THE TRANSACTIONS

OF

The Victoria Institute,

OR

Philosophical Society of Great Britain.

EDITED BY THE HONORARY SECRETARY,
CAPTAIN FRANCIS W. H. PETRIE, F.G.S., &c.

VOL. XXIV.

LONDON:
(Published by the Institute).
INDIA: W. THACKER & Co. UNITED STATES: G. T. PUTNAM'S SONS, *N.Y.*
AUSTRALIA AND NEW ZEALAND: G. ROBERTSON & Co., LIM.
CANADA: DAWSON BROS., *Montreal.*
S. AFRICA: JUTA & Co., *Cape Town.*
PARIS: GALIGNANI.
1890.

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The following Paper was then read by the Author:—

SKETCH OF THE GEOLOGICAL HISTORY OF EGYPT AND THE NILE VALLEY. By Professor EDWARD HULL, LL.D., F.R.S., F.G.S.

PART I.—INTRODUCTORY.

YOUR respected Hon. Secretary has suggested to me that a sketch of the Geological or Physical History of Egypt might be acceptable to the members of the Institution, and I have great pleasure in complying with his suggestion. The paper may be considered as supplementary to those I have already contributed on Sinai and Palestine, giving the results of the expedition sent out in 1883 by the Committee of the Palestine Exploration Fund.*

Within recent years, much has been done towards the elucidation of the physical history of this remarkable country. It is scarcely necessary that I should even refer to what was done before geology became a branch of exact science; but, amongst recent researches, special mention should be made of those of the late Mr. Leonard Horner,† of Sir J.

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* *Journal Victoria Institute*, vol. xxi, p. 11.

† *Phil. Trans. R.S.* (1885), vol. 145, p. 105, and more fully elaborated in his work *Modern Science in Bible Lands* (1888).

W. Dawson,* Oscar Fraas, in his work entitled *Aus dem Orient*, of Carl A. Zittel,† whose elaborate work is the most important essay on the subject which has hitherto appeared; and numerous reports by Dr. Schweinfurth, who has for a series of years been carrying on geological investigations in Egypt and adjoining countries under the auspices of the Berlin Geological Society. In connection with the geological structure of Sinai and Palestine, that of Egypt necessarily calls for some observations, as the physical history of all the region bordering the Levant is very much the same. Geologically speaking, those countries extending from Asia Minor and the Lebanon through Palestine and into Egypt are all of very recent age, and came into existence as land areas, reclaimed from the ocean in Middle Tertiary times.

But before entering on such details, a rapid survey of the physical features of Egypt and bordering countries may be considered desirable.

PART II.—GENERAL STRUCTURE OF UPPER AND LOWER EGYPT.

The physical divisions of Egypt are somewhat different from those of Ptolemy, wherein we have Lower, Middle, and Upper Egypt in succession from north to south, or from the Mediterranean coast to, and beyond, the First Cataract. Physically and geologically, the most convenient plan of territorial arrangement is to assume a ternary division in a somewhat different direction, as follows:—

1st, The Delta (or Lower Egypt) and Nile Valley; 2nd, the Libyan Desert, lying to the west of the Nile Valley above Cairo; and 3rd, the region between the Nile Valley and the Red Sea and Gulf of Suez, called in some of our maps by the rather misleading name of the "Arabian Desert," a name more properly applicable to the region east of the Red Sea and the Gulf.

A very brief description of these three regions is all that is here necessary.

1. The Delta‡ is the smallest, but, economically, the most important, of the three divisions, extending from the open-

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* "Notes on the Geology of the Nile Valley and of Egypt," *Geol. Mag.*, Nos. 241, 242, 243, 244; and *Egypt and Syria* (1883).

† *Ueber den Geol. Bau der Libyschen Wüste* (München, 1880).

‡ See Plate, also Dr. Porter's description of this region, *Journal*, vol. xx, p. 15.

ing of the Nile Valley at Cairo to the shores of the Mediterranean, and from the plateau of the Libyan Desert on the West to the Isthmus of Suez on the East. This western margin of the Delta is formed of horizontal beds of Nummulite limestone, which break off in an escarpment, rising from 200 to 250 feet, above the surface of the Delta, and thus producing a commanding site for the Pyramids, the Sphinx, and other structures of ancient Egyptian art.

The range of hills forming the margin of the Badiet et Tîh, or Desert of the Wanderings, east of the Isthmus of Suez, is formed of similar limestone strata, and these are again met with along the range of hills, extending from Jebel Mokattam, near Cairo, to Jebel Attaka, which rises above the Gulf of Suez in a terraced escarpment of limestone rock, strikingly imposing when viewed from the waters of the gulf.

The general structure, therefore, of the tracts bordering the Delta to the south, east, and west leads us to infer that the region of Lower Egypt has been formed by the denudation or erosion of the limestone strata, which once extended over its whole surface, almost horizontally (Fig. 3). The eroded portion has been subsequently to some extent filled in by sediment brought down by the Nile, and annually distributed during flood-time over its surface, so that it consists of a vast plain of alluvial land with scarcely any natural elevations except the sandhills near the coast. These sandhills rest upon a reef which forms a powerful dam against the encroachments of the Mediterranean, and which Russegger describes as being in a constant state of formation and waste. It consists of a calcareous stone of a dull grey colour, composed of sand mixed with worn fragments of marine shells, sometimes minute or microscopic. A few of these are of land or fresh-water origin, brought down by the Nile and thrown up by the sea and mingled with marine shells.*

2. *The Libyan Desert.*—This second natural division consists of a vast slightly elevated plain composed of limestone, which breaks off in an escarpment ranging along the western margin of the Nile Valley and the plain of Lower Egypt, to the shore of the Mediterranean near Alexandria.

The average level of this plateau may be taken at 1,000 feet; but towards the south, in the latitude of Siut, the limestone plateau gradually rises to levels of about 1,500 feet, and below the First Cataract breaks off in lofty rocky escarp-

* *Reisin in Europa, Asien und Africa*, Stuttgart, 1843.

ments, along the Nile Valley and the northern boundaries of the Oases of Chargeh and Dachel.

From the Oasis of Siuah, in lat. 29° 10′ N., a well-pronounced escarpment trends in a N.N.W. direction for a distance of 200 miles, as far as Moghara, then bends sharply round to the north-west, and stretches away towards the coast of the Mediterranean, where it terminates in Ras el Kanais. The elevated table-land thus enclosed is represented by Zittel as formed of marine strata, consisting of limestones, marls, and shales of Miocene age.* To the south of the Oasis of Siuah at the "Echo-Thal," lacustrine beds set in, overlying those of marine age, and apparently extending under the vast tract of sand dunes which continues southwards for several hundred miles. Zittel arranges the Libyan Desert under three forms: (1) The plateau desert tracts, formed of hard stony ground, destitute of vegetation, and covered by blocks and fragments of limestone, due to the decomposition of the rock; the process of decomposition being accelerated by the changes in temperature from day to night, which cause the stone to crack and disintegrate in all directions. (2) The hollows (Daga) in the horizontal beds of limestone, containing small lakes or salt marshes, and bounded by mural terraces and escarpments. Of these, the most remarkable is the Birket-el-Querûn (or Lake of the Horn), lying in the depression of the Fajûm (Fayûm) at a distance of about 20 miles to the west of the Nile above Cairo.† It is about 30 miles in length from west to east, bounded on the north by a terraced escarpment of limestone cliffs, and its surface, according to Mr. Cope Whitehouse, about 150 below the level of the Mediterranean.‡ Inside this basin are recent terraces composed of estuarine materials. The lake is fed by the Bahr Jussuf (or Joseph's Canal), which takes its supply from the Ibrahmic Canal, fed by the Nile not far from Assiut, and serves to both irrigate and

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* First described by Ehrenberg in 1820, see further on, p. 13.

† Schweinfurth, "Karte des Depressionsgebetes in Umkreise des Fajûm," *Zeitschrift d. Gesells. f. Erdkunde*, Berlin, 1882. See also Cope Whitehouse, *The Bahr Jusuf*, London, 1886.

‡ Schweinfurth makes the surface 40·071 mètres; Mr. Cope Whitehouse makes it 150 feet below the level of the sea, and the Rayân depression still deeper, viz., 200 feet below. At the meeting of the British Association at Leeds a paper was read by Mr. C. Whitehouse on the great works of irrigation and water supply being carried out by utilising this great natural depression as a reservoir for the Nile waters when in flood.

drain the western side of the Nile Valley for a distance of 150 miles, as well as to irrigate the Rayân and Fajûm basins. Other hollows and oases are those of the Sittrah Sea, Uttiah, Aradj, and Siuah, some parts of which are lower than the Mediterranean. The origin of these remarkable depressions is somewhat difficult to explain. They are, it must be recollected, hollowed out of limestone strata, in which water acts as a solvent when containing carbonic acid gas. But their original formation doubtless dates back to the Pluvial period, to which we shall presently recur, when water action was vastly more effective over these regions than at the present day.

3. The sandy desert, the most frightful of all desert surfaces, is covered by mounds, sometimes 100 mètres high, of pure quartz sand. The source of this sand, which often covers limestone strata on the borders of the Sahara, was, according to Zittel, probably the "Nubian sandstone formation," which underlies the limestone, and which has been drifted from its outcrop by the winds northwards from the Oasis of Chargeh, and westwards along the parallel of lat. 25°. Doubtless, also, some of this sand may have constituted the sandy bed of the sea, when the whole region of northern Africa was gradually rising from beneath the waters, in later Tertiary times, and extensive denudation of the strata was in progress.*

Forest of Silicified Wood.—Lying in a direction due west of Cairo, lat. 30, and in a region but little explored, are to be found great numbers of silicified stems of trees, apparently belonging to a sandstone deposit, and extending over a tract 1,600 square miles. This forest is formed of the stems of trees of the genus *Nicholia*, &c., and has its counterpart in a similar forest on the plateau of Jebel Ahmar, near Cairo, where the trees have been embedded in reddish loam and variegated sandstone or conglomerate. This deposit is generally regarded as of Miocene age.†

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* Professor Judd states that the sands of the alluvial deposits of Lower Egypt give evidence of having been derived originally from granitoid rocks, as the grains contain fluid-cavities and crystals of rutile seen under the microscope. A similar observation has been made by Dr. J. S. Hyland as regards the grains of quartz in the sands at Korti, which contain gas- and fluid-cavities as well as hair-like needles, presumably of rutile. *Scient. Proc. Roy. Dublin Soc.*, Feb. 10, 1890.

† For fuller accounts of this deposit, see Dawson, *Modern Science in Bible Lands*, p. 543. Zittel, *Libyschen Wüste*, p. 132. Carruthers *Geol. Mag.*, 1870.

The great tracts of desert above described lying to the north of lat. 25° terminate along the south in the escarpment of Jebel Djefata, which reaches a height of 1,550 feet above the sea level. To the south of this escarpment the beds of the Cretaceous formation set in, with a slight northerly dip, to be succeeded still further south by those of the Nubian sandstone, which first makes its appearance in the Nile Valley at Esbeh, near Edfu, and which in turn reposes on the crystalline rocks of the First Cataract at Assouan, the ancient Syene.

3. *The Region of the Arabian Mountains.*—This region, lying between the Nile Valley and the Red Sea, presents a striking contrast to that we have just described lying to the west of the river. Its western portion consists of the same strata as those which form the Libyan Desert, but it is generally more diversified by high plateaux bounded by terraced escarpments and deep valleys, and is also intersected by a range of mountains formed of crystalline rocks of vast geological antiquity, which gives a special character to this region, and which may be designated "the Archæan protaxis." In a word, while the region west of the Nile is an elevated tableland, that we are now considering is, properly speaking, a mountainous tract. (See Fig. 1, p. 14.)

At Cairo, the lofty terraced banks which form the eastern margin of the Nile Valley abruptly change their direction and bend round to the east at Jebel Mokattam and thence extend in a broken escarpment to Jebel Attaka, already referred to as overlooking the Gulf of Suez. These escarpments form the northern margin of the Arabian Mountains, which stretch southwards, till they ultimately merge into the vast Nubian plateau.

The protaxis, or culminating ridge, of this tract is formed by the line of crystalline rocks which ranges from the Wady el Arabah in a southerly direction, and therefore parallel to the shore of the Gulf of Suez, by Jebel Ghareb (Mt. Agrib), by Doukhan (Mons Porphyrites) to Fateereh, and Zobara, containing quarries of green breccia marble, quarried by the ancient Egyptians. The higher elevations of this range attain a height of 6,000 to 7,000 feet above the sea. The ridge presents its steepest flank to the eastward, and sends off numerous valleys on either side; those running to the east opening out on the sea coast, those in an opposite direction opening into the Nile Valley, between lofty terraces of limestone. The most remarkable of these valleys are the Wady Qeneh, which runs along the western base of the ridge for a

distance of 100 miles, and opens out on the Nile at the village of the same name. The Wady el Arabah, which opens on the Gulf of Suez, is remarkable for its width and the loftiness of the cliffs by which it is bounded, and has been graphically described by Schweinfurth, who has discovered Palæozoic strata therein.*

These valleys are now waterless, but from their ramifying form, and the physical features of the sides, indicating extensive erosion of the strata, together with the alluvial gravel of their floors, they enable us to infer, without any hesitation, that they were originally formed by water-action, and that they were once the channels of no inconsiderable streams and rivers. They have their counterparts in Arabia Petræa and Southern Palestine, and other districts of the African Continent.

Part III.—The Nile.

The region thus described is traversed from south to north by the one river of Egypt, the Nile, which, rising in the great central lake, embosomed amidst lofty mountains, the Victoria Nyanza, at a level of 3,740 feet, flows for a distance of 2,000 miles, till it enters the Mediterranean by its two great branches, those of Rosetta and Damietta; the only representatives of seven original outlets known to ancient geographers.

In its upper reaches, south of lat. 10° N., the Nile receives many tributaries, but north of this, there are but two, the Bahr el Azraq (or the Blue River) and the Atbara or Bahr el Aswad (or the Black River), which descend from the highlands of Abyssinia. It is now known, from the account of Sir Samuel Baker and others, that the periodic inundations of the Nile in Egypt are due to the thunderstorms which burst upon the Abyssinian mountains about the summer solstice, and which, pouring down in torrents by its great rivers, chiefly the Atbara, carry along the muddy sediment derived from the breaking down of their banks. At the island of Philæ, about five miles south of Assouan, the Nile may be considered to make its entrance into Egypt. At Assouan, the level of the river is, according to the barometric measurements of Russegger about 300 feet above Cairo, and 365 feet

* *Bull. Institut Égyptien*, No. 6 (1885). There is another and greater valley of the same name in Arabia Petræa, extending northward from the Gulf of Akabah.

above the Mediterranean; and, the distance between Assouan and Cairo by the river being 556 miles, the average fall is little more than half a foot in a mile. Between Philæ and below Assouan the river passes through a labyrinth of granitic and crystalline rocks, causing a series of rapids, known as the First Cataract. The Arabian hills, forming the right bank of the river, break off in a line of cliffs throughout nearly their whole length. In the neighbourhood of Assouan, they rise little more than 200 feet above the river, but they go on increasing in height to the vicinity of Thebes, where they attain an elevation of 1,065 feet above the Nile; and from this northwards, they have a gradual fall, but rise again on approaching the apex of the Delta to about 900 feet. Above Cairo, the cliffs of Eocene limestone are worn into terraces and caverns, indicating former depressions of the whole land surface beneath the sea, and ancient sea margins to which I will have occasion to refer again. Below Assouan, the granitic rocks are covered by the Nubian sandstone, which extends along both sides of the river as far as Esneh, about 85 miles below Assouan, where it in turn passes below white limestone strata, referable to the period of the Cretaceous Limestone or Chalk of England.*

PART IV.—GEOLOGICAL FORMATIONS.

Such being the general form and features of the region now under description, it remains to give very briefly some account of the geological formations of which it is built up; and, as this subject has already been so fully dealt with by geologists of eminence, only a slight sketch will be necessary here before we come to discuss the physical changes which the region has undergone from the time when the land first emerged from below the ocean until it assumed its present form and condition.

(1.) *Fundamental Crystalline Rocks.*—The rocks which constitute the foundation of all others in this part of the world are probably of the age known as "Archæan" or "Laurentian." They form the ridge which crosses the Nile at the First Cataract† and extend into the protaxial range of

* An excellent account of the physical phenomena connected with the Nile and its channel is given by Mr. Horner in his paper on Lower Egypt, *Philosophical Transactions*, 1855; also in Réclu's *Nouvelle Geographie*, vol. x. Space does not permit of any fuller description here.

† These rocks have been described by Lieut. Newbold, F.R.S., *Quart. Jour. Geol. Soc.*, vol. iv, p. 324; J. C. Hawkshaw, *ibid.*, vol. xxiii, p. 115

Mt. Agrib, in the Arabian Mountains. They also constitute the mountain masses of the Sinaitic Peninsula, and the flanks of the Edomite range on the borders of the table-land of the Arabian Desert.* They consist of micaceous, hornblendic, and chloritic schists, clay-slate, and quartzite, with numerous granitic veins, below which are beds of gneiss and schist with dykes of granite and diorite, which have been used in Egyptian works of art. According to Dawson, this older series, which may be referred to the Archæan age, is overlain unconformably by a second series seen at the Island of Biggeh, above the First Cataract, and near to Philæ; which series consists of porphyry, gneiss, and porphyritic granite, all probably of Plutonic origin, and possibly referable to the Huronian Series of North America. Newbold has described granitic and schistose rocks as ranging from near the shore of the Red Sea at Kosseir inland, in a band about 30 miles in breadth, forming a part of the great central axis of Mt. Agrib. The fundamental part of this range appears to be granite (or gneiss), supporting various schists, and penetrated by dykes of basalt, greenstone, porphyry, and serpentine. In Gebel Zubara are found emeralds, avanturine, and specular iron ore; and from the potstone, nephrite, and "green felspar" of Mount Baran have been sculptured cooking vessels, images, and scarabæi.

In the same region is also found the celebrated Breccia di verde, resting on the slate in unconformable thick-bedded strata, containing angular fragments and rounded pebbles of greenstone, gneiss, slate, serpentine, and marble cemented by a slightly calcareous paste. This breccia has been largely used for ornamental work, in Egypt, Italy, and Constantinople.† These old crystalline rocks form the core of the Abyssinian Highlands, and range into the region of the Central African Lakes by Mounts Kenia and Kilimanjaro.

(2.) *The Nubian Sandstone.*—This formation is found resting on the Archæan crystalline rocks north of Assouan on both banks of the Nile, and on the flanks of the great central axis of crystalline rocks in the Arabian mountains. Having been extensively used by the ancient Egyptians in their works of monumental art, amongst which may be

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(with map); J. Russegger, "Reisen in Europa, &c.," *Journ. Leonhard und Bronn;* Sir J. W. Dawson, *Modern Science in Bible Lands*, p. 556, &c.

* "Phys. Geol. Arabia Petræa and Palestine," *Mem. Palest. Explor. Society*, 1886.

† Newbold, *supra cit.*, p. 329.

specially mentioned the colossal statues of the Memnium at Thebes, it was called by De Rozière the "Monumental Sandstone."*

This rock consists of red and variegated sandstone several hundred feet in thickness, and is destitute of fossils, except plants. Where it rests upon the old crystalline rocks it becomes a breccia, or conglomerate; in fact it constitutes a beach or shore bed, made up of pebbles derived from the original floor and bordering uplands of crystalline rocks. Red sandstone occupies large areas in Nubia, and Middle and Southern Sahara.† It is also found in Arabia Petræa, and along the eastern slopes of the Arabah Valley and shores of the Dead Sea. Its geological age has been long a subject of discussion amongst observers and travellers in the East, and it has been referred successively to the Cretaceous, Triassic, Permian, and Devonian ages. It is now known that it belongs in part to two geological periods widely separated, viz.: the Lower Cretaceous and the Lower Carboniferous. The discovery of limestone strata with Carboniferous marine fossils, within the mass of the red sandstone in the Wady Arabah, near the western shore of the Red Sea, by Schweinfurth;‡ in the Wady Nasb, in the Sinaitic Peninsula, by Bauerman;§ and to the east of the Dead Sea by the author, shows that the lower portion at least is in some places Carboniferous, or older; while the upper strata, passing as they do into the Lower Cretaceous series and conformably stratified therewith, indicates that these beds are of Cretaceous age. It is probable that the Carboniferous sandstones are only local; and that more generally the greater mass, including that in the Nile Valley, is of Cretaceous age. To the lower (or Carboniferous) division I have given the name of "The Desert Sandstone," to distinguish it from the upper or Cretaceous division, to which the name "Nubian Sandstone" properly belongs.‖ It is not improbable that the Adigrat sandstone formation of

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* "Grès Monumental," which happily avoided any theory regarding its geological age. De Rozière, "Description de l'Égypte," *Hist. Nat.*, 11.

† Zittel, *loc. cit.*, p. 41. The red sandstone of the Ahaggai Mountains is considered by Zittel to be Palæozoic.

‡ "Sur une récente Exploration géologique de l'Ouadi Arabah," *Bull. del'Institut Egyptien*, 1887.

§ *Quart. Journ. Geol. Soc.*, vol. xxv., p. 27; also "Geol. Arabia Petræa and Palestine," *Mem. Pales. Exploration Fund*, p. 44.

‖ *Ibid.*, p. 45.

Abyssinia, described by Dr. Blanford as underlying Jurassic limestone, belongs to this lower or Palæozoic division.*

The only fossils in the Nubian sandstone proper are stems of plants; and it is probable that this great formation was deposited within the waters of a vast inland lake, occupying the greater portion of Northern Africa. The sediment of which it was formed was derived from the disintegration of the granites, crystalline schists, and quartzites of the Archæan rocks, forming the continental land by which it was enclosed. Gradually this region subsided and was invaded by the waters of the Cretaceous ocean.

(3.) *Cretaceous and Eocene Limestones.*—The calcareous strata which overspread the Libyan Desert and the greater part of the Arabian Mountains belong to two formations: the Cretaceous and Eocene. The former is represented by the Chalk formation of England, France, and Belgium, and consists of soft white limestone and calcareous marls with characteristic fossils such as: *Exogyra Overwegi, Inoceramus Crispi, Hippurites, Nautilus desertorum, N. Danicus, &c.*

The Eocene limestone, generally known as the Nummulite limestone, from the occurrence of species of *Nummulites*, often in great numbers, is chiefly formed of solid beds of limestone with bands of chert. The fossils, which are numerous, are specifically different from those of the Cretaceous beds, though the strata are similar in character and origin, and are approximately conformable to each other. How are we to account for this remarkable change in the fauna of the two similar formations? Probably somewhat in this way: The Cretaceous limestones and marls were formed over the bed of the great ocean which spread its waters over all this region, from the Red Sea to the Atlantic, except where the mountainous tracts of ancient Palæozoic or Archæan rocks rose above its surface. In the waters of this ocean the characteristic Cretaceous forms lived abundantly; but, towards the close of the period, the bed of the ocean was slowly and generally elevated till it became either dry land, or very shallow. During this process of upheaval and desiccation the animals which had lived in the waters were necessarily destroyed; and when the region again partially subsided and became oceanic, new forms of living beings migrating from other oceanic areas, took possession of the waters, amongst which Foraminifera of the genus *Nummulites* were the most

* W. T. Blanford, *Geol. and Zool. of Abyssinia*, p. 170.

abundant. Thus we can understand how that, with but little discordance of stratification, the specific forms became changed.

The Nummulite limestone is fairly laid open to view in the quarries of Gebel Mokattam, near Cairo, and amongst other forms may be seen well preserved specimens of crabs, with their limbs attached to the crustaceous body; also large Nautili, and Echini of the genera *Echinolampas* and *Spatangus*. The ancient quarries on the right bank of the Nile above Cairo are those which yielded the stone of which the two great Pyramids have been constructed.*

The combined thickness of the two limestone formations, the Cretaceous and Eocene, in the Egyptian territory may, according to Zittel, be estimated at nearly 4,000 feet; and as these strata were formed mainly from the remains of marine animal forms such as Foraminifera, Crinoids, Crustaceans, and Molluscs, the length of time included in this period of accumulation of material is necessarily very vast indeed.

(4.) *Miocene Strata.*—It is probable that at the close of the Eocene stage, the bed of the ocean was again subjected to elevatory movement, some portions became dry land, others were converted into inland lakes or estuaries. In these latter, clays and sandstones were deposited, and the plants peculiar to Africa grew round their margins, or partially were aquatic. The stems of these trees have in several places become silicified, and afford at the present day the remarkable spectacle of the silicified forests of Jebel Ahmar, near Cairo, and of the Libyan Desert, in lat. 30° N. and long. 29° 30′ E., called by Zittel "the Nicolien Wald," from the prevalence of the trees called *Nicolia Ægyptiaca* and *N. Oweni*, to which may be added several other forms, including a conifer and a palm. The presence of those trees in a region now arid and treeless shows that the climate of this region has undergone a great change in Post-tertiary times: to this subject I shall again refer.†

The Miocene period in Egypt, as in Europe and the British Isles, was one remarkable for terrestrial movement

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* It is lamentable to reflect that the Mahomedan Caliphs in their zeal for the religion they had adopted showed little respect for the memory of the ancient Lords of Egypt, and did not scruple to strip the polished and sculptured casing of marble from off the pyramids in order to obtain material for building their mosques, and the walls of the city.

† Zittel, *loc. cit.*, p. cxxxiii. The leaf of an oak, *Quercus ilex*, was found by this author in the Oasis of Chargeh.

and disturbance, and for faulting and flexuring of strata. Large areas of what had been for ages the bed of the ocean were converted into dry land, and along with this elevation of the strata extensive denudation was carried on by wave and river action. We may go so far as to say that to the Miocene period is to be referred the development of the leading physical features of the region here treated of, together with both Syria and Palestine. Owing to this cause, Miocene strata are of rare occurrence, as the period was one of denudation rather than of deposition of strata.

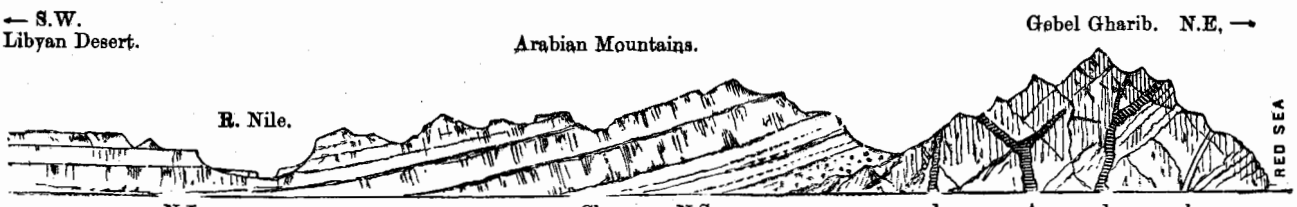
Nevertheless, strata both of marine and lacustrine origin, referable to this period according to Zittel, are to be found in isolated positions not much elevated above the sea level, as for example in the Oasis of Siuah, or Ammon, and adjoining plateau of Barco, at Jebel Geneffe north of Suez, and a few places bordering the Gulf of Suez, to the south of that place. The strata, consisting of limestone, marls, and sand in these localities, are generally of marine origin, as indicated by the fossils, which include *Pecten*, *Spondylus*, *Ostrea* of several species, *Placuna*, and Sea-urchins, such as *Echinolampas*, *Scutella*, *Clypeaster*.* They appear to be conformably superimposed on the Upper Eocene beds at Siuah; but in the case of the beds near Suez, they occupy positions in reference to the Nummulite limestone, which show that that formation had been upheaved and largely denuded previous to the deposition of the Miocene strata. They may therefore be regarded as representatives of the period locally deposited where the sea-water prevailed in the vicinity of the emergent lands.

5. *Pliocene* or *Pleistocene Strata*.—The representatives of this period consist of raised beaches and shore beds with sea shells and corals found at intervals on both sides of the plain of Lower Egypt, and at an elevation of 200 to 220 feet above the present sea level (Fig. 2). In the oases of the Fayûm and Rayân basins, by beds of sand, loam, and marl, with sea shells such as *Turritella transitoria*, Mayer, *T. turris*, Bast, *T. carinifera*, *Corbula pyxidicula*, *Tellina pellucida*, Desh.,† &c., and in the Nile Valley by terraces of gravel, sand, and loam, rising for 100 to 130 feet above the highest inundations of the river in the neighbourhood of Assouan. When these beaches and terraces were in course of formation, the gulf of Lower

* The Pliocene beds of Siuah were first noticed by Ehrenberg in 1820, those of Suez by O. Fraas, Fuchs and Schweinfurth. Plates of fossils are given in Zittel's work, Plates I, II, III, and IV, &c.

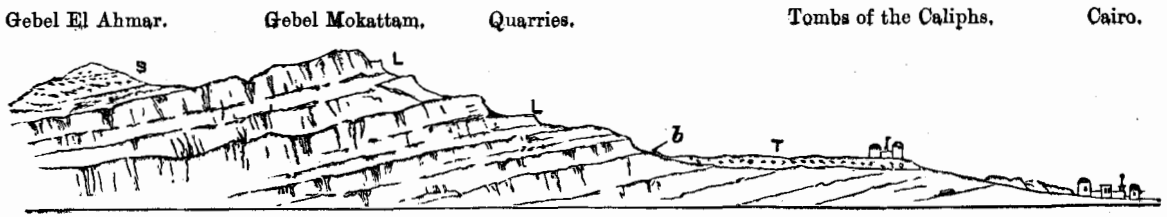
† Figured in Plate XXIII of Zittel's *Libyschen Wüste*.

FIG. 1.—SECTION ACROSS THE "ARABIAN MOUNTAINS," TO SHOW SUCCESSION OF STRATA.



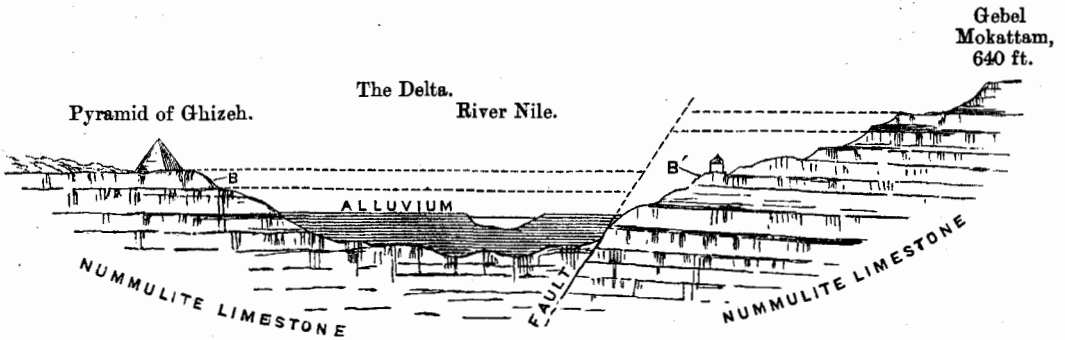
N.L. Nummulite Limestone (Eocene).
Ch. Chalk (Upper Cretaceous).
N.S. Nubian Sandstone (Cenomanian or Neocomian) with conglomerate or brecciated base.
A. Archæan Rocks, Granite, Gneiss, Schists, &c., with dykes of trap (*dd*).

FIG. 2.—SECTION THROUGH GEBEL MOKATTAM, NEAR CAIRO, TO SHOW THE RELATIONS OF THE STRATA AND RAISED SEA-BED.



S. Sandstone of Gebel El Ahmar with silicified trees.
L.L. Eocene Limestone. Upper beds brown with *Nummulites planulatus*.
" " Lower, white with *Nummulites Ghizehensis, &c.*
T. Terrace of sand and gravel, with recent shells; *b*, position of Pholas borings at 220 feet above Red Sea.

FIG. 3.—GEOLOGICAL SECTION ACROSS THE NILE VALLEY ABOVE CAIRO, SHOWING THE RELATIVE POSITION OF THE STRATA ON EITHER SIDE, AND THE CHANNEL WITH ALLUVIAL SILT.



The dotted lines show the position of the limestone strata before they were denuded, as displaced by the fault. B shows the position of the Old Pleistocene sea-beach near the Pyramid of Ghizeh, and B′ its position as shown by Pholas borings in the cliff on which stands the Mosque of Mehemet Ali, on the East of the Nile Valley.

Egypt had already been hollowed out of the Eocene limestone strata, and the whole region was re-submerged to a depth of over 200 or 250 feet below its present level, relatively to the surface of the Mediterranean and Red Seas. It is since that period of submergence that the alluvial deposits of the Delta have been accumulated.

PART V.—PHYSICAL HISTORY OF EGYPT AND THE NILE VALLEY.

(1.) During the Cretaceous and Eocene periods, the whole region embraced by Egypt and the Libyan Desert was submerged beneath the waters of the sea, which extended southwards from the Mediterranean area, probably as far as lat. 12° in the meridian of the Nile Valley (see map). The limits of the Eocene sea were probably defined by the Sinaitic and Arabian mountain chain extending southwards into the Abyssinian Highlands. The southern limits are at present uncertain. Without doubt the unsubmerged land of the period included the high region surrounding the great Central African lakes, and extending in a north-westerly direction into the Aïr and Tibesti district, constituting the Asgar (or Ahaggar) Mountains; composed, according to Zittel, of Palæozoic (Devonian?) sandstone, slate, gneiss, and granite with volcanic rocks, forming the southern border of the desert. Towards the north the borders of this Tertiary sea were formed by the Morocco Atlas and Algerian Highlands, amongst which various Palæozoic rocks appear, sometimes penetrated by granite and porphyry. Such were in brief the general limits of the Tertiary inland sea, and into its waters some of the existing affluents of the Nile, from the great equatorial lakes in the south, and the Abyssinian Highlands in the east, emptied themselves.

With the succeeding Miocene epoch, the quiescent condition of the earth's crust over this region came to a close. A general elevation of the sea-bed into land surfaces took place over Northern Africa and the adjoining tracts of Sinai and Palestine. Faulting and flexuring of the strata also supervened. It was during this period that the great Jordan-Arabah fault, which has been traced from the Lebanon to the Gulf of Akabah, was produced;* as also, in the Egyptian area, the fault running parallel with the

* "Geol. Arabia Petræa and Palestine," *Mem. P. E. F.*, p. 103.

Nile Valley, by which the strata of Nummulite limestone have been let down about 250 feet on the west side of the valley, as shown by Schweinfurth and Dawson, as compared with their position in Mokattam Hill, on the east bank* (Fig. 3). This line of fault, trending in a N.—S. direction along the base of the eastern cliff, corresponds with the line of the valley for a distance of nearly 100 miles, and doubtless caused the river to select its course in this particular district. With the rising of the sea-bed into land it became necessary for the various affluents of the Upper Nile to select a channel seawards, and it is easy to show that no other course than that actually selected was possible. It has been suggested more than once that the Nile at one time flowed through some abandoned channel into the Red Sea; but no such channel exists or was possible. The long range of the Abyssinian and Arabian Highlands, formed of ancient rocks, effectually barred any outlet in an easterly direction. And for a similar reason a westerly course, which would have brought the river into contact with the Tibesti and Ahaggâr Highlands, was impossible. A river in seeking an outlet towards the sea necessarily flows along the lowest accessible ground, and such a tract appears to have existed generally along the present Nile Valley, formed of Cretaceous and Tertiary limestone strata, which was probably slightly depressed as compared with the bordering tracts. The fault in the valley of Lower Egypt above described, which was an effectual guide to its course there, probably gave place further south to a slight depression or channel in the old sea-bed, and along this the river seems to have had a line of flow of least general resistance to its course towards the outer sea.

We may therefore suppose that, as the sea-bed over the Egyptian and Libyan areas gradually rose, and became land, the river waters followed the line of retreat of the sea waters northwards, the several streams converging into one central channel; and when the whole tract had been reclaimed from the sea, this channel would become deeper by reason of the increased eroding action of the waters, tending to deepen the channel back from the outlet.†

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* *Proc. German Geol. Survey*, 1883, quoted by Dawson, *loc. cit.*, p. 538. The disturbances and dislocations in the rocks near the Second Cataract, described by Leith Adams, are probably referable to the same period, *Quart. Jour. Geol. Soc.*, vol. xx, p. 11.

† These streams are well shown in Ramsay's *Orographical Map of Africa*, published by E. Stanford, and in the "Carte du bassin du Nil" in Reclus' *Nouv. Geog.*, vol. x.

One or two barrier ridges had, however, to be crossed in the case of the Nile, as in that of most rivers of any importance. The explanation of this singular physical fact is now fully understood. For a while these barriers, formed by the limestone escarpment where it crosses the valley north of the First Cataract, and by the sandstone and granite near Ipsambol below the Second Cataract, would prove formidable, and the waters probably accumulated behind them, till they rose above the lowest lip, and then poured down, continually deepening their channel as time went on. Once the channel was formed, it so remained,* and it must not be forgotten that the strata being somewhat elevated in a southerly direction during the period of movement, was itself undergoing denudation, or lateral erosion; and the rainfall being doubtless abundant (as testified by the forests now silicified), the rocks were worn down by rain and river action, along the lines of outcrop of the strata.

This deepening process, by water erosion, must have gone on *pari passu* with the uprising of the land. It is also necessary to suppose that the uprising continued until the land formed of Eocene limestone was elevated much higher relatively to to surface of the then ocean than is at present the case; because, the erosion of the limestone beds in the valley of the river, and the Delta, must have gone on till the present floor of the Delta was reached, but which is now filled with sediment up to (or above) the level of the Mediterranean. The maximum depth of the floor is not yet ascertained, notwithstanding the boring experiments carried out by the Royal Society, 1854, under Mr. Horner, and more recently in 1886. If we assume the greatest depth to be 200 feet below the present surface of the alluvial plain, then this will give us approximately the amount of the additional rise of the land, relatively to the surface of the then outer sea.†

The greater relative elevation of the land during the Miocene period would result in giving the river a greater fall, and increasing the eroding power. Very little sediment would under these conditions be deposited; and thus, at the close of the Miocene epoch, we may contemplate the Nile as rushing along its rocky bed towards the outer sea, its banks

* It will be understood I do not refer to the changes of position of the Nile within the limits of its alluvial plain.

† This will be evident when it is recollected that erosion could only go on above the sea level; for, under the opposite conditions of the land deposition of sediment, and not erosion, would be in progress.

of limestone rock towering some 200 feet more than at present where it leaves its narrow channel at the apex of the Delta,* and numerous streams wearing back the limestone cliffs till they had assumed somewhat of the form and position they now occupy all round the plain of Lower Egypt.

(2.) *Pliocene Epoch.*—Geological history, especially during the later periods, presents us with frequent examples of depression of land succeeding elevation, and this is still going on over the surface of our globe. We are therefore not to be surprised when in working out the physical history of Egypt we find evidences of such oscillations of land and sea. The Miocene period was evidently one of elevation and erosion, as we have just seen; but it seems to have given place to one of depression of the land to an extent not indeed sufficient to cover the Libyan and Arabian tracts with sea-water, but to an extent of about 220 to 250 feet, if we take the present sea level as a datum. This inference is arrived at by the discovery of raised beaches, and terraces with sea-shells at levels such as are above stated at various points along the flanks of the hills bounding the Delta on both sides,† as well as in other parts of the region bordering the Levant. The positions of these terraces and beaches are indicated in Figs. 2 and 3.

Before, however, entering upon the discussion of this last submersion, it may be well to refer to a remarkable episode in the zoological history of this part of the world, for the elucidation of which we are much indebted to Dr. Wallace. I refer to the great migration of Pachyderms, Carnivores, and other Mammalia from the Europasian continent into Africa, which took place about the time that we have now reached in the physical history of Egypt.

Zoological Episode.—Towards the close of the Pliocene period the animals which ranged over the Europasian tract of continental land were largely representative of those of the

* At what particular stage of the Miocene period the marine strat referable to this stage at Siuah (Ammon) and Geneffe were deposited it is difficult to say. Those of the former appear to have been formed within an arm of the sea stretching inland from the Gulf of Sidra. There are very few shells common to both deposits.

† Of course the existence of the shore beds here referred to might be accounted for by supposing the level of the outer sea (now the Mediterranean) to have risen 250 feet higher than at present; but this is not a probable supposition, as it would involve the idea of a general rise of the whole outer ocean. As Lyell and others have shown, it is the land which rises and falls, while the ocean surface maintains nearly always its geodetic level.

present day. A few forms, such as the Machairodus and Mastodon have become extinct; others have been somewhat modified, but the general change is not very great. During this epoch there is reason to believe that the continent of Africa was the abode of a very different and less varied fauna, which is now represented by that of the Island of Madagascar and the Seychelles at the present day. How then are we to account for the presence in Africa of the numerous forms of Pachyderms, Felides, Antelopes, and Ruminants which people this great continent? The explanation which Wallace offers is clear and satisfactory. At the close of the Pliocene, or commencement of the Pleistocene, period a great migration of the Europasian animals took place into Africa, by which the aboriginal forms were exterminated or driven out, and replaced by the invading host of fiercer and more powerful animals.* But in order to render such an invasion possible, one or more highways had to be constructed across the barrier of waters, caused by the Mediterranean, the Gulf of Suez, and the Red Sea. Under existing conditions, it is clear, such a migration would be impossible except by one narrow passage, the Isthmus of Suez, which would have been quite insufficient for such an invasion as is now contemplated. It would appear, however, that the very same cause which forced on the southward migration gave rise to the formation of, at least, two causeways from Europe to Africa across the Mediterranean as it now exists. This was the increasing cold of the on-coming Glacial period, which made itself felt towards the close of that of the Pliocene. The gradual lowering of the temperature, owing to which the animals were driven southwards, caused the streams which feed the Mediterranean from the northward to become frozen, and ultimately to be converted into ice. As the snows accumulated on the Pyrenees, the Alps, the Carpathians, and the vast plains of Russia, the sources of the rivers feeding the Mediterranean from the north would be dried up, or become much reduced, and as a consequence its surface would be lowered. Mr. Wallace considers that there were three causeways thus produced by which the animals passed over into Africa; one, the Straits of Gibraltar; another, between Italy, Sicily, the Maltese Islands, and Tunis; and a third, the Isthmus of Suez, which still remains. There may also have been a general elevation of the Mediterranean region, by which the connec-

* Wallace, *Island Life* (1880), and *Geographical Distribution of Animals* (1876).

tion with the Atlantic Ocean was cut off.* The large number of remains of Elephants, Hippopotami, and other forms in the caves of Sicily and Malta, as shown by the late Drs. Falconer and Leith Adams, bear testimony to the extent of the land connection here indicated; and it is known that there is a large extent of very shallow water in this part of the sea, separating deep gulfs on either hand.

Bearing on the subject of the formation of the channel of the Nile and the denudation of the plain of Lower Egypt, it may be observed that the lowering of the Mediterranean waters would cause increased velocity in the flow of those of the Nile, and consequently deeper and more rapid scouring out of the original channel. As already stated, the depth of the original floor of the basin of Lower Egypt is probably not less in some places than 200 feet from the present surface; the Rosetta boring described by Colonel Maitland, R.E., having gone down 153 feet without reaching the solid rock, and leaving off in coarse sand and pebbles.

Other excavations and borings made by the aid of funds granted by the Royal Society, reported upon by Horner and Judd, do not attain greater depths than about 75 feet, and are in alternating strata of desert sand and Nile mud.†

PART IV.—THE AGE OF MAN.

The period at which we have arrived, representing the "First Continental Period" of Lyell, continued on from the Pliocene into the Post-Pliocene or Glacial. It was one of general elevation of land, of shallowing of seas, of increasing cold and prevalence of glacial conditions over Northern and Central Europe and Asia. It was also the age of the Mammoth, of the woolly Rhinoceros, and, most important of all, of Palæocosmic Man.‡ Perhaps man followed in the steps of

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* The subject has been ably discussed by Mr. T. F. Jamieson, *Geologica Magazine*, May 1885, p. 199, and is treated in my *Sketch of Geologica. History* (1887), p. 129 *et seq.* The Mediterranean may have been considerably different in form at this epoch from what it is at present.

† Horner, *Phil. Trans.*, 1855; Judd, *Proc. Roy. Soc.*, vol. xxxix, Nov. 1885. Analyses of these deposits are given by both these authors, and by Dr. J. S. Hyland of those at Korti, in the Nile Valley, *Scien. Proc. Roy. Dublin Soc.*, Feb. 1890.

‡ I have taken this term from Dawson in preference to Palæolitic, which is more generally in use. The reader will do well to consult Sir J. W. Dawson's excellent work, *Modern Science in Bible Lands*, for a fuller account of this part of my subject than I can give here.

the great Pachyderms and Felines into Africa, where they became objects of the chase. Certain it is, that rude stone weapons, works of human art, occur in the ancient terraces on the banks of the Nile at Wady Halfa, and perhaps elsewhere, and which are of an age long anterior to the most ancient works of Egyptian art which adorn the banks of the river.

(4.) *Pluvial Period* (" *Champlain Period* " *of America*). *Depression of Land and Raised Beaches.*—I have already referred to the raised sea-beaches of Lower Egypt, at intervals along the margin of the table-lands by which the alluvial plain of the Nile is bounded. They have been recognised on the slopes of Gebel Mokattam, behind Cairo, at an elevation of about 220 feet above the present sea level; at G. Attaka, and Moses' Wells, near the coast of the Gulf of Suez,* and at a spot about 2 miles south of the Pyramid of Ghizeh, on the margin of the platform of Nummulitic limestone on which the Pyramids have been erected. These old sea-margins were first recognised by Dr. Oscar Fraas,† and have since been described by Schweinfurth,‡ Dawson,§ and the Author.‖ At Gebel Mokattam, the Eocene limestone cliff has been perforated by Pholades (*Ph. rugosa*, Broc.), and in the gravel beds lying up against the rock, and sloping away towards the south, shells such as *Ostrea undata*, *Terebratella forscata*, *Pecten Dunkeri*, and *Balanus*, now inhabiting the Red Sea, are also found. The beds of gravel and marl, near the Pyramid platform, contain similar shells and numerous large *Clypeasters* (*C. Ægyptiacus?*), which have long been known to the Arabs, but only recently to the scientific public. The terrace of the one side of the valley is undoubtedly representative of that on the other, and, together with others at various parts of the coast of Palestine and Syria, prove a general depression of the land

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* These terraces are very well marked between Moses' Wells and the escarpment of the limestone, at the base of which are terraces of sand full of oysters, Trochus, Conus and other shells at successive levels.

† Fraas, *Aus dem Orient*, p. 161.

‡ Schweinfurth. "Ueber de Geolog. Schichten d Mokattam," *Zeitsch. d. Deuts. Geol. Geselischaft* (1883).

§ Dawson, *Geol. Mag.*, No. 241; also *Modern Science in Bible Lands*, p. 537.

‖ *Phys. Geol. Arabia Petræa*, p. 70. These beds were considered as Miocene by Fraas, but Schweinfurth and Dawson both consider them more recent, probably " Pleistocene," in which view I concur.

to a depth of over 200 feet, at a very recent period* (see Figs. 2 and 3).

Thus after the general elevatory movement of the Miocene and early Pliocene periods above described, a movement of depression in later Pliocene times set in, and the ocean waters gradually spread over the deeply eroded plain at the Nile mouth. As the land continued to sink, the sea would continue to wear down the cliffs and carry away exposed rock masses, and thus ultimately Lower Egypt became a wide gulf, into which the Nile Valley opened out northwards, until the waters reached the level indicated by the shell beds of Mokattam and Ghizeh.

The submergence of Lower Egypt and the Mediterranean coasts could not but make itself felt far up the Nile Valley. The sea must have sent an arm into the channel, while the waters of the river still higher would be pent up and rise to higher levels.

The effect of this inundation may be clearly recognised in the terraces which occur on both banks of the river from below the First, to above the Second, Cataract, and in the caves marking higher levels of the river margin. These occur both in the limestone and Nubian sandstone, and are from 60 to 70 feet above the highest Nile. The terraces, consisting of gravel and alluvial matter, with fluviatile shells, have been described by the late Dr. Leith Adams.† These old terraces with fresh-water shells were observed at levels of 110 to 130 feet above the highest inundations of the present river; as, for example, at Derr, the capital of Nubia, and at Abusir, Gharbea, north of Koroske, &c. The shells in these terraces belong to fresh-water species, such as *Cyrena fluminalis, Unio pictorum, Paludina bulimoides,* and *Bulimus pulus.* The tooth of a Hippotamus considered by Dr. Falconer to be that of *H. amphibius,* the existing species of the country, was dug out of one of these terraces by Dr. Adams.

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* These raised beaches were recognised by the author at Akabah, Wady esh Sheriah, near Gaza, at El Mejdel and Esdud, in Palestine, &c. Dr. J. Walther describes two coral reefs of modern date on the shores of the Red Sea near Tor at levels of 230 and about half this height above the surface, *Die Korallenriffe d.Sinai halbinsel,* ch. vi.

† *Quart. Journ. Geol. Soc.,* vol. xx, p. 6. These terraces are also described by Sir J. W. Dawson. It may be presumed that the numerous hammerstones and worked flakes found by Surgeon-Major S. Archer at Wady Halfa during the recent Soudan Campaign, and described by Dr. J. S. Hyland, come from these terraces, but this is not very clear from the description itself. See *Scientific Proceedings Royal Dublin Society,* Feb., 1890.

There can be little doubt that these old river terraces are the fluviatile representatives of the ancient sea-beaches of Lower Egypt, formed during the latest submersion of the region bordering the Levant. The First Cataract is at a level of about 100 mètres above the present sea, which is a little higher than the level of the old sea-beach at Mokattam and Ghizeh; so that when the waters rose to this level, they extended nearly to the First Cataract, above which the Nile waters, thus dammed back, and probably very much more abundant than at the present day, spread over large tracts of alluvial land, clearly described by Dr. Leith Adams as stretching for miles away beyond the present river margin. During the same period, with the submersion of the present plain of Lower Egypt, the Mediterranean and the Red Sea were united, and strips of varying width along the coasts of these two seas were overspread by the waters, including a large part of Philistia, the vale of Achre, and the coasts of Asia Minor and Cyprus. As I have endeavoured to show elsewhere, the waters of the Jordan rose so high as to fill the whole valley to a level of about 1,400 feet above the present surface of the Dead Sea, forming a lake of about 120 miles from north to south, that is, about 100 feet above the present surface of the Mediterranean.*

It now remains to consider what may be the precise period in the physical history of Egypt to which the submergence above described is to be referred. First, it is clear from the species of shells, both marine and fluviatile, that it is very recent. Nearly all the forms are those still surviving in the Red Sea, notwithstanding the great change this sea has undergone since it was cut off from the Mediterranean on the emergence of the land. Again, there is every reason for supposing that it was a period of excessive rainfall over the now arid regions south of the Mediterranean. In looking at the map, or examining the country itself, we are struck by the large and deep valleys which must have been once the channels of rivers, but are now permanently dry. The valleys entering the Nile from both sides show great deposits of ancient river gravel and sand, sometimes cut down into by

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* According to the measurements of the officers of the Ordnance Survey, the surface of the Dead Sea is 1,292 feet below that of the Mediterranean. The old terraces of the Jordan Valley have been described by Canon Tristram in his *Land of Israel*, 2nd Edit: by Dr. Lartet in his *Voyage d'Exploration de la Mer Morte*, and the Author, *Geol. Arabia Petræa and Palestine.*

more recent channels due to occasional storms. The wide and ramifying valleys, such as the Wadies Queneh, Tarfeh, and Sonoor, by which the Arabian Mountains east of the Nile are traversed; those of the Sinaitic peninsula,* and of the Arabah, the deep-cut channels of the Edomite, Moabite, and Palestine table-lands, all testify to the existence of rivers in former times which have either altogether disappeared, or are represented only by occasional and evanescent floods. The same observation applies to very large regions of Central Africa.† Hence, we are obliged to have recourse to cosmical, and not merely to local, agencies for an explanation of this remarkable diminution of rainfall, and consequent drying up of the springs and rivers.

In casting about for such agencies, we are brought face to face with the fact that, about the period at which we have now arrived in the history of Egypt, physical conditions very different from those of the present prevailed over the Northern Hemisphere. I refer to the conditions of climate during the Glacial period already referred to. These are now so generally recognised that it is unnecessary to insist upon them, so that I need only observe that during their prevalence a climate resembling that of the Arctic Regions prevailed over the northern and central portions of Europe and Asia: the higher mountainous regions besides much of the plains and valleys were filled with perennial snow and ice, where these are only to be found now during winter. The Lebanon was the seat of glaciers; and where these now exist, as in the Alps, Pyrenees, and Caucasus, they descended at the time referred to far below their present limits. Under such conditions of Northern and Central Europe, it is evident that the regions lying immediately to the south of the snowy tract must have experienced a climate very different from that of the present day. Their climate would necessarily be of a humid and temperate character, with abundant rainfall and vegetation. Large streams would flow down the valleys of Egypt, Libya, Sinai, and Southern Palestine, where now there are none; it is thus that the erosion of these great valleys may be accounted for. To the same period may in all probability be referred the erosion of those remarkable

* Maps of the Ordnance Survey of Sinai, under Col. Sir Charles Wilson, R.E.

† As noticed by Livingstone in his *Last Journals*, vol. ii, p. 217. Prof Henry Drummond states that Lake Nyassa is slowly drying up, *Tropica Africa*, p. 196.

basin-like depressions already referred to in the Libyan Desert, of which the Fayûm and Rayân are the most important examples.

We have already seen the effect which this refrigeration of the climate at the commencement of the Glacial period had upon the animals of the Europasian continent in driving them southwards into Africa; this was at a time of land-elevation, and of lowering of the Mediterranean waters. The period of submersion, now being discussed, succeeded to this, and may have to some extent continued while the climate was undergoing amelioration after the epoch of intense cold. With the melting of the snows and the accompanying copious rainfall, the river valleys would become channels of large streams. Hence, this may well be designated the "Pluvial period," coextensive with the later glacial stages of the European area, and gradually passing into that of recent times, and the dawn of ancient Egyptian civilisation.*

(5.) *Silting up of the Nile Valley and Plain of the Delta.*—During the Pluvial period the waters of the Nile, independent of the periodic floods of Abyssinia, probably carried down larger quantities of sediment than at the present day, and partially filled up the great gulf formed during the period of elevation. This precipitation of sediment, no doubt, continued during the rising of the sea-bed, and after Lower Egypt had been converted into a fluviatile plain with its seven rivers.† Within historic times, there is every reason to believe the waters of the Red Sea extended far north of their present limits at Suez, as places far north of that town

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* A sketch map of this region during the Pluvial period will be found in the *Phys. Geol. and Geog. of Arabia Petræa, &c.*, p. 72. The Pluvial period of the Eastern Hemisphere is representative, at least in part, of the Champlain period of American geologists; on which subject see paper by Prof. J. D. Dana, *Amer. Journ. Sci.*, vol. xxiii (1882).

† The following is an account of the strata passed through at the deep boring made at Rosetta, communicated to the Royal Society by Col. Maitland, R.E.:—

1. Alluvial mud and clay	....	33 feet.
2. Sands and clays	....	61 „
3. Hard clay in lumps	....	29 „
4. Sand and clay alternating...	....	20 „
5. Coarse sand with pebbles....	....	10 „
Total	....	153 „

The pebbles above stated may possibly be concretions.

were on the coast in historic times; and on a former occasion I have shown how this fact solves a difficulty regarding the passage of the Red Sea by the Israelites under Moses, which must occur to every Biblical student who regards the present limits of sea and land as conterminous with those in existence at this eventful epoch. The Isthmus of Suez, as far as the great Bitter Lakes, is an old sea-bed, and was no doubt under water at the time of the Exodus.*

Attempts have been made to estimate the length of time required for the deposition of the alluvial deposits of the Nile Delta from data observed regarding the rate of deposition within historic times. Such estimates can never be more than very loose approximations, because the present rate of deposition may be very different from that of previous years. In the earlier years of the recent period, deposition, as well as erosion, were in all probability more rapid than subsequently. Sir J. W. Dawson, on an assumption of one-fifteenth of an inch per annum, arrives at the conclusion that the length of time required would be about 5000 years, and that from the period to be allowed for the colonisation of Egypt since the Palæocosmic age is about B.C. 3000 years.† The computations of authorities on the periods of Egyptian dynasties are at present hopelessly at variance. Fortunately for us, they are outside the scope of this paper.‡

The CHAIRMAN (H. CADMAN JONES, Esq., M.A.).—I am sure all will accord their best thanks to Professor HULL for this paper, which opens our 1891 Session.

Captain F. PETRIE, F.G.S. (Honorary Secretary).—The following communications have been received.

The first is from Professor T. RUPERT JONES, F.R.S., who, in making some suggestive remarks, says: "I should like to state what I think of the paper; it is a careful and satisfactory account of the physical structure and physical history of Egypt, and certainly it is a good example of the necessity of a knowledge of geology in depicting geographical features. I do not know that any remarks are needed on the clear and useful description of the strata and their relative position, and their effect on the constitution of land surface."

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* *Mount Seir, Sinai, and Western Palestine* (1884).

† Dawson, *Modern Science in Bible Lands*, p. 330

‡ Thus M. Mariette places the First Dynasty at a period B.C. 5004, while Professor Lepsius places it at B.C. 3892, a difference of 1112 years!

The second is from the Rev. A. IRVING, B.A., D. Sc., F.G.S., Senior Science Master at Wellington College, who writes:—

I regret very much that my professional duties prevent me from being present at the reading of the important paper by my friend, Professor HULL, on Monday evening. One can only wish that more were done by competent experts, whose minds are free from all hostility to Revelation, to make us better furnished with exact knowledge of the countries which form the background of Sacred history. In these days of criticism, some friendly, some hostile, this becomes every year a matter of increasing importance, as tending to add often concurrent and incidental testimony to the substantial truth of the historical books of the Bible.

I may perhaps be allowed to add an extract from a letter which I received last week from an old pupil, Lieutenant H. G. LYONS, who is stationed now at Cairo, and has already done such good work at home as to give promise of becoming, with the facilities which his position as an officer in the Royal Engineers afford, a very competent geologist. He has lately been up the Nile with Colonel Ross, of the Irrigation Department. He writes:—

"The geology of the Nile Valley would be extremely interesting to any one who had a year or two to study it carefully and quietly. There is plenty to be done. I must say I learned much in my ten days' trip as to river-silting, &c., as I went up at high Nile and got a number of specimens of last year's Nile mud. Another thing I have learnt from riding in the desert is the enormous amount of sub-aërial erosion at work by heat and cold, and by the heavy few hours' rain which falls in the winter; great gorges, with cliffs 300 to 500 feet high, and deeply undercut by water at their bases. There is a deposit here of a dense quartzite-like sandstone (Gebel Ahmar) which Dawson puts down to geyser action. This Zittel rejects, and certainly I can see no support for it. It looks to me much more like the Sarsen-stone case again, and I am going to prepare some sections for the microscope. Then these fossil-trees, the silicification of which no one has hitherto explained: I think they are possibly due to the same cause, for in all cases the decay seems to have commenced externally at the time of the replacement of their tissues by silica."

The discussion which followed, was of a general character; many expressed warm appreciation of the value of Professor HULL'S paper, and it was felt that it was so full of close research and so carefully arranged, that no room was afforded for criticism. Professor HULL having thanked those present for the kind way in which they had received the paper, the meeting was then adjourned.