plantation to the right (R3 is much lower). Further to the right is Glen Glaster, extending away from Glen Roy. On the skyline is Col R2, clearly on about the same level as Road R2. Why did Lauder and Darwin fail to see this pass, which was only "discovered" later by Milne? (Darwin reported enjoying fine weather, so it was presumably not concealed by low cloud).



MacCulloch's paper 1817

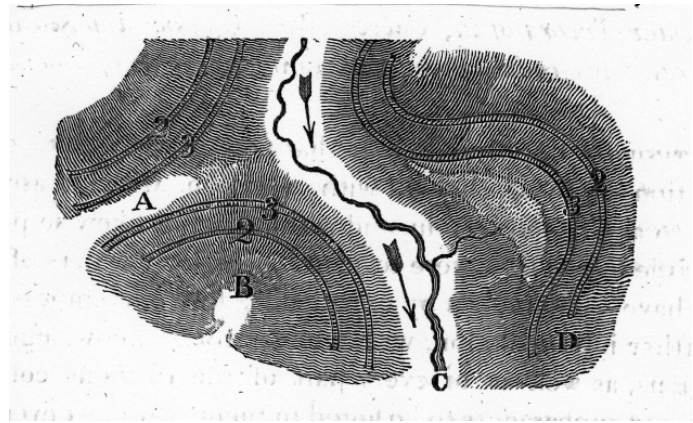
Map (detail) of Roads in lower Glen Roy; Bohuntine is the rounded spur in the middle; Glen Glaster is lower right [north is in the top-right direction].

"The three *lines* [Roads R1, R2, R3] continue [down the east flank of Glen Roy] as far as **Glen Glastric**, on the north side of which they turn up for a short space, and then disappear [i.e. they do *not* extend far up into Glen Glaster]."

Lauder's paper 1821

enlarged map of Roads 2 [R1] and 3 [R2] on Bohuntine Hill [B] and foot of Glen Glaster (right). (Lauder omitted the lowest Road [R3] for clarity.)

Glen Glaster was *seen* only as a shallow embayment or “amphitheatre”, not as a long side-valley: see quotation below, and his general map of the area.



“Shelf 2d [Road R1] and Shelf 3d [Road R2], being both of elevation superior to that of the bottom of the high plain [**Glen Glaster**], naturally bend away from Glen Roy . . . and winding round the amphitheatre of hills, and returning with them again, all traces of Shelf 2d [Road R1] are suddenly lost, nearly opposite to the point where it begins on the south-east side of the hill of **Bohuntine** [B]. Shelf 3d [Road R2] runs on a little farther, to the rocky angle of **Craig-dhu** [D], where it likewise is abruptly terminated, also opposite to the spot where it is first observed on the hill of Bohuntine.”

Darwin's paper 1839

“These cases [of Roads on same levels as Cols or “land-straits”] are so remarkable, that the coincidence of level must be intimately connected with the origin of the shelves; although such relation is not absolutely necessary, in as much as the middle shelf of Glen Roy [Road R2] is not on a level with any watershed.” [Note that Darwin's map (title-page of this Guide) depicted the Roads in Glen Glaster – incongruously - much like Lauder's, although his base map shows Glen Glaster more accurately as a long and deep side valley.]

Darwin to Lyell [9 March 1841] [after Agassiz proposed his glacial-lake interpretation]

“But how [on Agassiz's theory] was the Glen Roy lake drained when the water stood at level of the middle ‘road’ [R2]? it must (for there is no other exit whatever [i.e. no Col R2]) have been drained over the glacier. Now this shelf is full as narrow in a vertical line & as deeply worn horizontally into mountain-side, and with as large accumulations of shingle, (I can give cases) as the other shelves [R1, R3]. We must, therefore, on Glacier theory suppose, that the surface of the ice remained at exactly the same level, not being worn down by the running water, or the glacier moved by its own movement, during the very long period, absolutely necessary for a quiet lake to form such a beach, as this shelf presents in its whole course.”

Milne's paper 1847

“The discovery that I made, was its [Road R2's] exact coincidence with a water-shed [Col R2] at the head of **Glen Glaster**, a glen which, though branching up from Glen Roy near the bottom of it [i.e. the lower end of the valley], oddly enough does not appear to have been visited, and certainly not to have been described, by any former observer.” [See also Day Two, Upper Glean Spean: Loch Laggan.]

Darwin's paper 1839

"I paid particular attention to the following observation, namely, that on both sides of the hill of **Bohuntine**, and on the opposed mountains, where the shelves terminate, there was not the smallest change in the composition or in the outline of the smooth rounded surfaces. Yet it is in this very spot, where the lines insensibly disappear . . . [and] where there is not a remnant of any projecting mass, that we are compelled by the [lake] theory to believe that the two enormous barriers stood, which formed Glen Roy into the imaginary Lake Roy.

...

This shelf [Road R3] passes uninterruptedly, and with its usual breadth, on both sides of Glen Roy and **Glen Collarig** [see below], in the very part where the barriers of Loch Roy, if they existed, *must* have crossed the valley . . . [yet] no trace of them is left on the smooth slope of the hill. . . In conclusion, therefore, I do not hesitate to affirm, that more convincing proofs of the non-existence of the imaginary Lake Roy could scarcely have been invented, with full play given to the imagination, than those which are marked in legible characters [*sic*] on the face of these hills."

Darwin to Lyell 8 [September 1847]

"Now I do not believe in the ice-lake theory [i.e. Agassiz's], from the following weak, but accumulated reasons . . . [*inter alia*] the very gradual dying away of the terraces at the mouth of Glen Roy, does not look like a barrier of any kind . . . [and] I shd have expected great terminal moraines across the mouth of Glen Roy, Glen Collarig & Glastig, at least at the bottoms of the valleys; such I feel pretty sure do not exist."

Darwin to Scotsman [September] 1847 [not published]

"The middle shelf [Road R2] of Glen Roy, extends further than the upper one [Road R1] at the mouth both of this Glen & of Glen Collarig, & both shelves at their terminal points die away in the most insensible manner: this further extension of the middle shelf agrees well with the theory of a retreating glacier, & the very gradual dying away of the extremities of both shelves, which always struck me as most remarkable & opposed to the former existence of any barrier, might be explained, as was suggested to me by Mr Lyell . . . by the lake having been generally frozen near the great icy barrier, littoral action having been thus prevented."

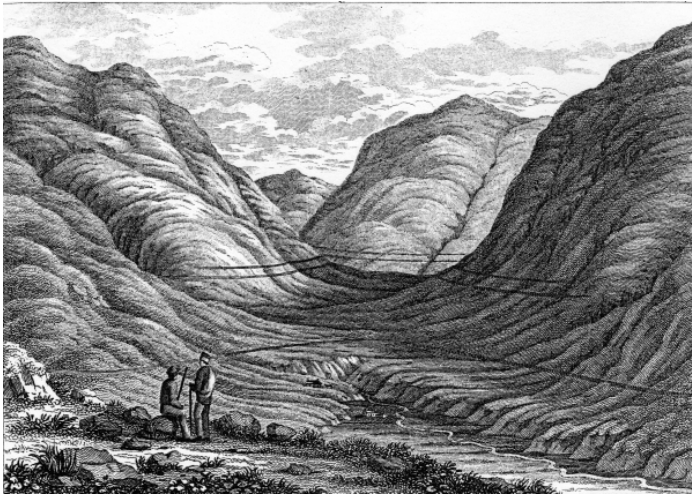
Return to "Viewpoint" car park.

LOWER GLEN ROY: COLLARIG

Drive up valley 1.5km to Achavady and park by the side of the lane just before a grid [296866]. Walk up track just beyond the grid (passing level of Road R3, here indistinct, en route) to the col ["Gap"] over to Glen Collarig; walk on to the hillock on the left, as a viewpoint [allow 30min for walk]. On the hillside to the north (right) Roads R1 and R2 are visible, but also other vague "minor" terraces.

Darwin's Agenda 1838 [before travelling to Lochaber]

"4th. Is there lip of escape [i.e. a Col R2] to shelf 3rd [Road R2] in Glen Fintac [i.e. into Glen Gloy to west]." [No! This side valley ([mis]named Glen Fintac by MacCulloch) is encircled by high hills except on the south (left) where it slopes down into Glen Collarig.]



Lauder's paper 1821:

View (from the *far side* of Glen Spean) up Glen Collarig to the low pass or "Gap"; Lauder used a "Romantic" pictorial style in striking contrast to MacCulloch's accurately "topographical" images. Bohuntine hill is on the right; note Roads R1 and R2 terminating on both sides of the valley as it opens out into Glen Spean.

Look down into Glen Collarig; on its further (west) flank, Road R2 extends to the edge of a plantation, but R1 fades away before that. So at both phases a barrier, on Lauder's lake theory, would have been some way down the valley, not at the "Gap"; Darwin, on the contrary, saw the topography as marine. The "Gap" is an example of what he called "land-straits", in this case not "coincident" with any Road.

Darwin's Notebook 1838

"In **Glen Collarig**, on side of Hill of **Bohunthine** upper road (2) [Road R1] extends as far nearly as house, the 3rd [Road R2] below them . . . Lines die away where slope less, best developed on steep earthy slope, two circumstances rarely united - die away also, without any cause, must [*sic*] be tides &c. . . Even on Lauder Dicks Hypothesis impossible to explain absence of lines in certain parts.

...

At the pass ["**Gap**"] of Glen Collarig two little lines of Hill . . . descend from shelf 3rd [Road R2] & almost meet, but are separated by flat bottomed strait [*sic*]. . . 4th shelf [Road R3] runs up some way on great sloping plain of alluvium . . . & not to head of plain . . . In Glen Collarig, by [Lauder] Dicks theory lake burst in most improbable part & not in Pass, where shallowest.

...

NB In Glen Collarig tidal channel [*sic*], sides 15 ft above bank or terrace, from terrace of 2d shelf [Road R1]."

Darwin's paper 1839

"Observing in **Glen Collarig** the gradual disappearance of either set of lines [Roads R1 and R2], and that there is not the smallest apparent cause for it in the nature of the ground, the first and obvious [*sic*] supposition is that a sheet of water extended from Glen Spean into Glen[s] Roy and Collarig, and that the mere widening of the mouths of the latter [two], as they approached the less protected expanse of the Spean, gradually became unfavourable to the accumulation of detritus, and therefore to the formation of the shelves.

...

Whoever walks over these mountains, and believes [*sic*] that each part has been successively occupied by the subsiding waters of the sea, will understand many trifling

appearances which otherwise, I believe, are unintelligible. Thus . . . at the **Gap of Glen Collarig**, with its flat bottom and cut off sides like a gateway, he will recognise a channel, at last choked up with matter drifted by the tides, and now left in the state in which it was when the waters retired from it.”

Darwin to Lyell 8 [September 1847]

“When I think of the gradual manner in which the 2 upper terraces [R1, R2] die out at **Glen Collarig**, & at the mouth of **Glen Roy**, - the smooth rounded form of the hills there, - the lower shelf [R3] retaining its usual width where [on Lauder’s and Milne’s interpretation] the immense barrier stood; I can deliberately repeat [from his own 1839 paper] ‘that more convincing proofs of the non-existence of the imaginary Loch Roy could scarcely have been invented with full play given to the imagination,’ &c But I do not adhere to this remark with such strength when applied to the Glacier-lake theory. . . [Yet] the manner in which the terraces [R1, R2] die out when entering **Glen Spean**, which [on Darwin’s own theory] must have been a tideway, shows on what small circumstances the formation of these shelves depended.”

Return down track to lane at Achavady.

MIDDLE GLEN ROY: BRUNACHAN

*Drive up lane about 3km to **Brunachan** and park by the side of the lane overlooking it [318898]. View three well-marked Roads on the far side of the valley. The lowest (R3) here extends into a broad shelf with steep flanks, interpreted by Jamieson as a small delta (subsequently bisected by a ravine cut by the stream flowing out of the small side valley).*

Jamieson to Darwin 3 September 1861

“[In this part of Glen Roy] I was much struck by the extreme neatness & precision of the lines which seemed to me very unlike what might be expected from the shore of a lake subject to tidal action. Very different from the appearance of true old coast-lines which I had seen on the West coast of Argyleshire last summer.

...

But what seemed to me even more important evidence in this respect [i.e. against Darwin’s marine theory] was the wonderfully fine preservation of the deltas at the mouths of some of the streams near the head of Glen Roy. These deltas have the appearance of being lodged in the waters of a placid lake, even in a stagnant pool, so undisturbed is the outline of some of them. This seems inexplicable to me had the lake been an arm of the sea, subject to the flux & reflux of the tides.”

MIDDLE GLEN ROY: TURRET

Drive up lane about 2km and park at the end of the public road [334912]. *Walk further* along the track past the grounds of **Brae Roy Lodge** and its farm, and out on to open ground beyond. Above the track (on the left) is the steep flank of a very broad terrace on the level of Road R3, as noted and depicted by MacCulloch, and interpreted by Jamieson as a large delta at the mouth of **Glen Turret**, which here joins Glen Roy from the northwest.

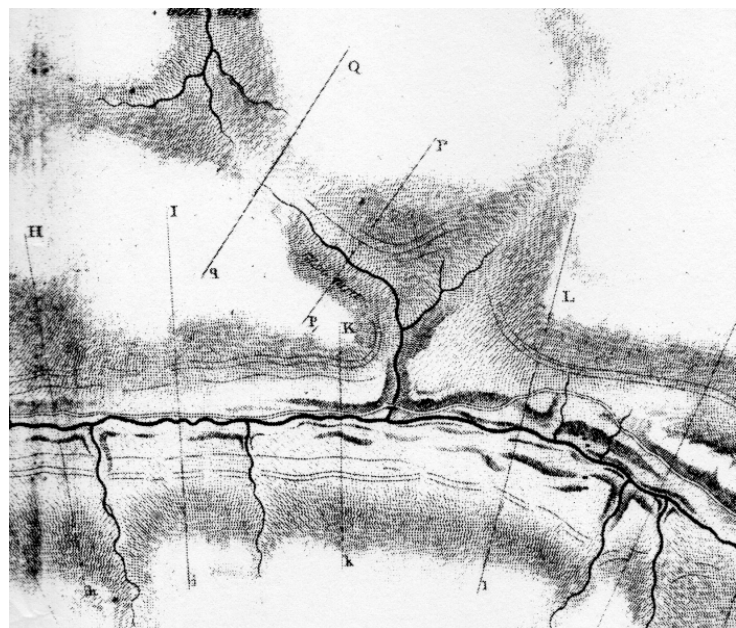
MacCulloch's paper 1817



View *down* Glen Roy (from *above* junction with Glen Turret), with the edge of the large Turret delta (on right) on the level of Road R3, and several ordinary river terraces below it.

“Here a great series of terraces is found . . . The highest of them will hereafter [i.e. later in his paper] be proved to lie on a level with a third *line* [Road R3] . . . It falls off however by many successive stages of terraces, and numerous smaller ones are also to be seen descending down to the very bed of the river [Roy].

Map of Roads in Glen Roy, around its junction with Glen Turret (centre), with a broad shelf or *delta* on the level of Road R3 (bisected by a ravine eroded subsequently by the river Turret); note also Col G [at line Q-q] over to Glen Gloy (top), and the “intermediate” shelf (Road R2+) between R1 and R2 [at line L-l].



Jamieson to Darwin 3 September 1861

“Again the delta at the mouth of the **Turret** is out of all proportion too large for the size of the stream. This I think can be explained only by supposing the Turret delta to be partly due to the outflow from **Glen Gluoy**.”

*Walk up track, bearing left at the fork, over **Turret Bridge** [339918] and up on to the top of the Turret delta or “fan”. Beyond a fence, walk up on to the hillock on the left [339924, 270m], as a viewpoint. Look further up Glen Roy, with Roads R1 and R2 visible on both sides of the valley. R2 ends within sight; R1 extends beyond, out of sight, to Col R1 over into Glen Spey.*

Darwin’s notebook 1838

“plain of 4th shelf [Road R3] at head of Lower [i.e. Middle] Glenroy . . . appears like one uniform slope slightly bending up each main valley. - & that river alone had modified it - perhaps however sea also [*sic*]”

*Look up Glen Turret: at the head of the side valley to the left, out of sight, is Col G over into Glen Gloy, a few metres above Road R1. Most important, on the right flank of Glen Turret (hill of **Tombhran**), note the well-marked “intermediate” shelf (R2+) between R1 and R2, which Darwin regarded as powerful evidence for his marine theory.*

MacCulloch’s paper 1817

“Between the two upper lines [Roads R1 and R2] on the right hand [of **Glen Turret**, i.e. on flank of **Tombhran**] an intermediate one [Road R2+] now becomes visible for a space of about half a mile.”

Lauder’s paper 1821

“And here [describing **Glen Gloy**, but relevant generally] I take the opportunity of offering a caution to future observers, not to decide too hastily as to such faint appearances [i.e. “intermediate shelves” or Roads] . . . For, aided by fancy [fantasy], which is always alive in an investigation of this kind, the eye is very apt to lead the judgment into error.”

Darwin’s Agenda 1838 [before travelling to Lochaber]

“9th. Are there traces of more lines than the three” [i.e. are MacCulloch's “supernumerary” or “intermediate” Roads genuine?]

Darwin's Notebook 1838

“2d or upper one [Road R1] more perfect in this part than 3d [Road R2]. 3(a) [Road R2+] less perfect than upper & lower but quite as perfect as those lines in Glen Collarig”

Darwin's paper 1839

“The following case proves, and it deserves particular attention, that the limits of the ancient waters cannot even approximately be inferred from the present extension of the

ancient beach-lines. Macculloch has drawn in his map a shelf [Road R2+] intermediate between the two upper ones [R1, R2], on the face of the mountain (**Tombhran**) opposite to where **Glen Turrit** joins Glen Roy (until I saw this shelf I doubted its existence . . .). Perceiving its importance I examined it with scrupulous care. . . It can be traced for nearly three quarters of a mile. . . I walked along its whole length, and its structure is perfectly characteristic [i.e. like the other Roads]. . . yet in no other part of Glen Roy . . . [has] a trace of this intermediate shelf been observed. Any argument whatever, therefore, from the non-existence of the shelves or beaches bearing on the former limits of the ocean over this part of Scotland . . . is valueless.”

Darwin to Lyell [12 March 1841]

“I should have thought that the most obvious objection to marine-beach theory for Glen Roy, would be the limited extension of the shelves – Though, certainly this is not a valid one, after the existence of an intermediate one [Road R2+], only half a mile in length & no where else appearing even in the valley of Glen Roy, has been shown to exist.”

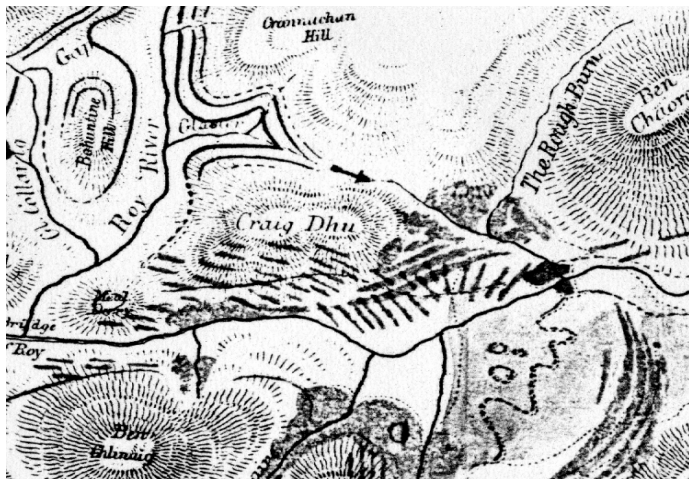
Darwin to Lyell 8 [September 1847]

“When the lake [on Agassiz’s glacial-lake theory] stood at the $\frac{3}{4}$ of mile shelf [Road R2+], the water from it must have flowed over ice itself for a very long time & kept at the same exact level: certainly this shelf required a long time for its formation.”

DAY TWO

UPPER GLEN SPEAN: LOCH LAGGAN

*From Spean Bridge, drive east on A86 about 17km and park at **Laggan Dam** [372808]. Loch Laggan is now dammed for hydroelectric power; a bronze relief model in the parking area shows the topography of Glen Spean and Glen Treig [see below]. Looking east along the lake, note the flat-topped and steep-flanked spur at **Roughburn** (in the middle distance on the left), interpreted by Milne as a large delta into “Loch Spean”, related to a former outflow from “Loch Roy” over the Col R2 he had “discovered” at the head of Glen Glaster.*



Map showing Col R2 [arrow] from Glen Glaster, and Roughburn delta [dark patch on right] (Jamieson 1863, after Milne 1847).

Milne’s paper 1847

“A little beyond this flat [Col R2] an *old river course* can be distinctly traced down a slope towards **Loch Laggan**. It has a rocky bed, over which a great body of water had evidently flowed at some former

period. . . I afterwards found the place where it had discharged its waters into Loch Laggan, when that loch stood at shelf 4 [Road S]. It is marked by a huge delta [at **Roughburn**]. . .”

Darwin to Milne 20 [September 1847]

“The oddest result of your paper on me (& I assure you, as far as I know myself, it is not perversity) is that I am very much staggered [i.e., wavering] in favour of the ice-lake theory of Agassiz and Buckland; until I read your important discovery of the outlet in Glen Glastig [Col R2] I never thought this theory at all tenable. Now it appears a very good case can be made in its favour. I am not, however, as yet a believer in the ice-lake theory, but I tremble for the result.”

Darwin to Scotsman [September] 1847 [not published]

“When this [glacier-lake] theory was first propounded, I mentally rejected it from my belief that when the water stood at the middle shelf [Road R2] of Glen Roy, there was no outlet for drainage except over the ice itself . . . but this prominent objection falls to the ground, since Mr Milnes important discovery of an outlet [Col R2] at the head of Glen Glastig.”

Walk west 100m on main road; cross it and climb the hillside a few metres on to a terrace identified (by levelling) as Road S. Looking east, the Roughburn delta is just visible beyond the rocky headland opposite the parking area, and can be seen to be on a level with this, the only Road to extend out of Glen Roy into Glen Spean.

UPPER GLEN SPEAN: PASS OF MUCKUL

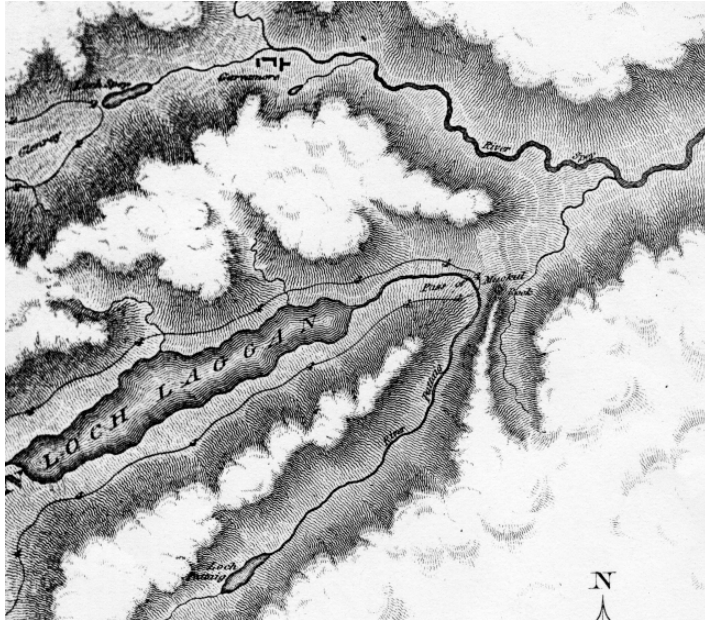
*Drive east on A86 for the whole length of **Loch Laggan**. Lauder and others traced Road S along this shoreline, a little above the lake, and noted that in some stretches the terrace had been exploited for building the carriage road (now enlarged into the modern A86). At Kinloch Laggan, note the mud-flats (a present-day delta) on the right, where the river Pattack flows into the head of Loch Laggan. Continue on A86 until the valley narrows and forest closes in on both sides (at Muckul [**Magh-cul**, 558904]).*

*Park in **Forestry car park** at Druim-an-Aird [566904] on the right of the road as it enters a long straight stretch (and just beyond another car park signed on the left). Although forest now conceals the topography, the road passes here through the low **Pass of Muckul**, which connects Glen Spean with the Spey basin to the east and is therefore on the watershed between the Atlantic and the North Sea.*

*Walk west on **signed path** 100m to view the fine waterfall below which the river Pattack, although only a few feet below the level of the Pass of Muckul, turns abruptly westwards towards Loch Laggan. Lauder mapped this odd feature and, unlike MacCulloch, interpreted the Pass as an overflow [Col S] from a former “Loch Spean” on a level with Road S. Darwin applied his marine interpretation to the Pass without having visited it.*

MacCulloch's paper 1817

"[At the **Pass of Muckul** there is] a barrier of low rocks . . . The barrier itself gives no rise to waters, as it consists of a narrow ledge of rocks; nor does it appear at any time to have been liable to suffer from the course of rivers."



Lauder's paper 1821

Detail of map, showing the Pass of Muckul and the sharp turn in the river Pattack, with the river Spey to the north.

"This **pass** . . . although it is not productive of any streams . . . yet the highest part of its bottom is only elevated a few feet above the present level of **Loch Laggan** . . . The **river Pattaig** . . . has a directly north-east direction, as if it were about to run towards the **river Spey**, which is

certainly its most natural course; but just before coming upon the bottom of the Pass of Muckul, [a rock] . . . compels it to make a sudden and capricious bend to the west, at a very acute angle to its former line."

Darwin's paper 1839

"I may remark, without wishing to lay any great stress on the argument, that these *land straits* [such as the **Pass of Muckul**], whether connected with the shelves, or not, are precisely what might be expected from *straits*, properly so called, between arms of the sea laid dry."

Milne's paper 1847

"The grandest exhibition of an ancient and deserted river-course is, however, at the head of **Loch Laggan**. The **Pass of Muckul** [Col S] is a channel, the bed and sides of which are entirely rock. . . The rocks at the sides are evidently water-worn for about 30 feet up. . . no stream whatever now occupies this water-course, except where, for a short part of it, the **river Pattaig** flows in a reverse direction into the head of Loch Laggan. . .

The ancient river-course now described is of much greater size than that at the head of Glen Glaster [Col R2], just as the Glen Glaster river-course is of greater dimensions than those respectively at the head of Glen Gluoy [Col G] and Glen Roy [Col R1]. The reason is obvious. The river at Muckul had to discharge not merely the waters which belonged to Glen Spean, but also those which flowed out from Glen Glaster, comprehending Glen Roy, Glen Collarig and Glen Gluoy. . .

Mr Darwin did not visit the Pass of Muckul. If he had studied the appearances presented by it, and by those almost as strikingly exhibited at Glen Glaster, he would have found it impossible to deny that the waters which formed shelves 3 and 4 [Roads R2 and

R3/S] flowed down river courses, and therefore could not be arms of the sea. . . There is no such thing in nature as a river flowing out of an arm of the sea, to a lower level. . . For these reasons I consider that Mr Darwin's explanation of the coincidence of the shelves with the water-sheds before described, is quite inadmissible.”

Darwin to Lyell 8 [September 1847]

“Mr Milne’s description of the outlets of his lakes, sound to me more like tidal channels nor does he give any arguments how such are to be distinguished from old river courses. I cannot believe in the body of fresh water, which must on the lake theory have flowed out from them. . . the whole seems to me far easier explained by a tideway, than by a formerly more humid climate [and therefore a higher rainfall].”

Darwin to Chambers 11 September 1847

“Mr Milne's description of the **Pass of Mukkul** expanding to a width of several hundred yards 21 feet deep, in the shoalest part, & with a worn Islet in the middle sounds to me much more like a tidal channel than a River Bed. . . I did not know Mukkul Pass.”

*Return to car park and walk east on A86 about 200m; turn left on a track (just before the entrance to a house at Feagour). In the wooded bank on the right, note a small exposure of well-rounded cobbles. Such deposits were interpreted by Jamieson as decisive evidence for a former major outflow of water through the Pass and down into the Spey basin. **Walk back to car park**, noting on the right (north) of the road what Jamieson would have recognised as a good glacial roche moutonnée, with its smoothed surface upstream (west).*



Jamieson’s paper 1863

Map of Loch Laggan (detail), with Pass of Muckul as an overflow [Col S, at arrow].

Jamieson to Darwin 3 September 1861

“At the **pass of Makoul** (or Muckul as it has been written by some) or rather a little to the Eastward of it there is clear evidence of a large stream of water having flowed out towards the basin of the Spey. . . Here also there had been previous glacial action, but the subsequent effects of water flowing eastward are quite unmistakeable . . . quantities of well rounded pebbles like cocoa nuts or cannon balls lie on the water-worn surfaces, and heaps of shingle in the recesses and sheltered spots to the East of

the rock masses . . . I satisfied myself that this could not have been caused by tidal action but that it was due to a current flowing downward and Eastward.”

Jamieson to Lyell 27 October 1861

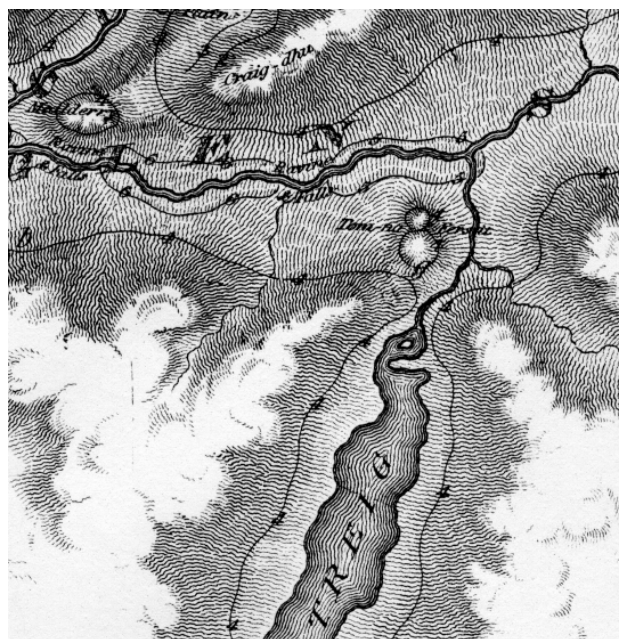
“[It is] significant that the lines [Roads] do not coincide neatly with each col but are slightly above it, so as to account for some depth of water flowing out. And this is most the case at **Makoul** where the lake that had to discharge its excess was much the longest.”

GLEN TREIG

*Drive back west on A86, past Laggan Dam. At junction [341809], turn sharp left on to the lane to **Fersit** at the mouth of **Glen Treig**; park at end of public road [350782]. Walk west on a small path 200m, up through a copse on to a former narrow-gauge railway line (cross the fence where it passes under the railway bridge on the right side of the ravine). Walk north along the track of the railway (probably built for the construction of the hydroelectric dam at Loch Treig) about 300m, then climb the hillside to the left, to locate the terrace of Road S, with a typical profile as in Glen Roy. Climb a little above it, and view it stretching to the north, cut obliquely by the rising line of the railway, then curving out of sight as Glen Treig opens into Glen Spean. Looking east, beyond a small lake [An Dubh Lochan], note the isolated hill of **Tom-na-Fersit** [352787, 274m] with a rocky outcrop above a broad flat shoulder on the level of Road S (its north side is now forested); it was interpreted by Lauder and others as a small island in the former “Loch Spean” (see below).*

Lauder’s paper 1821

Map (detail) of Glen Treig opening into Glen Spean. Note “8”-shaped hill of Tom-na-Fersit north of the mouth of Loch Treig, on the level of Road 4 [S].



Walk down to the old railway line and back along it. About 100m short of the old bridge, in the bank on the right, is a small exposure of bedrock with good glacial “striae” trending north-south. Such scratched rocks (though not this example, which was only exposed by the railway cutting) helped convince Agassiz and Jamieson that a former glacier flowed from Glen Treig out into Glen Spean (see their maps, below). Jamieson interpreted the irregular hilly ground between here and the parking area as some of the glacier’s moraines.

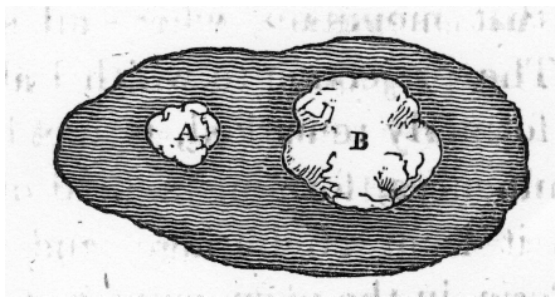
Jamieson to Darwin 3 September 1861

"I attentively examined the entrance to **Loch Treig**, and found both sides of the gorge to present the clearest evidence of most intense glacial action . . . and all these phenomena [scratched bedrock, moraines, etc] are most conclusively seen to have been effected by a great volume of ice flowing down the valley now occupied by the Lake, and issuing out of this gorge into **Glen Spean** . . . in fact the whole ground around the mouth of Loch Treig is a perfect study of glacial action. . ."

*Return to parking area and walk north on the lane 200m, then turn right on a grassy track up on to **Tom-na-Fersit** [352787, 274m]. Note the broad flattish area near the top of the hill (on a level with Road S), and the smoothed rock outcrops above it (any glacial scratches have been eroded away). Darwin realised (before seeing it) that such a former island offered the best chance of finding signs of the former marine shorelines he anticipated, not concealed by subsequent soil creep from a higher hillside; on the spot his search was in vain.*

Lauder's paper 1821

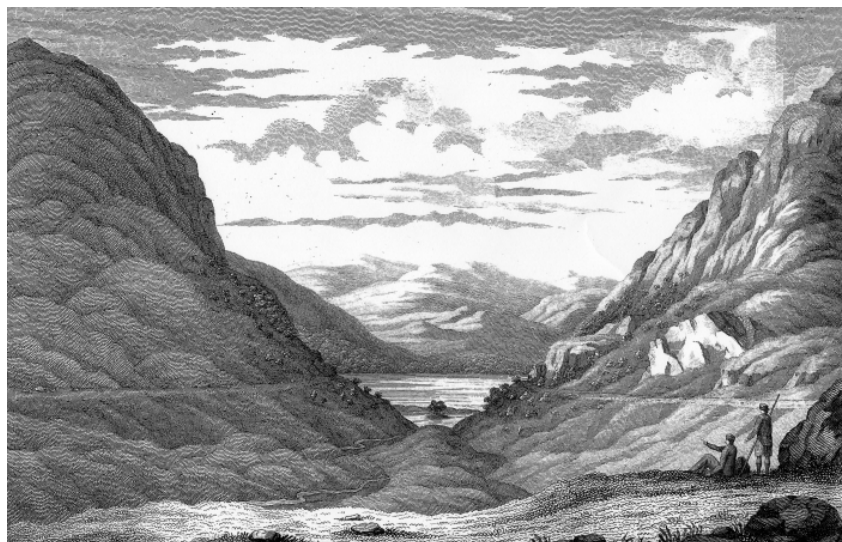
Large-scale sketch-map of Tom-na-Fersit [north to the left].



"By far the most satisfactory and perfect example, of any shelf completely surrounding the top of a hill, is to be observed on the isolated one of **Tom-na-Fersit**, immediately opposite to the opening into **Loch Treig**. Shelf 4th [Road S] is most distinctly and broadly traced around it, at the same level as it appears on the rocks where it enters to Loch Treig."

View from Tom-na-Fersit up into Glen Treig, with Road S on either side.

As usual with Lauder's images, this is a highly Romantic rendering of the view (the lake is now dammed, but little changed in level).



Darwin's Agenda 1838 [before travelling to Lochaber]

“2. [Look for] Organic remains. Balani [barnacles]. Serpula [fossilisable tube-worm]. - calcareous matter [i.e. shell fragments etc. (all three features would be signs of marine conditions)] . . .

13th. Examine **Tom-na-Fersit** and entrance to **Loch Treig** for Balani. and smooth waterworn rocks. also Barnacles on transported blocks.”

Darwin's notebook 1838

“Lake, must have remained very long at 4th shelf [Road S] from size of buttresses [e.g. flat ground on Tom-na-Fersit], to upper edge of which they cut near **Loch Treig**.”

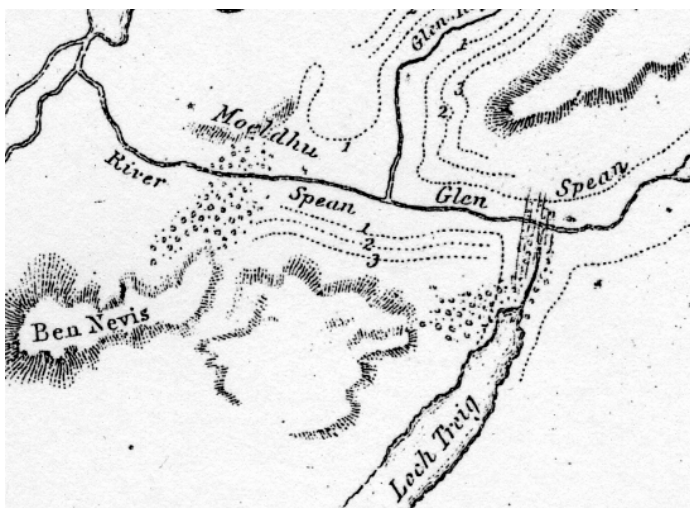
Darwin's paper 1839

“Standing on the precipitous and waterworn rocks [near exit from **Loch Treig**], it required little imagination to go back to former ages, and to behold the water eddying and splashing against the steep rocks on one side of the channel, whilst on the other it was flowing quietly over a shelving spit of sand and gravel [preserved on Tom-na-Fersit].”

Return to parking area, and drive back along lane. En route, as the lane passes the houses at Inverlair [339799], note the steep irregular hills interpreted by Agassiz as glacial moraines. At Inverlair Bridge [342806] the lane crosses the river Spean, flowing here in an evidently postglacial gorge.

Agassiz' paper 1842

“I shall never forget the impression I experienced at the sight of the terraced mounds of blocks at the mouth of the valley of **Loch Treig**, where it joins Glen Spean; it seemed to me as if I were looking at the numerous moraines of the neighbourhood of Tines, in the valley of Chamonix [in the Alps].”



Map of Lochaber on a glacial interpretation (detail), showing location of scratched bedrock [vertical lines] crossing Glen Spean at the mouth of Glen Treig.

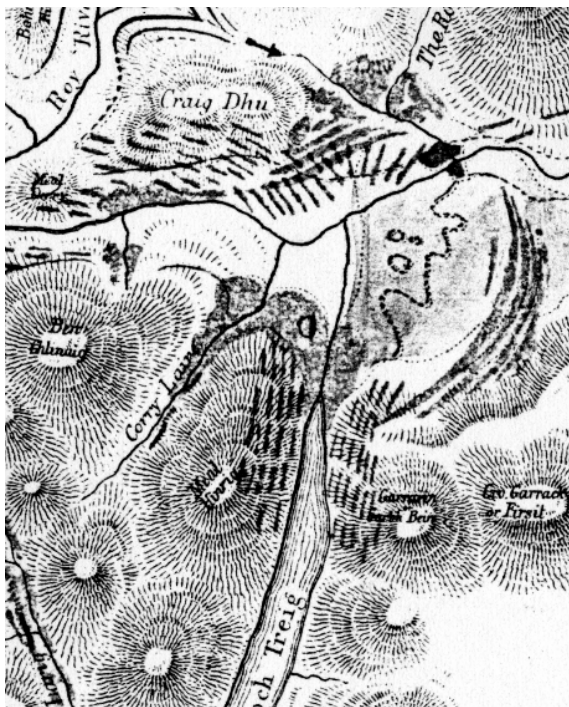
Darwin to Lyell 8 [September 1847]

“Oddly I was never at all staggered by [i.e. wavering in favour of] this theory [i.e. Agassiz’s], until now having read Mr Milne’s arguments against it; I now can hardly doubt that a great glacier did emerge from **L. Treig**, & this by the ice itself (not moraine) might have blocked up the 3 outlets from **Glen Roy**. I do not, however, yet believe in the glacier theory.”

Darwin to Chambers 11 September 1847

“Oddly enough, Mr Milne’s description of the Mouth of **Loch Treig** . . . leaves hardly a doubt that a Glacier descended from it, & if the Roads were formed by a Lake of any kind, I believe it must have been an Ice Lake. I have given in detail to Lyell my reasons for not thinking Ice-lakes probable; but to my mind they are incomparably more probable than detritus of rock barriers.”

Drive back to A68 and park briefly at the junction [341809]. Look back (south) across Glen Spean towards the mouth of Glen Treig. A few erratic blocks can be seen beside the road, but the scratched bedrock and moraines mapped and described by Jamieson on the north side of Glen Spean (and mostly to the north of the A86) are now obscured by afforestation.

**Jamieson’s paper 1863**

Map of Glen Treig opening into Glen Spean, with scratched bedrock and a semicircle of moraines].

Jamieson to Darwin 3 September 1861

“The glacial markings on the N. side of Glen Spean opposite the entrance to Loch Treig are among the finest specimens of ice-work I have seen, this with the heaps of moraine matter & the perfect wilderness of boulders made me stare with astonishment how any one, after Agassiz had drawn attention to all this, could go on the ground & yet deny that there had been any glacier here! I do not suppose there is any place in Britain where the traces of a great ice stream are more complete.”

Jamieson to Lyell 15 August 1862 [forwarded to Darwin]

“I have been again at Lochaber this summer, and have come away more convinced than ever of my last years view of the Glen Roy Lakes. . . . I also discovered the most beautiful set of moraines that I believe will be found in the United Kingdom. . . . They are the work of the old **Glen Treig** glacier but at such a distance from the mouth of the glen as to have eluded the observation of former visitors. . . . They have a sweep of several miles, forming a sort of huge semi circle – tier within tier – in many places almost as regular as a railway embankment – . . . these [syenite blocks] have been pushed by the glacier before it in

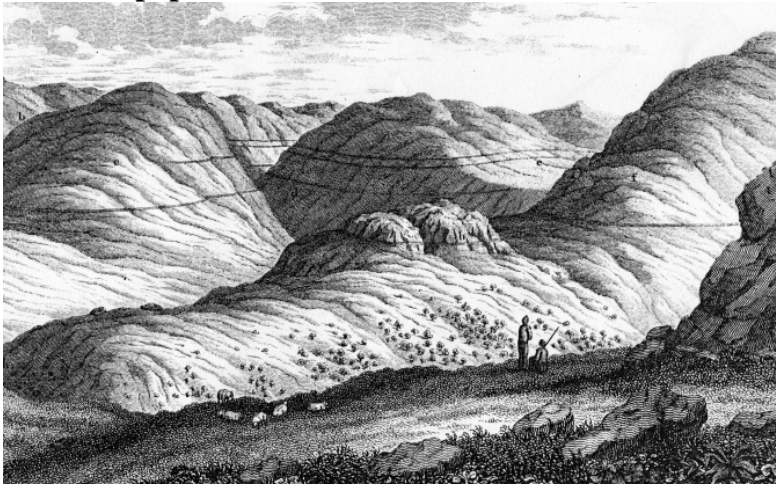
certain places off the syenitic [bedrock] mass up hill & left upon the gneiss [bedrock] on the N. side of **Glen Spean** . . . These moraines are as fine a sight as the Glen Roy lines themselves & to a geologist – as interesting. their fine preservation is certainly a treat.”

MIDDLE GLEN SPEAN

Drive west on A86 about 4km to Achluachrach. Turn sharp right, signed to Cille Choirill (look out for advance sign “Concealed Access” and TAKE CARE with acute turn), drive up the lane 400m to its end, and park on left just before the isolated chapel [307813]. Walk south on to the nearby grassy hillock with superb views over Glen Spean.

*On the far (south) side of the valley, note the prominent line of the former railway from Loch Treig, here sloping down to the west (right), and intersecting the fainter horizontal line of Road S, here high above the valley floor. Looking east, Road S is also visible on the north hillside beyond the chapel. Looking west, also on the near side of the valley, the isolated hill of **Meal Derry** [Meall Doire, 291813, 296m] is surrounded by Road S (not clearly visible from here); it was noted by Lauder as another former island in “Loch Spean”, and therefore attracted Darwin’s attention as a favourable site for evidence of a marine origin.*

Lauder’s paper 1821

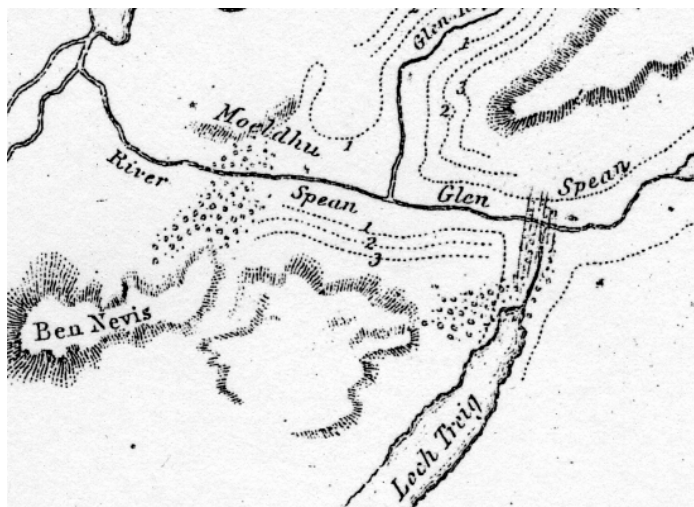


View of mouth of Glen Roy, from *south* side of Glen Spean with Meal Derry (centre) as a former island (at R3/S level).

Darwin’s notebook 1838

“On the summit & on [Glen] Spean side of **Meal Derry** there were perfectly rounded pebbles of quartz & other rocks not apparently in situ hill being gneiss . . . Boulder of granite above 4th shelf [Road R3/S] a little lower down the hillock with beach & channels precisely as with [an] Island.”

Look across Glen Spean again. Is there any trace of terracing on the hillside above Road S? Agassiz marked all three Glen Roy Roads here, where they were required on his reconstruction of a glacial lake.



Agassiz's paper 1842: detail of map of Lochaber on his glacial-lake interpretation.

Darwin to Lyell [5 and 7 October 1842]

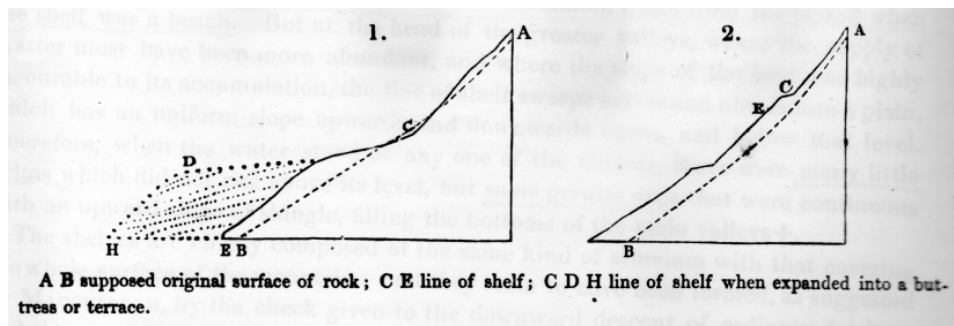
“Agassiz says he saw (and has laid down [on his map]) the two lower [i.e. upper!] terraces of Glen Roy [Roads R1, R2] in the valley of the Spean, opposite mouth of Glen Roy itself, where no one else has seen them. I carefully examined that spot, owing to two sheep-tracks nearly but not quite parallel to the terrace [Road R3/S], - so much again for difference of observation. - I do not pretend to say who is right.”

Finally, note the irregular terraces below Road S, which Darwin called “buttresses” and interpreted as evidence that sea-level had continued to subside intermittently (as the crustal plate rose) after the Road S period, thus connecting the Roads down to the uncontroversial “raised beaches” near present-day sea-level (see interpretative diagram in Appendix).

Darwin's notebook 1838

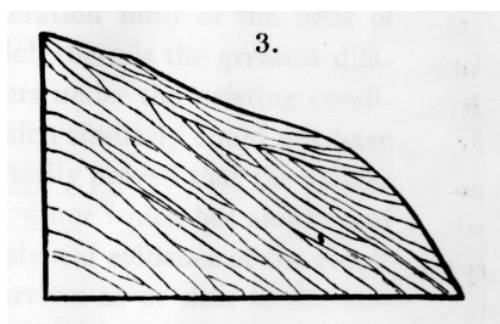
“Above **Spean Bridge** many flat terraces . . . In all cases <I urge> deposition marine - because if not chain of lake[s] & if so there would be barrier . . .

The buttresses of Alluvium [in **Glen Spean**] rise nearly up to **Glen Collarig** up within 200 ft of level of 4th shelf [Road S] = argument against river . . . Others below it - argument for lake <or sea> at successive levels.”



Darwin's paper 1839

1. Section of a Road extended into a “buttress.”



3. Section of a “buttress” in Glen Spean.

“No one will dispute, that those buttresses, which are mere extensions of a line of shelf [e.g. the delta at Brunachan, seen on Day One], were formed at the edge of an expanse of water (of which the shelf was the beach), and it is therefore by itself probable that the other buttresses, of similar external form and composition, though occurring at a different level, had a similar origin. . . The conclusion is inevitable, that a sheet of water must have stood at as many levels as there are buttresses, and this will include by small steps the whole space between the bottom of the [Spean] valley and the lower shelf [Road R3/S].”

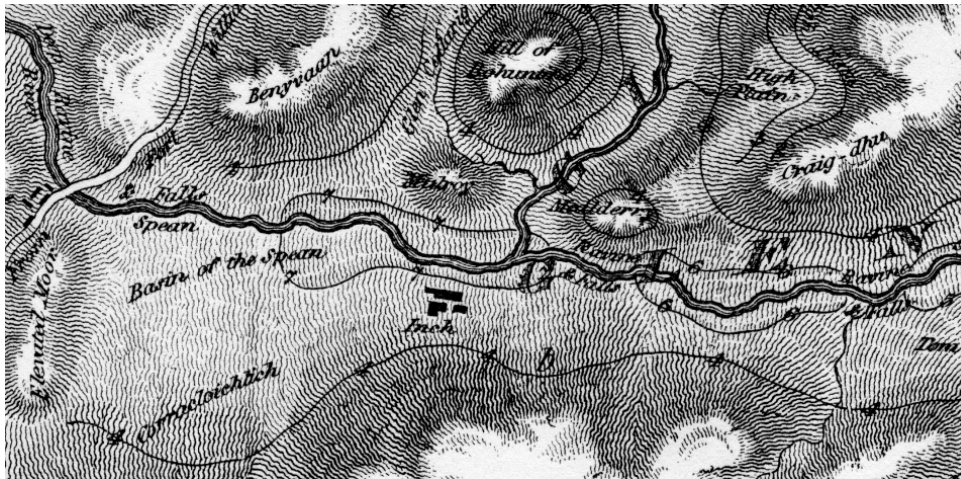
Darwin to Lyell [9 March 1841] [after Agassiz proposed his glacial-lake theory]

“I think I have thought over the whole case [of the Parallel Roads] without prejudice, & remain firmly convinced they are marine beaches. - My principal reason for doing so, is what I have urged in my Paper, the buttress-like accumulations of stratified shingle on sides of valley, especially those just below the lowest shelf [Road S] in **Spean valley**.”

Return to A86, and drive west about 5km through Roybridge to Inverroy. Turn right (signed to Upper Inverroy) and drive up lane, turning left at T-junction. Park at end of public road [249819]. Walk about 100m ahead along a track out into a field. High up on the hillside to the north is a well-marked stretch of Road S. Walk back to the lane, look south across Glen Spean, and Road S can be seen on the same level, to the left of the forested hillsides. At this point the putative “Loch Spean” was about 4km wide.

Lauder’s paper 1821

detail of map of lower Glen Spean.



Roads 2 [R1] and 3 [R2] end at mouth of Glen Roy; Road 4 [R3/S] extends into Glen Spean, but ends to the west, near Spean Bridge; 5, 6, and 7 are flat areas interpreted by Lauder as even later lakes, now silted up.

*Return to A68, drive west to Spean Bridge, turn right on A82 (towards Inverness) for about 1km. Turn left on B8004 (towards Gairloch) and immediately left again into the large car park of the **Commandos’ Memorial**, which is a superb viewpoint over the mouth of Glen Spean as it opens into the Great Glen, and south to the massif topped by Ben Nevis (1343m). Road S cannot be seen clearly from here, but it finally fades away on the distant hillside to the east (not far from where it was visible above Upper Inverroy) and on the even more distant flank of Ben Nevis to the southeast (now concealed within a large area of forest). These points are about 7km apart and about 200m above the river Spean between them,*

which shows the huge size of the putative barrier S on Lauder's lake theory. Conversely, one can see from here the explanatory attractions of Darwin's marine theory, which eliminated the need for any such barrier and explained the non-extension of Road S into the Great Glen in terms of its non-preservation where exposed to greater wave and tidal action. Of course, the size of the barrier became less of an objection once Jamieson extended the scale of the glacial theory and filled the Great Glen with a vast ice sheet.

Darwin's notebook 1838 [a post-fieldwork note, perhaps written while in the Great Glen]
 "Speculate on Beagle Channel."

Darwin's paper 1839

"It can scarcely be doubted, without making the most improbable assumptions, that the Great Glen of Scotland . . . was within this recent period an open strait; and, I may add, it must then have strikingly resembled the Beagle Channel in Tierra del Fuego. . .

That the movement [of subsequent crustal elevation] must have been exceedingly slow, may be inferred from the existence of so many [raised] beaches, each requiring time for its formation, which rise one above another on both coasts of Scotland . . . after what has been stated [earlier in his paper] it can hardly be disputed, that within recent geological periods an arm of the sea entered at least the mouth of the **Spean**, and very slowly retreated from it."

Return to Spean Bridge: end of field trip.

NOTE ON DARWIN'S ITINERARY

Darwin's field notebook is brief and scrappy – but he was just checking for himself (and re-interpreting) what he had read beforehand in MacCulloch and Lauder – and his itinerary is difficult to reconstruct with any precision. He seems to have travelled alone, though he may have hired a local guide; he may also have hired a pony for parts of his route, but for other parts he probably worked on foot. He reached Lochaber by the western route (now the A82) to Fort William, perhaps by public coach; he probably based himself at Spean Bridge, where there was an inn. He seems to have explored – though not in this exact order – Glen Spean as far as the mouth of Glen Treig, and thence diverting as far as Loch Treig; Glen Collarig up to the "Gap" at its head; Glen Roy from Bohuntine Hill right up to its head at the col over into Glen Spey; and Glen Turret. He also climbed over Ben Erin [Beinn Iaruin] into the upper part of Glen Gloy. He did not make the long trip to the Pass of Muckul at the far end of Glen Spean. He left the area by traversing the Great Glen to Inverness.

COMMENTS AFTER DARWIN'S FIELDWORK

This is a selection of general comments on the Glen Roy problem, not related to any particular location, arranged in chronological order, and focussed on the development of Darwin's own opinions.

Darwin to Lyell 9 August [1838] [shortly after his field-trip]

“Here [in Lochaber] I enjoyed five days of the most beautiful weather, with gorgeous sunsets, & all nature looking as happy, as I felt. . . It is far the most remarkable area I ever examined. I have fully convinced myself (after some doubting at first) that the shelves are sea-beaches, - although I could not find a trace of a shell, & I think I can explain away [*sic*] most, if not all, the difficulties. . . I can assure you Glen Roy has astonished me.”

Darwin “Journal” 1838

“September 6th. Finished paper on Glen Roy - one of the most difficult & instructive tasks I was ever [*sic!*] employed on.”

Darwin to Lyell [14] September [1838]

“Supposing I can prove to others satisfaction [in his Glen Roy paper], what I have convinced myself is the case, the inferences, I think, you will allow to be important. – I cannot doubt the molten matter beneath the earths crust possesses a high degree of fluidity, almost like the sea beneath the Polar ice.” [i.e. explaining the horizontality of the Roads, on his theory of a rising crustal plate.]

Darwin's paper 1839

“The conclusion is inevitable, that no hypothesis founded on the supposed existence of a sheet of water confined by *barriers*, that is, a lake, can be admitted as solving the problematical origin of the ‘parallel roads of Lochaber’ . . .

Having attentively considered these several and independent steps of the argument, the theory of the marine origin of the ‘parallel roads of Lochaber’ appears to me demonstrated [i.e. *proved* beyond reasonable doubt].”

Darwin to Buckland 17 February 1841 [after Agassiz’s and Buckland’s glacial-lake theory]

“I cannot give up the sea, after thinking over many points of minor detail in that country, though, I am very sure, if your theory had occurred to me, during the first two days of my examination, I should have given up their marine and ordinary [i.e. non-glacial] lacustrine origin at once.”

Buckland to Geological Society 19 February 1841 [report of Anniversary Address]

“M. Agassiz and Dr Buckland recognized the evidences of glacial action . . . [*inter alia* in] the rounded, polished and striated surfaces, accompanied by morains, in Glen Roy and the valley of the Spean; from the position of which they infer that the lake, to which many writers have referred the origin of the parallel roads of Glen Roy, was caused by two glaciers descending from Ben Nevis across the valley of the Spean, in the same manner as in 1818 a temporary lake was formed by a barrier of ice in the Val de Bagnes [in the Swiss Alps].”

Darwin to Fitton [28 June 1842]

“I am also more convinced [after seeing glacial traces in North Wales] that the valleys of Glen Roy & the neighbouring parts of Scotland have been occupied by arms of the Sea, & very likely (for on that point I cannot of course doubt Agassiz and Buckland) by glaciers also.”

Darwin to Fox [4 September 1843]

"Whenever I give myself a [field] trip, it shall be, I think, to Scotland, to hunt for more parallel roads. My marine theory for these Roads was for a time knocked on the head by Agassiz ice-work, but it is now reviving again. – I don't mean, that I ever doubted, but others did (even Lyell for a time became a [glacialist] catastrophist) & they have now gone back to the elevation theory [of a rising crustal plate]."

Darwin to British Association [August or September] 1846

"The parallel Roads of Glen Roy have been the object of repeated examination, but they have never hitherto been levelled with sufficient accuracy. . . Although the observations here specified [to be made by the Ordnance Survey] would probably be laborious, yet, considering how rarely such evidence is afforded in any quarter of the world, it cannot be doubted that one of the most important problems [*sic*] in Geology - namely, the exact manner in which the crust of the earth rises in mass - would be much elucidated, and a great service done to geological science."

Darwin to Lyell 8 [September 1847] [reflecting on Milne's theory, and Agassiz's]

"Well, I enjoyed my trip to Glen Roy very much, but it was time thrown away. I heartily wish you would go there; it should be some one who knows glacier and iceberg action, and sea-action well. I wish the Queen would command you."

Darwin to Hooker [12 September 1847]

"I have been bad enough for these few last days, having had to think & write too much about Glen Roy (an audacious son of dog (Mr Milne) having attacked my theory) which made me horribly sick."

Darwin to Scotsman [September] 1847 [not published]

"Weighing, as well as I am able, these difficulties on both hands, I am still inclined to abide by the marine theory. . . If the marine theory be found to be erroneous, then I believe that the theory of Agassiz and Buckland will prove the true solution, & that Macculloch, Sir Thomas Dick Lauder, & Mr Milne are all so far right that the shelves were formed round shores of lakes & not of arms of the sea."

Darwin to Ramsay 1 July [1859]

"Do not forget that with your knowledge of Glacial action two days at Glen Roy would for ever settle the question which has nearly driven so many of us mad. . . I shd so like to see the case settled, even if it proved me ever so egregiously wrong."

Jamieson to Darwin 3 September 1861

"I returned a few days ago from a trip to Lochaber where I spent a fortnight and now hasten to present you with some of the results of my visit, and I may at once state that all I saw tended to impress on me the conviction that these parallel roads have been formed along the margin of freshwater lakes and finding the marks of ice action so plain over the whole district I cannot help thinking that Agassiz hit upon the true solution of the problem when he pronounced these marks to be the effect of glacier-lakes. . . I had most villainous weather . . . and it was only by going doggedly to work with a waterproof and an umbrella that I could get any thing done at all."

Darwin to Jamieson 6 September [1861]

“Your arguments seem to me conclusive. I give up the ghost. My paper is one long gigantic blunder. . . . What a wonderful record of the old icy lakes do these shores present! It really is a grand phenomenon. I have been for years anxious to know what was the truth, & now I shall rest contented, though ashamed of myself. - How rash it is in science to argue because any case is not one thing, it must be some second thing which happens to be known to the writer.”

Darwin to Lyell 6, 10, 15 and 22 September 1861

“I am smashed to atoms about Glen Roy. My paper was one long gigantic blunder from beginning to end. Eheu. Eheu [Alas!]. . . . I grieve over poor dear Glen Roy. . . . I have just been glancing at my Glen Roy paper; & there yet seem to me several points of very difficult explanation [on Jamieson’s glacial-lake theory]. . . . But I suppose ice-lakes must be true cause. . . . You have a grand problem [in working out the implications of the glacial theory], & Heaven help you & Mr Jamieson through it. It is out of my line now a-days, & above & beyond me.”

Darwin to Lyell 1 October [1861]

“What a capital observer and reasoner Mr Jamieson is. . . . A nice mess I made of Glen Roy! . . . I am very poorly today, and hate everybody and everything. One lives only to make blunders.”

Darwin to Lyell 1 April [1862] [in this reconstruction, note his vivid mix of past, present and future tenses!]

“I suppose the whole of Glen Spean filled [at first] with ice; then water would escape from an outlet [Col R1] at Loch Spey, and the highest shelf [R1 in Glen Roy] would be first formed. Secondly, ice began to retreat, and water will flow for short time over its surface; but as soon as it retreated from behind the hill marked Craig Dhu [south flank of Glen Glaster], where the outlet [Col R2] on level of second shelf [Road R2] was discovered by Milne, the water would flow from it and the second shelf would be formed. This supposes that a vast barrier of ice still remains under Ben Nevis, all along the lower part of the Spean. Lastly, I suppose the ice disappeared everywhere along Loch Laggan, L. Treig, and Glen Spean, except close under Ben Nevis, where it still formed a barrier, the water flowing out at level of lowest shelf [R3/S] by the Pass of Mukkul [Col S] at head of L. Laggan. This seems to me to account for everything. It presupposes that the shelves were formed towards the close of the Glacial period.”

Darwin to Lyell 14 October [1862]

“I return Jamieson’s capital letter. I have no comments, except to say that he has removed all my difficulties, and that now and for evermore I give up and abominate Glen Roy and all its belongings. It is certainly a splendid case, and wonderful monument of the old Ice Period. - . . . How many have blundered over those horrid shelves! . . . I do believe every word in my Glen Roy paper is false .”

Lyell's *Antiquity of Man* 1863

“When I examined ‘the parallel roads’ in 1825, in company with Dr Buckland, neither this glacier theory nor Mr Darwin’s suggestion of ancient sea-margins had been proposed, and I have never since revisited Lochaber. But I retain in my memory a vivid recollection of the scenery and physical features of the district, and I now consider the glacier-lake theory as affording by far the most satisfactory solution of this difficult problem.”

Darwin autobiography 1876

“This paper [on Glen Roy] was a great failure, and I am ashamed of it. Having been deeply impressed with what I had seen of the elevation of the land in South America, I attributed the parallel lines to the action of the sea; but I had to [*sic*] give up this view when Agassiz propounded his glacier-lake theory. Because no other explanation [*sic*] was possible under our then state of knowledge, I argued in favour of sea-action; and my error has been a good lesson never to trust in science to the principle of exclusion.”

Darwin to Prestwich 3 January 1880

“As soon as I read Mr Jamieson's article [1863] on the parallel roads, I gave up the ghost with more sighs and groans than on almost any other occasion in my life.”

FURTHER READING

(A few sources accessible outside major research libraries)

Primary sources

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Secondary sources

Browne, Janet. *Darwin: Voyaging* (Pimlico, 1995) [see index under *Glen Roy*].

Herbert, Sandra. *Charles Darwin, Geologist* (Cornell, 2005). [see esp. pp. 245-294].

Rudwick, Martin. Darwin and Glen Roy . . . *Stud. Hist. Phil. Sci.* 5 (1974): 97-185 [reprinted in Rudwick, *Lyell and Darwin, Geologists* (Ashgate, 2005), art. X].

Rudwick, Martin. *Worlds Before Adam* (Chicago, 2008) [see esp. pp. 493-97, 528-32].

APPENDIX

These diagrams, reproduced from Rudwick, "Darwin and Glen Roy" (1974/2005), complement the maps reproduced in the Introduction to this Field Guide.

Lauder's paper 1821 (and new element introduced in **Milne's paper 1847**)

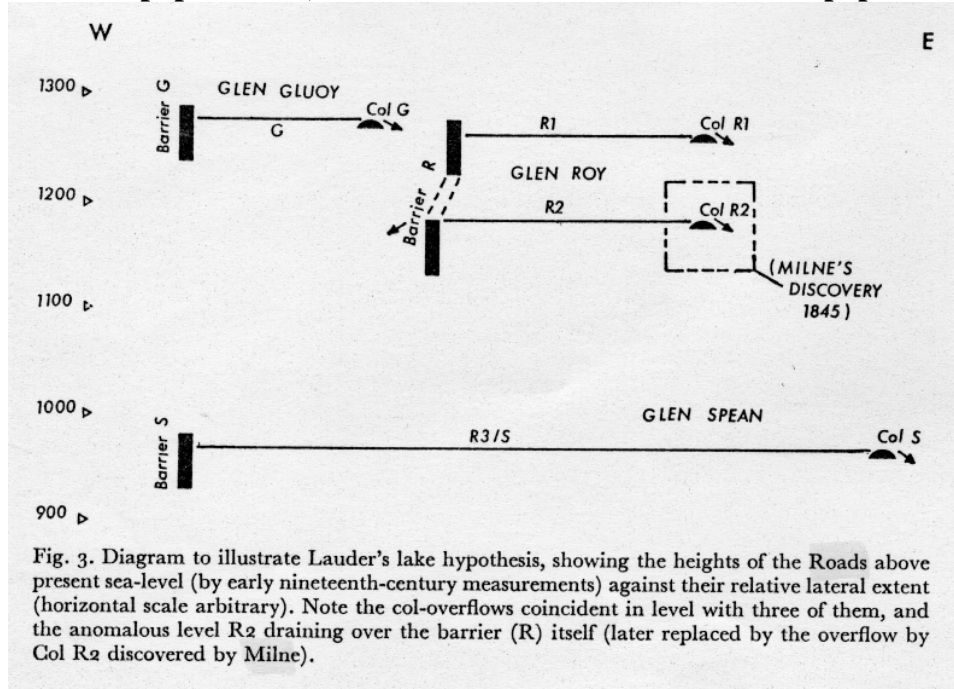


Fig. 3. Diagram to illustrate Lauder's lake hypothesis, showing the heights of the Roads above present sea-level (by early nineteenth-century measurements) against their relative lateral extent (horizontal scale arbitrary). Note the col-overflows coincident in level with three of them, and the anomalous level R2 draining over the barrier (R) itself (later replaced by the overflow by Col R2 discovered by Milne).

Darwin's paper 1839

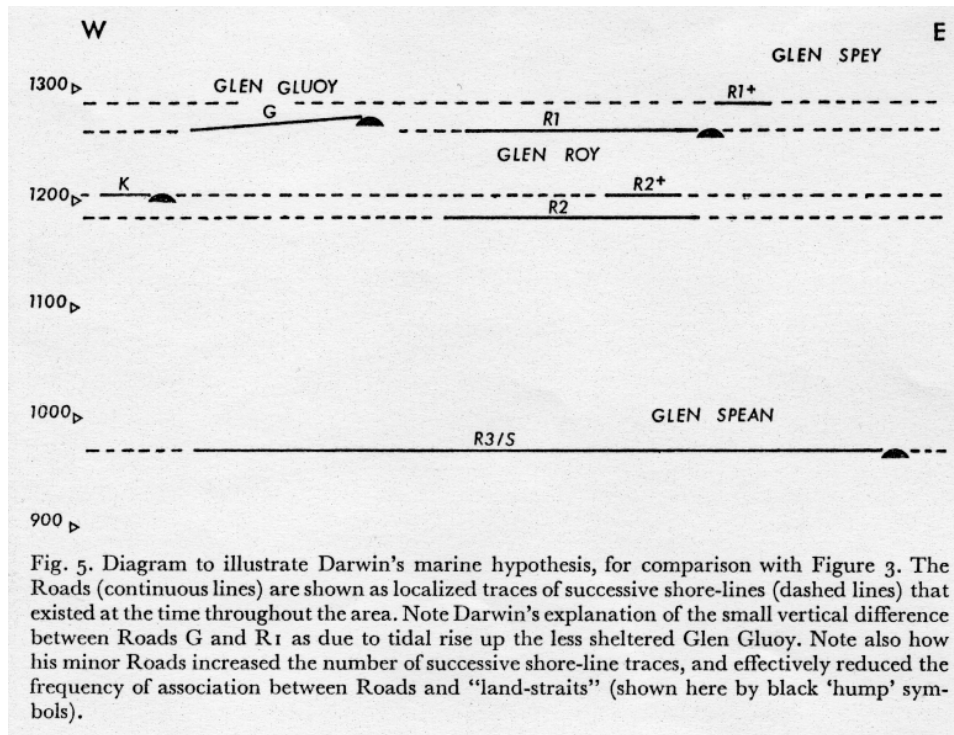


Fig. 5. Diagram to illustrate Darwin's marine hypothesis, for comparison with Figure 3. The Roads (continuous lines) are shown as localized traces of successive shore-lines (dashed lines) that existed at the time throughout the area. Note Darwin's explanation of the small vertical difference between Roads G and R₁ as due to tidal rise up the less sheltered Glen Gluoy. Note also how his minor Roads increased the number of successive shore-line traces, and effectively reduced the frequency of association between Roads and "land-straits" (shown here by black 'hump' symbols).

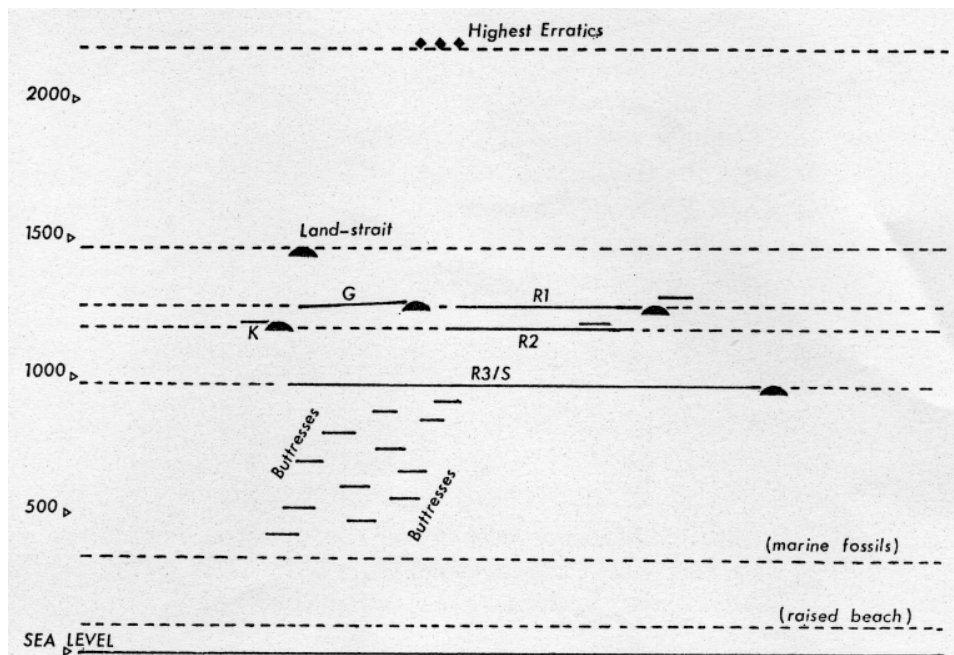


Fig. 6. Diagram for comparison with Figure 5, showing Darwin's assimilation of the Roads into a 'consilience of inductions' from other phenomena, all indicating formerly higher relative sea-levels. Successive levels (dashed lines) are shown for the principal Roads and for a selection of other features: the highest erratic boulders and highest isolated "land-strait" mentioned by Darwin; and the highest (geologically recent) marine shells and the highest unambiguous marine 'raised beach' known elsewhere in Scotland (*not* in Lochaber). Note how Darwin's "buttresses" (shown here at arbitrary levels) bridged the gap between the lowest Road (R₃/S) and the highest uncontroversial evidence of higher sea-levels. Vertical scale in feet above present sea-level (on measurements accepted by Darwin).