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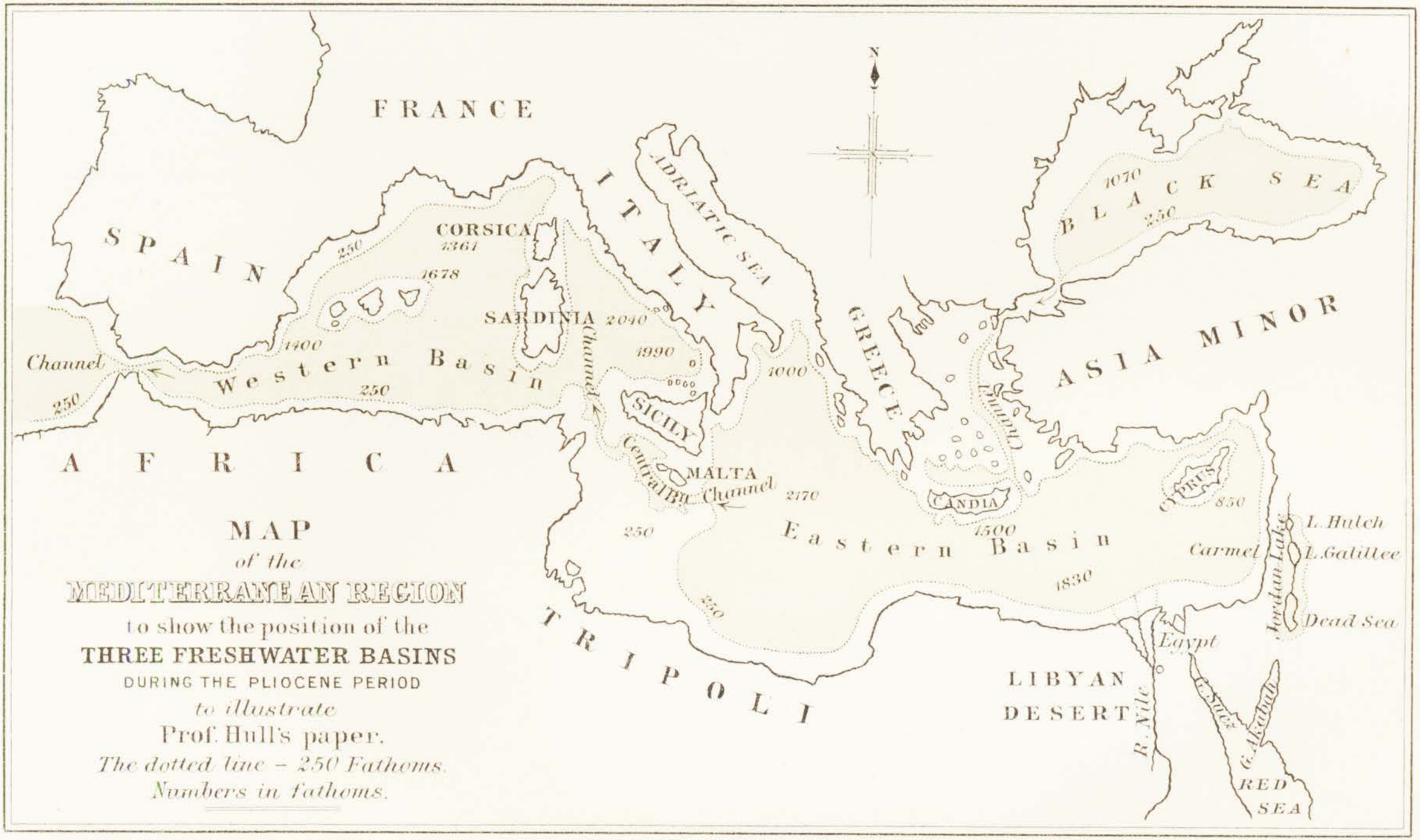

MAP

of the

MEDITERRANEAN REGION

to show the position of the

THREE FRESHWATER BASINS

DURING THE PLIOCENE PERIOD

to illustrate

Prof. Hull's paper.

The dotted line – 250 Fathoms.

Numbers in fathoms.

ORDINARY MEETING.*

SURGEON-GENERAL SIR C. A. GORDON, K.C.B., Q.H.P., IN THE CHAIR.

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

MEMBERS :—Rev. P. Prescott, M.A., Oxon, Middlesex ; Rev. B. N. Switzer, M.A., Middlesex.

ASSOCIATES :—M. V. Portman, Esq., Andaman Islands ; Mrs. A. Du Sautoy, Middlesex.

The following paper was read by the author :—

ON THE PHYSICAL CONDITIONS OF THE MEDITERRANEAN BASIN, WHICH HAVE GIVEN RISE TO A COMMUNITY OF SOME SPECIES OF FRESH-WATER FISHES IN THE NILE AND THE JORDAN BASINS. By EDWARD HULL, M.A., LL.D., F.R.S., F.G.S. (With Map.)

SOME years ago I brought before one of the sections of the British Association, a paper in which I endeavoured to account for the origin of the peculiar forms of some of the fishes of the Lake of Tiberias which have been recognised by Lortet, Tristram, and others.† I suggested that these special forms were the modified descendants of those which had inhabited it at the time, namely, the Eocene, when the whole region was occupied by the waters of the ocean, and that upon the elevation of the land of Western Palestine, and the formation of the Jordanic depression during the Miocene and Pliocene periods, these ancestral forms were imprisoned within the waters of the inland lake thus formed. It

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* 11th of 30th Session. Paper as finally passed for press.

† *On the origin of the fishes of the Sea of Galilee*, Rep. Brit. Assoc., 1885, p. 1066.

appeared to me conceivable, that the Eocene fishes of oceanic habitat may have undergone modification in their characters during the gradual freshening of the Jordanic waters.

But the problem we have here to deal with is somewhat different from that above stated. Besides the special and peculiar forms above referred to, it has been shown that some of the fishes and other forms (such as the crocodile) of the Jordan basin are identical with those now living in the Nile and other African streams entering the Mediterranean.* It is needless to observe that these freshwater forms are now absolutely isolated from each other, by the intervention of the salt waters of the Mediterranean, as well as by the land barrier of Western Palestine. Yet so considerable is the number of species common to the African and Asiatic fresh waters, that it can scarcely be questioned that they had a common origin, and that the waters they inhabit were once physically connected.

In the words of Dr. Lortet, the crocodile has migrated along with the papyrus from the Nile to the Zerka, and the lake of Huleh is full of the African *Chromis*.†

If this be admitted, it becomes a very interesting problem how, and at what geological period, this intercommunication took place. It is a problem which has long been before my own mind, and to which I have given much thought; but it is only recently that I have begun to see my way towards its solution on grounds which can be substantiated step by step.

The following table shows the distribution of the Palestine Forms as gathered from the works of Lortet and Tristram:—

	Total (Species).	Palæarctic.	North African and Nile.	Indian.	Peculiar.
Reptilia, Chelonia and Amphibia.	91	49	27	4	11
Pisces (Freshwater).	49	8	8	7	26

* L. Lortet, *Poissons et Reptiles du Lac de Tiberiade*, Archives du Musée d'Histoire Naturelle de Lyon, t. III (1883). Tristram, *Fauna and Flora of Palestine*, Mem. Palest. Explor. Fund (1884).

† *Loc. cit.*, p. 122.

The Crocodile (*Crocodilus vulgaris*, Cuv.) and fishes of the genera *Chromis* and *Hemichromis*, which occur in such numbers in the waters of the Jordan basin, are the forms which especially establish the former connection of the waters of the Jordan and the Nile; but there are also other forms of fishes which, according to Lortet, are common to the Palestine or Syrian streams and those of Tripoli in Northern Africa. The common specific forms are as follows:—

Blennius vulgaris. Pollini. Nahr el Bared and Tripoli.
Mugil curtis. Yarrel. Nahr el Kadisha, Nahr el Bared, and Tripoli.
Mugil octoradiatus. Günther. Nahr el Bahsas and Tripoli.
Mugil capito. Cuv. Nahr el Kelb, Nile and Mediterranean *embouchures.*
Chromis Niloticus. Hasselquist. Jordan, L. of Huleh, and Nile.
Hemichromis sacra. Günther. Sea of Galilee. (Allied to Nile species.)
Clarias macracanthus. Günther. Sea of Galilee and Upper Nile.

I have now to lay before the Institute the view according to which the waters of the Jordan basin were formerly connected with those of the Nile by way of the Mediterranean; and in the attempt to work out the problem we shall have to follow as briefly as possible the course of the physical changes which the Mediterranean basin has undergone during Tertiary times. The problem is intimately connected with the history of this great inland sea itself.

Condition of the Mediterranean area at the commencement of the Tertiary period.—It is generally admitted that up to the close of the Cretaceous epoch the Mediterranean Sea and the adjoining land areas formed a portion of the great ocean in which were deposited chiefly limestones characterised by *Hippurites.* It is unnecessary that I should attempt to define the limits of this vast oceanic region, which extended over large portions of the three continents.

At the close of the Cretaceous epoch certain movements of the crust occurred, chiefly of an elevatory character, which resulted in the destruction of nearly all the forms which had inhabited the Cretaceous waters, and converted certain areas into either land-surfaces, or into tracts of very shallow water. But in the Eocene epoch subsidence again became general,

and the inflowing oceanic waters brought with them new specific and generic forms, of which the most remarkable were the Nummulite foraminifera. Throughout the region of Northern Africa and Western Asia, there does not appear to have been much flexuring, or denudation, of the Cretaceous strata previous to the overspread of the Eocene waters; so that the junction of the two formations bears the character rather of a *hiatus* than that of unconformity of stratification.

The Miocene period.—We have now arrived at an epoch which by universal consent is recognised as one of great terrestrial changes in the region here described. To the close of the Eocene period we may refer not only the uprise of the Alps, Pyrenees, Carpathians, and other ranges having E. and W. axes, such as the Atlas in Africa, but also the great subsidence along the line of the Mediterranean basin. Large portions of Africa and Western Asia became dry land for the first time, and the chief physical features of the Palestine area may be considered to have received their incipient outlines. To this epoch may also be referred the Jordan-Arabah depression along the line of the great fault, or system of faults; and the formation by upheaval on the one hand, and depression on the other of the Gulfs of Akabah, of Suez, and the Red Sea. However, depression of a local kind again ensued, for marine strata of Miocene age are found in detached areas over parts of Northern Africa and the Libyan Desert, as Zittel has shown,* as also in the Isle of Cyprus,† along the shores of Asia Minor,‡ in Italy and Sicily, Candia, the South of France, Algeria, and other tracts; while the whole of the island of Malta is formed of strata referable to this (Miocene) period.§ It is therefore probable that this central part of the Mediterranean area remained submerged during the period of post-Eocene movements.

We are now approaching the critical point of our inquiry, but the preceding statements seem necessary in order to lead up to it.

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* Zittel, *Ueber den Geologischen Bau der Libyschen Wuste.* Munchen, 1880.

† Spratt, *Quart. Journ. Geol. Soc.*, vol. xxiii, p. 283. Gaudry, *Géologie de l'isle de Chypre*, Mem. de la Soc. Géol. de France (1862). Unger and Kotschy, *Die Insil Cypern.* Wien, 1865.

‡ De Tchihatcheff, *Sur les depôts de l'Asie Mineure*, Bull. de la Soc. Géol. de France, 2 ser. 1850.

§ Spratt, *supra cit.*, p. 295; Prestwich, *Geology*, vol. ii, p. 409. 1888.

Post-Miocene stage.—This epoch is characterised as is well known by movements of the crust of extraordinary intensity. In the Alps, as abundantly illustrated by Professors Heim, Schardt, C. Schmidt, and Baltzer,* we have exhibitions of prodigious movements of the crust resulting in flexures, inversions, and lateral displacements or overthrusts, seldom reached and never exceeded in magnitude. These Alpine movements had their counterparts in the Mediterranean area but in greatly diminished intensity. The general effect was to elevate large areas into dry land, and to cause adjoining tracts to undergo subsidence. This we may infer was the epoch when the Mediterranean was converted into three distinct basins separated by intervening land-ridges, or causeways, by which Europe was united to Africa, and by which, according to Dr. Alfred Wallace, in later Pliocene times the land animals of the former migrated across into the African continent. The islands of Sicily and Malta afford the clearest evidence of such a connection; and although the evidence has been fully discussed by the late Admiral Spratt, and Dr. Leith Adams, I will venture briefly to recapitulate it here.†

Ossiferous Caves of Malta and Sicily.

The evidence to which I refer is derived from the occurrence of numerous remains of elephants, hippopotami and other forms in the caves of Malta, and in those of the north of Sicily. Two species of *hippopotami* have been described from the Malta caves by Leith Adams and Spratt, a larger and smaller, as also two species of elephant (*Elephas antiquus* and *E. Melitensis*). They appear to have inhabited the district in enormous numbers, remains of several hundred distinct individuals having been collected by Adams alone.‡ In the Sicilian district these inhabitants were not less abundant. From the Grotto di Maccagnone near Palermo, Dr. Falconer collected large quantities of bones of elephants and hippopotami, amongst which were two species of the

* See sections and descriptions in the *Livret-Guide Géologique dans Le Jura et Les Alpes de la Suisse.* Lausanne, 1894.

† Adams, *Notes of a Naturalist in the Nile Valley and Malta.* Edin., 1870; also, *On the dentition of the Maltese fossil Elephants. Trans. Zool. Soc.*, Lond., vol. ix, 1873.

‡ Dr. Leith Adams considers these two varieties of pachyderms lived together; on the other hand Admiral Spratt believes they inhabited the region at successive intervals of time.

latter, *H. antiquus* and *H. Pentlandi*, together with remains of *bos*, *cervus*, *ursus*, *canis* and a large species of *Felis* (*F. spelæa?*). Similar remains were also obtained from another cave near San Ciro.* In his excavations Falconer was assisted by Baron Auca di Mangalaviti, who subsequently recovered from another cave overlooking the Bay of Palermo a large number of bones of carnivores.† These caves are hollowed out of Cretaceous limestone at levels of 200 to 250 feet above the present surface of the Mediterranean, and a little above the upper limit of the Pliocene strata which descend from the cliffs to the water edge. Miocene strata do not appear to be present on this northern coast of Sicily, but the ossiferous caves of Malta, being hollowed out in Miocene strata, show that the caves in that island are of post-Miocene, or early Pliocene age, and we may fairly infer this to be the date of the caves on the Sicilian coast, containing similar remains.

The conclusion arrived at both by Leith Adams and Spratt with regard to the conditions under which these large animals lived and multiplied is identical, and is one which can scarcely be gainsaid. They consider that there was a general upheaval of this part of the Mediterranean basin at, or towards, the close of the Miocene period, by which Europe was joined to Africa, those portions of the bed of the sea surrounding Sicily and Malta having been at this epoch in the condition of dry land: the extent of the upheaval between Sicily and Tunis would be 250 fathoms (1500 feet) as compared with the level of the present sea-bed.‡

Three Mediterranean Basins.—We may assume with these authors, supported by Dr. A. Wallace and Sir A. C. Ramsay, that the great uprise at the close of the Miocene period resulted in the conversion of the Mediterranean area into three distinct basins, connected with each other by channels through which the waters passed from one to the other and ultimately into the Atlantic. One of these channels through the "Medina Bank" has been identified by Admiral Spratt, and is clearly indicated in his map as connecting the central

* Spratt, *Quart. Journ. Geol. Soc.*, vol. xxiii, pp. 288, 291.

† "Une prodigieuse quantité d'os des Carnivores," accompanied by stone weapons, quoted by Dr. Falconer, *Quart. Journ. Geol. Soc.*, vol. xvi, p. 106. Coprolites of hyæna were exceedingly abundant in some of these caves.

‡ Ramsay, *Europe. Compendium of Geography and Travel*, Stanford, p. 8, 1885.

with the eastern basin; the other connecting with the western basin was discovered by Admiral Smyth.*

This chain of inland lakes was supplied not only by the streams directly entering from Europe on the north, and from Africa on the south by the Nile, but with the central Asian drainage, so that there was a continuous flow from the Caspian, through the Black Sea, the Dardanelles, the Sea of Marmora into the Mediterranean lakes. Ramsay infers that the waters of this great chain of lakes emptied themselves into the Atlantic, but he is in doubt whether the waters were salter or fresher than they are now; and he adds, "that they were not fresh we may be certain;" though he modifies the statement by saying that "it may be, that like the Black Sea now, these inland Mediterranean lakes were gradually freshening."†

It is at this point, which is of the highest importance in our present inquiry, that the evidence to be gathered from the abundance of hippopotami and freshwater turtles comes to our aid.‡ Doubtless at the commencement of the elevatory period the waters of the whole area were salt; but the ultimate effect of the establishment of the conditions above described must, as it seems to the author, have resulted in the formation of freshwater basins; and it was only in waters of this kind that (judging by the present habits of the animal) hippopotami could have lived and multiplied.

In the first place the evaporating area was greatly contracted as compared with that of the present day. We cannot say exactly to what extent as compared with the present surface of the Mediterranean and its offshoots, but we shall probably not greatly err in considering the evaporating surface to have been about two-thirds that of the present day. (See Map.) In order to establish land communication between Sicily and Tunis an elevation of the sea-bed to the extent of 250 fathoms would be necessary; but the chain of lakes connected by river channels as indicated by Spratt would be established by a rise of 200 fathoms. Such a

* Spratt, *loc. cit.*, p. 292.

† *Ibid.*, p. 8, the depth of the shallowest portion of the Straits of Gibraltar is a little over 400 fathoms, so that the rise of the bed of the Mediterranean Sea by 250 fathoms would allow of a channel 150 fathoms deep to carry the waters into the ocean.

‡ We might also add elephants, as the large herds of these animals which, with the hippopotami, must have occupied the Maltese region, would have required a considerable extent of fresh water for their enjoyment.

physical change over the central and eastern area of the Mediterranean would (as will be seen by the accompanying map) reduce the evaporating area very largely, and would extend the present land surfaces proportionately. At the present day the Mediterranean waters are a little salter than those of the ocean, owing to the constant inflow of these latter, produced by excess of the evaporation over supply from rivers over the Mediterranean basin; but under the conditions here indicated the process would be reversed, as the supply would exceed the loss from evaporation, with the result that the waters would become fresher, and the flow would be outwards into the ocean.

Such was presumably the land and sea distribution during one of the phases of change of the post-Miocene or Pliocene period. The land communication between Europe and Africa at Gibraltar and Sicily may have been complete at one time and broken in another. But it is unnecessary to investigate these changes further than to assure ourselves that they are consistent with the conclusion that a chain of freshwater lakes was established into which flowed the waters of North Africa from the south and those of Europe and Asia Minor from the north.* If this be so, then we have a sufficient explanation of the community of some of the species of freshwater fishes inhabiting these rivers, such as those of Tripoli and Syria at the present day, and now separated by a barrier of highly saline waters. But we have still to account for this community as it occurs in relation to the waters of the Jordan Valley.

The Jordan Valley Lake.—On a former occasion I have shown that there is clear evidence that the whole valley of the Jordan, from the Lake of Huleh on the north to the Arabah on the south, was the bed of a lake over 200 miles in length, and 1,300 feet (or more) above the present surface of the Dead Sea.† A few feet higher would have caused the waters of this lake to surmount the rim of the basin (as it is at present) and to have escaped by the bed of the Kishon, or some antecedent stream, into the Eastern Mediterranean basin, through the plain of Esdraelon. In this way a connection may have been established between the waters of

* The Straits of Gibraltar by which the waters of the freshwater lakes entered the ocean have a depth of 400 fathoms. This would allow abundant passage for the waters even with a shallowing of 250 fathoms.

† *Phys. Geol. and Geog. of Arabia, Petræa, and Palestine*, Mem. Palestine Exploration Fund, pp. 99, 111, and 113. 1885.

the Jordan-Arabah basin and those of the Mediterranean, and the fauna would have had a means of spreading itself throughout the whole system of waterways.

There is of course a little uncertainty as to the exact time when the waters of the Jordanic basin reached their highest level. In the memoir above referred to I have assumed that this took place during the Pluvial Period, which may be regarded as including the Glacial Epoch, but the filling up of the Jordan valley with water may have commenced at an earlier stage, namely, the Pliocene, concurrent with the general elevation of the Mediterranean area, when the rainfall must necessarily have been augmented and the decreased temperature would have resulted in diminished evaporation. It may be desirable that I should give some description of the Plain of Esdraelon, through which it seems probable that the physical connection of the outer and inner waters was carried out.

The Plain of Esdraelon.—When we examine an orographical map of Palestine, we observe that the central table-land extending from the Sinaitic Peninsula by Hebron, Bethlehem, Jerusalem and Nablus (Sichem) breaks down along the northern base of Carmel, which rises above the southern shore of the Bay of Acre (Haifa) on the Mediterranean coast. From this bay stretches the rich plain of Esdraelon, composed of deep alluvial material,* and it gradually ascends inland towards the margin of the Jordan depression till it reaches a level of about 150 or 160 feet above the Mediterranean.† It is drained by the Kishon, which flows westward into the Mediterranean; but at least two streams rising along the summit-level, namely, the Nahr el Birreh and the Nahr el Jalud, flow in the opposite direction into the Jordan. The sources of these respective streams are not far from each other, and were the Jordan basin filled up to the brim, as we have reason to believe was the case in late Tertiary times, it might well have become a tributary of the Mediterranean through a primeval Kishon. Through such a channel we may infer the Nilonic fishes, crocodiles and other forms may have found their way into the Jordan basin, connected as the two river systems were by the great freshwater lake which occupied the Levantine basin of the Mediterranean.

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* The railroad to Damascus now in course of construction passes over this plain.

† As I am informed by Mr. G. Armstrong of the Palestine Survey.

Such were the conditions under which a community of freshwater faunas amongst the tributaries of the Mediterranean seems to have been brought about; at least, such is the view which I venture to submit to the Institute; and having thus brought my proposed task to a conclusion, I might leave the matter as it stands, but I may be permitted before I conclude to refer briefly to the subsequent changes which the region of the Mediterranean area underwent after the post-Miocene epoch.*

Pliocene submergence.—Amongst the numerous changes which this region has undergone, none are better established than the submergence to a limited extent in the later Pliocene times. With this submergence the waters of the Atlantic flowed into the Mediterranean basin in one direction and those of the Red Sea in the other, and permanently established marine conditions. The upper limit of this depression is marked throughout Egypt, Palestine and Syria, Cyprus,† Sicily, and the bordering tracts of the Mediterranean by beaches of sand, gravel and marls with sea-shells, rising from 150 to 300 feet above the present surface of the waters. To this stage belong the raised beaches of Jebel Mokattam at a level of 220 behind Cairo, and the border districts of Philistia and the coast of the Lebanon.‡ Whether the salt waters of the Mediterranean at this period entered the Jordanic valley by the Esdraelon plain cannot be determined, but it may be supposed that they were to a great extent excluded owing to the higher level of the Jordanic waters themselves. In any case, the narrow channel of connection, if such existed, appears to have been insufficient to destroy the fishes of the great lake, which was over 200 miles in length, 40 in breadth, and about 2,500 feet in depth.

This late Pliocene submergence, extending into the Pleistocene epoch, was followed by a final upraising of the sea-bed, and the establishment of the existing conditions of land and sea over the region bordering the Levant. There are few regions on the surface of the globe in which the oscillations of the land can be so clearly followed as in that which is the subject of this paper.

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* During the period of elevation we have been discussing we may suppose that the Nile waters eroded their channel down to the solid limestone floor, which at varying depths underlies the modern alluvial deposits.

† Albert Gaudry, *Géologie de l'île de Chypre.* Wien, 1865.

‡ Sir J. W. Dawson, *Modern Science in Bible Lands*, pp. 448, 456. 1888.

The CHAIRMAN (Sir C. GORDON, K.C.B.) conveyed a vote of thanks to the author for his paper, and the Chair was then taken by

Dr. T. CHAPLIN, who remarked on the value of Dr. Hull's paper. He referred to the "Crocodile River" in the Holy Land, the existence of crocodiles in which had been drawn attention to by "Rob Roy" MacGregor, and a stuffed crocodile was now in the rooms of the "Palestine Exploration Fund" which had been found and killed on that river bank in 1893. He added that the Egyptians were alleged, with what truth he could not say, to have brought crocodiles to that river, and it was curious, in connection with St. George, the patron saint of England, that he was said to have slain the dragon in this locality. Crocodiles now were only heard of west of the central chain of hills in Palestine.

General A. B. TULLOCH, C.B., C.M.G., spoke of having caught trout in Morocco which Dr. Buckland had recognised as "true trout."

Other speakers referred to considerable terrestrial changes having taken place in North Africa, also a tradition of the sea having covered the Sahara Desert, the truth of which was shown by the presence of sea-shells there. It was stated that the late Rev. J. G. Wood had spoken of fish being gradually accustomed to change from living in salt to living in fresh water, and *vice versâ;* and Mr. F. W. Kirby spoke of being under the impression that a chain of lakes may have extended from the Mediterranean to the Arctic Ocean.

The AUTHOR—referring to Mr. Kirby's remark—said that no doubt there had been, so far as one could judge, a considerable elevation of land in Central Asia; as to the crocodile, Dr. Lortet, in the passage he had quoted, said "the crocodile has migrated along with the papyrus from the Nile to the Zerka, and the lake of Huleh is full of the African *Chromi*." The author concluded by thanking Dr. Chaplin for occupying the Chair, adding, "most of us are aware that he has spent some twenty years in the Holy Land, in doing valuable medical and religious work amongst the inhabitants, and it is a gratification to see that he is able to return, after that long period of arduous work, in that health and strength which we hope may long be accorded to him."

The Meeting was then adjourned.

COMMUNICATION.

Among the communications received since the subject was first brought forward :—

Dr. R. T. SCHARFF, curator of the Natural History Department of the Science and Art Museum in Dublin, writes :—

Dr. Hull's connection of Greece with Asia Minor agrees exactly with my own views derived from the distribution of the mollusca, etc., but I think for part of the Pleistocene period, Sicily and Tunis and Spain and Africa must have been connected.