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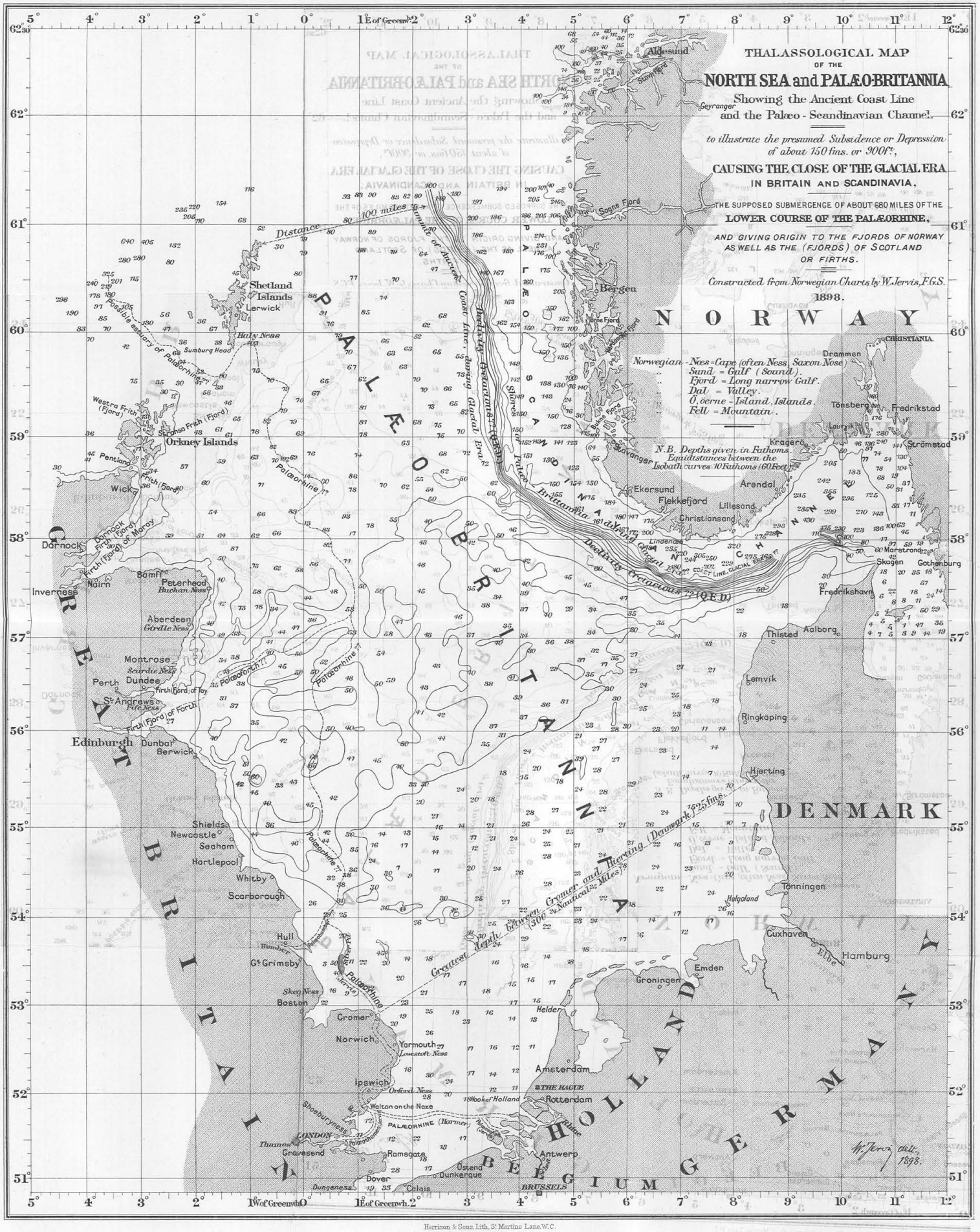

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ORDINARY MEETING.*

DAVID HOWARD, ESQ., D.L., IN THE CHAIR.

The following was elected a Member :—Professor H. M. Ami, F.R.S., Canada.

The following paper was read by Professor J. Logan Lobley, F.G.S., in the absence of the author.

THALASSOGRAPHICAL AND THALASSOLOGICAL NOTES ON THE NORTH SEA. By CAV. W. P. JERVIS, F.G.S., A.V.I.,† Conservator of the Royal Italian Industrial Museum, Turin. Being a few observations suggested by Professor Hull's papers read before the Victoria Institute. (With Map.)

> "Ce que nos connaissons est peu ; ce que nous ignorons est infini."

SUCH were the sublime expressions of that truly great scientific man, Laplace, and after having sat for thirty-five years at the School of Practical Mineralogy and Geology, I proclaimed that I had not met with a single fact which in the slightest degree clashed with inspired writ, in fact, wherever there are apparent contradictions these will disappear as our knowledge advances. True science consists in the collection of a store of facts, in classifying, weighing, and making use of them. It is observations which are the foundation stones upon which the structure of science is to be raised. Old Seneca truly taught: *Stude, non ut plus aliquid scias, sed ut melius.* Though perhaps bold, such is the course which I desire to follow in the present paper.

Professor Hull ably sketches in the paper he read before the Victoria Institute "On the Submerged Terraces and

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* April 2nd, 1900.

† *Vide* my work on the *Topographical Distribution of Minerals and Mineral Springs throughout Italy.* Loescher. Turin.

River Valleys bordering the British Isles," the most important pelagic features presented between Rockall to the north and the south coast of Ireland, as well as along the St. George's and British Channels, to their junction with the former line.

With his permission I will endeavour to follow up the subject under his inspiring leadership, by pourtraying some of the grand features of the North Sea, that is, limiting myself to the region east of Great Britain, by no means intending to invade his ground, but rather to show how he has opened my eyes to understand facts well known to me, but which I hitherto considered to be merely curious and absolutely unimportant.

My first initiation into these facts was when in London in 1886, my attention was riveted by Mr. Jordan's model in the Educational Department of the South Kensington Museum, and in which he so admirably delineates the British Platform. Professor Hull's first paper dwelt upon the phenomena of the Glacial Epoch, and I shall keep that broader subject in view, hoping that these studies may conduce to further results in abler hands that mine, anticipating much from the discussion which may follow the reading of the present paper.

The Glacial Epoch may, indeed, have been confined to the period which dawned at the close of the Pliocene, as far as regards Scandinavia, Scotland, Greenland, etc., or it may not have been so. That is foreign to my present point. Certain it is that Dr. Heim,* as also other eminent Swiss geologists, accept two distinct periods during which glacial action took place in the Western Alps of Switzerland; the first in Pliocene times, the later in Pleistocene times, with an interregnum of milder climate. I have seen abundance of boulders of Alpine Archaic serpentine and other ancient rocks in the Collina di Torino, which forms the last link of the Apennines, a fact first pointed out by Gastaldi, these boulders being embedded in fossiliferous Miocene strata.

The structure and description of the portion of our globe which is at present covered by the sea is of such importance and interest, in order the better to understand the nature and even the genesis of a great proportion of that which constitutes dry land, that we must hail all investigations in this direction as tending to fill up many a hiatus in natural science. The scientific corps of the *Challenger* and *Blake*

* *Die Geologie der Umgebung von Zürich*, 1894.

expeditions have already achieved wonderful results, and Professor Hull has drawn the most important deductions of like nature. But we are still shivering on the shores of an unexplored ocean. In order to confer due honour to this vast subject I venture to ask the members of the Victoria Institute to consider whether we might not very properly introduce the two new terms THALASSOLOGY and THALASSOGRAPHY, instead of Geology and Geography of the sea. which would certainly be misnomers. In describing regions of the sea which were emerged at the period of which we are speaking, perhaps the prefix PALEO would confer clearness, not otherwise so easy to obtain, and obviate much circumlocution.

§ I.—NORWEGIAN COAST.

Evidence of important submergence of Norway, once entirely covered with ice.—Let us land at Christiania, and starting thence make a coasting tour of Norway, for many hundreds of miles, passing through the Skager Rack into the North Sea, and reaching a parallel of latitude corresponding to that of the extremity of the Shetland Isles, by which voyage we shall fall in with Professor Hull's "Gulf Stream."

Thus early it is well to point out that it is a characteristic feature of the Norwegian fjords to have numerous ramifications on a large scale, so that it is difficult to meet with an isolated fjord, and each branch bears its own special name; since they are often so large it is a difficult matter to know which of them to select in naming the region. For the present purpose it would be both monotonous and useless to stop to examine more than a few of the principal ones.*

Christiania fjord. Lat. 59°—59° 50′ N.—On embarking from the head of this fjord, at the quay of the beautiful capital of Norway, the water is shallow, only 7 to 10 fathoms

* During the mission confided to me by the Ministry of Public Instruction at Rome, to the Paris Universal Exhibition of 1878, on behalf of the Royal Italian Industrial Museum at Turin, Mr. W. Christophersen, the Royal Commissioner for Norway, and Mr. N. Christensen, Secretary of the Commission, presented a copy of the magnificent topographical and geological surveys of Norway, and the charts of the coasts and fishing grounds published by the Government. Without the aid of such invaluable documents I could not have pretended to make the accompanying studies, much less to claim confidence in my data, as I do; I here take the opportunity of publicly returning the most hearty thanks to those so kindred minds, whose warm friendship and noble character I shall never forget.

deep; further down the soundings reach 47 fathoms, then 87, and afterwards 118 fathoms, even below the junction of the Drammen fjord from the west, which has a similar depth. Near Tonsberg the depth is 230 fathoms, which is the same as that at the point where the Christiania fjord enters Bohns Bay, at 55 miles below the capital. Beyond this, however, the central channel of the submerged fjord is closely bounded on either side by depths of 50 to 60 fathoms, notwithstanding the evidence that the sea current has considerably filled up the original central channel, preventing the progress of the detritus to any great distance.

Langesund fjord. Lat. 59° N.—Some remarkable facts can be observed near the entrance of the great Frier fjord, which originates in grand mountains 6,000 feet high, that is, where it discharges itself into Bohns Bay, and after having assumed the name of Langesund fjord, in honour of the town it passes. Though the depth of the fjord below Brevik is only 130 fathoms, for upwards of 10 miles out to sea we can clearly trace the central channel of the magnificent submerged fjord, many miles in width, with soundings giving 205 fathoms, while on either side they do not reach that amount by 100 fathoms. The line of 100 fathom soundings approaches to within two miles of the mainland.

Proceeding westward for 100 miles, from Langesund to Ekersund, the bathometrical curve of 100 fathoms follows the present line of coast of Norway with considerable regularity at a distance of 10 miles.

From Ekersund nearly to the 61st parallel of latitude—120 miles—the 100 fathoms isobath runs within a distance of from one or two to 11 miles from land.

Lister fjord. With its tributaries the *Fedde fjord* and the *Flekke fjord*, near the town of Flekkefjord. Lat. 58° 15′.—At the mouth of the Lister fjord a deep submarine channel is traceable for 5 miles to sea, indicating the original course of the fjord, so that the 100 fathom soundings approach to within a short distance of the coast on either side, and run up the present fjord for another 5 miles, where they hug the precipitous rocks. The submerged fjord commences at once with a depth of 120 fathoms, gradually increasing to 295 fathoms. The sea bottom invariably consists of slik.

Stavanger fjord. Lat. 59° N., Long. 5° 40′ E.—Near Stavanger there is a family party of secondary fjords, partly caused by the submergence of the land having given origin to

numberless islets and rocks, many of them sunken, and of the most dangerous kind, both in the land course of the fjords themselves and off the coast on all hands. All these fjords concentrate in the Bukne fjord, strictly speaking a wide land-locked gulf.

Forty miles before reaching the coast Vinda fjord branch is already 368 fathoms deep, and (disregarding the constant local changes of name), at 20 miles it attains 382 fathoms, reduced to 200 fathoms in passing the last island guarding the entrance into the sea, a circumstance easily explicable by the fact that the slackened current was no longer strong enough to carry off the immense amount of detritus borne down from the mountains any further, on account of the counter current from the sea. Yet, as the 100 fathoms isobath is in immediate proximity to the islands there is a clear width of 5 miles of the submerged fjord, and which preserves a mean depth of 190 fathoms. For 30 miles to sea the whole sea bottom on all sides is slik, with a pretty uniform depth of 140 to 159 fathoms.

Bömmel, Hardanger and His fjords. Lat. 59° 30′—60° N.—The extreme length of these fjords is 62 miles. At 50 miles inland the Hardanger fjord shows soundings of 315 fathoms, but for the last 20 miles of its course the depth is only from 160 to 200 fathoms, evidently the result of the extensive deposits of detritus, for the sea bottom for upwards of 20 miles from the coast line never exceeds a still lesser depth of 140 fathoms, and consists invariably of sand and slik.

The imposing Skjæggedalsfos—unparalleled in Europe—and the Vöringfos, are two charming waterfalls belonging to the Hardanger fjord.

Group of Sælbjörns fjord, Kors fjord, Björne fjord, Fuse fjord, etc. Lat. 60° N.—Total length 65 miles. Depth at 28 miles inland 230 fathoms, at 18 miles from the sea 310 fathoms, while at 10 miles further down it already attains 338 fathoms. Only 9 miles from the coast of the island of Sotrö the soundings at sea show 182 fathoms in the submerged prolongation of the Kors fjord with sand and slik, a depth merely local, and without any parallel in all the bathometrical measurements hence in a direct line to the shores of Britain.

Bergen group of fjords, viz., *Jelte fjord, By fjorden, Öster fjord, Sör fjorden.* Lat. 60° 20′—60° 45′ N.—These complex fjords penetrate 45 miles inland, but do not appear to have any important direct outlet for the last 15 miles northwards,

or for the same distance to the south, where they communicate with the Kors fjord. The shipping entrance to Bergen is even further south, by the Sœlbjörns fjord. At 30 miles from the sea the Öster fjord is found to be 340 fathoms deep, but much lower down it must have been considerably silted up, for the depth is greatly reduced. On the other hand the Sör fjord branch, which is only 198 fathoms deep at 30 miles from the sea, rapidly increases to 275 fathoms depth near its junction with the Öster fjord. At 11 miles inland the Radö fjord is 229 fathoms deep, which is exactly what it measures at its termination on the coast.

It would appear most probable that these fjords originally discharged themselves into the sea south of Feje, Lat. 60° 45′ N.

Sogne fjord. Lat. 61° N.—If we steam up this imposing feature of Norwegian scenery, which, together with those which change names as we proceed, is 127 miles long, and for many miles 2½ miles broad, we readily realize that the whole mercantile and war fleets of the world could manœuvre in it without risk of collision. After proceeding up it for a certain distance the grandest landscapes succeed each other, and mountain masses rapidly descend from heights of 4,000 to 5,000 feet to the water's edge, so that at numerous places the largest vessels could load directly from the shore. For the first 25 miles up this fjord the depth of the water is between 630 and 660 fathoms, except at one place, near the village of Brekka, where a lateral fjord joins it from the south at right angles, and the detritus brought down by which cannot find easy means to proceed onwards. Here the soundings are only 450 fathoms. Thence to the coast, a further distance of 28 miles, the depth of the great exit is reduced to 128 fathoms, and even in places to 93; but the gorge to the north, through the Aspö fjord, is still over 200 fathoms, a depth marked for 50 miles of its course.

For 6 miles out to sea the soundings to the north of the central channel of the submarine fjord are 100 fathoms less than in this latter. Bottom invariably sand or slik.

Bru fjord, Stav fjord, Beksten fjord. Lat. 61° 30′ N.—Depth: 27 miles before reaching the sea 178 fathoms; at 20 miles 205 fathoms; entrance channel 180 fathoms.

Group of fjords south of Aalesund, viz., *Sule fjord, Stor fjorden, Sunelvs fjord, Gejranger fjord,* etc. Lat. 62° 6′—62° 30′ N.—

From Gejranger to the sea is 60 miles, and near this village is situated the magnificent group of waterfalls known as the Seven Sisters; but besides this waterfalls are abundant, and even measure from 2,000 to 3,000 feet in height. With a more particular account of the perfect example of a submerged fjord exhibited by the Sule fjord it is time to close these unpalatable lists of soundings along the Norwegian coast, and we would fain have the opportunity of speaking of the fine inhabitants. Five miles to the west of the busy little fishing town of Aalesund is the submarine valley known to every fisher lad in the place under the name of the Bredsund dybet. It commences immediately below the mouth of the Sule fjord, without change of form, and extends westward for 25 miles to sea, and within a like distance of 25 miles in every direction, and it is one-third deeper than any other spot, except where other fjords debouch into the Atlantic. In general terms it may be described as bound laterally by a sea bottom of 50 fathoms depth, covered with sand, the depth very gradually diminishing in receding laterally from the dybet.

The greatest depth of the Bredsund dybet is 160 fathoms, at the lower extremity. To the right, or north, the 50 fathom soundings correspond precisely to the upper margin of the declivity, which presents a marked slope. On the left hand side the margin is indicated by soundings beginning with 30 fathoms and ending with 60. Extreme breadth 2 miles, remarkably regular, although the course is slightly tortuous. Mid-way a sunken islet dominates its course, rising to within 50 fathoms of the surface of the water. The mid-channel beginning at a mile and a half from the shore with 220 fathoms, soon attains 150, and finally 160 fathoms; but evidently the currents have demolished all the upper portion of the islet, for the surface gently slopes on all sides, and the detritus has reduced the depth of the channel in its proximity by one-third. For a long distance the thalassological Thalweg is a mile wide and the regular steep slopes of the submerged valley may be about 1 : 5. For the first 18 miles the bed consists of fine sand, which nowhere rises so high as the 50 fathom soundings, where the sand is invariably coarser,—it likewise covers the lower 7 miles of the dybet. This truly remarkable physical feature has no outlet into the Atlantic, but terminates in an amphitheatre of horse-shoe form, 2 miles long, beyond which the sea resumes its

ordinary 50 fathoms depth. Such obstruction of the submerged valley is plainly established, since the bed of the sea for at least another 25 miles further out consists of sand and shingle, which the various currents have deposited and equally distributed in their lateral course, and so have absolutely obliterated the merest further traces of the Bredsund dybet.

No human being ever attempted to count the islets and rocks, a multitude of which are sunken, all along the west coast of Norway—not even the swarm of rocks off the coast of Nordmark, where the powerful currents rush in opposite directions, and change with the winds, the ebb and flow of the tides, and the phases of the moon—all such ideas would soon be abandoned. But, with the exception of the Lofoden islands, it is particularly to be noticed that *none of the channels running in the direction parallel to the coast, whatever be their width, are deep.* The whole of these facts point to the subsidence of mountains of all heights, and mountain slopes preserving traces of their original form. This last, during geological eras, having been characteristically irregular in outline, would easily lead us to understand the occurrence of miniature islands, while the sunken rocks would be the remains of the harder crystalline rocks at their base. The Maelström is a well-known classical example of the force of conflicting currents at given phases of the oceanic tides.

§ II. Palæoscandinavian Channel.

A second line of 100 fathom soundings skirts the Danish province of Jutland. Proceeding due south from Christiansand it lies at the distance of 30 miles from the Norwegian coast. This isobath runs for 120 miles westward, always preserving, as near as possible, the same distance from the shores of Norway—as though these lines were arcs of concentric circles—as far as a point S.W. of Ekersund. From thence it trends to the N.W. as far as Lat. 60° 45′ N., where it lies at a distance of 50 miles from the Norwegian mainland. A short distance further on, Lat. 61° N., it is only 100 miles distant, due east, from Saxavord Hill, the extremity of Unst, in the Shetland Islands.

This line is, in fact, the eastern boundary of the British platform, or what might be more elegantly termed Palæo-britannia.

Opposite the shores of Jutland the plateau lies within 30 fathoms of the surface of the water, gradually becoming lower, until we reach Lat. 58° N., Long. 5° E. Between the two lines of 100 fathom isobaths thus described there is a conspicuous channel of very marked depth, which might be termed, for the sake of clearness, the Palæoscandinavian channel, at first 20 miles wide in its southern portion, and 40 miles across in its northern, but in its entire length into the Atlantic approximately parallel to the coast of Norway.

It will be advisable to commence the study of the configuration of the bed of this channel still farther to the east, apparently where it originated.

Cattegat.—Doubtless the great danger this passage presents to shipping is owing to the fact that the depth of the sea between Marstrand, in Sweden, and the northernmost point of Jutland, in Denmark, as well as for 60 miles, at least, farther upwards, nowhere reaches 60 fathoms, and is in general only half that amount.

Skagerak (*Skager Rack*).—A transverse section of this sea between the entrance to the Christiania fjord and Jutland already shows 165 fathoms in mid-channel; that between Kragerö and Jutland 355 fathoms; that between Arendal and Jutland—which is precisely in prolongation of the axis of the Norwegian mountain chain—430 fathoms, its maximum depth. Between Christiansand and Jutland it is 328 fathoms; also from Christiansand due south, towards the western coast of Denmark, the depth is 330 fathoms; off Farsund the depth is reduced to 235 fathoms. Broadly speaking the deepest part of this Palæoscandinavian channel is one-third of the distance from the Norwegian mountainous coast towards the flatter shores of Denmark.

North Sea.—Between Lat. 58° N., Long. 5° E., and Lat. 61° N., the former coast line of the British plateau, or Palæobritannia, is pretty uniformly marked by a definite incline, with soundings of 70 fathoms at its summit and 150 fathoms at its base. Off the Danish coast the inclined plane bounding the channel is very gentle, becoming gradually steeper as we proceed westward. But whatever be the inclination, *the base still continues to mark with considerable regularity* 150 *fathoms.* To the west of Norway the mid-channel rarely exceeds a normal depth of 160 fathoms; a few soundings at the northern extremity mark 200 fathoms, and in some local instances even 231 fathoms. Between the parallels of 60° 30′ and 61° 30′ the soundings across the channel vary but

slightly from 200 fathoms within a central part 10 miles wide.

Since we have found a depth of 430 fathoms in the Skager Rack, off Avendal; 368 fathoms in the Vinda fjord; 348 fathoms at a great distance from the coast; 348 fathoms in the Oster fjord, while the depth of water in the Sogne fjord is no less than 660 fathoms, it seems reasonable to conclude that the bottom of the Palæoscandinavian Channel must have been filled up with a thickness of from 230 to 450 fathoms of newer tertiary deposits.

§ III. PALÆOBRITANNIA.

From any point along the coasts of Denmark, and thence to Belgium, the ancient mariners could steer in a direct course across the North Sea, so as to land at any locality on the east coast of England, between Dover and Newcastle, without leaving the British platform, and find that the soundings were exclusively less than 50 fathoms—frequently far less—as between Tonning and Yarmouth in no instance exceeding 27 fathoms; the bed of the sea being everywhere sandy.

It may be interesting to state, in passing, that at least 70 localities are specified by name in the map of Eastern Palæobritannia, or, more strictly speaking, in the charts of the North Sea. Such names are given to parts of the bed of the sea where the depths are considerably different from those of the adjacent portions. Navigators are compelled to give heed to them, and fishermen know by experience that fish have their haunts regulated by them.

But what is this to the marvellous thalassography of Norwegian mariners? There every small rock peeping above the level of the water has its particular name, and often the very sunken rocks. The charts of the coast-line are crowded with such information. In the vicinity of Aalesund and the Bredsund dybet, of which we have given a sketch, there are far more than 70 names given for positions in the Atlantic within the radius of a few miles.

It is to be hoped that future charts will register all such data, which will serve in the most marked manner to give precision to our knowledge of two-thirds of our globe, which remain yet as little explored as is the centre of Africa to geographers. To talk of the phenomena, the fauna, the flora, etc., of the *North Sea* or *Atlantic*, is about as

vague as to speak of the same scientific data of *Europe*, or *America*, and it is high time to take the splendid researches of the *Challenger* as the model upon which we must carefully pursue our future investigations.

I confess candidly to have glanced with considerable complacency on Mr. Harmer's paper on the Geology of the Eastern Counties. But on taking up this paper again, with our mind enlightened by Prof. Hull's observations relating to submergence of the British Isles, we have been brought to agree with Mr. Harmer in his deductions, hoping even to be able to show that they are capable of being very greatly extended without poetry or risk of erring.

The following are briefly some of his remarks on several purely local beds of the Pliocene of Norfolk and Suffolk, in descending order, and employing his terminology.

Cromer beds.—Contain teeth and bones of elephants, hippopotami, and other forms characteristic of *southern climate*; but likewise bones of the musk ox and glutton, animals of *northern facies*, these latter probably indicating more nearly the temperature then prevailing in Norfolk.*

Weyborne Crag.—Contains *arctic forms* of marine mollusca.

Chillesford Clay.—Mineralogically characterised by great abundance of *minute particles of mica*, as also are similar beds in Holland, having been brought down by the Rhine and Meuse, and derived, according to Mr. Harmer, from Devonian and Carboniferous rocks.† For our own part we think this to be erroneous, for we should attribute the mica in such characteristic abundance as due to the destruction of granite and allied rocks, gneiss, mica-schist, etc., of the crystalline lower palæozoic, archaic and intrusive region of the Swiss and Austrian Alps.

Norwich Crag.—Contains *mica* and Rhenish pebbles.

Red Crag.

All the Pliocene beds of Norfolk, says Mr. Harmer, contain *pebbles of white quartz*, similar to those of the Rhenish and Mosean drifts of Holland.‡

It is by the help of these incontestably southern mineral substances that Mr. Harmer has traced the map of the course of the Palæorhine, as far as it still lies above the ordnance datum.

Basing his arguments on the similarity of the fauna of the

* *Quart. Journ. Geol. Soc.*, vol. lii, p. 774.
† *Ibid.*, p. 770. ‡ *Ibid.*, p. 770.

newer Pliocene strata of Holland, as revealed by well-boring, and those of the Eastern Counties, as well as on their mineral constitution, Mr. Harmer concludes that Great Britain still formed part of the Continent of Europe, and traces the course of the "Rhine" by such data, or, as we distinguish it, the Palæorhine, in a tortuous course, from Walton-on-the-Naze (Suffolk), for a distance of 70 miles, uninterruptedly, to Mundesley, near Cromer (Norfolk). Were the river still to run in its original bed we might speak of Ipswich-on-Rhine, Lowestoft-on-Rhine, Norfolk-on-Rhine.

The North Sea currents, acting during thousands of years, have so distributed the fine sediment brought down by the Rhine, Schelt, and Thames, forming numerous shoals, that the course of the Palæorhine for a distance of 103 miles, which is the crow flight between the Hook of Holland and Walton-on-the-Naze, has been entirely obliterated.

In this part of its course the Palæorhine received two important affluents on the left, the Schelt and the Thames, which may have been of a width similar to what it now has near Greenwich, until it blended its waters with those of the parent stream from the Alps.

Mr. Harmer leaves the Palæorhine at Mundesley, supposing for reasons we cannot follow that it had reached its estuary. But is such a deduction logical?

The Silver Pit.—Fifteen miles out to sea off the coast near Grimsby, lies the Silver Pit, well known to fishermen. This remarkable physical feature is a distinctly marked, tortuous, submerged river valley, 23 miles long by 2 miles broad, running towards the north. For the first 15 miles the depth of the mid-channel rapidly increases from 40 to 45 and 50 fathoms consecutively, bounded by lateral declivities 40 fathoms in height, in other words by respectable elevations of 240 feet. Farther on the depth gradually diminishes to 35 fathoms and finally is only 23 fathoms, beyond which we cannot now follow the valley, which has been quite filled in with sediment.

Cromer (Mundesley) is 33 miles distant to the S.E. from the head of the Silver Pit, which we consider to have undoubtedly formed part of the course of the Palæorhine. There is nothing to surprise us if all evidence of the line the river followed should have been obliterated (as between Holland and Walton), except in this one isolated place, seeing that it ran principally through Tertiary strata with low banks. Possibly the Silver Pit, on the other hand, marks its

passage through chalk rocks. What with the strong littoral currents, and the detritus caused by the very considerable encroachment of the sea on the east coast of Lincolnshire and Norfolk, the wonder is that any trace of the original valley should have come down to our times.

If this theory is accepted we have been enabled to trace the course of the Palæorhine for 60 miles farther than Mr. Harmer. But that is not all.

One hundred fathoms sounding, North Sea, Lat. 58° 45′ N., Long. 0° 22′ W.—Precisely 300 miles north from the Silver Pit the first deep sounding is marked as 102 fathoms. *No other spot in the North Sea in its vicinity, and none in Eastern Palæobritannia at lower latitudes, approaches in the remotest degree to such a depth.*

Channel between the Orkney and Shetland Islands.—Off Sumburgh Head, which constitutes the southern extremity of Mainland Island, Shetland, Lat. 59° 55′ N., Long. 1° W., there is again a depth of 103 fathoms in the channel communicating between the Atlantic and the North Sea. Similar soundings occur in the Atlantic, proceeding thence in a N.W. direction, until 48 miles to the W. of Shetland, Lat. 60° 44′ N., Long. 3° 7′ W., a depth of 249 fathoms is attained. Five miles farther on 640 fathoms marked on the chart was probably taken at some spot on Professor Hull's Great Declivity.

Corollary.—Mesozoic strata, with well-marked elevations, stretch uninterruptedly from the British Channel to Yorkshire. Farther north the Palæozoic hills are followed by Archaic rocks, rising into noble mountains in the lake district of the North of England and in Scotland. If we are correct in tracing the Palæorhine as far as the Silver Pit there is no way whatever out of the dilemma, unless we admit frankly that it must have followed a northerly course, probably passing by the two points referred to, and finding its way somehow into the Atlantic after reaching the western shores of Palæobritannia, of which (between the Hook of Holland and Shetland alone) it must have fertilized upwards of 600 miles, thus doubling its present length.

The principal tributaries to the left would have been successively: the Palæoschelt, the Palæothames, Palæohumber, Palæoforth, Palæotay, etc. By such an extension of its Thalweg it must have been comparable in size in days of yore to the Oronoco, or by its geographical position to the Mackenzie river or Yenisei.

Palæobritannia was flooded by the waves, and as regards the eastern portion would appear to have been submerged about 900 feet (150 fathoms), if not 4,000 feet (660 fathoms) since the Pliocene times, when the glacial peaks of Norway could have been visible for a distance of hundreds of miles along the shores, and when the bears of Russia infested all the forests, their principal obstacle having been to ford the majestic stream which often bore on its way towards the arctic circle the swollen, half-putrid carcases of drowned elephants, dead hippopotami, and all kinds of ancient denizens of warmer climes.

The sea had not yet burst a passage at the Straits of Dover, but chalk downs probably extended between the sites of Dover and Calais. On the other hand there is great probability that the chalk rocks of Denmark formed bold cliffs along the coast line. In all which precedes we are far from approaching the immense submergence so clearly established with reference to the Atlantic.

To follow up the image. Great Britain's isolation has proved to be her most precious boon: she is a microcosm. Forty fathoms of water are a greater protection than as many citadels. Her bravest sons instinctively toil in the now submerged regions, undaunted by winds and waves. While every race of men has the same sacred right to independence in their respective countries, an All-wise Providence gave the sea for the free neutral use of mankind, to serve as the great bond of union for friendly intercourse between the most varied members of the one human family; and who could better exercise such a privilege than the inhabitants of the sea-girt British Isles?

The CHAIRMAN.—We have in this paper the following-up of a very important subject, which has occupied us on more than one occasion, on what is to be learnt from deep-sea soundings, and it is very interesting to have traced some of the information we have received. Of course it becomes immensely difficult to trace the ancient channels under such waters as one finds in the south of the North Sea and the coast of Holland, filled with dilute sand and gravel, and the wonder is that any channels have remained at all.

But it is a very interesting subject and deserves careful attention, and I hope some of those present will favour us with their views.

Professor E. HULL.—I think our thanks are due to the author of this paper, Cavaliere Jervis. He is a Fellow of the Geological Society, and has for a long time been Curator of the Royal Museum at Turin. When at Turin, last autumn, I had the pleasure of calling on him, and I was much gratified by that visit. Our thanks are also due to Professor Logan Lobley for reading the paper.

Now, as has been observed, the subject which Mr. Jervis has opened is a very wide one and opens out many questions of interest.

I am glad to say that Mr. Harmer, whose elaborate investigations in this region are testified to by his paper read before the Geological Society, is able to attend to-day, and no doubt he will meet the points that the author has raised with reference to these channels.

I do not see any necessary discrepancies between the results arrived at by Mr. Harmer and those arrived at by the author as regards the Palæorhine. I think both are compatible with each other.

Now the principal points the author has brought before us in the first part of his paper are the soundings of the fjords, and he has brought to our notice a very remarkable circumstance, viz., that these fjords, which run up for so many miles into the heart of the Scandinavian mountains, almost always (perhaps I might say always) deepen their channels as they go up into the mountains from their mouths where they open out into the North Sea. That is a very remarkable fact, and the soundings testify to that without question. We have several illustrations of it mentioned by the author—in the great Langesund fjord, for instance, and the Hardanger fjord, where the depth varies from 315 fathoms to 160 fathoms, or a difference of 155 fathoms; and the Sogne fjord, where for the first 25 miles the depth is from 630 to 660 fathoms, until it is reduced to 128 fathoms, or a difference of 532 fathoms.

Now what is the origin of these fjords? Unquestionably they are old river valleys; and river valleys of immense geological antiquity. They come down, probably, from the period preceding the Old Red Sandstone, or Devonian, as their representatives in Scotland certainly do, and they have remained in the con-

dition of river valleys during the uprise of the whole of the Scandinavian promontory and all that part of Europe, which is the oldest land in Europe except part of Moravia. It is the oldest land in the north of Europe; and all the time, while part of the British Islands and other parts of Europe were submerged under the sea, receiving enormous deposits of great thickness, this old Scandinavian land remained above the waters, and the rivers were employed in ever deepening their channels. We all know that when a river flows down it continually deepens its channel from its source to its outlet; but, as I have observed, and the author points out, that is not the case with these fjords. They are, of course, submerged river valleys. That is unquestionable; and the question arises, Why is it that they do not, as in the case of ordinary rivers, continue to deepen their channels all the way? The author attributes the shallowing of the channel towards the mouth to the silting up of that part of the channel. For my part, I cannot accept that explanation as at all sufficient. In fact, the beds of these submerged rivers are "rock basins." Their floors are of solid rock, not silt, towards their outlet. Of course they are covered, to a certain extent, with silt and mud carried down and deposited on their floors; but their solid part is probably not far below the silting beds, and, in the case of the islands, comes up to the surface. In fact, the valleys are old rock basins. [*The author here illustrated his meaning by a drawing on the board.*] The late Sir Andrew Ramsay expounded the formation of rock basins by showing that they are basins scooped out or eroded by glacial action. In Norway, as we all know, we find the most remarkable examples of glacial erosion. All along these fjords the rocks, where not covered with detritus or old sea beaches, are glaciated in a most remarkable manner. You can understand how that during the Glacial period enormous masses of ice, coming down from the sides of the mountains and entering these old river valleys, loaded with stones and rocks, would continually, as long as the ice lasted, be engaged in eroding the floor of the valley deeper and deeper, until, at last, a rock basin was formed; because the farther the ice receded from the mountain source the less powerful would be the erosion, and, consequently, the greater amount of the erosion would be near the base of the mountains and the higher part of the valleys. In Scotland we have precisely similar instances of rock basins—for instance, Loch Lomond, which is

100 fathoms deep very far up under Ben Lomond, but at its outlet it is near the level of the sea floor in the same way as Loch Etive, which comes out near Oban; in fact, nearly all these lochs (once river valleys) in the North of Scotland are, as Professor James Geikie has so well shown,* rock basins, which enter at the sea very little below the level of the surface and are not very deep, while some miles up higher they are considerably deeper. I think it would be a very interesting subject to take up (which perhaps I shall be able to do) to show the comparisons or analogies between the rock basins of the West of Scotland and the fjords of Norway.

I am very much inclined to believe that the author has proved his point about the Silver Pit off the coast of Lincolnshire being the ancient river bed of the Palæorhine, and that it has been silted up is only what one would expect. As the Chairman remarked, it is a wonder, considering that the sea was at a former time filled with glacial ice carrying great masses of material which it spread over the floor, that we have any of these old river valleys remaining in such a condition that they can be determined by the soundings of the Admiralty Charts.

As others are going to speak, I will not detain you longer except to express the great pleasure I have derived from listening to the author's paper.

Mr. HARMER, F.G.S.—The author has been good enough to write to acquaint me with the fact that this paper was coming on, and I am glad to be here. The subject is most interesting, and I am very glad to be able to agree with many of the conclusions that the author has reached. There is no doubt, I think, that from the time the Rhine began to run northwards it must have forced itself out to the North Sea between Scotland and Scandinavia. I agree with Professor Hull that it is not strange that we cannot trace the whole of this old channel. The wonder is that there is any trace of it left.

With regard to the point he raises, with which my name has been connected, I am afraid I cannot follow the conclusion he reaches, and if it will not take too much time I will sketch out my views shortly. [*The speaker here illustrated his theory on the blackboard.*] Changes of level took place in the North Sea area during both the Pliocene and Pleistocene periods, but the stages in the

* Geikie, *The Great Ice Age.*

geological history referred to in my paper belong to the former, and those dealt with by the Cavaliere Jervis, I believe, to the latter epoch. The so-called forest-bed of Cromer, and the Chillesford Clay, can, therefore, have no connection with the elevation of the North Sea basin, which occurred in glacial and post-glacial times, when England was joined to the Continent, and the sea retreated sufficiently far to the north for the "Silver Pits" depression to form part of the Rhine valley.

The Chillesford beds, with their marine shells, and the mammaliferous deposits of the Cromer coast, do not represent, in my opinion, any former existence of the Rhine itself in East Anglia, so much as some of the estuarine channels by which, during the Pliocene epoch, it found its way to the sea; the latter then reaching, probably, as far south as the north coast of Norfolk.

I agree with the author that the mica, the presence of which is so constant a feature of the Chillesford Clay, may possibly have been derived from the Alps, as well as from the highly micaceous Devonian schists of the Ardennes. Of course it is always exceedingly unsatisfactory to criticise an author's paper in his absence, and I am very sorry that he is not present. It is possible that I may have misunderstood him to some extent, and I should have been too glad that he should have had an opportunity of replying to my remarks.

[A long discussion here took place, in which the Rev. Dr. WALKER, Mr. MARTIN ROUSE, Mr. HARMER, and Professor HULL took part. Dr. WALKER pointed out some analogies between the features of the coast of Norway and those of Iceland.]

Rev. G. F. WHIDBORNE, F.G.S.—I have kept very carefully away from such slippery things as glaciers, and therefore I will only just ask a question.

It seems to me, if I understand rightly, that what this paper points to is the time of the elevation of the whole west coast of Norway, England, and France, and, apparently, the point of disagreement between the author and Professor Hull is that the author thinks these fjords were filled up with detritus washed down by the Rhine, and Professor Hull says, "No—the reason of the central depression is a scooping out by ice action."

Then Mr. Harmer says this elevation could not have been at the time of the Cromer beds because they point to a time of depression and not of elevation. I really wanted to ask

whether I am right in what I have gathered from the paper because I thought it might clear one's mind. May the whole question of the great elevation that has gone on in the Rhine's action have something to do with the great elevation that must have occurred in the raising of the Alps, or any subsidiary elevation connected with it ?*

Professor LOGAN LOBLEY.—I would say a word in reply to the point as to some of the fjords being deeper at the sea end and others not. It does not at all follow, because some of the fjords are deeper at the sea end, that Professor Hull's explanation of the other fjords that are deeper in the interior is at fault. We have river valleys deepening out towards the sea now, and other river valleys that do not. So there may be one explanation that will afford grounds for one class of river valley, and another that will suit the other class. Therefore the one does not contradict the other at all.

The rocks that have been spoken of are clearly not moraines, but much older. If they were of moraine matter they would have been swept away long since by the great storms and currents of the coast.

As to the age of elevation, we are dealing with a period of enormous duration, and it would be a period when the levels would be similar to what they are now, and other stages when the levels were quite different. The period of elevation, I take it, was subsequent to the Pliocene period, when the deposits on the east coast of England were laid down.

I think this paper is very interesting, and very noteworthy as following in Professor Hull's steps, and is one of great importance, not only to geographical and thalassographical studies, to use the new word, but also to geological studies; for it gives us fresh grounds for coming to a conclusion with respect to phenomena which have undoubtedly existed on this earth and which have been a great puzzle to many deep thinkers.

Mr. M. L. ROUSE.—I thought the contention of Professor Hull was that all these valleys were formed by glacial action. That is

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* The answer to Mr. Whidborne's question seems to be : 1st, that the period of the great elevation and of glacial erosion was subsequent to that of the Cromer beds, and 2nd, that the valley of the Palæorhine participated in the general upheaval of the whole region.—ED.

the general opinion, that the fjords were so hollowed out by glacial action, is it not?

Professor HULL.—They were formed in the first place by river erosion; but they have been deepened in certain parts by glacial erosion.

Mr. ROUSE.—Then we might suppose, regarding the Christiania fjord and such of them as are not shallow at the mouth, that they were not subject to glacial erosion.

Professor HULL.—Not at present.

Mr. ROUSE.—At present there is no erosion at the head of the Christiania fjord?

Professor HULL.—No.

The HON. SECRETARY (Captain Francis Petrie, F.G.S.).—I have received a communication from Professor Rupert Jones, written in his usual very graphic style, and he agrees, in the main, with the whole of the contention which is included in Mr. Jervis's paper.

The CHAIRMAN.—I am sure we must ask the Hon. Secretary to convey to the author of the paper our great appreciation of it, and he will learn of the interesting discussion that it has given rise to. We also thank Professor Logan Lobley very much for reading it.

The Meeting then terminated.