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Bathymetrical Survey of the Fresh-Water Lochs of Scotland. Part VII. Lochs of the Shiel District

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Avalanches are a danger which it is, I hold, the duty of every climber who has been in these regions to insist on. They are on a scale wholly different from those of the Alps, and Alpine experience is at first likely to be misleading. Mr. Mummery's fate supplies the most emphatic warning on this point.

A minor but very serious trouble is the inflammation of the lips, mentioned by Dr. Workman. It becomes torture to eat, and men cannot climb without eating. Perhaps Dr. Workman may be able to suggest a palliative. I found boracic ointment useful.

The greatest difficulties in the way of climbers in the Himalaya are weather and transport.

As to weather, I can only suggest that some year luck may reward patience, and a climbing party get the ten consecutive fine midsummer days needed for an assault on a great peak. They must wait on the spot to profit by them.

As to transport, I see little hope until the Indian Government co-operates with an attempt to climb K<sup>2</sup> or Kangchenjunga, as the Home Government has co-operated with Arctic expeditions; until it puts fifty militarily trained and disciplined mountaineers at an explorer's disposal. Without this help a money grant would be little use; with it a relatively small sum, £1000 or £2000, might accomplish that desirable end—the conquest of the highest mountain in the world. We have heard lately a great deal of the moral qualities called out by polar exploration. I venture to think they are also called out to a great extent in mountaineering at high altitudes. There is surely some reason in the rhyme of the poet—it is true he was a mad poet—Blake—

“ Great things are done when men and mountains meet ;  
These are not done by jostling in the street.”

## BATHYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOTLAND.\*

Under the Direction of Sir JOHN MURRAY, K.C.B., F.R.S., D.Sc., etc., and  
LAURENCE PULLAR, F.R.S.E.

### PART VII.—LOCHS OF THE SHIEL DISTRICT.

IN this paper it is proposed to deal with the results of the work of the Lake Survey among the lochs lying near the borders of Argyllshire and Inverness-shire, viz. (1) Lochs Shiel and Dilate, which drain by the river Shiel into Loch Moidart; (2) Loch Eilt, which flows by the river Ailort into Loch Ailort; and (3) Lochs Màma, na Creige Duibhe, and Dubh, which drain into Loch nan Uamh. The relative positions of these lochs are shown in the index map (Fig. 1). The principal loch is Loch Shiel, lying on the boundary-line between Argyll and Inverness, while Loch Dilate lies in Argyllshire, and the other lochs mentioned are situated in Inverness-shire. Mr. Garrett drew up some notes on Lochs Eilt, Dubh, Màma, and na Creige Duibhe before leaving for Borneo, and these have been embodied in this article.

\* Plates, p. 352.

### 1. LOCHS OF THE SHIEL BASIN.

There are only two lochs belonging to this basin to be dealt with here, viz. Lochs Shiel and Dilate; one or two other small lochs within the basin (the principal one being Lochan Dubh, at the head of Glen Hurich) were not sounded.

*Loch Shiel* (see Plates I. and II.).—Loch Shiel is one of the larger Scottish fresh-water lochs, having a total length of  $17\frac{1}{2}$  miles. In this

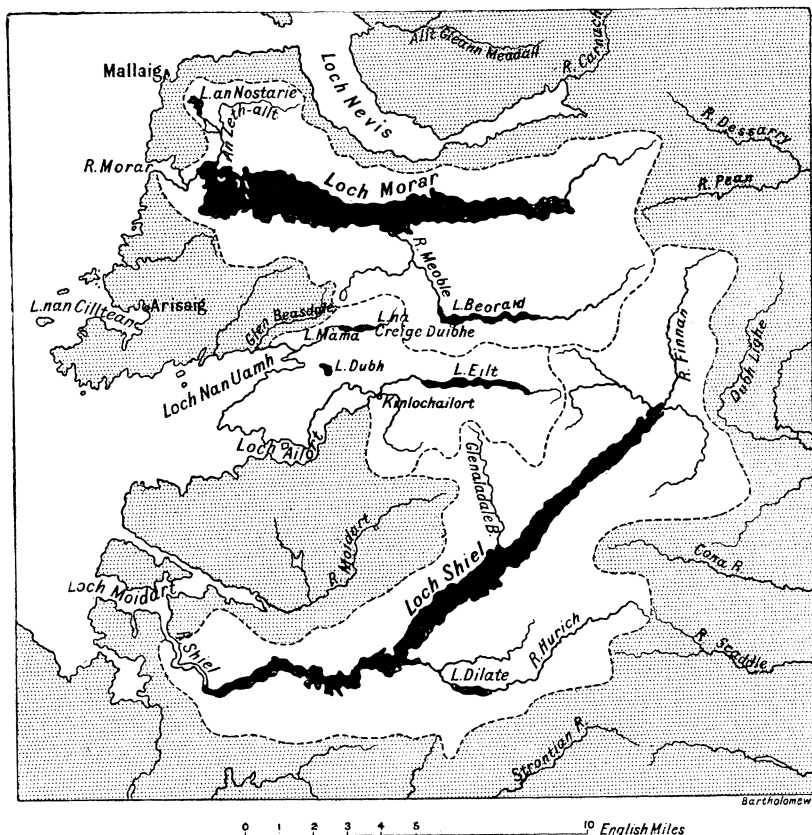


FIG. 1.—INDEX MAP OF THE SHIEL DISTRICT.

respect it is inferior only to Lochs Awe, Ness, and Lomond, which are 23, 22 $\frac{3}{4}$ , and 22 miles in length respectively, and is closely followed by Loch Shin, which is 17 $\frac{1}{4}$  miles in length. Its elevation above the sea is only 11 $\frac{1}{2}$  feet, so that a slight subsidence of the strip of land through which the river Shiel flows would convert it into an arm of the sea. Seals occasionally make their way into this loch from the sea at the present time. The principal upper portion of the loch trends in a

north-east and south-west direction, but about 6 miles above the outflow there is a bend in the outline of the loch, and the lower portion trends almost due west. The river Shiel follows a north-westerly course for about 2 miles before emptying itself into Loch Moidart. The scenery around the loch is very fine, becoming grand and wild towards the head. At the foot of the loch the surrounding ground is low, but on proceeding up the loch mountainous country borders the loch on both sides, culminating in heights exceeding 3000 feet at the head of Glen Finnan. To the south rises Ben Resipol (2774 feet), between Loch Shiel and Loch Sunart; to the east Sgor an Tarinachain (2474 feet), Meall Mor (2487 feet), Meall nan Creag Leac (2474 feet), Glas Garbh (2369 feet), Meall Doire na Mnatha (2094 feet); to the north Beinn nan Tom (2603 feet), Streap (2988 feet), Sgor Choileam (3164 feet), Sgor nan Coireachan (3133 feet), Fraoch-bheinn (2489 feet); to the west Beinn Odhar (2895 feet), Druim Fiaclach (2851 feet), a' Chroit-bheinn (2178 feet), and Beinn Gaire (2179 feet). The principal feeders are the river Finnan, Amhainn Shlatach, and Callop river, which enter the loch at its head, Glenaladale river entering about 6 miles down on the north-western shore, and the river Polloch (bearing the outflow from Loch Dilate) entering about 11 miles down on the south-eastern shore, where the bend in the trend of the loch occurs. There are numerous small islands and a few larger ones, the largest being Eilean Gleann Fhionainn at the head of the loch, while on Eilean Fhianain, at the narrows towards the foot of the loch, are the remains of St. Finnan's Church and a romantic burying-place of the Clanranald. At the head of the loch stands Prince Charlie's monument, erected by the late Colonel Macdonald, of Glenaladale, on the spot where that ill-fated prince raised his standard. Salmon, grilse, sea-trout, and brown trout abound in the loch, and yield fair sport, some of the salmon and trout being very heavy.

Considering its great length, Loch Shiel is very narrow, for at no place does the loch attain a width of a mile, the maximum breadth being about nine-tenths of a mile, and this occurs at the great bend in the outline of the loch, opposite the entrance of the river Polloch. The mean breadth of the loch is less than half a mile, being only  $2\frac{1}{2}$  per cent. of the length—a smaller percentage than has been observed in any of the larger lochs surveyed by the Lake Survey, the lochs most nearly approaching it in this respect being Loch Shin with 3 per cent., and Loch Ness with 4·3 per cent. The waters of Loch Shiel cover an area of about 4840 acres, or over  $7\frac{1}{2}$  square miles, and it drains directly an area of over  $72\frac{1}{2}$  square miles, but, since it receives the outflow from Loch Dilate, its total drainage area is about  $85\frac{1}{2}$  square miles—an area over eleven times greater than that of the loch. Over 700 soundings were taken, the maximum depth recorded being 420 feet, about 4 miles from the head of the loch, between the heights of Beinn a' Chaoruinn



and Beinn Odhar Bheag to the north-west, and of Meall nan Creag Leac to the south-east. The volume of water contained in the loch is estimated at 17,215 million cubic feet, and the mean depth at  $81\frac{1}{2}$  feet, or nearly 20 per cent. of the maximum depth. Loch Shiel was surveyed on July 2 to 9, 1902. The elevation of the lake surface above the sea was determined by levelling from bench-mark as being 11·4 feet; when levelled by the officers of the Ordnance Survey on November 6, 1897, the elevation was found to be 12 feet above sea-level. The water may rise 4 to 5 feet higher than the level given above.

The floor of Loch Shiel is on the whole rather irregular. The



FIG. 2.—LOCH SHIEL, FROM PRINCE CHARLIE'S MONUMENT.

(Photo by T. N. Johnston, M.B., C.M.)

50-foot contour-line encloses a continuous area extending from close to the upper end to within 2 miles from the lower end at Acharacle, but all the deeper contours are broken up so as to enclose two or more isolated areas. The 50-foot contour follows approximately the general outline of the loch, but it is in places of a sinuous character. At the head of the loch it extends both to the north-west and south-east of Eilean Ghleann Fhionainn. About 2 miles down there are sinuosities in the contour on both sides of the loch, due to a tongue of deep water projecting between the south-eastern shore and the island Sgeir Ghiubhsachain, and to a shoaling of the water off the north-western shore from 33 to 15 feet. Further down, off the north-western shore, above the entrance of the Glenaladale river, there is a twist in the 50-foot

contour, where the water shoals from 55 to 20 feet. Still further down, opposite the entrance of the Allt na Dalach, sinuosities in the 50-foot contour occur on both sides of the loch, the water shoaling off the south-eastern shore from 47 to 35 feet, and off the north-western shore from 41 to 19 and 22 feet. The last-mentioned shoaling occurs to the north-east of Eileanan Comhlach, at the entrance of the Allt a' Ghiubhais, and it is curious to observe a similar shoaling on the opposite (south-west) side of the island from 41 to 18 and 21 feet, while between the island and the mouth of the stream a depth of 32 feet was observed.

Towards the lower end of the wide part of the loch, and almost due south of Eilean Druim nan Laogh (or Heron island, as it is now called in the district), there is, near the middle of the loch, a shoal covered by only 2 or 3 feet of water. During the visit of the Lake Survey the regular mail steamer was laid up for repairs, having shortly before struck on this shoal and damaged the propeller. The captain of the steamer supplied information as to the position of the shoal, and the local gillie employed by the surveyors stated that in calm weather the bottom can be seen, but in the stormy weather prevailing at the time of the survey he was unable to find it, so that it must be of very small extent, for deep soundings were recorded near the spot indicated. The same gillie stated that a shoal bank extended from Ruadh Bac na Moine in an approximately south-west direction towards the opposite shore; this was confirmed by fishermen, and is probably indicated by the outward bend of the 50-foot contour-line at that place.

The 100-foot contour-line is less sinuous in character than the 50-foot contour, the main basin being about 12 miles in length, extending from near the head of the loch to the narrows at Eilean Fhianain, with two small subsidiary basins — one off Rudha Leathan, about  $3\frac{1}{2}$  miles from the foot of the loch, based on a sounding of 112 feet; the other between the promontory on the south-eastern shore called Rudha Torr a' Chonnaidh and the outlying islands, about 7 miles from the head of the loch, based on a sounding of 148 feet. A remarkable rise of the bottom was observed within the main 100-foot basin, about a mile above the entrance of the river Polloch, where soundings of 84 and 43 feet were taken, surrounded on all sides by about 150 feet of water. The contour of the lake-floor along this line of soundings is shown in cross-section C-D on the map (Plate I.).

The main 200-foot basin is nearly 8 miles in length, approaching to within half a mile from the head of the loch, and extending as far down as Eileanan Comhlach. There are two small subsidiary basins, separated from the main basin by an interval of over half a mile, between the entrance of the Allt na Claise on the south-eastern shore and the entrance of the An Garbh-allt on the north-western shore. This line of soundings shows a curious configuration of the bottom, which rises in the central part of the loch and sinks again on both sides nearer the

shore: thus, on proceeding from south-east to north-west the water deepens to 201 feet, then shoals to 122 feet, then deepens again to 172, 209, and 224 feet, shoaling again towards the north-western shore. It is interesting to note the close proximity of these two small deep basins to the rise covered by 43 feet of water already mentioned. The 200-foot contour shows a peculiar loop off the north-western shore, about 4 miles from the head of the loch, where the water shoals from 199 to 163 feet.



FIG. 3.—LOCH SHIEL, FROM HIGH GROUND AT THE HEAD OF THE LOCH.

(*Photo by Mr. David Brigham.*)

The principal 300-foot basin is distant about a mile from the head of the loch, and extends down the loch for over 4 miles, enclosing the deepest parts of the loch. Separated from this basin by an interval of a quarter of a mile (in which the greatest depth is 282 feet) is a second small basin based upon a sounding of 307 feet, and after a similar interval (in which the greatest depth is 284 feet) there is a third 300-foot basin 2 miles in length, having a maximum depth of 385 feet. Within this third basin there is a slight rise of the bottom covered by 288 feet of water; the line of soundings on which this rise is situated is shown in cross-section E-F on map (Plate II.).

There are two small basins with depths exceeding 400 feet, the smaller about 3 miles from the head of the loch, based on soundings of 416 and 419 feet, separated by an interval of three-quarters of a mile (in which the greatest depth is 375 feet) from the larger, which is less than a mile in length and encloses the maximum depth of the loch (420 feet), recorded near the north-eastern end of this larger basin, and over 4 miles from the head of the loch. The line of soundings which includes the deepest one, is shown on cross-section G-H on map (Plate II.).

From the foregoing description, it will be noticed that in Loch Shiel the deeper water occurs towards the head of the loch. Proceeding from Acharacle at the foot of the loch, one must row 2 miles up before encountering a depth of 50 feet; a further  $1\frac{1}{2}$  miles before meeting with a depth of 100 feet, and this merely a small patch, a further  $1\frac{1}{2}$  miles having to be traversed before reaching the main 100-feet basin, or a total distance of 5 miles from the foot of the loch. The main 200-feet basin is distant about 9 miles, the lower 300-feet basin nearly 10 miles, and the principal 400-feet basin over 12 miles, from the foot of the loch.

The areas between the consecutive contour-lines drawn at equal intervals, and the percentages to the total area of the loch, are as follows :—

Feet.				Acres.		Per cent.
0 to 100	...	...	...	2632	...	54·4
100 „ 200	...	...	...	968	...	20·0
200 „ 300	...	...	...	711	...	14·7
300 „ 400	...	...	...	484	...	10·0
over 400	...	...	...	45	...	0·9
				4840		100·0

This table shows that more than half of the entire floor of Loch Shiel is covered by less than 100 feet of water, and about three-fourths by less than 200 feet, while only 1 per cent. is covered by water exceeding 400 feet in depth. The slope of the bottom is on the whole gentle, but in certain places deep water was found comparatively close inshore, and the consequent crowding of the contour-lines indicates a steeper slope than usual in these positions.

*Temperature Observations.*—Numerous observations were made on the temperature of the surface water of Loch Shiel during the week spent on the survey, the range observed being  $8^{\circ}\cdot 2$ , from  $54^{\circ}\cdot 2$  to  $62^{\circ}\cdot 4$ . Three serial temperatures were taken beneath the surface, with the following results :—

TABLE OF SERIAL TEMPERATURES TAKEN IN LOCH SHIEL.

Depth in feet.	July 5, 1902, 6 p.m. Off Scamodale.	July 8, 1902. Off Eilean Druim nan-Laogh.	July 9, 1902, 5 p.m. 3 miles from head of loch.
	° Fahr.	° Fahr.	° Fahr.
0	57·1	55·9	56·5
5	—	54·9	—
10	57·0	54·5	—
20	56·3	54·4	56·5
30	55·5	—	—
50	50·2	54·0	56·0
75	—	50·9	—
100	47·0	47·0	47·4
130	—	46·2	—
200	45·7	—	45·2
280	45·3	—	—
300	—	—	45·2
400	—	—	45·3

In this table the observations are arranged chronologically, but the series given in the first column was taken about midway between the other two series, the second column giving a series taken towards the foot, and the third column a series taken towards the head, of the loch. The central series in the first column was taken three days earlier than the others, and is therefore not strictly comparable; it shows a higher temperature in the surface waters, and a lower temperature at a depth of 50 feet, than in either of the others. The temperature observed near the foot of the loch was lower at all depths than that observed towards the head, the difference amounting to 2° at 20 and at 50 feet, and to 0°·4 at 100 feet. The most pronounced fall in temperature was recorded between 50 and 100 feet towards the two ends of the loch, but between 30 and 50 feet in the central series (first column). The range of temperature shown by these serial observations is about 12°, while the extreme range of all the observations from surface to bottom during the week spent on the survey is over 17°.

*Loch Dilate* (see Plate III.).—*Loch Dilate* (or *Doilate*) lies about 1½ miles to the east of the lower portion of *Loch Shiel*, into which it flows by the river *Polloch* entering *Loch Shiel* about 6 miles above its outflow. The ground between the two lochs is low, the fall from *Loch Dilate* to *Loch Shiel* being only 10½ feet, but high and mountainous country surrounds *Loch Dilate* in all other directions. The principal feeder is the river *Hurich*, which takes its rise in *Lochan Dubh* at the head of *Glen Hurich*, and after a course of 6 miles empties itself into the east end of *Loch Dilate*. The loch trends east and west, and is nearly 1½ miles in length. It is widest towards the east end, where the maximum breadth is over one-third of a mile, the mean breadth being about one-seventh of a mile. Its waters cover an area of about 142 acres, or nearly a quarter of a square mile, and it drains an area fifty-eight times greater, or nearly 13 square miles. Forty-five

soundings were taken in Loch Dilate, the maximum depth observed being 55 feet. The volume of water contained in the loch is estimated at 145 million cubic feet, and the mean depth at  $23\frac{1}{2}$  feet, or 43 per cent. of the maximum depth. The loch was surveyed on July 8, 1902, and the elevation of the lake surface above the sea by levelling from benchmark was found to be 22 feet. When levelled by the officers of the Ordnance Survey on October 16, 1867, the elevation was found to be 23·4 feet above sea-level.

Loch Dilate forms a simple basin, the deeper water being centrally placed, and the contour-lines following approximately the outline of the loch. A sounding of 12 feet was recorded off the bay in the south-east corner of the loch, apparently surrounded by shallower water, though possibly continuous with the 10-feet area, but this is the only irregularity in the lake-floor indicated by the soundings. Along the central portion of the southern shore the contour-lines closely hug the shore, indicating a comparatively steep slope in this locality. A section along the central line of the loch from west to east is shown in section A-B on the map. The areas between the contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	78	...	55·4
25 „ 50	...	...	...	49	...	34·3
Over 50	...	...	...	15	...	10·3
				142		100·0

*Temperature Observations.*—The following serial temperatures were taken at 3 p.m. on July 8, 1902, in the deepest part of Loch Dilate:—

Surface	...	...	...	...	...	...	62°·3 Fahr.
10 feet	...	...	...	...	...	...	62°·3 „
20 „	...	...	...	...	...	...	62°·3 „
25 „	...	...	...	...	...	...	61°·5 „
30 „	...	...	...	...	...	...	55°·3 „
50 „	...	...	...	...	...	...	53°·3 „

This series shows a constant temperature from the surface down to a depth of 20 feet, a slight fall of 0°·8 between 20 and 25 feet, then a very rapid fall of 6°·0 between 25 and 30 feet (a fall exceeding 1° per foot of depth), and a further fall of 2° between 30 and 50 feet, the extreme range of temperature being 9° Fahr.

## 2. Ailort Basin.

Loch Eilt is the only loch to be dealt with here; the few very small hill lochs within the basin were not surveyed.

*Loch Eilt* (see Plate IV.)—Loch Eilt lies about  $1\frac{1}{2}$  miles to the east of the head of Loch Ailort (into which its outflow is carried by the river Ailort), and about 4 miles to the west of Glenfinnan. The hills

around it rise steeply up to a height of over 1500 feet, the highest points exceeding 2000 feet. It was formerly considered a good loch for salmon and sea-trout; but Mr. Harvie-Brown believes that the blasting operations during the construction of the Mallaig extension of the West Highland railway resulted in the destruction of a large amount of spawn and fry, and that now the fish are greatly disturbed by the passage of the trains across the bays on the south shore.

Loch Eilt trends east and west, and is  $3\frac{1}{5}$  miles in length, with a



FIG. 4.—LOCH EILT, LOOKING EAST.

(Photo by Mr. David Brigham.)

maximum breadth of half a mile, the mean' breadth being one-fifth of a mile. Its waters cover an area of about 424 acres, or two-thirds of a square mile, and it drains an area of 12 square miles. Over 250 soundings were taken, the maximum depth recorded being 119 feet. The volume of water contained in the loch is estimated at 686 million cubic feet, and the mean depth at 37 feet. The loch was surveyed on July 9 and 10, 1902; the elevation of the lake-surface was found, by levelling from bench-marks, to be 96·4 feet above the sea. The keeper stated that the water might rise about 3 feet above, and fall about

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9 inches below, this level. During the night of July 9 and 10, 1902, the water rose nearly 10 inches.

Loch Eilt is naturally divided into three portions by two narrow constrictions in its outline, the western portion being by far the largest and deepest, covering an area of about 360 acres, while the area of the central and eastern portions is in each case about 32 acres. The western portion is connected with the central portion by a channel 6 feet in depth, with a rocky islet in the centre, the sides of the channel being also of rock *in situ*, thus dividing the loch into two rock-basins; the central portion is separated from the eastern portion by detritus brought down by the Allt a' Choire Bhuidhe, the channel between them having a depth of 7 feet. The small eastern and central basins are quite simple in conformation, the maximum depth observed in the eastern one being 52 feet, and in the central one 70 feet. The floor of the large western basin is much more irregular, there being four areas with depths exceeding 50 feet: (1) a small area near the east end, based on a sounding of 52 feet; (2) the main 50-foot area, which encloses the deepest part of the loch, over a mile in length, and with a rocky islet rising to the surface near its western margin; (3) a small area between the large island (Eilean Mòr) and the northern shore, based on a sounding of 55 feet; and (4) a small area near the west end, based on two soundings of 55 feet. At the extreme west end of the loch, between the two islands, a depth of 40 feet was recorded. The 75-foot area is about half a mile, and the 100-foot area about a quarter of a mile, in length, occupying the wide central part of the western basin, but rather nearer the east than the west end. The deepest part of the loch falls below sea-level (the 100-foot contour-line corresponding approximately with the level of the sea), and is flat-bottomed in character, as shown in cross-section C-D on the map.

The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	187	...	44·1
25 „ 50	...	...	...	111	...	26·0
50 „ 75	...	...	...	88	...	20·9
75 „ 100	...	...	...	20	...	4·8
Over 100	...	...	...	18	...	4·2
				424		100·0

*Temperature Observations.*—The temperature of the surface water in Loch Eilt during the two days spent on it varied from 58° to 60° Fahr., while the air-temperature varied from 53°·5 to 57°·9. On July 10, 1902, three series of temperatures were taken beneath the surface, one in each of the three basins into which the loch is divided, with the following results:—



Depth in feet.	Loch Eilt (eastern basin). July 10, 1902, 2.30 p.m.	Loch Eilt (central basin). July 10, 1902, 3.30 p.m.	Loch Eilt (western basin). July 10, 1902, 5 p.m.
	° Fahr.	° Fahr.	° Fahr.
Surface	58.0	58.1	60.0
10	58.0	58.1	60.0
20	58.0	58.1	60.0
27.5	55.7	57.7	60.0
35	52.8	53.6	59.7
50	50.7	52.8	54.8
75	—	—	53.0
100	—	—	51.0

These series show a constant temperature down to 20 feet in each case, but the water in the deep western basin was 2° warmer than in the other two basins. Beyond the depth of 20 feet, again, the temperature was about 2° higher in the western basin than in the central basin, and 2° higher in the central basin than in the eastern basin, so that at a depth of 100 feet in the western basin the temperature was rather higher than at a depth of 50 feet in the eastern basin. The water in the western basin was warmer at all depths than that in the central basin, and in the central basin than in the eastern basin. To explain this peculiar distribution of temperature in the waters of Loch Eilt on the afternoon of July 10, 1902, the weather conditions during the few preceding days must be taken into account. The wind had been blowing strong from the north-east from the 3rd till the afternoon of the 9th. Rain commenced to fall about 6 a.m. on the 9th, and continued till about 8 a.m. on the 10th, so that during the twelve hours from 9 p.m. on the 9th to 9 a.m. on the 10th the surface of the loch rose  $9\frac{3}{4}$  inches. About 11.30 a.m. on the 10th the wind rose from the west, and by 4 p.m. was blowing a gale, so much so that the greatest difficulty was experienced in keeping the boat in position for the 5 p.m. series of temperatures. It would thus appear that the easterly winds of the previous week had blown the warm surface water into the western portion of the loch, and the west wind of the 10th had not yet had time to reverse this effect; the fact that the area draining into the western basin is nearly double that draining into the other two basins would doubtless accentuate this result, since more water would enter the western basin than the other basins, and this inflowing water at this season of the year would be warmer than the water of the loch. The range of temperature from surface to bottom in the eastern basin was 7°.3 Fahr., the greatest fall being 5°.2 between 20 and 35 feet; in the central basin the range was 5°.3, the greatest fall being 4°.5, also between 20 and 35 feet; in the western or main basin the range was 9° (representing the extreme range observed throughout the entire loch), and the greatest fall was 4°.9 between 35 and 50 feet.

### 3. *Lochs of the nan Uamh Basin.*

The lochs to be dealt with here are Loch Dubh, between the head of Loch Ailort and the head of Loch nan Uamh, and Lochs Màma and na Creige Duibhe lying to the north-east. Loch Doir' a' Gherrain in Ardnish could not be sounded, because there was no boat on it at the time of the visit of the Lake Survey.

*Loch Dubh* (see Plate V.).—Loch Dubh is a small loch situated at the head of the peninsula of Ardnish, which separates Loch Ailort from Loch nan Uamh, the two branches of the Sound of Arisaig. The Mallaig extension of the West Highland railway runs along its southern shore, and the outfall flows through the old bed of the little Lochan Deabhtha, which has been completely drained by the railway, leaving only a channel through it for the escape of the waters from Loch Dubh. After leaving Lochan Deabhtha the outfall joins the Schoolhouse burn, which has been deflected, thence into the Arnabol burn, falling into the head of Loch Beag, an inlet of Loch nan Uamh. It is surrounded, except on the western side, by low though steep hills, which impart a dark and sullen appearance to the loch, hence its name—the Black loch. Considering its superficial area, it is the deepest loch visited by the Lake Survey.\* Its great depth, and the remarkable temperature conditions discovered in it, well repaid the trouble of carting a boat from Loch nan Uamh and carrying it down to the loch. Its catchment area is very small, and it would seem that the unpleasant taste of its water, resembling that of a stagnant pool, is due to the small amount of fresh water entering it. This unpleasantness is probably something more than mere taste, for attempts to stock the loch with trout have been unsuccessful, the fish rapidly dying; eels, however, abound in it.

Loch Dubh trends in a north-west and south-east direction, the broadest part being rather near the south-east end. Its length is under half a mile, its maximum breadth one-sixth of a mile, and its mean breadth one-tenth of a mile. Its waters cover an area of about 32 acres, and it drains an area eight times greater, or about 262 acres. Sixty-five soundings were taken, and the maximum depth observed was 153 feet, which bears the ratio to the length of the loch of 1 to 15. This low ratio is only equalled by the little loch on Eilean Subhainn in Loch Maree, and the loch which most nearly approaches it is Loch Fender in the Tay basin, in which the ratio is as 1 to 22, followed by Loch Dhugaill, near Kishorn, in which the ratio is as 1 to 27. Among the larger Scottish lochs, the nearest approach is found in Loch Treig, with a ratio of depth to length of 1 to 62. The volume of water

\* The deepest lake in East Prussia is, according to Halbfass (*Globus*, Bd. 86, p. 187, September 15, 1904), the Wuchsnigsee, which is about  $1\frac{1}{2}$  miles in length, and has a maximum depth of about 210 feet. Loch Dubh is less than half a mile in length, and its maximum depth is 153 feet.

contained in the loch is estimated at 86,956,000 cubic feet, and the mean depth at nearly 63 feet, or 41 per cent. of the maximum depth. The loch was surveyed on July 12, 1902; the elevation of the lake surface above the sea was found, by levelling from bench-marks, to be 103 feet; when visited by the Ordnance Survey officers on August 6, 1869, the elevation was 103·3 feet above sea-level. No drift-marks were seen, but the keeper stated that the annual range in level was about 9 inches.

Loch Dubh is very simple in conformation, the contour-lines following approximately the shore-line. Near the north-west end there is a slight rise of the bottom, as shown in section A-B on the map, but otherwise the lake-floor slopes down regularly to the deepest part, which lies towards the north-eastern shore. The maximum depth of 153 feet was observed at a distance of about 120 feet from this shore, giving a slope of  $59^{\circ}$ ; the height of the hill immediately adjoining is 240 feet, and the slope  $35^{\circ}$ , hence the slope from the top of the hill to the bottom of the loch is one of  $45^{\circ}$ . The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows :—

Feet.			Acres.		Per cent.
0 to 50	...	...	14·8	...	40·7
50 „ 100	...	...	8·9	...	30·9
100 „ 150	...	...	7·6	...	26·5
Over 150	...	...	0·5	...	1·9
			31·8		100·0

*Temperature Observations.*—A most interesting series of temperatures was taken in Loch Dubh at the time of the survey, as given in the first column of the following table. The loch was revisited in March, 1903, when the water was found to be uniform in temperature from surface to bottom, as given in the second column of the table—

Depth in feet.	Loch Dubh. July 12, 1902, 3 p.m.	Loch Dubh. March 28, 1903.
	° Fahr.	° Fahr.
0	59·0	41·0
10	59·0	—
16	58·9	—
20	56·0	—
25	53·7	—
35	51·5	—
50	47·1	41·0
75	44·1	41·0
100	43·6	40·9
150	43·5	40·9

The series taken in March calls for no discussion, but the series taken in July is remarkable for the low temperature of the deep water at this season of the year, and for the great range of temperature from surface to bottom. Compared with the temperatures recorded in Loch Shiel a week earlier in the same month, we find the temperature in

Loch Dubh  $1^{\circ}7'$  lower at the bottom in 150 feet than in Loch Shiel in 420 feet, and in Loch Morar (the deepest of all Scottish lochs), ten days earlier in the same month, a temperature equal to that at the bottom of Loch Dubh was recorded only after descending to a depth of 250 feet. The extreme range of temperature shown by the series in Loch Dubh amounts to  $15^{\circ}5'$ , while the series taken in Loch Shiel shows a range of only  $12^{\circ}$ , and the series in Loch Morar shows a range of only  $13^{\circ}$  from surface to bottom. The extraordinary temperature conditions observed in Loch Dubh may probably be accounted for (1) by the great depth of the loch compared with other lochs of similar area; (2) by the small extent of its drainage area, so that very little rain-water enters the loch; and (3) by the small area of the loch and the steepness of the surrounding hills reducing the mixing effect of the wind to a minimum.

Lochs Màmà and na Creige Duibhe doubtless formed at no distant date one sheet of water, which was gradually separated into two portions by the deposition of material brought down by the Allt Dearg. This is evidenced by the fact that locally the name Màmà is applied to both divisions, but in this place that name is restricted to the western basin, the name na Creige Duibhe being applied to the larger and deeper eastern basin. The connecting stream is about 60 yards in length, with a depth of 7 to 8 feet, the fall from Loch na Creige Duibhe to Loch Màmà being less than a foot. The tract of alluvium separating the two lochs was about  $2\frac{1}{2}$  feet above the water of Loch Màmà, and the keeper stated that he had often seen it flooded when the lochs were high. The hills along the northern and southern shores of the lochs rise steeply up to heights exceeding 1000 feet, approaching 2000 feet along the northern shores, down the sides of which a few torrents rush after heavy rains. The two lochs trend east and west, and the outflow from Loch na Creige Duibhe passes into Loch Màmà, and thence by the Gleann Màmà into Loch nan Uamh.

*Loch Màmà* (see Plate V.).—Loch Màmà is over one-third of a mile in length, one-eighth of a mile in maximum breadth, and one-twelfth of a mile in mean breadth. Its waters cover an area of about 17 acres, and it drains directly an area of two-thirds of a square mile, but since it receives the outflow from Loch na Creige Duibhe its total drainage area is over 2 square miles, an area seventy times greater than that of the loch. Nearly forty soundings were taken, the maximum depth observed being 44 feet. The volume of water contained in the loch is estimated at 11 million cubic feet, and the mean depth at  $14\frac{1}{4}$  feet. The loch was surveyed on July 11, 1902, and the elevation of the lake surface above the sea was determined from spot-levels as being 359 feet. It forms a simple basin, the deepest part being found towards the east end. The areas between the contour-lines, and the percentages to the total area, are as follows:—

Feet.				Acres.		Per cent.
0 to 10	...	...	...	8.0	...	46.9
10 „ 25	...	...	...	6.4	...	37.5
Over 25	...	...	...	2.6	...	15.6
				17.0		100.0

*Loch na Creige Duibhe* (see Plate V.).—Loch na Creige Duibhe is four-fifths of a mile in length, one-eighth of a mile in maximum breadth, and one-fourteenth of a mile in mean breadth. Its waters cover an area of about  $36\frac{1}{2}$  acres, and it drains an area twenty-four times greater, or about  $1\frac{1}{2}$  square miles. Over seventy soundings were taken, the maximum depth recorded being 93 feet. The volume of water is estimated at 52 million cubic feet, and the mean depth at  $32\frac{1}{2}$  feet. The loch was surveyed on the same day as Loch Màma (July 11, 1902); the elevation of the lake surface above the sea, from spot-level and by comparison with Loch Màma, was found to be 359.7 feet. An inspection of the map shows Loch na Creige Duibhe to be (like Loch Màma) a long narrow basin of very simple conformation. It is much deeper than Loch Màma, and the deeper water approaches nearer to the west than to the east end, that is to say, nearer to the alluvial cone separating the two lochs. A similar state of matters has been noted in the case of Lochs Voil and Doine in the Forth basin, formerly a continuous loch, now divided into two portions by the deposition of material brought down by the river, where deep water approaches close to the dividing promontory of land on both sides.\*

The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	21.2	...	58.1
25 „ 50	...	...	...	6.9	...	19.0
50 „ 75	...	...	...	5.1	...	14.1
Over 75	...	...	...	3.2	...	8.8
				36.4		100.0

*Temperature Observations.*—The surface temperature observed in Loch na Creige Duibhe on the date of the survey was  $57^{\circ}4$ , in the stream between the two lochs  $57^{\circ}1$ , and in Loch Màma  $56^{\circ}5$ . The following serial temperatures were taken in the deepest part of Loch na Creige Duibhe at 4.45 p.m. on July 11, 1902:—

Surface	...	...	...	...	...	...	$57^{\circ}4$ Fahr.
10 feet	...	...	...	...	...	...	$57^{\circ}4$ „
20 „	...	...	...	...	...	...	$57^{\circ}4$ „
30 „	...	...	...	...	...	...	$53^{\circ}0$ „
50 „	...	...	...	...	...	...	$50^{\circ}8$ „
75 „	...	...	...	...	...	...	$49^{\circ}2$ „
90 „	...	...	...	...	...	...	$48^{\circ}8$ „

\* See *Geographical Journal*, vol. 15, p. 325, April, 1900.

## SUMMARY TABLE.

*Giving Details concerning the Lochs described in this Paper.*

Loch.	Height above sea. Feet.	Number of sound- ings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean Feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Shiel	11.4	715	17.40	0.88	0.43	2.5	420	81.65	19.4	219	1125	17,215	7.56	85.42	11.30
Dilate	22.0	45	1.43	0.37	0.15	10.5	55	23.50	42.7	137	321	145	0.22	12.81	58.23
Eilt	96.4	254	3.37	0.51	0.20	5.8	119	37.12	31.2	149	479	686	0.66	12.05	18.26
Dubh	103.0	65	0.43	0.17	0.10	23.2	153	62.70	41.0	15	36	87	0.05	0.41	8.20
Na Creige Duibhe	359.7	74	0.80	0.13	0.07	8.7	93	32.49	34.9	45	130	52	0.06	1.46	24.33
Mama	359.0	38	0.37	0.13	0.08	21.6	44	14.29	32.5	44	137	11	0.03	2.09	69.66
		1191										18,196	8.58	99.97 *	11.65

\* The drainage area of Loch Dilate is included in that of Loch Shiel, and that of Loch na Creige Duibhe in that of Loch Mama.

This series shows a constant temperature down to 20 feet, then a fall of  $4^{\circ}4$  between 20 and 30 feet, and a further fall of  $2^{\circ}2$  between 30 and 50 feet, the extreme range of temperature from surface to bottom being  $8^{\circ}6$ .

The details regarding the lochs dealt with in this paper are collected together in the table on the opposite page for convenience of reference and comparison.

From this table it will be seen that in the six lochs under consideration nearly 1200 soundings were taken, and that the aggregate area of the water surface is over  $8\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 139. The aggregate volume of water contained in the lochs is estimated at about 18,200 millions of cubic feet. The area drained by these lochs is nearly 100 square miles, or  $11\frac{1}{2}$  times the area of the lochs.

*Geology of the Loch Shiel Catchment Basin.*—Though the basin of Loch Shiel has not been surveyed by the Geological Survey, we understand that certain members of the staff have examined the rock cuttings on the line of railway between Loch Eil and Kinlochailort. The rocks exposed in these cuttings consist of muscovite-biotite gneiss and flaggy mica-schists, which are included in the Moine series of crystalline schists by the Geological Survey. The general strike of these strata is north-east and south-west, so that in all likelihood they are continued to the south-west along both sides of Loch Shiel. This conclusion is supported by the fact that on the lofty watershed between Loch Shiel and Loch Linnhe these muscovite-biotite gneisses have been mapped by the Geological Survey. These schists and gneisses, which are supposed to represent altered sediments, are traversed by numerous veins of pegmatite and dykes of diorite, dolerite, and basalt.

On the watershed between Glen Hurich and Glen Scaddle, on the crest of Sgor Dhomhail (2915 feet), there is a mass of foliated granite, and, further to the south-west, the later igneous intrusions of the Strontian district may enter the Loch Shiel catchment basin.

## NOTES ON THE BIOLOGY OF THE LOCHS IN THE SHIEL DISTRICT.

By JAMES MURRAY.

OF the six lochs dealt with in this paper, tow-nettings were taken in four, and a shore-netting in a fifth. The biology presented little of special interest. *Diaptomus laciniatus* was found in two of the lochs (Shiel and Eilt); these are the most southerly lochs in which this northern species was observed by the Lake Survey, though it has been recorded by Dr. Scott from one loch (Loch Doon) much farther south.

*Loch Shiel.*—Owing to the great abundance of *Holopedium*, which choked up the nets, it was difficult to collect other animals in any numbers. The most plentiful animals were: *Diaptomus gracilis*, *Diaptomus laciniatus*, *Cyclops strenuus*, *Bosmina obtusirostris*, *Bythotrephes*, *Polyphemus*, six species of pelagic Rotifers (including *Floscularia pelagica*) and *Dinobryon*. The plants noted were: *Xanthidium antilopeum*, *Staurastrum gracile*, and *Staurastrum braziliense*. *Lobelia* and *Littorella* were in flower at the upper end of the loch.

*Loch Dilate*.—As compared with Loch Shiel, the most notable features of this loch were: the greater abundance of life, the absence of *Holopedium* and *Diaptomus laciniatus*, and the presence of *Diaphanosoma brachyurum* in considerable numbers. Among the organisms observed were: *Diaptomus gracilis*, *Cyclops strenuus*, *Synchaeta pectinata*, *Pleusoma truncata*, *Dinobryon*, *Peridinium*, two species of *Ceratium* (*C. hirundinella* and *C. cornutum*), *Anabæna flos aquæ* with its adherent *Vorticellæ*.

*Loch Eilt*.—Life was abundant, the characteristic animals being *Holopedium*, *Diaptomus laciniatus*, *Cyclops strenuus*, *Anuræa cochlearis*, *Notholca longispina*, and *Polyarthra*. *Leptodora* and *Bythotrephes* were scarce. *Bosmina obtusirostris* and a variety approaching *B. longispina* were seen. The brilliant red and blue Rotifer, *Notops pygmaeus*, was plentiful. Some immature specimens of *Diaptomus* probably belonged to *D. gracilis*. On the mud in the deepest part of the loch were numbers of a pretty little green larva of an insect, enclosed in transparent flask-shaped cases.

*Loch Dubh*.—This little loch, remarkable for its great relative depth and temperature conditions, resembling those in a great lake, was examined on two occasions. On the first visit in July, 1902, the surface temperature was 59° Fahr., while on the second visit in March, 1903, the temperature throughout was about 41° Fahr. Notwithstanding this difference in temperature there was little difference in the animals observed on the two occasions. Those found in July were: *Diaptomus gracilis* (blue and red, grey, red, blue), *Cyclops strenuus*, *Bosmina obtusirostris* (small, purple), *Daphnia lacustris* (all pale red), *Eurycerus*, *Polyphemus*, *Triarthra*, *Polyarthra*, *Anuræa cochlearis*, *Conochilus*, *Ceratium hirundinella*, *Dinobryon*. In March all the same animals were found, except *Polyphemus*, and there were in addition a few larvæ of *Corethra* (phantom larvæ), *Notholca foliacea*, a second species of *Ceratium* (*C. cornutum*—less common in lakes), *Mallomonas*. A very small form of *Asterionella* occurred. Near the shore large spheres of *Ophridium* were found on the weeds. In the mud from the bottom were many Rhizopods of the species *Cyphoderia ampulla*, *Diffugia pyriformis*, *D. globulosa*, and *D. arcuata*. *Lobelia* and *Myriophyllum* were growing along the shores.

*Loch na Creige Duibhe*.—As this loch was only examined by means of a net thrown out from the shore, it is probable that some of the pelagic animals may have been missed. The animals seen were: *Diaptomus gracilis* (reddish), *Cyclops strenuus* (yellow), *Alonopsis elongata*, *Chydorus sphaericus*, *Anuræa cochlearis*, *Bosmina obtusirostris*, *Arcella vulgaris*. A few of the commonest filamentous Algae and Desmids were seen. *Asterionella* was scarce.

## A JOURNEY TO LAKE SAN MARTIN, PATAGONIA.

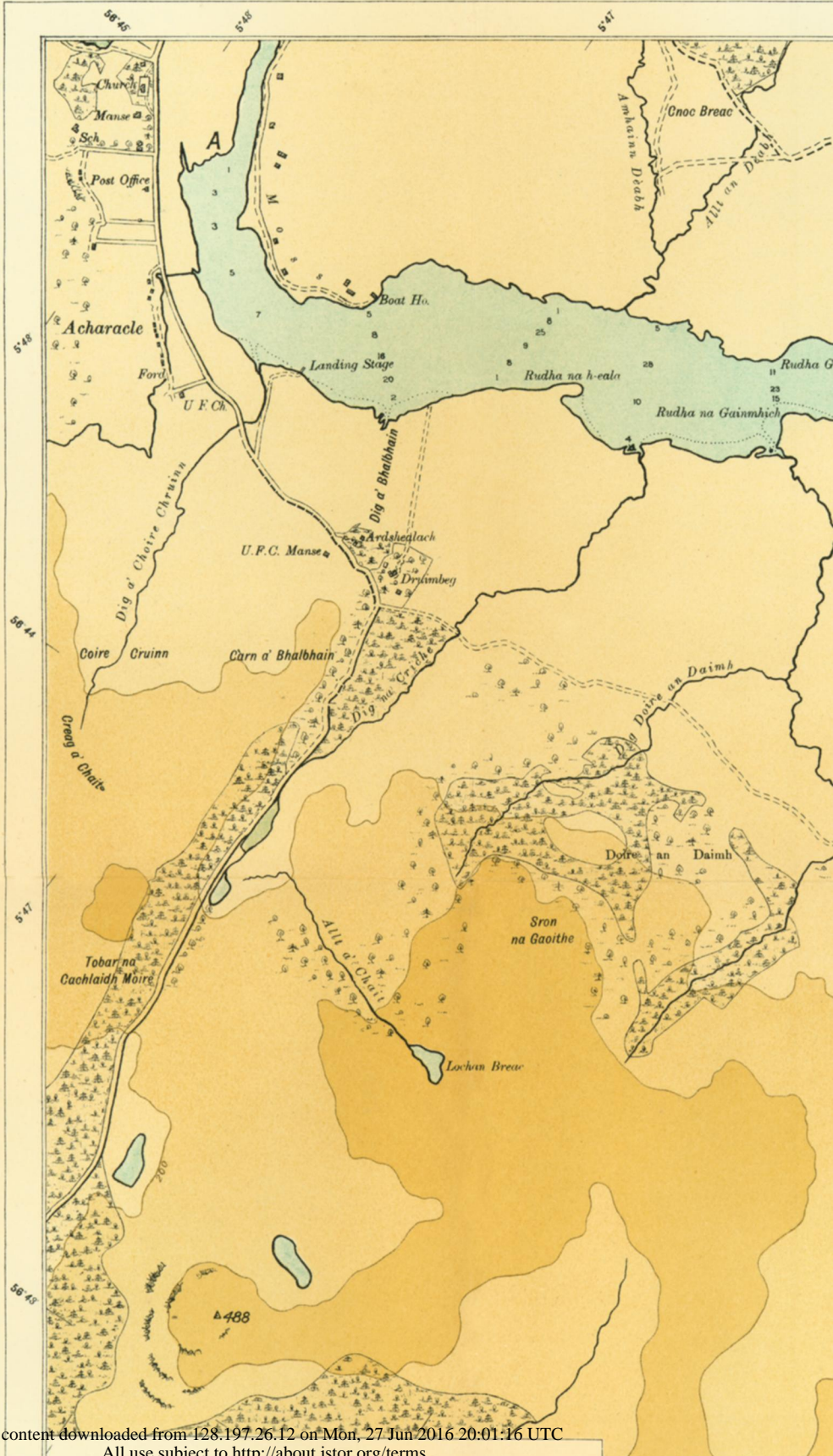
By Captain H. L. CROSTHWAIT, R.E.

THIS journey was undertaken in connection with the demarcation of the Chile-Argentine boundary. Before, however, landing in Patagonia, we made a short trip through the channels of Tierra del Fuego on board the Argentine cruiser *Nuevo de Julio*, Captain Quiroga, which had been placed at the disposal of Sir Thomas Holdich.

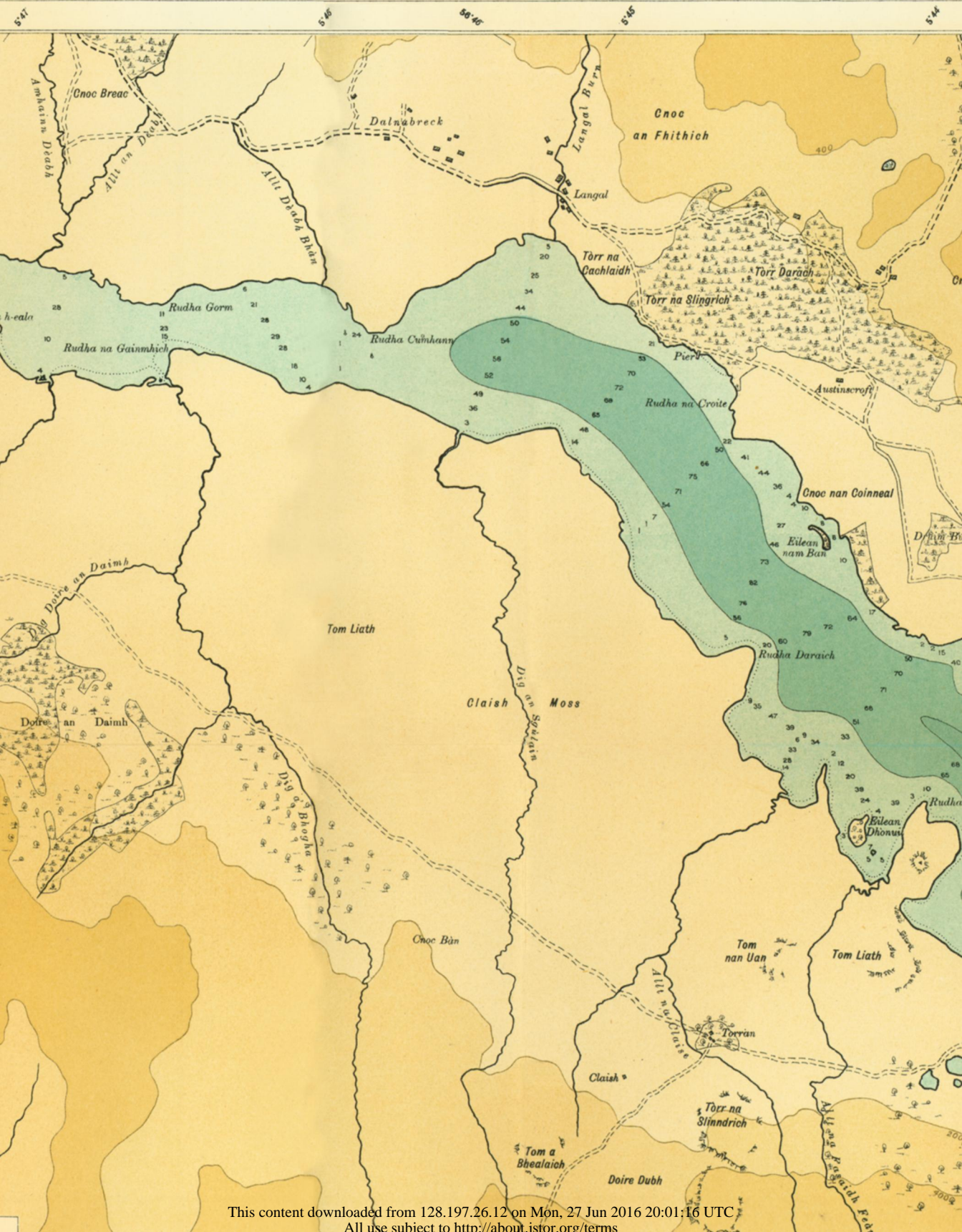
The first place we touched at was New Year island, a small island situated in lat. 54° 59' S., about 5 miles off the north coast of Staten island. Our object was to visit the magnetic and meteorological observatory established there by the Argentine Government, as a base observatory, in connection with the Antarctic Expedition, then in



PLATE I



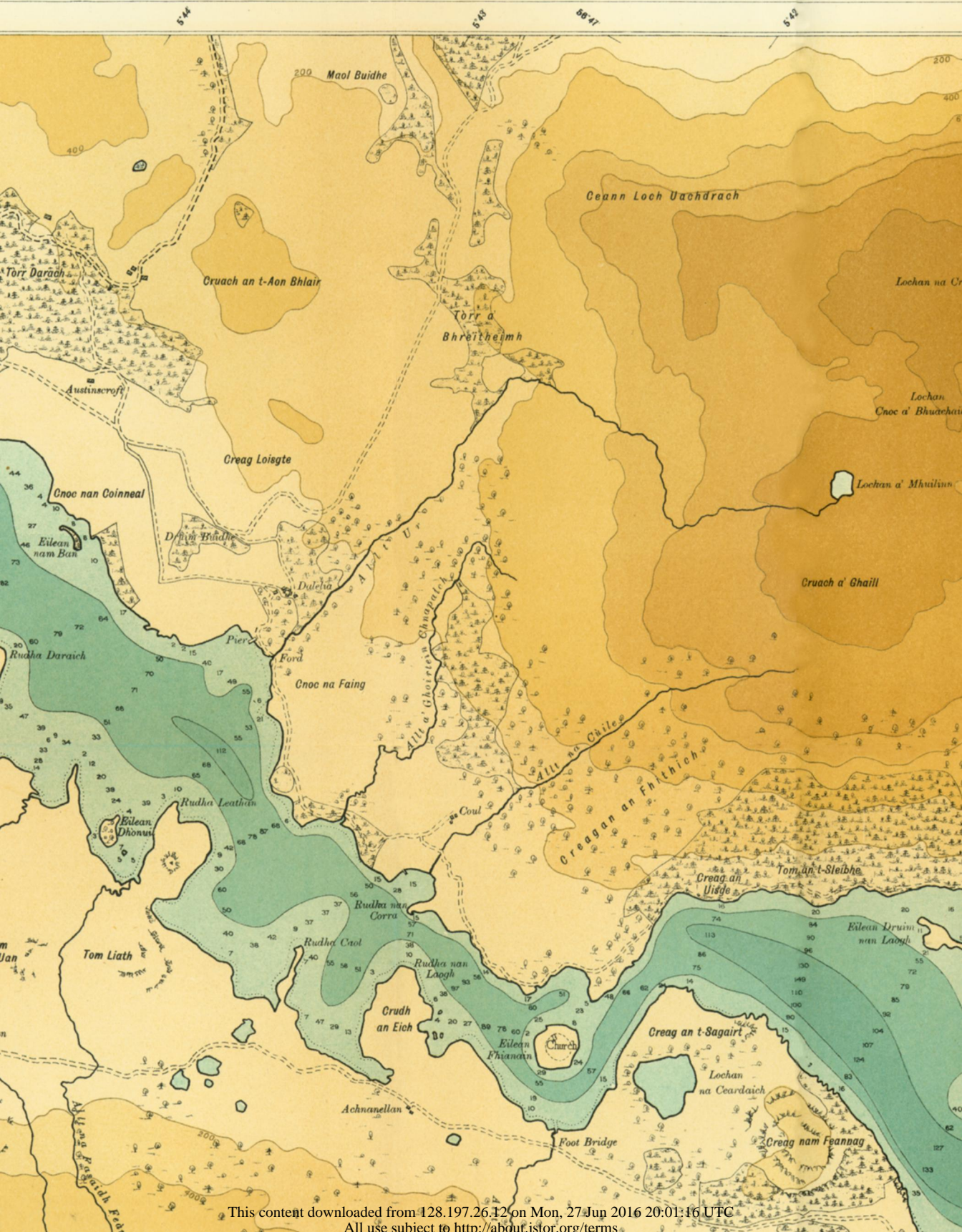






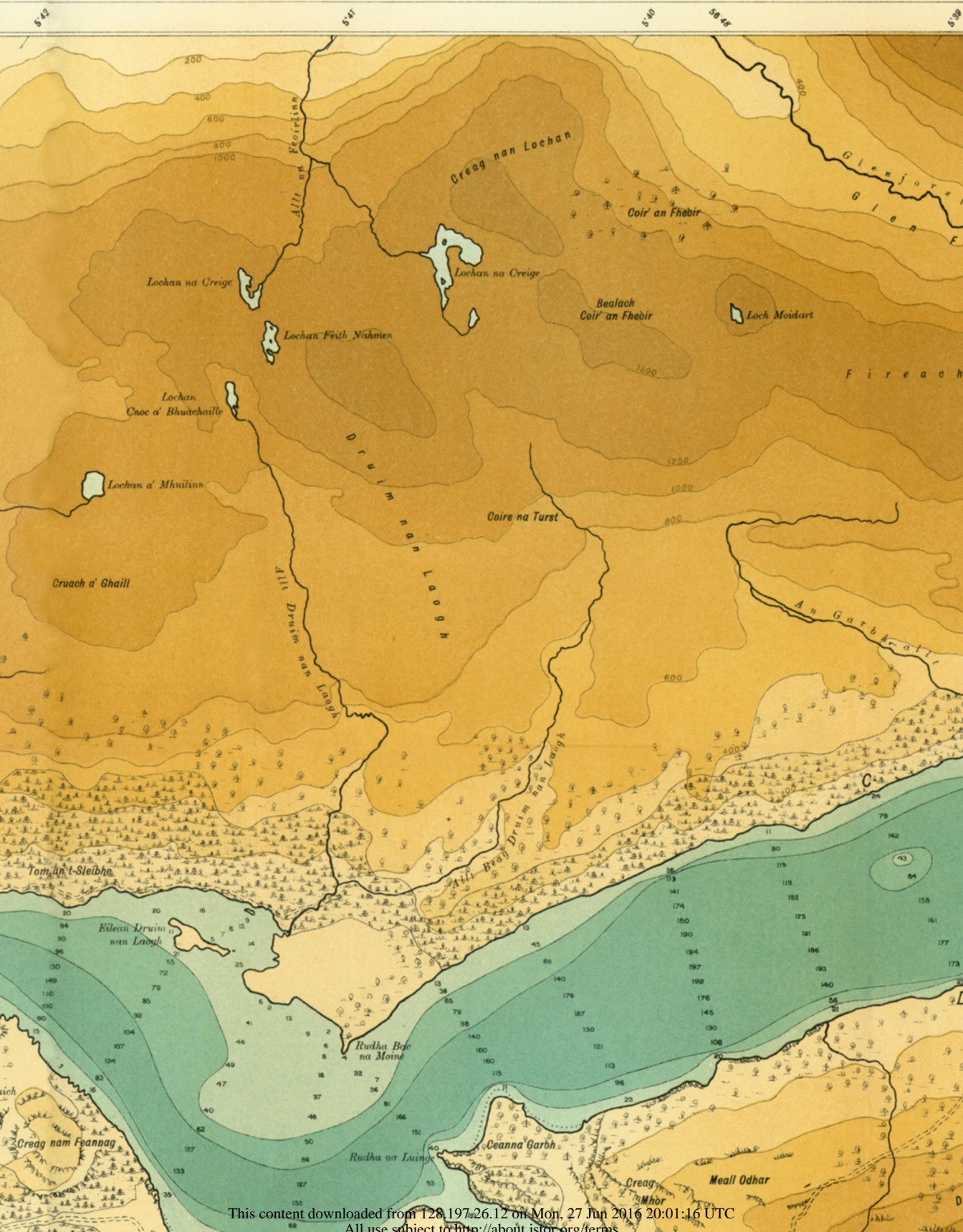
# HYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOT

UNDER THE DIRECTION OF  
SIR JOHN MURRAY, K.C.B., F.R.S., D.Sc., AND LAURENCE PULLAR, F.R.S.E.

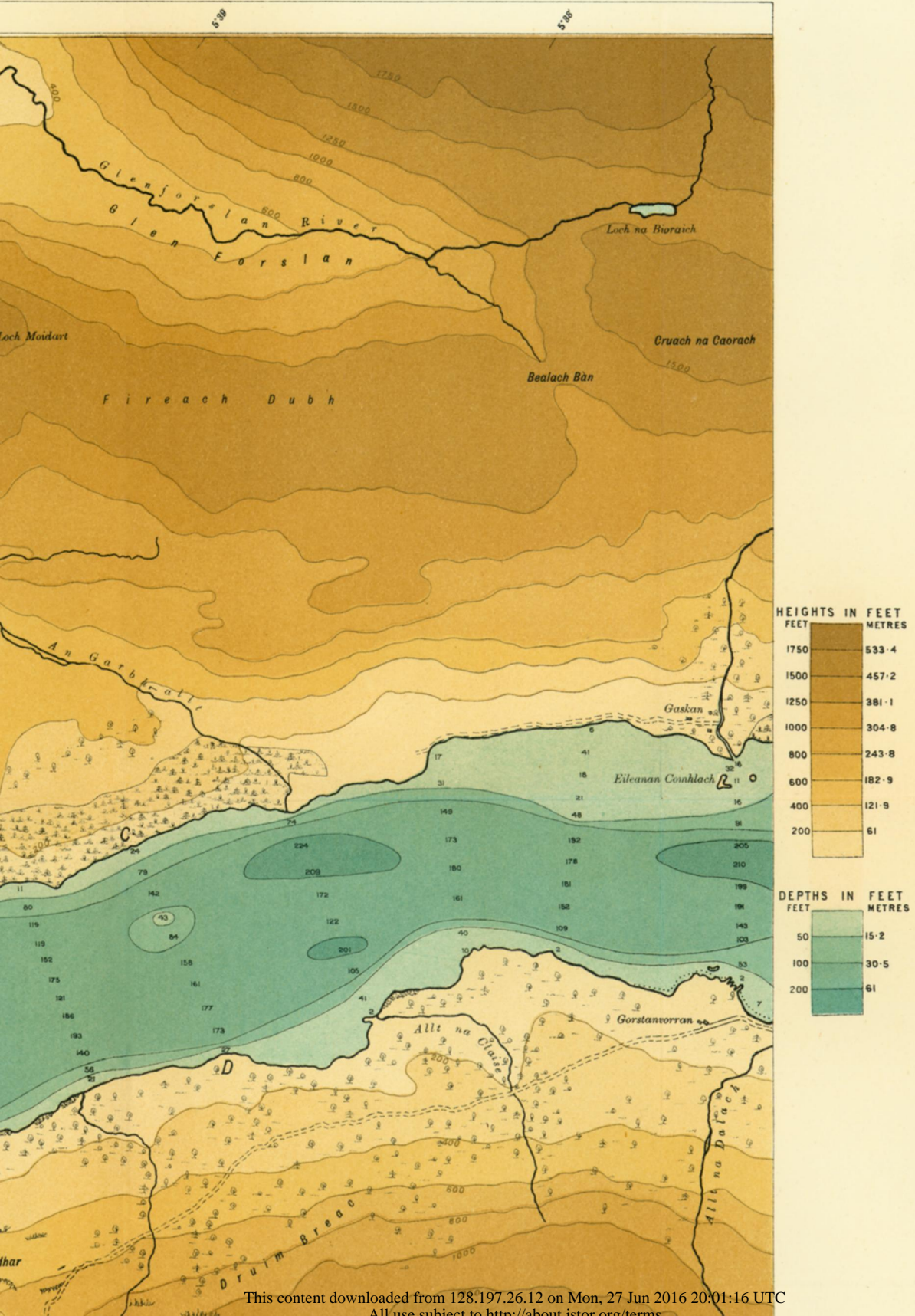




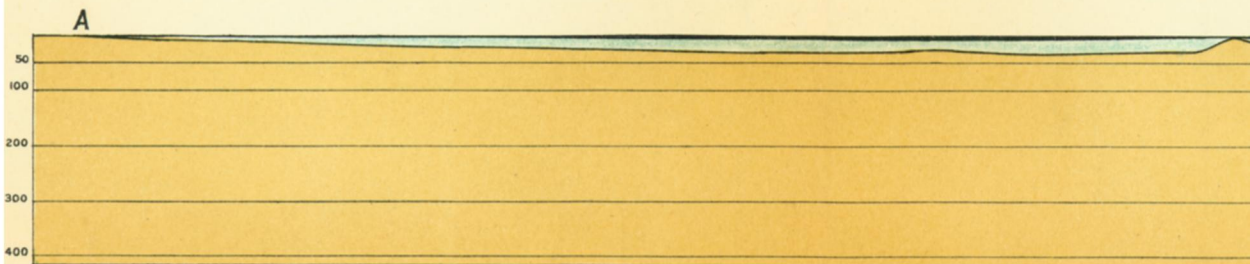
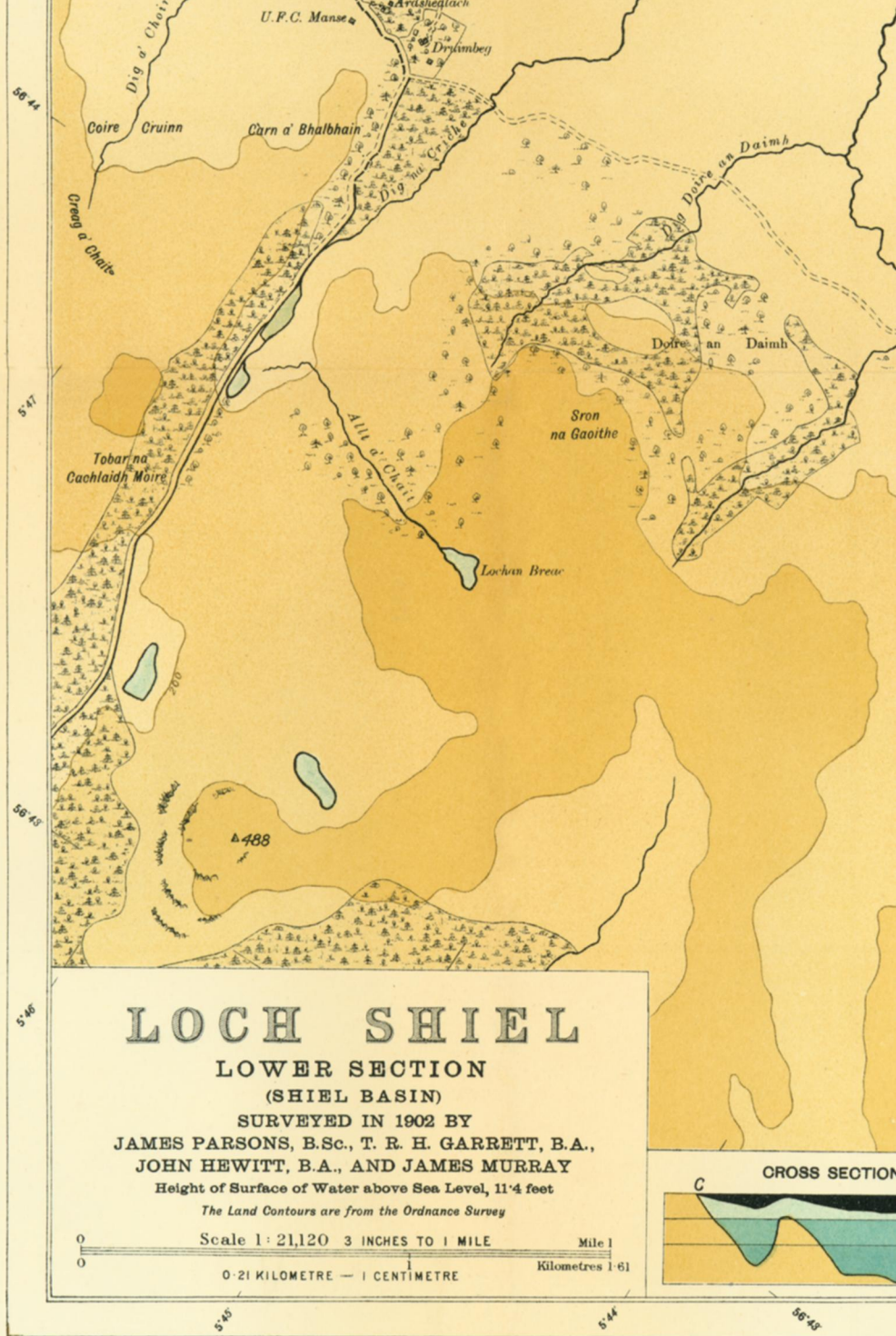
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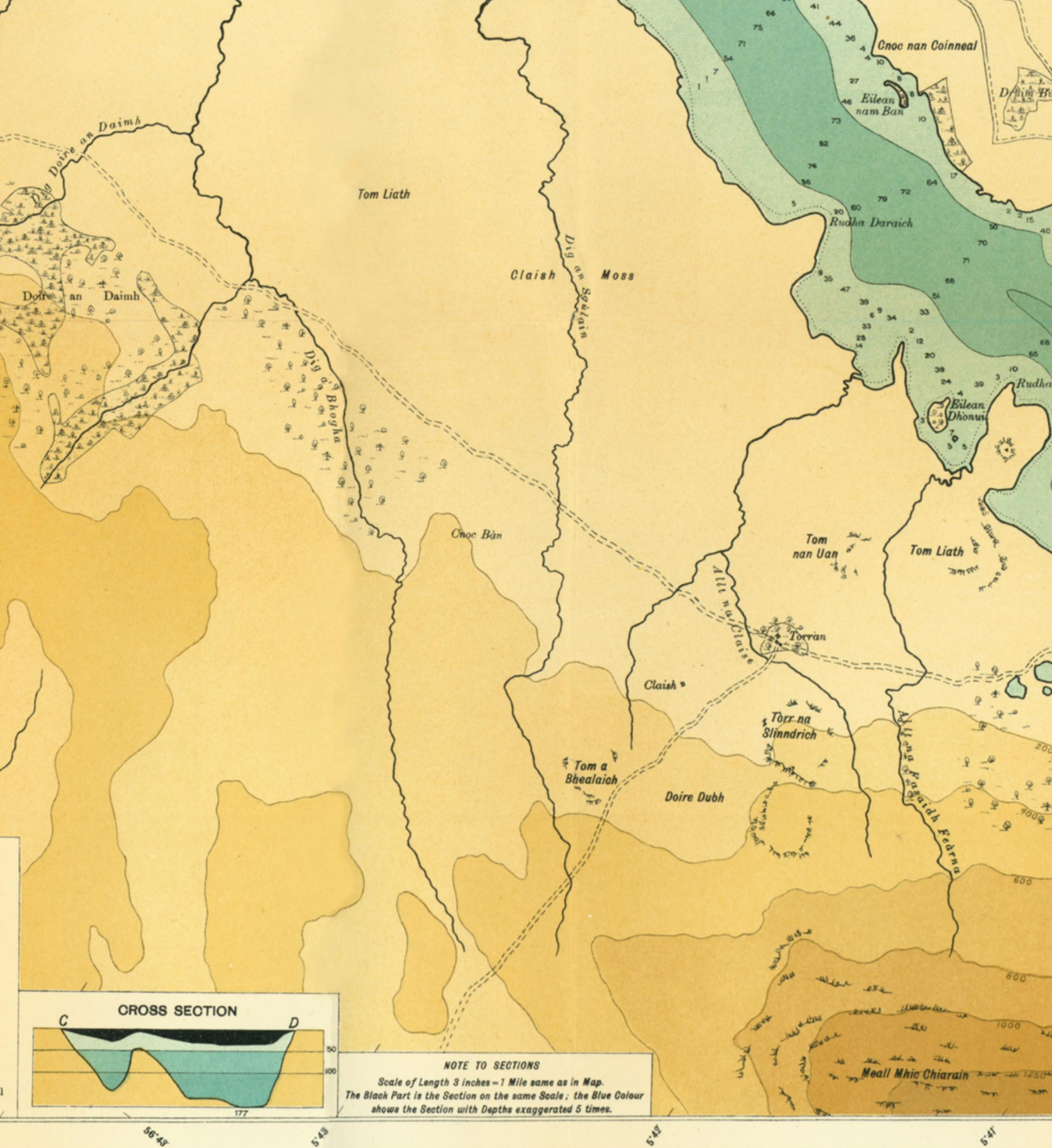




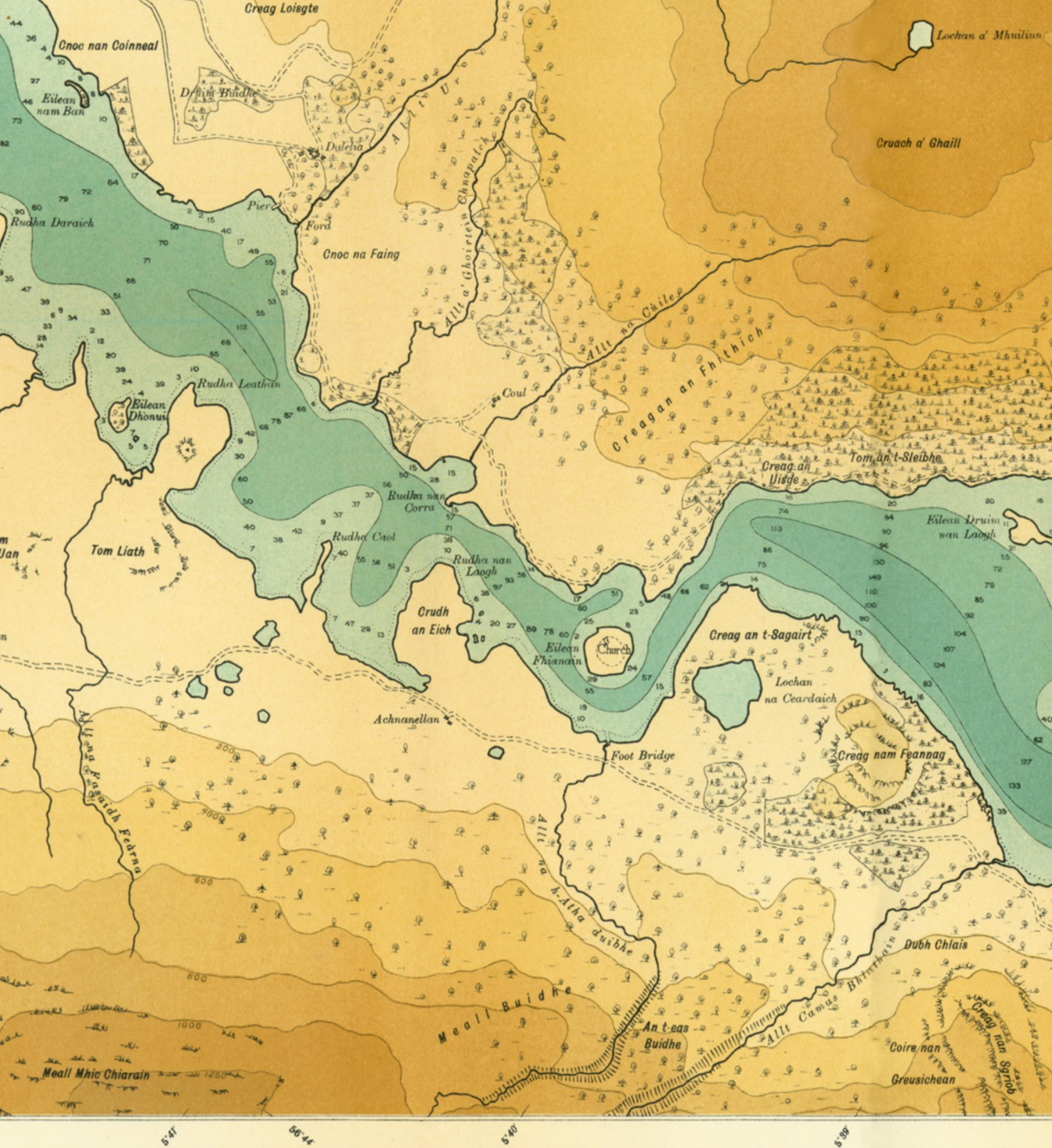






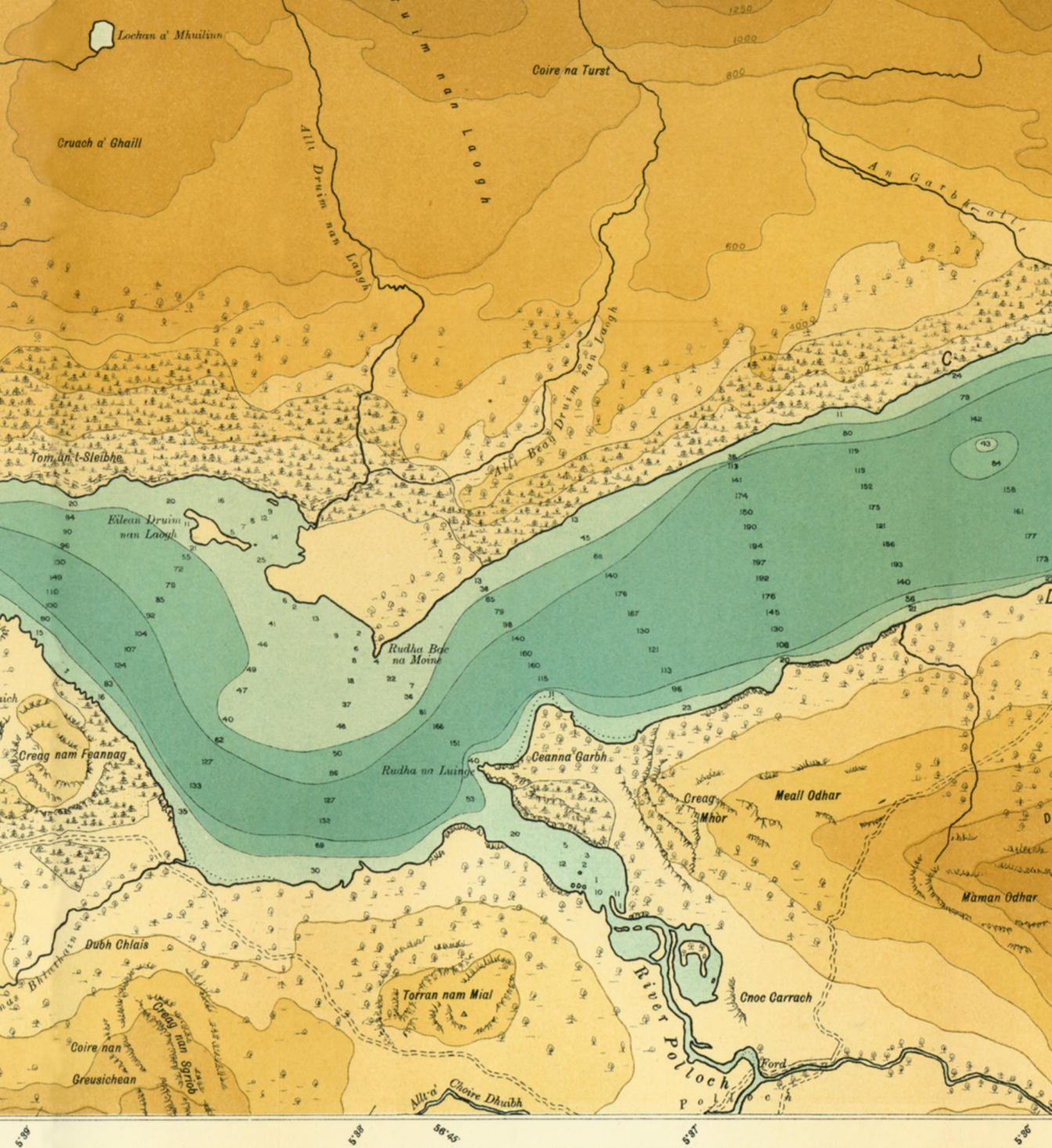




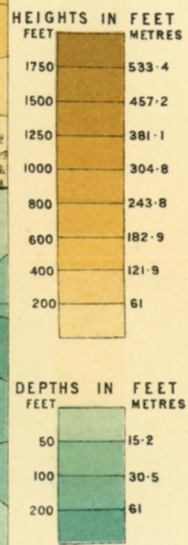
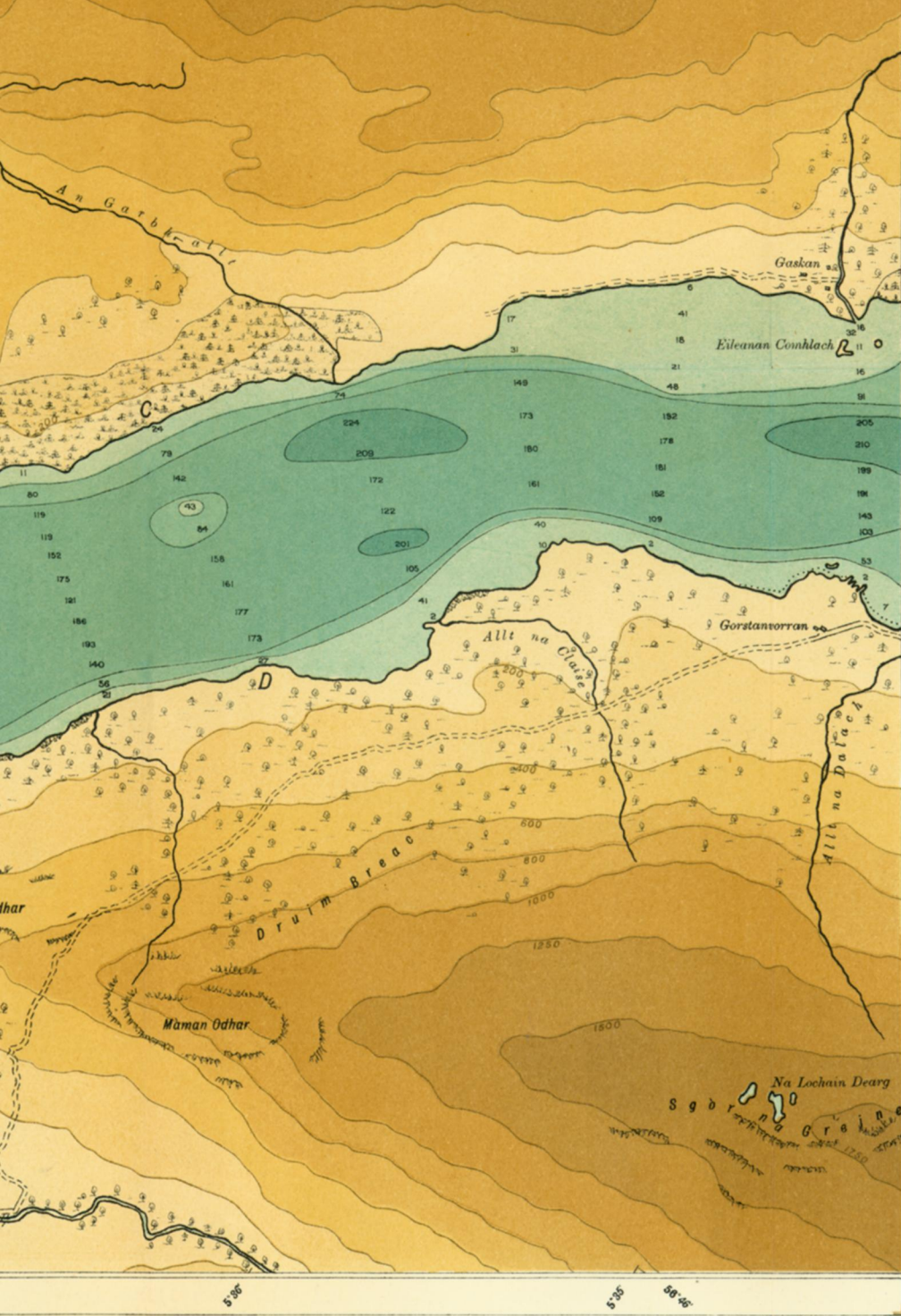


LONGITUDINAL SECTION ALONG AXIS OF MAXIMUM DEPTH





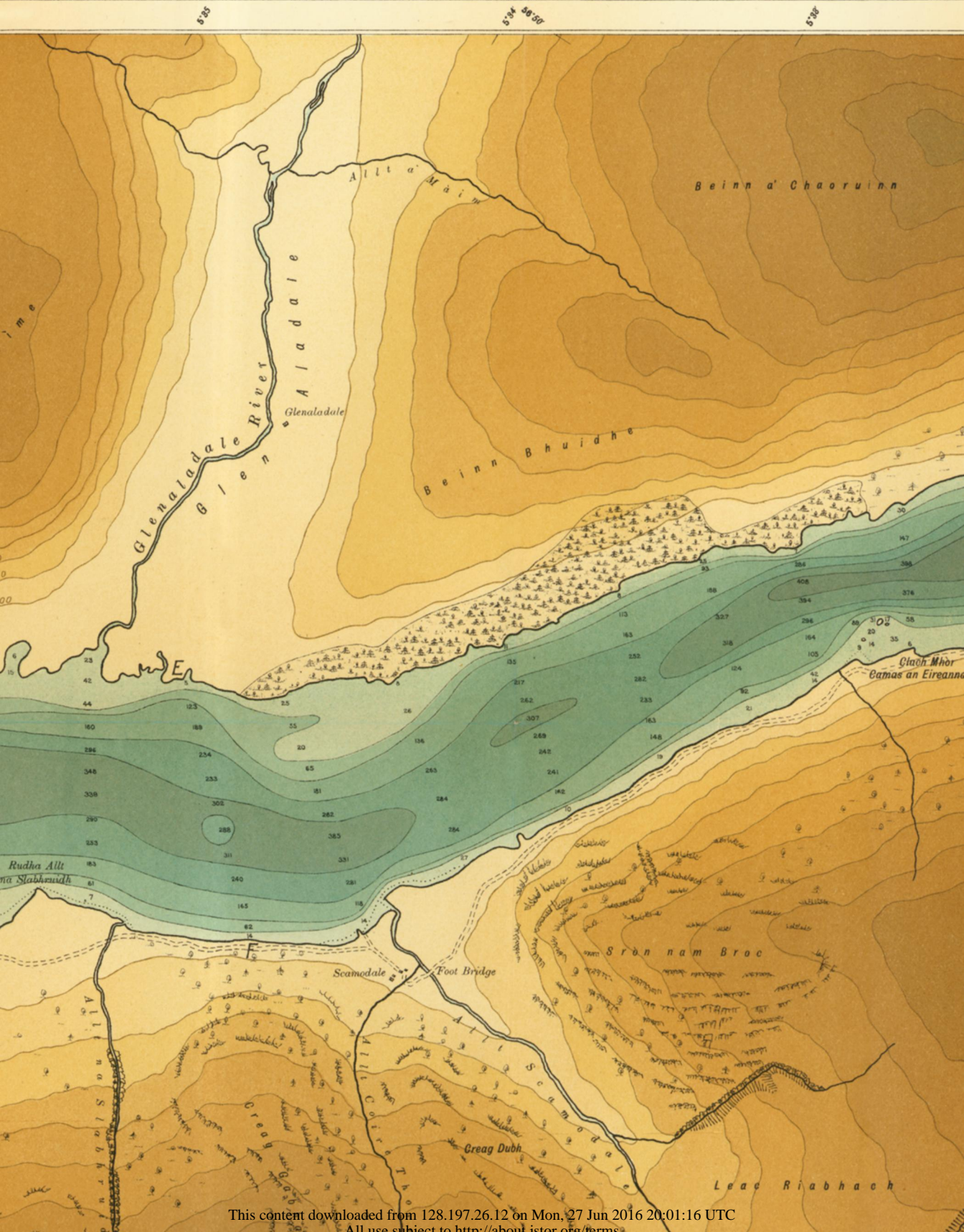










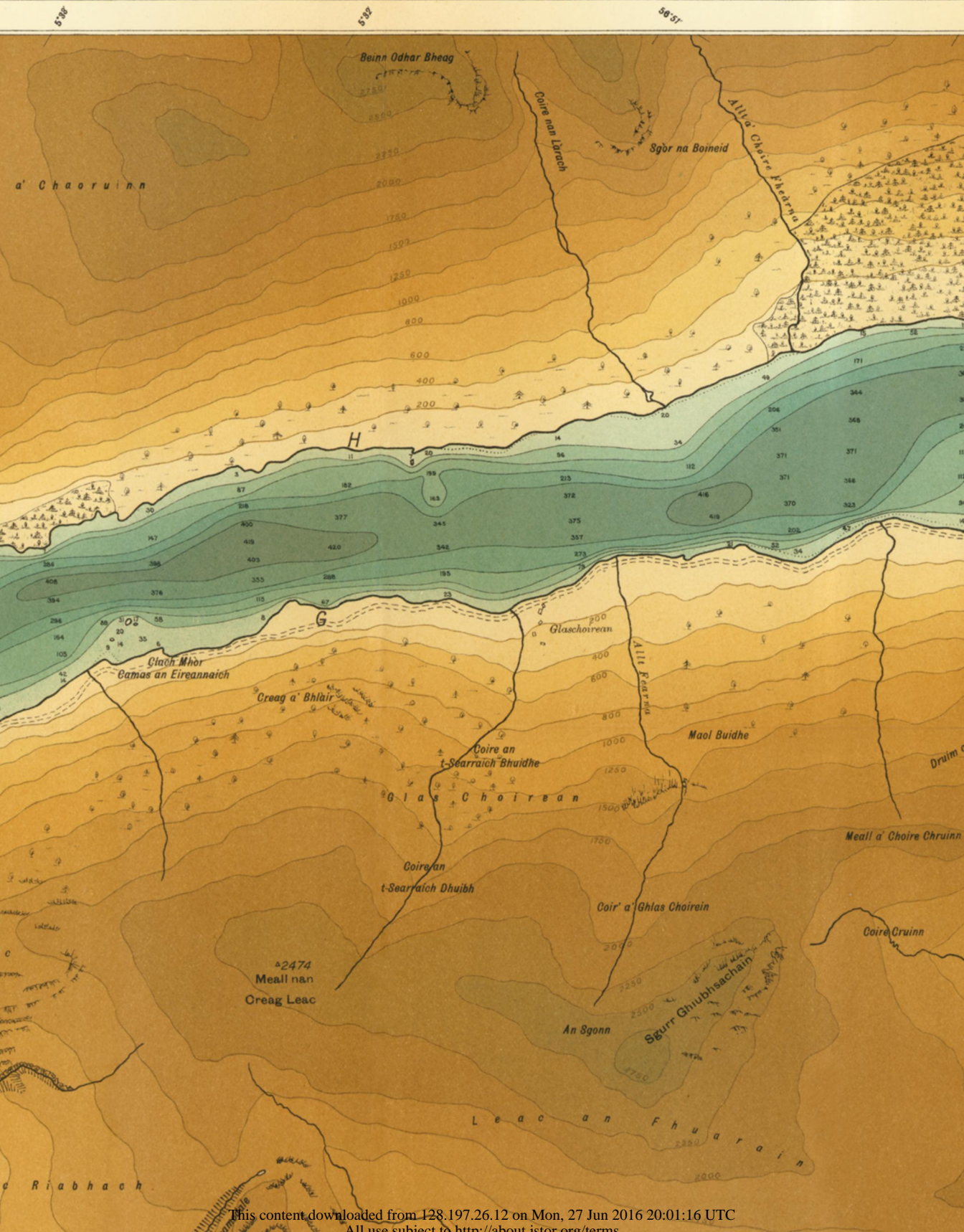




## HYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOT

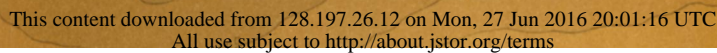
UNDER THE DIRECTION OF

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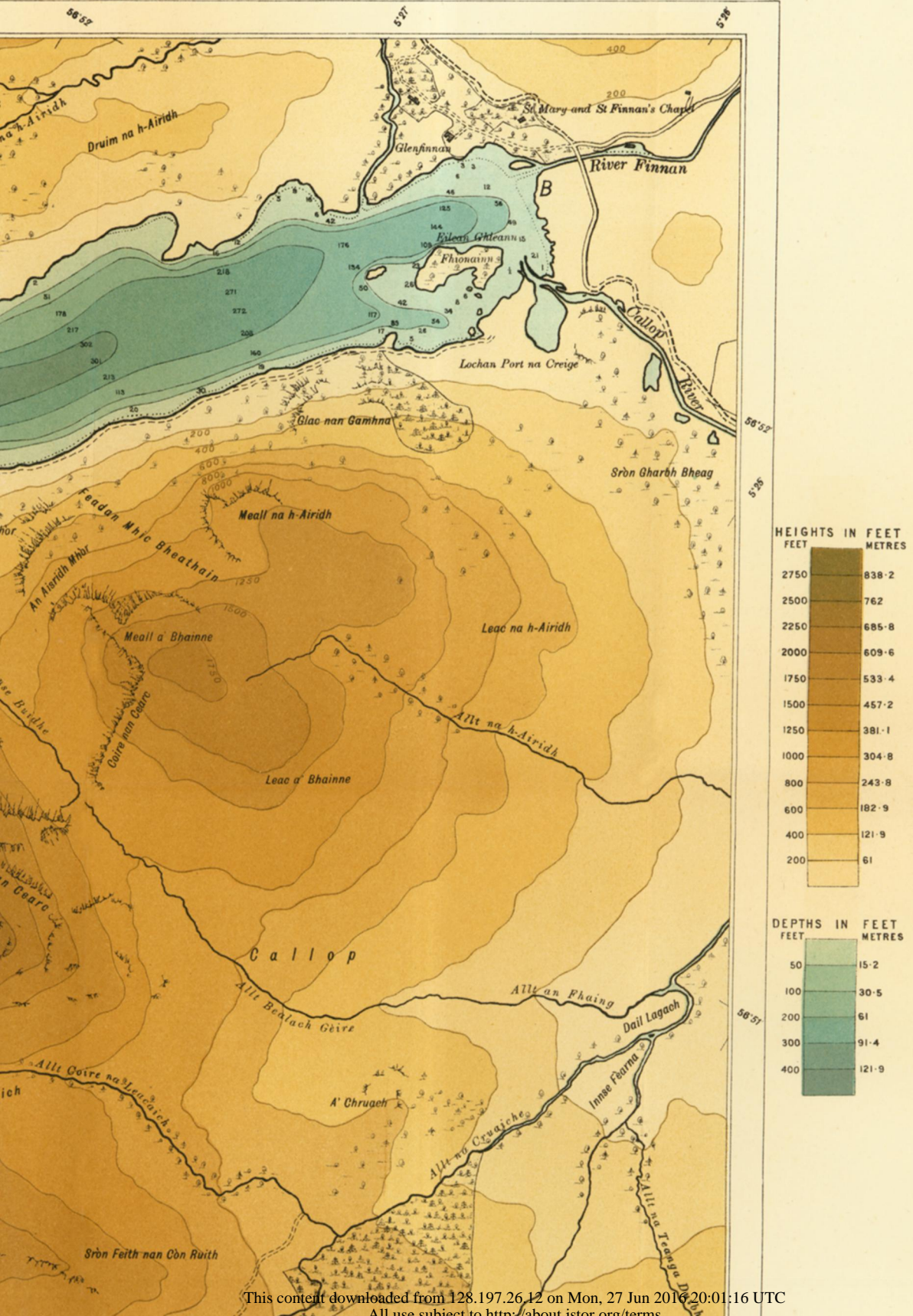




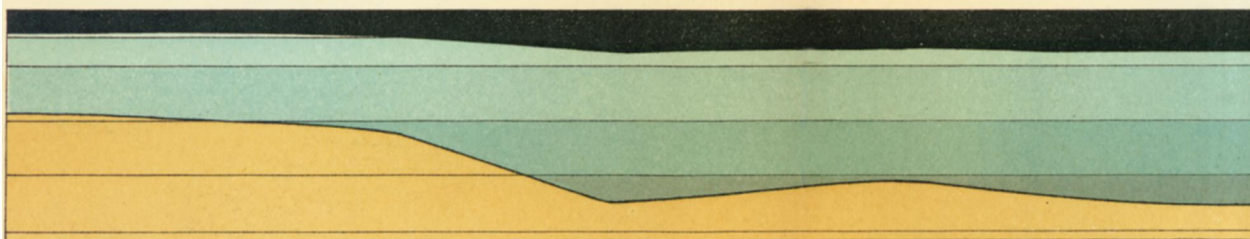
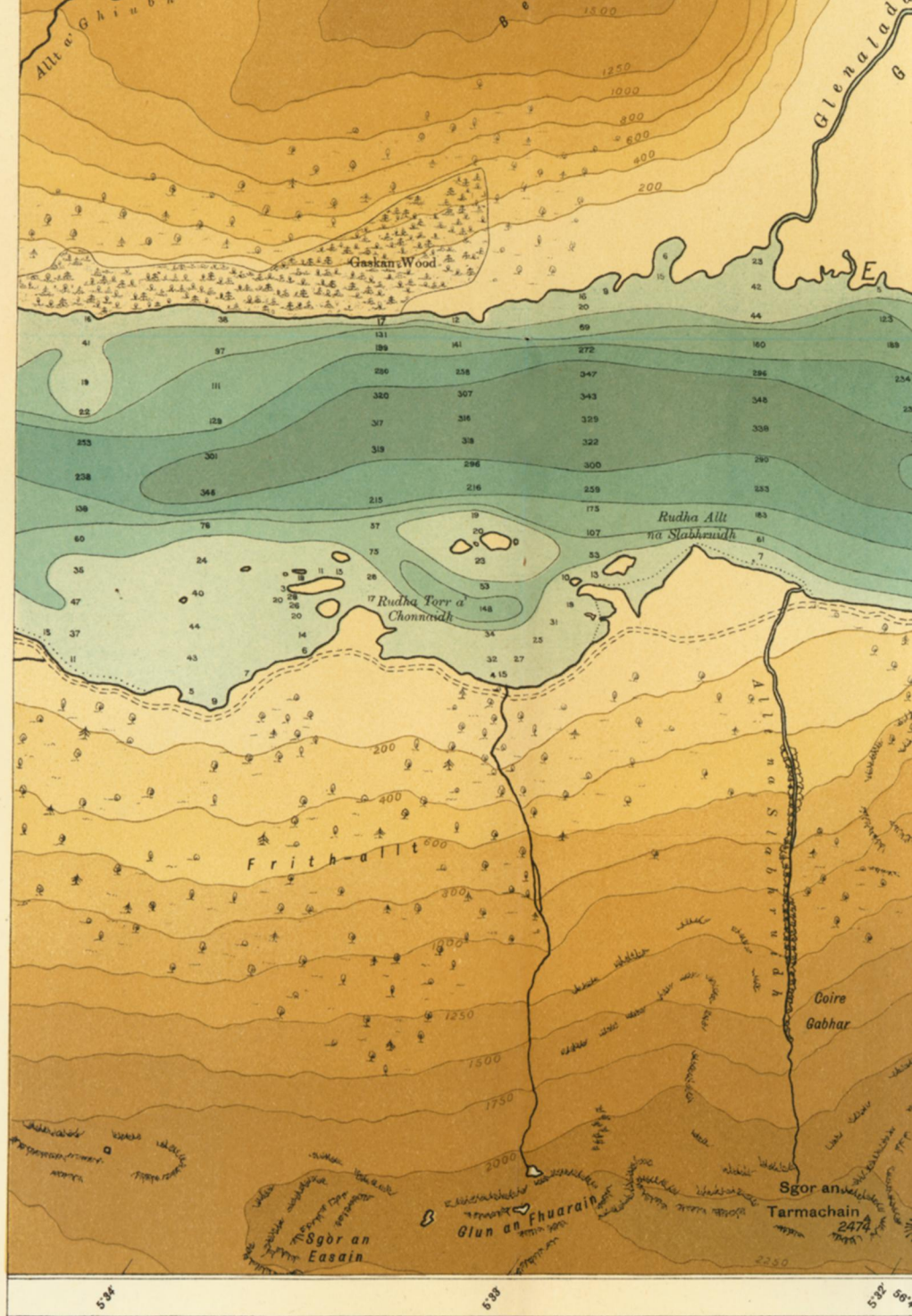
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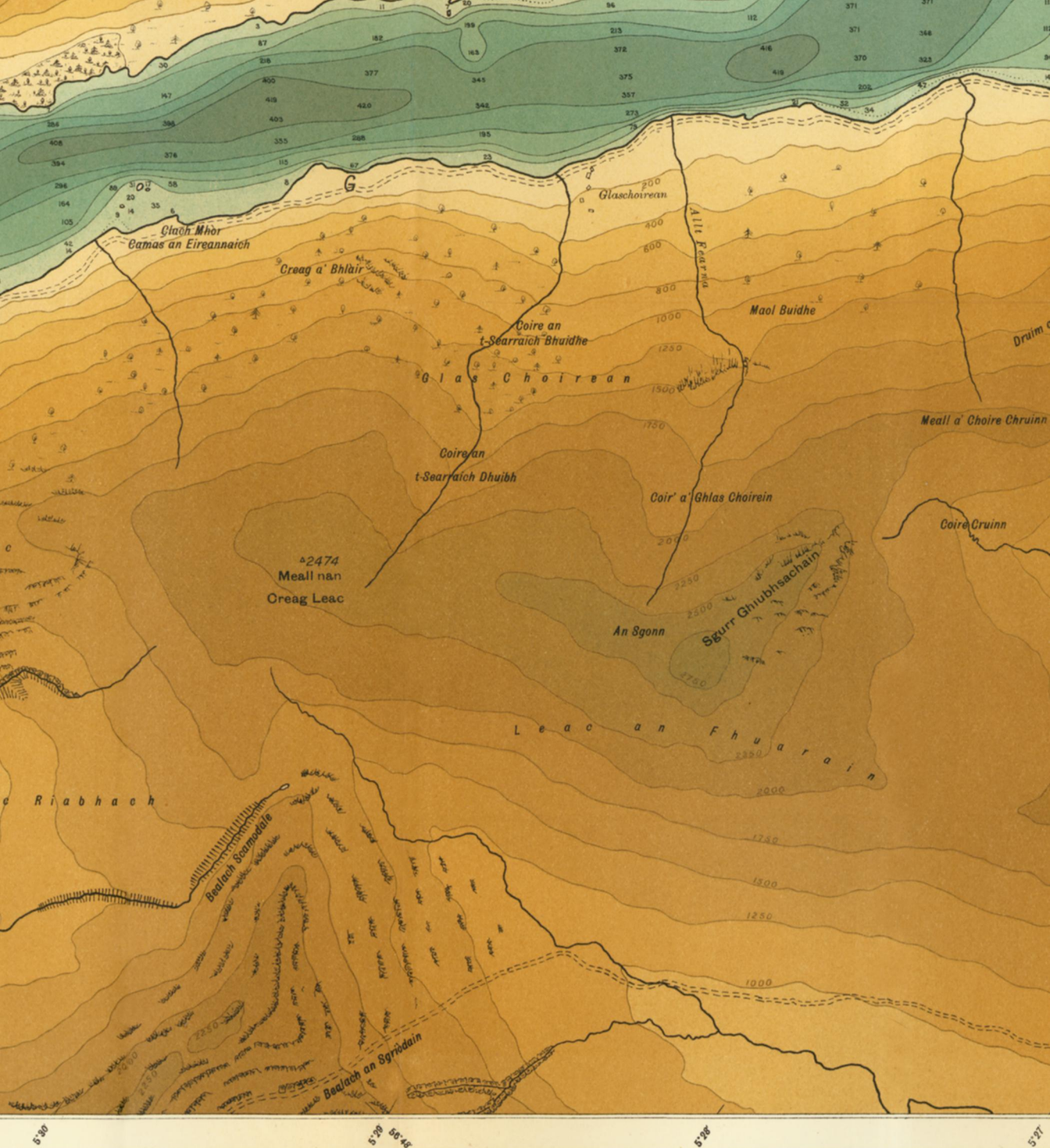




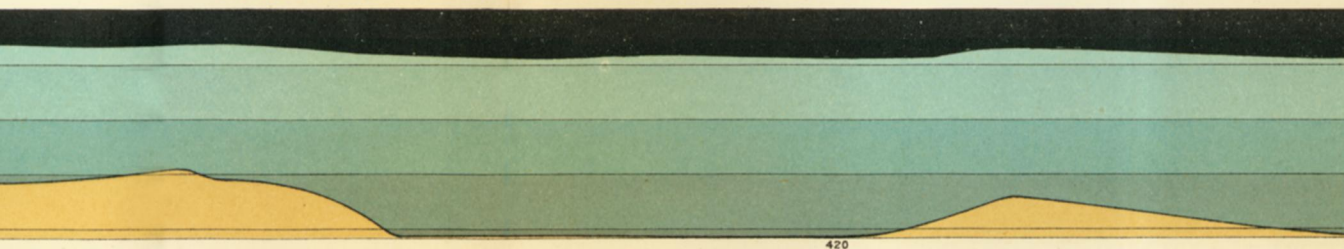






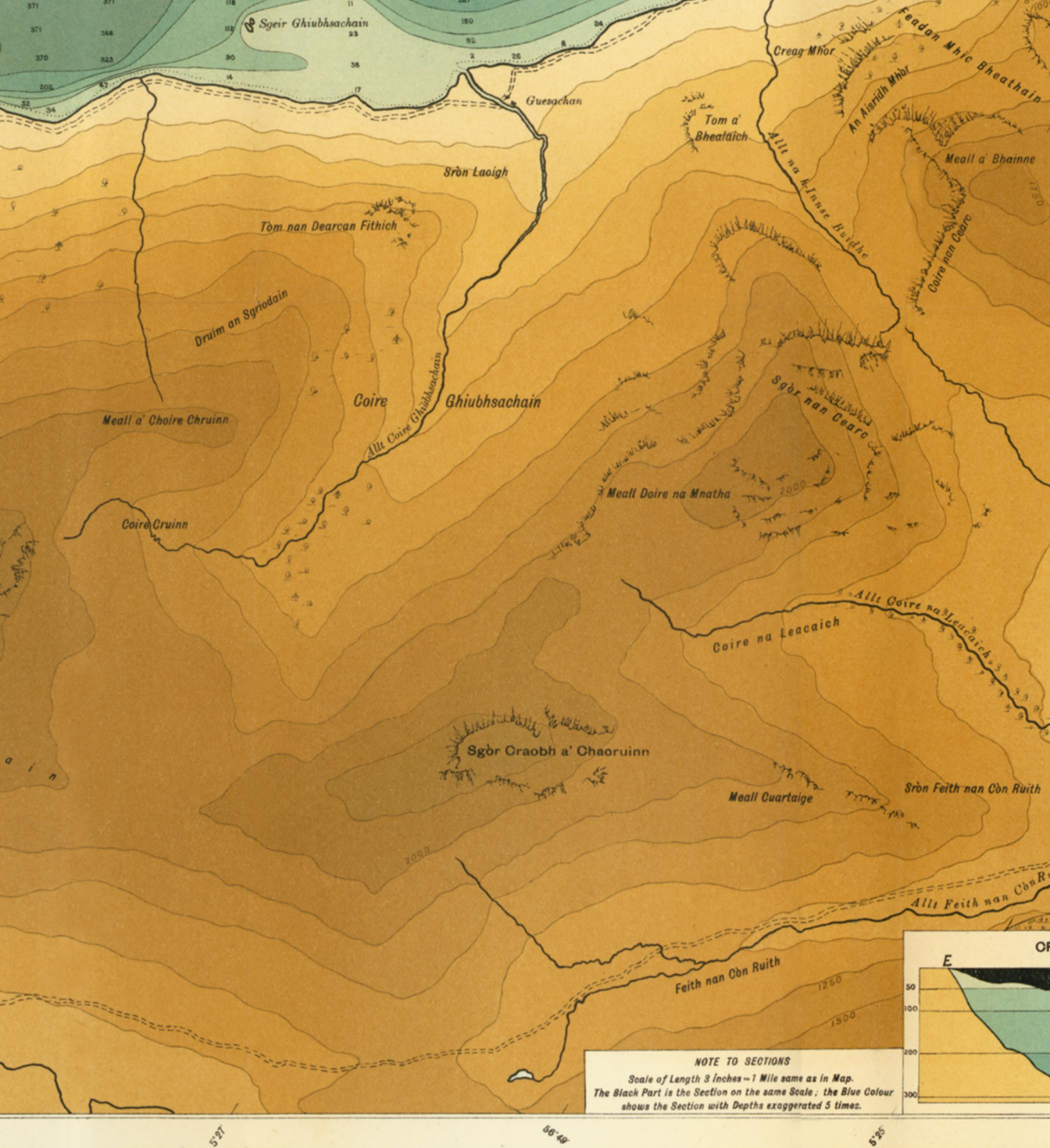


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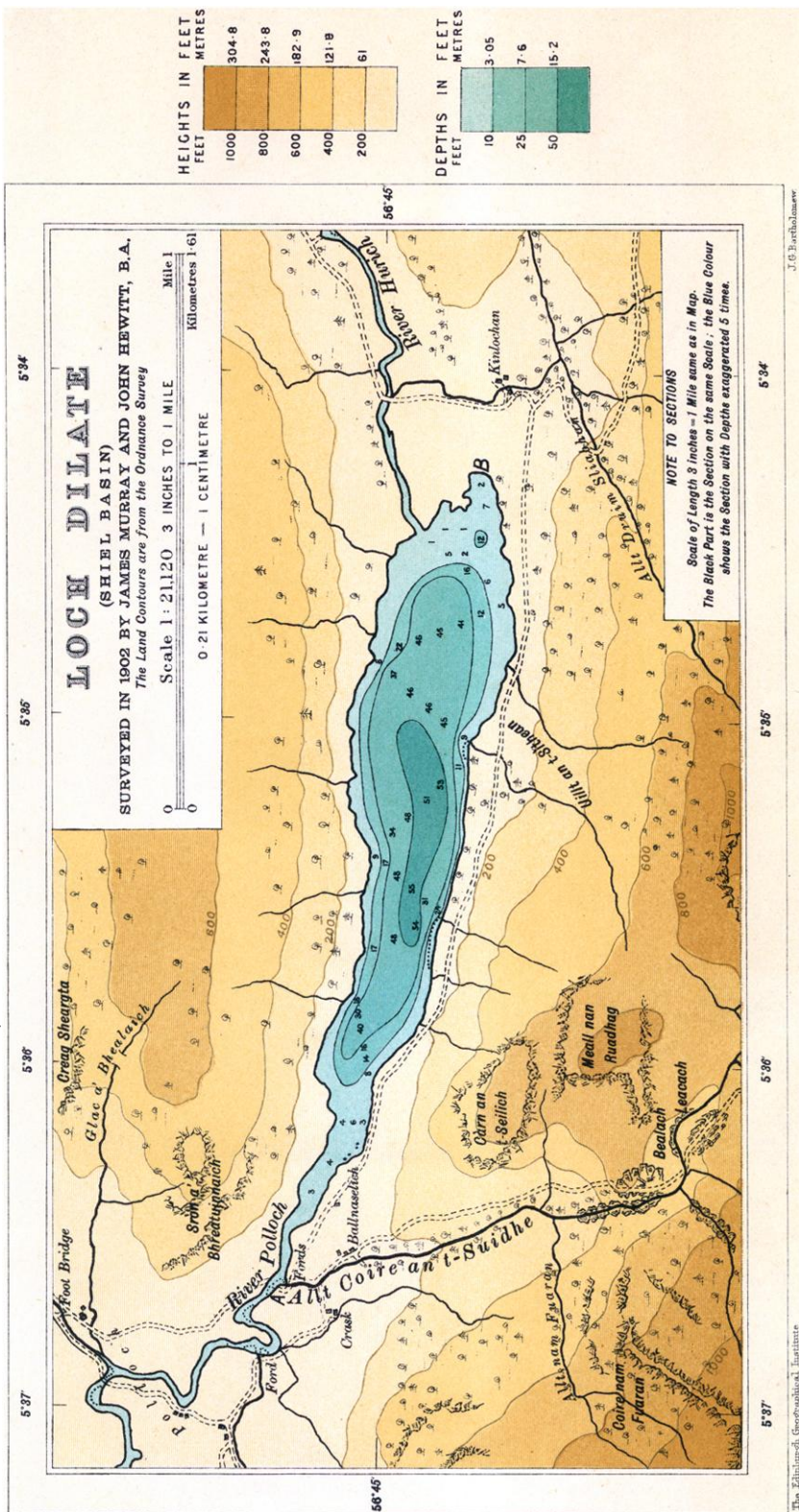






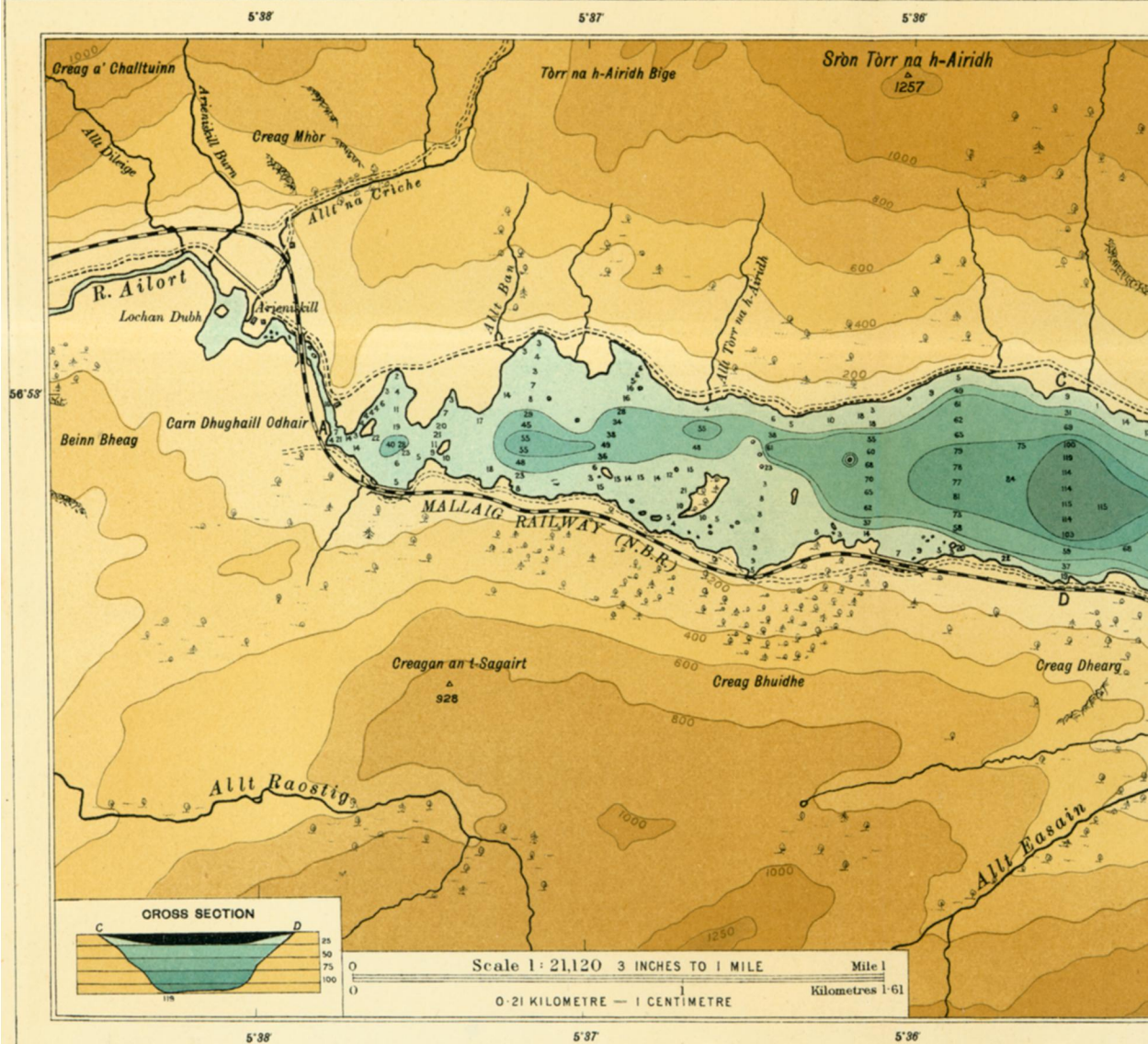
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SIR JOHN MURRAY, K.C.B., F.R.S., D.SC., AND LAURENCE PULLAR, F.R.S.E.

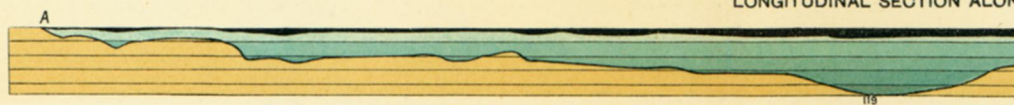




## PLATE IV



The Edinburgh Geographical Institute



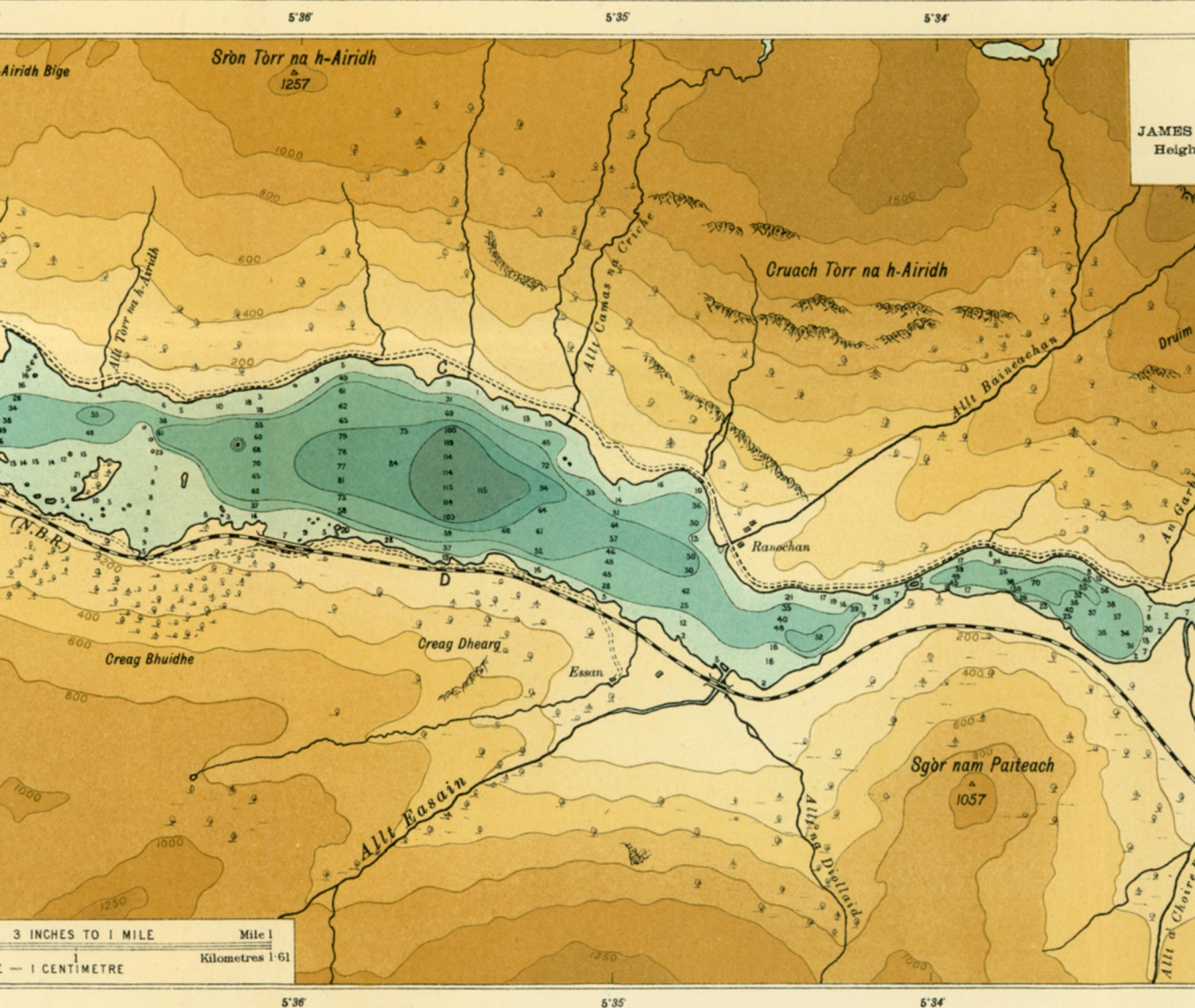
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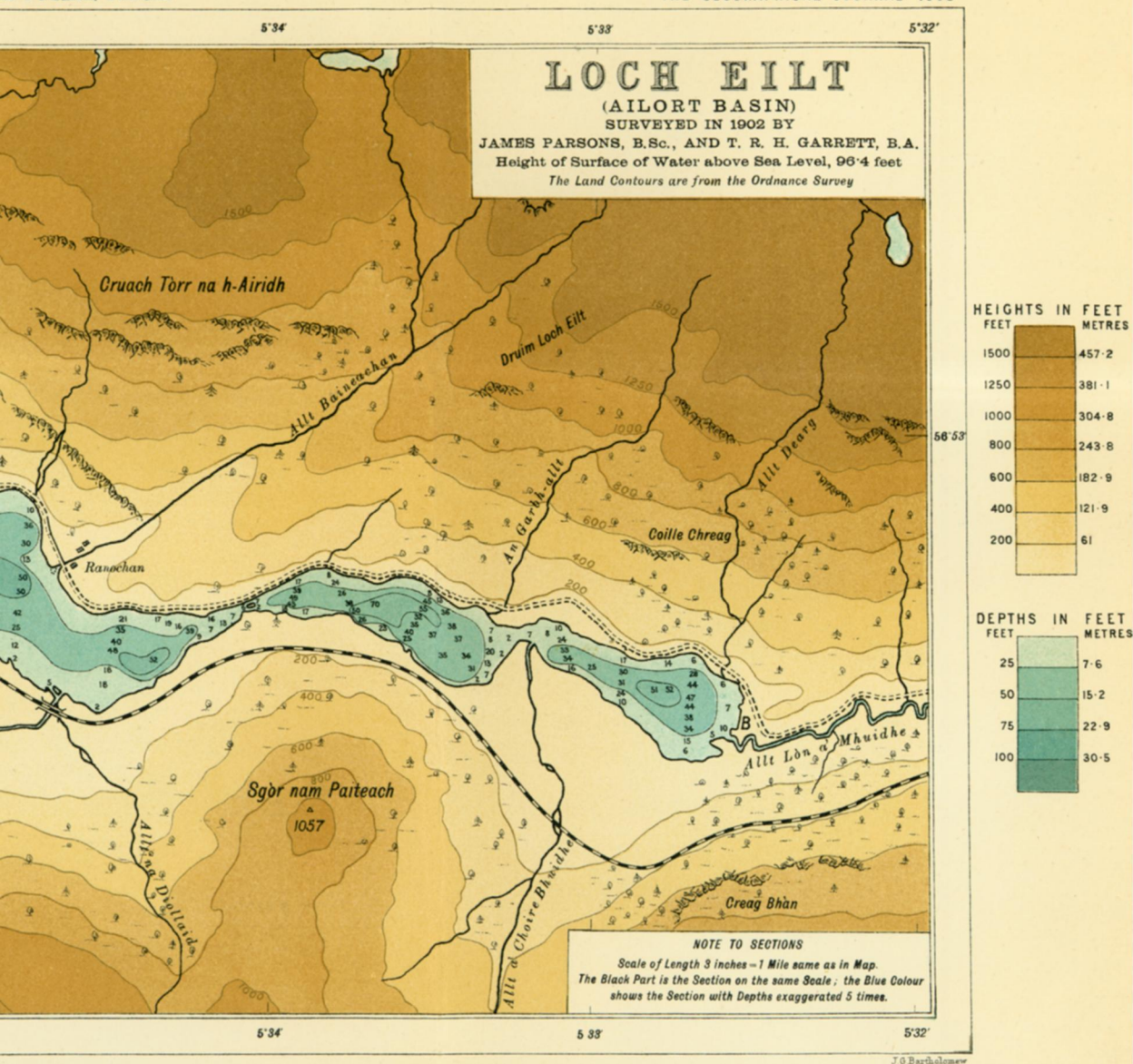


LONGITUDINAL SECTION ALONG AXIS OF MAXIMUM DEPTH



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