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1898.

ORDINARY MEETING.*

COMMANDER G. P. HEATH, R.N., IN THE CHAIR.

The Minutes of the last Meeting were read and confirmed, and the following Election was announced :—

ASSOCIATE :—J. R. Swanston, Esq., M.A., United States.

The following paper was then read by the author :—

FURTHER INVESTIGATIONS REGARDING THE SUBMERGED TERRACES AND RIVER VALLEYS BORDERING THE BRITISH ISLES.

By Professor EDWARD HULL, LL.D., F.R.S., and G.S.

(*With chart.*)

I. *Introductory.*—The researches of previous investigators have had the result of showing that the platform on which are planted the British Isles and adjoining parts of the European continent was formerly connected by land with Iceland through the Shetland and Faeröe Islands, and this again with Greenland. This former connection is placed beyond doubt by the character of the fauna and flora. Dr. Wallace includes Iceland in his Palæarctic region which embraces the British Isles and Europe,† and as Professor Newton has shown—all the land mammalia, with only three exceptions, are European. The exceptions are those of Arctic habitats—the polar bear, the Arctic fox, and a mouse (*Mus Islandicus*). Amongst the birds—the peculiar species—are allied to those of Europe and the Faeröes. The botany and ento-

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* 2nd May, 1898. The importance of a full consideration of the points brought out in Dr. Hull's paper, has been held to require its early insertion in the Journal.

† *Geographical Distribution of Animals.*

mology of Iceland have been described in the Transactions of this Institute by the Rev. Dr. Walker, F.L.S.,* and his observations bear witness to the former land connection of Iceland with the British Isles. His remark that "the first thing that strikes a visitor from the latter country is not the number of Arctic species, but the great abundance of plants that are very rare and local in Britain, such as *Saxifraga cæspitosa, Lichnis alpina*, and *Erigeron alpinum*, etc." The disappearance of the former glacial conditions from the British Isles and their continuance in Iceland accounts for the remarkable abundance of the plants referred to.

The very ample survey of the insects given by Dr. Walker leads him to the following conclusions:—

1. The total absence of butterflies.
2. „ „ orthoptera.
3. Neuroptera only represented by *Phryganidæ*.
4. The most abundant tribes of insects in Iceland are moths and *Diptera*.

On the whole, the insect fauna, as well as the flora, of this island bear a remarkable affinity to those of Scotland.† As regards Greenland, while some of the forms are European, others are American, a few being purely Arctic, and Wallace includes it in his Nearctic province. At the same time about one-third of the vertebrates are European,‡ and indicate a former connection with that continent, though not to the close extent of that of Iceland.

Now, we must not forget that this community of fauna and flora is characteristic of existing genera and species, and indicates a very recent physical, or land, continuity. It may date back, perhaps, as far as Pliocene times, passing into Recent, but not earlier; and if this be so, we have to consider to what extent the bed of the Atlantic Ocean requires to be raised in order to establish such a land connection, or in other words the amount of recent submergence which it has undergone; we have also to determine the tract of the ocean over which the continuity of land surface formerly existed.

The remarkable results established by American naturalists regarding the submerged terraces and river valleys

* *Trans. Vict. Inst.*, vol. xxiv, p. 205.
† *Supra cit.*, p. 241.
‡ Wallace, *supra cit.*, vol. ii, p. 138.

adjoining the American continent and prolonged into the North Atlantic, which have already been communicated to the Institute by Mr. Warren Upham,* and more recently by myself, have induced me to take up the investigation of the sub-oceanic region adjoining the British Isles with the aid of the Admiralty charts of soundings, which afford most ample materials for such investigation. The results, which appear to me of remarkable interest, I now venture to place before the Institute; from which it will be found that all tend to confirm the view of a former but very recent elevation of the British and adjoining continental areas to the extent of several thousand feet as compared with the level of the ocean surface at the present day.

II. *Land connection with Iceland.*—An examination of the hydrographical charts shows that it would be necessary to raise the bed of the ocean to the extent of 1,320 feet (220 fathoms) in order to establish a land connection between the British Isles and Iceland. The actual amount of elevation was probably greater and may have reached about 6,000 feet. The evidence for this will be seen further on, and it corresponds very closely with the amount of elevation determined for the coast of North America by the observers already referred to.† Indeed all the evidence obtainable by soundings goes to show that the whole area of the North Atlantic has undergone stupendous changes of level in very recent times both as regards emergence and submergence.

III. *The British Platform.*—The submerged terrace on which the British Isles and adjoining portions of Europe are planted is generally known as "the 100-fathom platform." It is often represented on hydrographical charts, such as those of the late Professor Sir Wyville Thomson, by the 100-fathom contour taken from the Admiralty Chart.‡ But this strict adherence to the 100-fathom contour is misleading as regards the great physical features of the submerged lands; and the same observation applies to the other contours. These features vary in elevation and depression according to geographical position; and it is only by a close

* *Trans. Vict. Inst.*, vol. xxix. See also Prof. J. W. Spencer on the "Reconstruction of the Antillæan Continent," *Bull. Geol. Soc.*, America, vol. vi.

† I have given a short preliminary notice of the results of my examination of the Admiralty charts in *Nature*, March 24th, 1898.

‡ *The Depths of the Sea*, Plates II, IV, V (1873).

observance of the changes of depth, as indicated by the soundings, that the features themselves can be recognised and portrayed.*

Throughout a distance of 500 miles from the vicinity of Rockall on the north to the entrance of the Bay of Biscay, the British platform terminates seaward along the margin of a grand escarpment of 7,000 to 8,000 feet in height; remarkable for the steep descent of its flanks, which in some cases are precipitous. The edge of this escarpment is quite sharp and well-defined by the sudden descent of the soundings; and at (or towards) its base it gives place to the abyssal plain with a very gentle descent towards the oceanic bottom. The general outline of the platform and escarpment will be understood from the diagrammatic sections. (Figs. 1, 2, 3 and 4.) Off the coast of Scotland the escarpment is known as the Vidal Bank.† Its upper margin here very closely coincides with the 100-fathom line; but on tracing the margin southwards it is found to gradually become deeper till opposite the entrance of the English Channel, it nearly coincides with the 180–200 fathom contours. The sections taken at intervals from off the Hebrides to the coast of France, at the entrance to Bay of Biscay, will illustrate this general statement. (*See* PLATE, Figs. 1, 2, 3, 4.)

No. 1. Drawn through Rockall to the Isle of Mull, illustrates the form of the sea-bed near the head of the great bay which here penetrates northwards into the plateau which stretches from Scotland by Rockall towards Iceland, on which the Faeröe Islands and Orkneys are also planted. The margin of the British platform is sharply defined by the 100-fathom contour at about 70 miles from Uinst, at which point the escarpment descends at a steep angle to the 1,000 fathom contour, where it gives place to the abyssal floor of the ocean, descending to a depth of about 1,350 fathoms or 8,100 feet. The total height of the escarpment is here 7,500 feet approximately.

No. 2. Represents the outline of the sea-bed west of County Donegal, at Slieve Liag, which rises in a bold headland of nearly 2,000 feet from the ocean. Here the margin of the British platform is still closely represented by the 100–120 fathom contour, and the escarpment descends to the 1,000 fathom line, from which the floor of the ocean

* The British platform is described by Professor Spencer, *Geological Magazine*, No. 403, p. 37 (1898). † Admiralty chart.

gently descends to a depth of about 1,600 fathoms or 9,600 feet; the form and height of the escarpment are similar to those of Section VII, but somewhat steeper.

No. 3. This section is remarkable for two points; first, the width of the British platform, and the depth of its western margin below the ocean surface. It is drawn from the coast of Clare (where the cliffs of Mohir, formed of Carboniferous sandstone, rise 400 feet above the sea) along a series of soundings stretching due west for a distance of 280 miles. The platform is here about 200 miles across, and its western margin is indicated by the 200 fathom contour very nearly; that is twice the depth of the margin opposite Donegal and the Hebrides. The escarpment here, just west of the "Porcupine Bank," is very bold and lofty; descending abruptly from the 200 to the 1,500 contours, being a total descent of about 7,800 feet. Directly north of the Porcupine Bank, the escarpment is quite precipitous, as the two terminal contours (the upper and lower) are in close proximity. With this tremendous descent of over 7,000 feet, the escarpment stretches southward, till opposite the south of Ireland it sweeps round eastward, producing a wide bay about 200 miles across, and sloping upwards to the marginal line of 200 fathoms, at which point the old channel of the river Shannon seems to have descended to the ocean when this was emergent land. Opposite this bay the floor of the ocean descends to a depth of 2,500 fathoms (or 15,000 feet) within a distance of 200 miles.

No. 4. This section is drawn from the coast of Kerry in a south-westerly direction, and is continued eastward over Carantual, the highest mountain in Ireland, reaching a height of 3,400 feet above the sea. The platform is here only 60 miles across, and the descent from its margin is less precipitous than in the case of Sections 2 and 3. The depth of the margin is about 200 fathoms, and after the initial steep descent to about 1,500 fathoms, the ocean bed gently declines till, at a distance of 170 miles from the margin, it reaches a depth of 2,300 fathoms or 13,800 feet. This is the last of the sections I have drawn; but if another were taken in a south-westerly direction from Ushant, off the coast of France, it would show a platform of 80 miles in breadth, breaking off at the 200-fathom line in a sheer precipice of 5,000 feet just south of La Rochelle Bank, which is situated at the edge of the platform itself.

We have now reached the southern limit of the region

which I have on the present occasion proposed to myself for investigation, at the northern end of the Bay of Biscay, but I do not doubt that the features here described are continued still further south.* From what has been stated it will be seen that throughout a line of coast of 600 or 700 miles we have a remarkably uniform succession of features, consisting of a gently sloping submerged terrace, stretching out from the coast to a variable distance, but which, on reaching a depth of 100 to 200 fathoms, breaks off in what would be a grand escarpment of 7,000 to 8,000 feet, if viewed from the outer ocean. Such regularity of features through so great a distance cannot be regarded as accidental; it points to uniformity of cause and mode of production. It is to a terrestrial surface we must have recourse for the explanation of the physical conditions here described. We are familiar with examples of plateaux bounded by escarpments leading down into plains both in the British Islands and in other countries. We have a familiar example in the Cotteswold Hills of Gloucester and Somerset; in the range of the Jura; in the range overlooking the Delta of the Nile above the plains of Egypt. All these terraced escarpments have been formed on the surface of emergent lands; they are absolutely terrestrial, not sub-oceanic in their origin; and in ascribing a similar origin to those here under consideration, we are only drawing a logical deduction from the premises laid down. In a word, this grand terraced escarpment of the British Isles must have been formed during a period of emergence of the whole region to an extent of several thousand feet above the surface of the ocean, as it is at the present day, and of subsequent submergence, during which the Atlantic waves, driven by prevalent winds, have undermined the cliffs of rock. Professor James Geikie has recognised the generally abrupt descent of the continental plateau, but does not appear to have recognised that such features must have had a terrestrial origin.†

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* This statement I have since verified by an examination of the Admiralty chart over the Bay of Biscay, which affords most interesting results, especially in the determination of the channels of the rivers Loire and Adour traversing the platform, and descending through deep cañons to the base of the great escarpment, and I hope, ere long, to have an opportunity of making these results public.—E. H. (April, 1898.)

† Address to Geographical Section, Brit. Assoc., 1892. *Proc. Roy. Geog. Soc.*, Sept. 1892, p. 639. The author however, clearly describes the

IV. *Submerged river channels.*—The views I have just expressed receive remarkable confirmation from the existence of old river channels, which may be traced on the Admiralty charts by the soundings. It will be evident that during the period when the British platform was in the condition of a land surface, the rivers descending from the adjoining land, as well as the rain which fell upon its own surface, must have had outlets to the ocean towards the west; and we are, therefore, led to inquire, are such outlets, in the form of river channels, to be recognised by the soundings? I am able to give a very decisive answer in the affirmative to this question. Notwithstanding that the submerged lands around the British Isles have for thousands of years been covered by water, more or less loaded with sediment, and during the later glacial stages, laden with icebergs and floes carrying and depositing stones and mud, two old river channels, at least, can be clearly traced, one draining the lands now occupied by the waters of the Irish Sea, and the other, by those of the English Channel. The courses of these old rivers are indicated by slightly irregular depressions in the soundings, varying in depth from 2 to 20 fathoms below the general levels adjoining, but they become remarkably accentuated on approaching the margin of the great escarpment, where they are converted into gorges or cañons bounded by precipitous walls of rock, and traceable down nearly to the base of the escarpment.*

V. *The English Channel River and the "Hurd Deep"* (Figs. 5 and 6).—The course of the river which drained the area of the English Channel can generally be traced by a curving line of depression from its source near the Straits of Dover to the margin of the great escarpment, where it cuts deeply into the rock in the form of a gorge or cañon. Owing, probably, to silting up by sediment the course is less evident than it would have been had no sediment been deposited. But at one part of its course its position is still clearly defined on the chart for a distance of 70 miles under the name of the "Hurd Deep." This is a nearly straight E. and W. gorge about 4 to 5 miles across, and at its deepest part 354 feet

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mode of formation by marine action on emergent lands of such plateaux as the British platform, p. 644.

* In a recent paper read before the Geological Society Mr. T. Codrington has described various river valleys in the south and west of England and Wales in which the solid rock is found at various depths below the sea-level, the original channel being filled in with "glacial deposits," that of the Dart being 110 feet below low water mark.

below the general floor of the sea bed.* Here, we may suppose, the channel has been kept open and free from sediment, unlike the portions of the river valley above and below. The cause of this dissimilarity of conditions is not far to seek. On looking at the map it will be seen that the "Hurd Deep" lies in the narrowest part of the channel west of the Straits of Dover, between the Isle of Wight and Portland Bill on the north, and Cape de la Hague and Cape de Barfleur on the south. Above and below this strait the channel broadens out to about twice its breadth between these points; hence the tidal currents have here extraordinary force and swiftness, owing to which the sediment, deposited above and below, appears to have been prevented from settling down and filling up the gorge of the old river. The general outline, the direction, and position of this remarkable rift, all point to the "Hurd Deep" as a river channel which has been cut down into the solid rock, and is bounded by steep, or precipitous, cliffs resembling on a small scale the American cañons. The two submarine rivers here described must have exceeded in size any of our existing streams, and we may infer entered the ocean in a succession of grand cascades.†

VI. *Comparison with the American Submerged Platform.*—In my former paper‡ I described briefly the results arrived at by Professor Spencer and other American geologists regarding the "drowned" plains, escarpments, and river valleys lying outside the North American coast, and I showed that they consist (1) of the "Continental Shelf," stretching out into the Atlantic as far as the 100-fathom line, or thereabouts, where it breaks off along an escarpment, descending to a depth of 450 or 500 fathoms. This escarpment is then succeeded by a second and more extensive terrace, known as "the Blake Plateau," which in turn terminates along a second grand escarpment descending to the abyssal depths of the ocean.

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* The deepest point shown by the soundings is 95 fms., while the bordering level of the sea-bed is 36 fms.

† Man was not present to view the scene presented by the British Isles at this time; but we may easily reproduce before our minds its grandeur as visible from the ocean at a distance of a few miles from the coast. In front would rise the lofty terraced cliffs, several thousand feet in height, and stretching away to the north and south in bold headlands and wide bays till lost to sight in the distance; while, planted on the nearly level terrace above, would be seen in the far distance the mountain heights of Britain or Ireland robed in a white mantle of snow.

‡ *On Another Possible Cause of the Glacial Epoch*, 1898. (Now preparing for publication.)

It will be observed that as compared with the British sub-coastal features there is a general resemblance, but with one important exception, namely, the absence of the representation of the "Blake Plateau." We may, without hesitation, recognise our British platform as the equivalent of the Continental shelf; but as I have already shown, this terminates along the margin of one great escarpment descending to depths of 8,000 or 9,000 feet. A solid escarpment of this kind indicates a slow continuous elevation, after the British platform had been planed down by wave action, and subsequent depression after a long lapse of time. On the coast of the American continent, however, there appears to have been an intermediate period representing a pause in the process of elevation and subsequent depression, during which the second shelf, or "Blake Plateau," was elaborated. In all cases, however, it must be remembered that the formation of these escarpments was mainly due to wave action, undermining the cliffs during prolonged pauses in the process of elevation or subsequent depression.

VII. *Geological Age of the Submerged Features.*—The formation of the British platform, like that of the American "Continental Shelf," may be referred back with confidence to the Mio-pliocene period, and that of the grand escarpment to the succeeding early Pleistocene or Glacial stage. This view is in harmony with analogy and what we know of the physical conditions of these periods. The Mio-pliocene stage was one of great terrestrial changes of land and sea over the European and adjoining areas; but the climatic conditions were warm and genial, with a foretaste of more rigorous conditions towards the close. An elevation of 100 to 200 fathoms round our coasts would have been insufficient to have brought on glacial conditions, although undoubtedly tending in that direction in our more mountainous districts; but a further elevation to the extent of several thousand feet would undoubtedly bring about such conditions; and we are, therefore, justified in inferring a close relationship between this latter rise of the land, with the adjoining oceanic bed, and the incoming of those Arctic conditions which resulted in covering, not only our mountain heights with perennial snow and glaciers, but also the adjoining plains.

Having already in my former paper treated the subject of the origin of the Glacial period at some length, it is unnecessary that I should dwell upon it here—or explain how the great rise of the land would necessarily result in bringing

about glacial conditions in the north temperate zone, especially when combined with alterations in the temperature of the Gulf Stream. On these points the reader is referred to my former communication, and I shall only add here, that the conclusions which I ventured to annunciate on the basis of the statements of previous authors have been fully verified by my own study of the Admiralty charts, which I have here communicated to the Institute.*

VIII. *The great rise and fall of the land, by what standard to be measured.*—The question of a rise and subsequent depression of the British and adjoining Continental areas, such as is here postulated—amounting to about 9,000 feet—may well cause not only surprise, but also some doubt in the minds of many; but their hesitation may find some relief from two or three considerations:—

(1) We have unquestionable evidence that late Tertiary strata of marine origin are found in the Alps and other regions at elevations of 10,000 feet, and over, above the sea.

(2) The probability that during the Glacial period large quantities of oceanic water were locked up in the form of snow and ice round the North Pole as supposed by the late Mr. A. Tylor,† and apparently concurred in by Dr. A. Wallace. Mr. Tylor estimated that the amount of water thus locked up would have lowered the surface of the ocean by 2,000 feet. On the other hand, a general lowering of the surface may have been brought about by depressions in the bed of the great oceans as suggested by Professor Suess.‡

(3) In trying to realize such great changes of level we must recollect that as regards the *standard of measurement*, namely, the diameter of the globe, they are really insignificant. Even a rise or fall of the surface, to the extent of 10,000 feet, will only amount to $\frac{1}{4184}$th part of the diameter. We do not postulate a greater rise or fall than about 1,200–

* Professor T. McK. Hughes, in his interesting paper on *The Evidence of Later Movements of Elevation and Depression in the British Isles*, read before the Institute in 1879, postulates a rise of the land to the extent of several thousand feet and infers the climatic changes which would thence result. I hope he will now concur with me that such a rise has actually taken place.—E. H.

† *Trans. Nova Scotia Institute of Natural Science*, 1866.

‡ There are other ways, more or less speculative, by which the alteration of the general level of the ocean may have been brought about, and which the reader will find described in Professor J. Geikie's comprehensive address already referred to. *Loc. cit.*, p. 639.

1,500 fathoms (7,200–9,000 feet), but, as Professor J. Geikie shows in his Bathy-hypsometrical map of the world, there is a total range of 9,488 fathoms, or 56,932 feet, between the highest altitudes of the land and the lowest depths of the ocean.

IX. *General Conclusion.*—From what has been stated above it will be seen that the North Atlantic Ocean down to great depths along the European coast is characterised by physical features similar to those we observe on the land and due largely to similar causes, namely, marine and atmospheric erosion. I hope to be able to produce additional evidence of this conclusion when describing the sub-oceanic features of the Bay of Biscay.

POSTSCRIPT.

Mr. A. J. Jukes-Browne in his *Building of the British Isles*, 2nd Edit., 1892, has very clearly described some of the physical changes which the British Isles have undergone in later Tertiary and Post-Tertiary times, and, as represented in Plate xiii, has given a restoration of the drainage of the British Isles during the Newer Pliocene Period, showing two principal rivers entering the ocean—and draining the regions now occupied by the Irish Sea and English Channel. But it does not appear that he has recognised the channels and cañons, such as "the Hurd Deep," as determinable from a study of the Admiralty charts, nor the great escarpment which it is the special purpose of this paper to elucidate. The chart of the Crag period originally drawn by Mr. R. A. C. Godwin-Austen (*Q.J.G.S.*, vol. xxii, p. 240) was the first attempt to restore the physical geography of the Pliocene period of these isles.

The CHAIRMAN (Commander G. P. HEATH, R.N.).—Professor Hull's very interesting paper is, I am sure, one upon which some would like to make remarks.

Professor R. ETHERIDGE, F.R.S., F.R.S.E., F.G.S., &c.—The important paper by Professor Hull can scarcely be discussed here; indeed, it would be hypercritical to do so. The conclusions in the entire paper are based upon facts selected from the hydrographical maps, published by the Admiralty, giving the soundings over, and westwards of, the British platform or 100-fathom line, ranging from the north-western coasts of Scotland and Ireland to the coast of Western France. Little or nothing had previously been done in the British area west of this 100-fathom or 600-foot line; but Professor Hull has extended observations through the analysis of the deeper soundings outside, or westwards of, the 100-fathom line or submerged terrace, to depths ranging from 250 to 1,500 or 2,000 fathoms. No one has hitherto applied these ocean soundings for the purpose of elucidating the past physical history of the old and now submerged land once extending far to the west, or into the now depths of the Atlantic ranging through the contours of 250, 500, 750, 1,000, to 1,500 fathoms. From the extensive series of soundings along our own coasts, and that of Western Europe, ranging from France to Spain, Professor Hull has selected the old and now depressed estuarine areas of certain rivers, notably those on the west coast of Ireland—the *Erne*, the *Shannon Channel*, the "*Irish Channel river*," the "*English Channel river*," and its once extensive cañon, with sections along or over the "*British Platform*" nearly 300 miles west of Ireland—to illustrate his views upon the great depression of the now submerged land beyond the known 100-fathom level or British platform, to depths varying, and ranging from 1,500, 4,500, 6,000 to 9,000 feet, ending in the abyssal plain of the Atlantic. Professor Hull, in his paper on "Another possible cause of the Glacial Epoch," read before the members of the Victoria Institute, refers to the views and labours of Mr. Warren Upham and Professor Spencer on the reconstruction of the antillian area, applying this to the *submarine* valleys of the western coast of Scotland, Ireland, England, and France to depths varying from 1,000 to 10,000 feet; the map and six sections prepared by Professor Hull most clearly illustrate these important discoveries or additions to our knowledge of this

outer or "grand submerged escarpment" which finally descends to the deeper oceanic or abyssal plain.

The courses of the rivers *Erne*, *Shannon*, and the "*Irish* and *English Channel rivers*" of Dr. Hull, on the south and west of Ireland, and between England and France, to the edge of the 1,500-fathom or 9,000 feet contour, convey to us, through this paper, facts hitherto unexpected. We are now able, through his analysis of the soundings *west* of the 100-fathom plateau, to restore the "drowned valleys" of Western Britain and Europe, and may prolong the deep soundings of the North British coasts across the North Atlantic to meet the line of soundings from North America in the region of 52° N. latitude, which rise northward to the Icelandic ridge north of Rockall.

Professor Hull's interpretation that the submerged, and now submarine, valleys were originally formed or fashioned through atmospheric denudation in the widest sense, prior to their submergence, is fully demonstrated in his paper, and by his accompanying map and sections, they are a clear exposition of the arguments therein adopted. The six bathymetrical sections, as would be expected, demonstrate the depths, or amount of depression shown through the contour lines. The two *cañon valleys* ("the *Irish Channel river*" and the "*English Channel river*" on the Continental platform) reach the outer deep-sea escarpment at the 250 and 270-fathom line, or 1,500 and 1,620 feet deep respectively. The *Shannon channel* descended to the 250-fathom line, or 1,500 feet; that of the river Erne to the 750-fathom, or 1,620 feet contour. We must congratulate Professor Hull on his affording us much new information relative to the hydro-geographical and probably hydro-geological research around the westerly extended submerged land extending from the coasts of North Scotland, Ireland, France, and on to Spain.

Mr. D. Howard, F.C.S., D.L., &c.—Judging from the shallower seas off the mouth of the Thames, and how powerful the silting-up process is there, the wonder is that the cañons should have remained as they are. The instances given in the paper show how rapidly the silting process may take place under favourable circumstances.

Professor J. Logan Lobley, F.G.S.—We must all feel indebted to Professor Hull for this important paper: it is not only a contribution to geological, but to geographical, knowledge.

Its chief value, geologically, is, perhaps, the aid it gives us in

interpreting the phenomena of the Glacial Period; for when we conceive the British Islands lifted 6,000 or 7,000 feet higher than at present, in reference to the present level of the sea, we can easily see how glacial conditions could take place.

I have always been in favour of this explanation of glacial phenomena rather than that given by Dr. Croll. But there may be other forces that have had to do with the production of great alterations of climate. We can easily conceive that a considerable elevation of land will lower the temperature very much below that of the latitudinal climate or region; but the depression of any area of little elevation will not raise the temperature above the latitudinal temperature of the region. We have had evidence brought to us very recently from Franz Josef Land of much warmer climatic conditions having occurred there in the Jurassic Period, for fossils show that the climate of that northern region was then similar to the climate of the British Isles.

In the paper I find it stated that it has been estimated that an amount of water, lowering the surface of the ocean to the extent of 2,000 feet, may have been locked up in the northern regions during the Glacial Period. I am afraid I cannot agree with that. I have estimated that, supposing the whole of the northern part of the globe north of the 50th parallel of latitude were covered with an ice-cap, that ice-cap would have to be 10,000 feet thick to lock up as much water as would lower the surface of the ocean 2,000 feet. I cannot conceive an ice-cap of 10,000 feet thick, for I do not see why ice should not have behaved in the Glacial Period as it is behaving now; and we find now that the ice comes off the coast of Greenland in icebergs constantly, and there is no reason why icebergs should not have come away from the northern land area into the sea and have melted and so restored, to some extent, the level of the sea. Therefore, I must be allowed to differ from that conclusion. It is not Professor Hull's conclusion, but is merely a theory that has been advanced. But generally it seems to be quite borne out that the glacial condition of the British Islands must have been largely dependent on a very considerable elevation of the land; and the way in which Professor Hull has marked out the contours of the surrounding sea bottom brings forward most cogent evidence in favour of that hypothesis.

Rev. F. A. WALKER, D.D., F.L.S.—Looking back, with one's mind's eye to the features of the country as it must have presented

itself when, according to Professor Hull, Iceland, the Faeröe Islands, and the Orkneys constituted one long, narrow chain of land united with the British Isles, one cannot help comparing their present condition to a set of jewels of which the string has got broken.

I suppose it will be conceded that as the fauna are on a small scale as regards number of species in Scotland, more scanty in the Orkneys, fewer still in the Faeröes, and fewest of all in Iceland, the reverse is the case with regard to the altitude of the hills: the highest cliffs in Iceland are up to 3,000 feet, descend sheer down to the deep, and the highest mountains and rocks are just over 6,000 feet in altitude. Then you get several, I should judge, of 1,500 feet in the Faeröes and only one in the Orkneys of 1,556 feet (Ward Hill of Hoy), and that is by far the highest in the whole of that archipelago; and looking back to the period that Professor Hull describes, supposing the north of Iceland to be united by continuous land for a distance of 500 miles with Caithness, would that—the fact of continuous land—tend to produce an increased number of species or a series of fauna in the north? I doubt it; because, when you think of the large intervening distance of land—500 miles—and that insects would have to cross from richer and more varied vegetation and from trees of considerable size, one doubts whether they would do so, or migrate north; and there is another very satisfactory reason, viz.: that lime trees, thistles, nettles, turnips, and cabbages, are either not found at all in Iceland, or they exist in very infinitesimal quantities, and so several of our common species of butterflies would not be found there, or, reaching it, would not survive and multiply. You can have the food plant without the insect, but you cannot have the insect without the food plant. It may be true to some extent that, ever since pre-historic times, the climate has been deteriorating, because there are certain indications that there were more trees in Iceland in the middle ages, from the names of several places commencing with the prefix of *Reydir Sorbus edulis*, the wild crab apple, which the outlaw may often have munched in his wanderings; and so trees of considerable size may have flourished and served for the preservation of various kinds of insects. All along the course of many centuries the climate may have suffered owing to the recurrence of volcanic outbreaks and through the forests having been carelessly fired by the natives. No doubt Iceland has suffered in two or three ways

within the last century. In 1772 Messrs. Olassen and Povelsen noted oats and rye in small portions of the island, and the great outbreak of lava in 1784 destroyed the production of corn there ever since, and now no grain is produced north of the Faeröes because the lava set free the subterranean streams which inundated the meadows. You cannot find butterflies in Iceland because of the want of hollow trees or any shelter; while, on the other hand, certain *Noctuæ* occur in numbers, as the caterpillars of these last go underground to change, and so rest secure from

"The dreadful pother o'er our heads"

of the winter storms and rain.

The CHAIRMAN.—Before conveying your thanks to Professor Hull, I would make one remark about these "deeps" to which he has alluded. It is very curious to observe how portions of the beds of these old channels continue deep, the remainder having entirely silted up. I know of several instances similar to that of the "Hurd Deep." I believe they are to be accounted for by the fact that the tides still continue to flow in the direction of, and in a line with these deeps, as they did originally, thus keeping the channel open. Where the channel has silted up, the direction of the tides has changed, and, running across the old channel, has filled it up. This silting-up process is of course always going on, the rivers bringing their sediment into these shallow seas, which is deposited gradually, as the movement of the water slackens. Most of us probably have noticed the change of colour of the water, as soundings are reached at the entrance to the Channel, which is caused by the quantity of matter held in suspension by the tidal water. Professor Hull has, I am sure, taken great trouble in tracing these old river beds which evidently drained the two channels between Ireland and Scotland, and between England and France. We are much indebted to him, and, if you will allow me, I will convey to him your thanks for his interesting paper. (Cheers.)

The HON. SECRETARY (Captain F. PETRIE, F.G.S.).—The following communication has been received from Professor T. RUPERT JONES, F.R.S.:—

In praiseworthy furtherance of his researches as to the former geographical conditions of what is now the North-Atlantic region, Dr. E. Hull, applying the methods adopted by Dr. Spencer and other American observers, is led by careful consideration of the Admiralty charts, and with accurate reasoning on the relative depths

of the water as indicated by the soundings, to map out the margins of the British area before it became divided up into the existing islands. The conclusions arrived at are not only interesting, but add much to our knowledge of geographical evolution, as brought about by natural causes during immense periods of time.

The 100-fathom line, running parallel with the present coasts, has been the chief datum which former observers have taken for their hydro-geographic workings; but, as he points out, that line is not everywhere coincident with the margin of the old plateau from which our islands now rise; for, especially in one tract west of Ireland, this "British Platform," as it is called, extends further out for 280 miles; and, again, to the north and north-west it forms part of the great Icelandic plateau, stretching to Greenland and North America.

Between the Hebrides and Rockall a deep gulf (of 2,000 fathoms) extends northward to about 50° N. latitude, opening out southward, at about 55° N. latitude, into the open ocean. The cliffs must have been successive steps of enormous escarpments, of rapid descent, except at the head of the gulf just mentioned, and of a smaller gulf cutting into the "British Platform" south-west of Ireland. The old Shannon entered the head of this bay, and the "Porcupine Bank" was the most elevated part of that portion of the platform which was cut off by the western gulf.

The river which brought the Seine and other streams down the valley, since changed into the English Channel, had deep cañons in its course (indicated by deeper local soundings); and, like the old Irish-Channel river and the Erne, higher up on the Irish coast, must have fallen into the sea with grand waterfalls, if seen from the ocean. The Shannon, however, opening into the shallow head waters of the above-mentioned bay south-east of the "Porcupine Bank," emptied itself less precipitately.

The distribution of animals and plants supports the conclusions arrived at by the author, as well as the relative periods at which the fauna and flora were distributed, and afterwards interfered with by the elevation of the land to the height of 7,000 feet. This change of level, as indicated in the author's former memoir, lately read before this Institute, brought about the greatest intensity of cold in the so-called Glacial Period. This has, fortunately for us, been modified, chiefly by the subsidence of the land to its present height.

The features of the ancient coast-line of this region are compared with those of the North American area, as defined by Dr. Spencer and others.

Reference is made to observations by others on the possible down-sinking of ocean-waters and the uprising of lands; and the author reminds us that we need not be surprised at the great movements in Pliocene times, for the present difference between the highest land and the lowest sea-bed is not quite 60,000 feet,

and a rise or fall of 10,000 feet would amount to only $\frac{1}{4184}$th part of the earth's diameter.

The CHAIRMAN.—I will now ask Professor Hull to reply to the remarks made upon his paper.

The AUTHOR.—I need not say that I am exceedingly gratified at the manner in which this communication has been received, and particularly by the comments thereon of Prof. Etheridge; from his position as one of the most eminent geologists in the British Isles, or, perhaps, the world, and as former President of the Geological Society, observations from him must have considerable weight, and what he has stated satisfies me that I have not pursued a mare's nest—in fact, I am indebted to him for having extended my observations to the Bay of Biscay. I had, incidentally, a conversation with him some time ago upon the subject, and he then expressed his desire that I should carry on my observations to the Bay of Biscay, and they proved so exceedingly interesting that I feel grateful to him for the suggestion he then made. I wish also to add my sense of the value of Professor Rupert Jones' letter, showing how clearly he has comprehended the sub-oceanic conditions considered in my paper.

Mr. Howard has introduced a very interesting point about the silting up of rivers, which of course is quite confirmed. I am also gratified by Professor Logan Lobley's statement and concurrence in my conclusions. As he has said, the statement in my paper as to the locking up of the ocean waters by permanent ice in the Glacial Period, as accounting for the lowering of the surface of the ocean, requires to be taken with a very large grain of salt. It is not my own.

Dr. Walker has given us some additional views about Iceland, and I agree with him that the further north we go from the European area the more likely is it that the fauna and flora would decrease in number and variety.

I must say that Dr. Walker's observations on Iceland,* published some years ago in the *Transactions* of this Institute, form one of the most valuable papers I have ever read; and it will well repay the perusal of any member of the Institute interested in the subject.

I am obliged to the Chairman for his suggestions as to the

* "The Botany and Entomology of Iceland," *Journal of Transactions*, vol. xxiv.

deposits in the "Hurd Deep." It is true the "Hurd Deep" does lie in the line of the current, and therefore, on the ground he states, it would be protected against the deposition of the mud. We all know the tremendous tidal currents that rush up and down this channel, that rise and fall something like 60 feet, I think, on the coast of France, and the rush of waters on the banks is tremendous and a great danger to navigation. Therefore, when there is such a rush of water along the channel of this "Hurd Deep," lying as it does in the line of the tidal stream, it is natural that the sediment should not have had opportunity to subside and thus fill up the old river channel.

The meeting was then adjourned.

COMMUNICATIONS RECEIVED IN REGARD TO THE PRECEDING PAPER.

The Cavaliere W. P. Jervis, director of the Royal Industrial Museum of Turin, writes July 13, 1898:—I have been familiar with the whole of the European bathometrical observations for twelve years and have often spoken of them, but I never understood the enigma until Professor Hull threw light on the matter, and now I feel the importance of those facts which I had all along looked upon as a mere curiosity.

[Cavaliere Jervis has contributed some matter towards a further consideration of the subject, and a communication has also been received from a valued member, Mr. H. P. Malet, who dissents from Professor Hull's view. These communications can only be adequately dealt with later on.]