G. M. Clark

APPENDIX

TO

MODERN SCIENCE IN BIBLE LANDS.

BY

SIR WILLIAM DAWSON, LL.D., F.R.S.

With Map.

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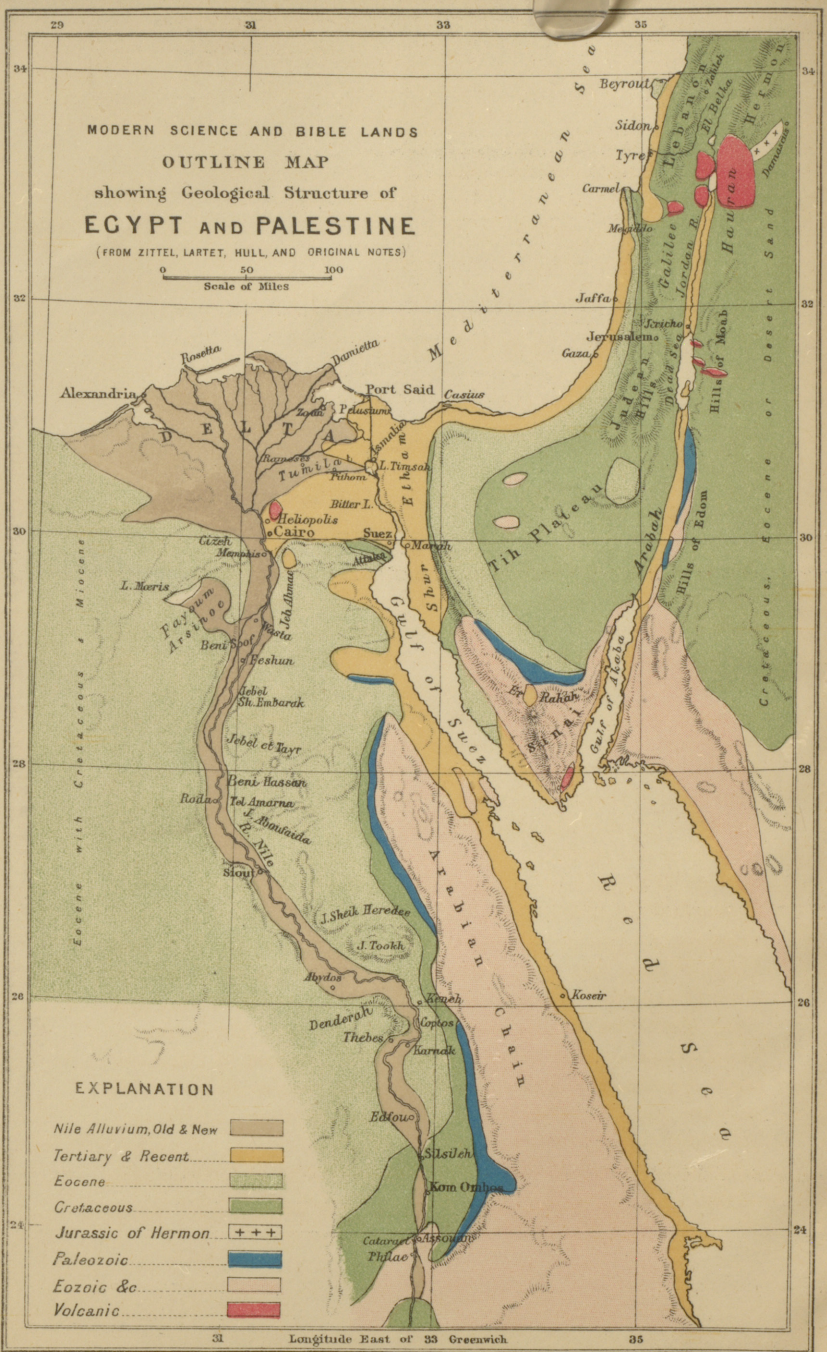

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APPENDIX.

SPECIAL NOTES ON THE GEOLOGY OF EGYPT AND PALESTINE.

I. GEOLOGY OF THE NILE VALLEY.[1]

1. *Raised Sea Margins.*

SHORTLY after my arrival in Cairo, Dr. Schweinfurth, of that city, was so kind as to conduct me to a remarkable sea-terrace at the foot of the Mokattam hill, behind the tombs of the Caliphs, and stated on the authority of Col. Ardagh, R.E., to be at an elevation of about 200 feet above the level of the sea, and which, I believe, was first described by Oscar Fraas. At this place a cliff of hard eocene limestone, about thirty feet in height, has been perforated by *Lithodomi*, whose burrows are now filled with grey calcareous deposit; and valves of a small species of oyster are also attached to the surface of the rock. The burrows resemble those of an ordinary Mediterranean species of *Lithodomus*, but I did not see the shells. The oyster has been described by Fuchs, as a new species, under the name *O. pseudo-cucullata*; but, according to Dr. Schweinfurth, it does not seem distinguishable, except as a variety, from *O. cucullata*, Born. (= *O. Forskali*, Chemn.), of the Red Sea. Since the locality was observed by Fraas, Dr. Schweinfurth has discovered other shells in the crevices of the rock, more especially a *Pecten*, a *Terebratula*, and a *Balanus*, all modern species. The recent character of these shells and their mode of occurrence and state of preservation, oblige us, I think, to assign them to the Pleistocene, or at farthest the

[1] The substance, in part, of the following notes was published in the *Geological Magazine* of London, 1884.

later Pliocene period, though I am aware that they have been regarded as Miocene.

Shortly after visiting this place, I was so fortunate as to discover on the opposite side of the Nile a similar exposure, distinct apparently from any of those referred to by Fraas, associated with an old sea beach, which I subsequently examined more carefully in company with Dr. Schweinfurth. It occurs at the summit of a rocky knoll, called by the Arabs

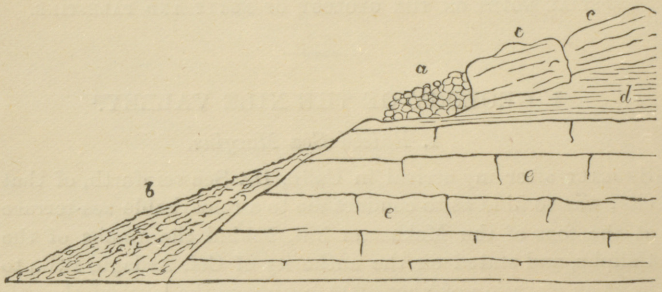

FIG. 1.—RAISED BEACH AT GIZEH.
(*a*) Beach. (*b*) Sand. (*c*) Brown Limestone. (*d*) Clay and Marl. (*e*) Limestone.

Het-el-Orab, or the Crow's Nest, a short distance to the south-west of the pyramids of Gizeh, and separated from the plateaux of the pyramids by the depression which contains the sphinx, and which is partly natural, but in great part produced by excavation, of which evidences exist not only in the remaining

FIG. 2.—MOKATTAM TERRACES FROM THE NILE.

chips of stone, but also in the sphinx itself, and in the tomb crowning an isolated mass of rock farther to the west.

I may remark here, that in the vicinity of the pyramids the great succession of Eocene beds, 600 feet in thickness, which,

in the Mokattam hill, appears in a perfectly regular manner,[1] has been so affected by lines of fault that some of the higher beds are brought down to a comparatively low level, and consequently in the Het-el-Orab a portion of the series which in the Mokattam is at a height of at least 400 feet, descends to an altitude of about 160 feet above the sea-level. The throwing down in this way on the Lybian side of the Nile valley, in contrast with the comparatively undisturbed condition of the beds on the Arabian side, has no doubt borne an important part in determining the present position of the river. The Nile valley, in short, occupies a north-and-south dislocation, not unlike, though inferior in amount of down-throw and up-throw, to that of the Jordan valley, described in the text.

The side of the Het-el-Orab next the pyramids presents

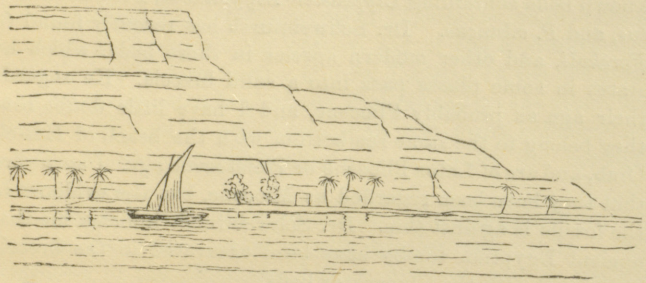

FIG. 3.—TERRACES IN EOCENE LIMESTONE ABOVE ASSIOUT, ON ARABIAN SIDE OF THE NILE.

a vertical quarried face, with a slope of *débris* below, and at top some beds of marl and gypseous clays, surmounted by coarse limestone containing Upper Eocene fossils, for the identification of which I am indebted to Dr. Schweinfurth. On the opposite, or south-east side, the hill is in its natural state, and shows a sea-worn cliff, in which the upper hard beds have been partially let down and disturbed by the undercutting of the marls and clays beneath them. Here the edges of the limestone have been perforated with *Lithodomi*, and are covered with oyster-shells, often showing both valves in

[1] Schweinfurth, "Proc. German Geol. Survey," 1883.

contact, and better grown than those in the locality of the Mokattam. There are also a few *Balani*, but we observed no other species. Under and against the edges of the rock has been piled a very coarse sea-beach, composed of rounded fragments of limestone, with a few basaltic-like pebbles not native to the locality. The interstices of these are often packed with loose oyster-shells. The pebbles of the beach are somewhat cemented together by calcareous matter, but otherwise the whole is as fresh as if only recently deserted by the sea. The old beach has however been cut by subsequent aqueous erosion since it became consolidated, as it now stands on the side of the cliff with a vertical face about forty feet above the sandy plain below.

A little way over this plain to the southward are the well-known beds containing *Clypeaster Ægyptiacus*, *Pecten benedictus*, and *P. aduncus*. Dr. Schweinfurth has recently found *O. Forskali*, and other modern species in these beds, which he states in some places pass into a solid breccia. He regards their age as probably Pliocene, and I have little doubt that they belong to the same sea-bottom with the beach of Het-el-Orab, and are of Later Pliocene or Pleistocene age. I am aware that they have been regarded as Miocene, but the evidence of the fossils is against this. Dr. Schweinfurth informs me that ancient Egyptian tombs have been excavated in the breccia associated with the Clypeaster beds.

It is evident that the submergence indicated by these sea-margins would with the present levels carry the sea far up the Nile Valley, as the top of the Cataract at Assouan is only 300 feet above the sea-level. I noticed at various points on the Nile as far up as Silsilis, a terrace corresponding with the height of the raised beaches, and probably a continuation of the same shore, indicating that in the Pliocene or Pleistocene age the Nile valley was an arm of the sea. Dr. Schweinfurth has noticed, in a paper of more recent date, the occurrence of similar deposits much farther up the Nile, at Seedment, near Beni Ssuef, which is precisely what I would have anticipated.[1] With this submergence I would also associate the older beds

[1] "Proc. Berlin Geol. Soc.," January, 1886.

of consolidated gravel seen at Thebes and elsewhere in the Nile valley, and the transport of boulders from the hills east of the Nile into Lybia, as seen at Denderah.[1] The Theban gravels above referred to are those in which flint flakes supposed to be of human workmanship were found by General Pitt Rivers. If really of this origin, they would prove the residence of man in Egypt at a time when only the higher parts of the country were above the level of the sea. For reasons stated elsewhere, however, I doubt very much whether they can be attributed to man.[2]

We may also connect this recent submergence with the sandstones and raised beaches holding modern shells in the vicinity of Alexandria and of the Red Sea, and with the similar sandstones of the maritime plains of Syria, which near Jaffa and at Beyrout attain to elevations of about 200 feet. We thus have evidence of a very extensive Pleistocene submergence, extending all around the eastern end of the Mediterranean. It is limited in date by the Middle Tertiary on the one hand, and by the elevated land of the Post-Glacial on the other, and was not improbably coincident with that great submergence of the Pleistocene which affects so generally the northern hemisphere.

There is, I think, evidence at Cairo that this submergence was in its earlier period of still greater magnitude. The elevation of the Mokattam hill is 640 feet, and it consists of slightly inclined Eocene deposits, the lower part of which are for the most part pure marine limestones, while about one-third of the upper part consists of coarse brown limestone, with marly beds and clays. At the height at about 500 feet, and near the junction of these two members, there is a broad flat terrace, especially on the western side; and though no marine shells have been found on this, it is scarcely possible to pass along it and examine its bounding cliffs and caverns, without being convinced that it has been produced by

[1] Newbold notices these, "Journal Geological Society of London," vol. iii. I saw numbers of these boulders scattered around Denderah. They seemed to be crystalline rocks from the Arabian range, and if not drifted by ice, must have been washed along a coast-line now removed.

[2] "Trans. Victoria Institute," 1884.

surf erosion. The continuation of this terrace may be observed here and there along the Nile as far as Assouan, beyond which place I had no opportunity to trace it. With this second terrace, older no doubt than that at a lower level, I would connect the denudation of the probably miocene sandstones containing silicified trees, of which Jebel Ahmar, near Cairo, is a remnant, and also the denudation of the Judean hills and the lower slopes of Lebanon, and the higher marine terraces of the Red Sea.

In contrast with these evidences of subsidence, I may now refer to the fact that at a later date, and more immediately preceding the historic period, the land of Egypt was probably higher than at present. The occurrence of patches of sand projecting through the Nile mud of the Delta, noticed long ago by Newbold, and the fact, ascertained by the recent borings by Col. Ardagh, that at a depth of 30 to 40 feet the alluvial mud of the Delta in some places rests on deposits largely composed of desert sand, show that in post-glacial or early modern times the plain of the Delta was a part of the desert, through which the Nile probably ran in a narrow and deep channel, and more to the eastward than at present.[1] A subsequent slight depression near the beginning of the historical period placed it in a position to receive and retain the inundation mud. This, with the further protection afforded by the line of raised beaches along its northern edge, rendered the formation of the Delta easy, and enabled its alluvial soil to be deposited in a much shorter time than would have been required had the Nile poured its deposits into a maritime bay of considerable depth, and unsheltered on its seaward side.

2. *Tertiary Deposits Later than the Eocene.*

The mass called Jebel Ahmar, or the Red Mountain, near Cairo, whose slopes consist of an immense accumulation of quarry rubbish, is composed of hard brown, reddish, and white

[1] The fresh-water deposits found in the central part of the Isthmus of Suez may belong to this period. See also the discussion of this point in the text, and extract from "Judd's Report," *infra*.

sandstone and siliceous conglomerate. In many parts it has the characters of a perfect quartzite, and appears at first sight extremely unlike a member of the Tertiary series, newer than the comparatively soft and unaltered Eocene beds on which it rests, apparently in a comformable manner, though its dip to the N.E. is somewhat irregular, and apparently affected by false bedding. The induration of the beds seems to be local, and to be connected with certain fumerole-like openings which have probably been outlets of geysers or hot siliceous springs, contemporaneous with the deposition of the sand.[1] Zittel, I believe, first gave this explanation, which suggested itself to me before noticing it in his memoir.

This mass is evidently a remnant of a formation at one time extensively distributed in this part of Egypt. This is shown by the fact that silicified trunks of trees, whose natural bed is in the lower part of this formation, near its junction with the underlying Eocene, are found scattered over the surface, not only in the great and little "petrified forests," but at Helouan, and even on the Lybian desert, on the opposite side of the Nile. Only the portions locally indurated by siliceous waters have escaped denudation, and it is the irregular appearance presented by these that has given the vague idea of a volcanic origin of these masses to so many travellers.

There has been much speculation as to the mode of deposition of the silicified wood;[2] but I think the study of it, as it exists *in situ* at Jebel Ahmar, is sufficient to set them at rest. It occurs in prostrate trunks, sometimes flattened and imperfectly preserved, and sometimes perfectly silicified, and occasionally lying in disintegrated cuboidal fragments, showing that the wood was imbedded in its natural state and in a decayed condition, and afterwards silicified. I consider the appearances decisive as to this point.[3] On the other hand, I could see no evidence that the trees are actually in the place of their growth. There seemed to be no "dirt-bed" or fossil

[1] Zittel, "Lybischen Wuste."
[2] Schweinfurth, "Proc. German Geol. Soc.," 1883.
[3] Newbold, "Quart. Journ. Geol. Soc.," 1848, vol. iv., states the same conclusion, p. 353.

soil. It seems probable, therefore, that the sand which was ultimately derived from the crystalline rocks of the interior, and perhaps proximately from the waste of the Nubian sandstone and the sandy Upper Eocene beds, was deposited in the vicinity of a wooded coast, or at the mouth of a river flowing through a wooded country, and that the trees are drift trunks imbedded in it. Their silicification is no doubt due to the presence of the siliceous springs to which the sand itself owes its induration. These springs, and perhaps also to some extent the deposition of the sandstone itself and its contained trees, may have been indirectly connected with the Tertiary volcanic phenomena which Schweinfurth has discovered[1] elsewhere in Lower Egypt. The thickness of these sandstones near Cairo must be about 100 feet.

The fossil wood of Jebel Ahmar and the petrified forests has been examined and partially described by various authors.[2] It includes several species of *Nicolia*, also conifers and a palm. Its affinities have been discussed by botanists, and it may be regarded as an African flora allied to that of the Soudan, and not improbably of Miocene age.[3]

It may be worthy of remark, that while this hard sandstone is now used only for millstones and for macadamizing the roads, it furnished to the ancient Egyptians the material of some of their most enduring sculptures. A curious shrine with a sphinx in the centre cut out of the same block, found in the temple of Tum at the site of the ancient Pithom, near Ismalia, is of this stone. Two large sacrificial tables in the Boulak Museum are of the white variety of the same stone, and are remarkable examples of the working on a large scale

[1] Beyrich, "Proc. Royal Acad. of Berlin," 1882.

[2] R. Brown, "Quart. Journ. Geol. Soc." iv. Carruthers, "Geol. Mag.," vol. vii. p. 306. Unger and Schenk,—Zittel, "Lybischen Wuste." The latter writers, besides *Nicolia Ægyptiaca* and *N. Oweni*, name five other dicotyledonous trees, *Acacioxylon antiquum*, *Laurinoxylon primigenium*, *Capparidoxylon geinitzii*, *Dombeyoxylon Ægyptiacum*, *Ficoxylon cretaceum*. They place also in this list *Araucarioxylon Ægyptiacum*, which seems rather to belong to the Nubian sandstone. The only conifer I have found among my Egyptian Miocene specimens is a species of *Taxites* not very remote in structure from the modern ginkgo.

[3] Schweinfurth, "Proc. German Geol. Soc.," 1883. Carruthers, "Geol. Mag.," xii. 306.

of a perfect quartzite. One of the colossi in front of the south propylon of Karnak is a monolith of similar material. Each of six colossi in front of this propylon was made of a different kind of stone, representing quarries in different parts of Egypt; and the one sculptured in this hard and refractory rock shows the bands of flint pebbles cut through and polished, along with the paste, which is nearly as hard as themselves.

The convenient name of "nicolia sandstone" has been bestowed on this formation by Zittel. Its relation to the underlying Eocene beds appears in the section Fig. 4, which also indicates the supposed outlets of hot springs and the horizon of the silicified wood, which, when laid bare by the denudation of its matrix, constitutes the so-called "petrified forests" of the deserts near Cairo.

Zittel has described extensive areas of Miocene deposits in

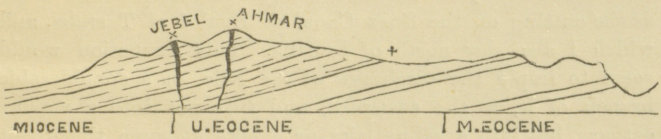

FIG. 4.—RELATION OF THE MIOCENE SANDSTONE OF JEBEL AHMAR TO THE EOCENE OF THE BASE OF THE MOKATTAM HILL.
(× ×) Supposed Geyser pipes. (+) Horizon of fossil trees.

the Lybian desert west of the Nile; and in the neighbourhood of Jebel Geneffeh, north of Suez, Fraas has found similar beds, but which do not appear to be very extensive in their distribution, being apparently limited to the district between Cairo and Suez. I had no opportunity to study these formations; but their chief point of interest appears to lie in the fact that they occupy low grounds resulting from the partial removal of the Eocene, which seems to have experienced both elevation and marine denudation before they were deposited. These Miocene beds have sometimes been confounded with the raised beaches and terraces holding *Ostrea Forskali*, and with the *Clypeaster* sands near Gizeh; but these, as already stated, are probably somewhat newer.

Another deposit, also newer than the Miocene, is that which

occupies the highest part of the Isthmus of Suez, immediately north of Ismalia, and which has been described by Fraas and Le Vaillant.[1] Though occupying a narrow space at the Isthmus, these deposits extend to a considerable distance east and west, and as they are overlain at both sides of the Isthmus by more modern beds, may be of greater breadth than appears at the surface.

As they occur near Ismalia, and in the cuttings on the Canal between that place and El Gisr, they consist of thin-bedded grey limestones with vermicular holes, in horizontal beds, and resting on marls, sands, and clays, with gypsum and nodules of chalcedony. The greater part of these beds are destitute of fossils; but in, or associated with, the series, there are layers holding freshwater shells, more especially *Ætheria Caillaudi*, Férussac, a species now confined to the Upper Nile, but which has been found by Le Vaillant in these deposits, as far south as the cutting on the Suez Canal at Shaluf el Terraba, and which I also saw north of Ismalia. This formation would seem to imply the discharge of the Nile, or a considerable branch of it, to the eastward, and this not into a marine estuary, but into a saline lake, or a lake at some times salt and at others fresh. The greater part of these deposits indeed greatly resemble those occurring in the elevated terraces of the Dead Sea. The deposition of these beds would also seem to have occurred at a time of continental elevation, when the Isthmus was represented by a wide extent of land, and during the prevalence of a warm climate.

The date of these beds must be placed between the Miocene period and the modern Red Sea and Mediterranean marine deposits which flank the Isthmus on the south and north. But within these limits we have two continental periods to decide between—that of the Pliocene and that of the later Pleistocene or Post-Glacial. Between these periods there does not seem at present any certain evidence to decide; but perhaps the modern character of the fauna, so far as it goes, may rather incline the balance to the later one. In this case we

[1] "*Aus dem Orient;* Bul. Geol. Soc. of France," vol. xxii. 1868.

should have a fact pointing to the solution of the difficulties felt by Lartet and Günther respecting the identity of Jordan and Nile fishes. We should at least be in presence of a state of things in which the outlets of the Nile and the Jordan would be much nearer together than at present.

Since these "Isthmian" beds, as we may name them for convenience, have been laid down, a submergence has occurred in which the modern sandstones and clays which flank them were deposited, as those of the Red Sea at least rise to heights nearly as great as that of the Isthmian beds themselves. As seen near Suez, these beds, some of which have been sufficiently consolidated by infiltration to form a serviceable building stone, consist of ordinary and pebbly grey sandstones, holding modern shells, still retaining their colours and animal matter, on which are, in places, marls and clays holding gypsum and salt. Though some of these beds are as much as forty feet above the sea, others are at the sea-level, and may be still in process of deposition, more especially as certain low areas of the desert are covered with salt water, and receive additional deposits in high tides accompanied with storms, during which, I was informed, large areas of desert south of Suez are overflowed by the sea. Between Suez and Jebel Attaka we rode over extensive tracts of low desert, which we were assured were occasionally overflowed in this way. These desert surfaces were in many places strewn with recent shells, while workmen were quarrying, at and near the sea-level, modern sandstone holding similar shells, and which was being employed in building a pier at Suez.

Under this head may be mentioned certain igneous rocks of age later than the Miocene, described by Zittel, as existing in the Lybian desert west of the Nile, and by Schweinfurth in the country north-east of Cairo, near Abou Zabel, and to which I have referred above. This eruptive rock is described as a basalt or fine-grained dolerite with olivine,[1] and may be of the same age with the basalts of the Hauran and Dead Sea, which it resembles in character.

[1] "Proc. Berlin Roy. Acad.," 1882.

3. *Eocene and Cretaceous Geology.*

Eocene beds occur on both sides of the Nile, from Cairo to El Kab, near Edfou, and have been very well described by several geologists, more especially by Fraas and Zittel. They are largely or dominantly calcareous, and rich in *Nummulites* in their middle portion. According to Zittel they attain to the thickness of 760 mètres, of which nearly one-third, or 600 feet in vertical thickness, can be seen in the single section of the Mokattam hill, near Cairo.[1] In this section, the upper or middle portions are those exposed. The lower part is to be seen in the vicinity of Thebes.

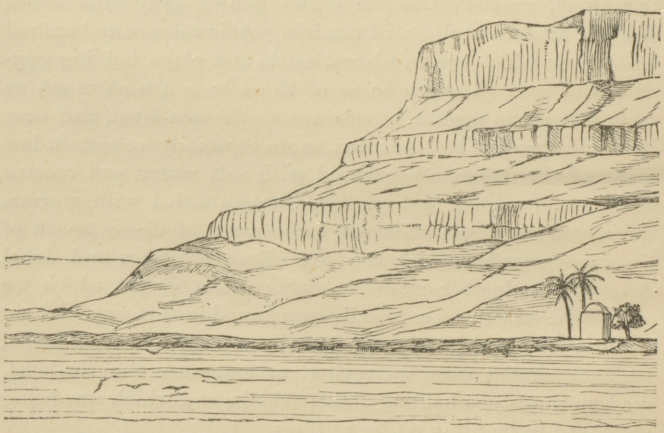

FIG. 5.—LOWER EOCENE LIMESTONE AND SOFTER BEDS NEAR THEBES.

Though these beds are nearly horizontal, or with only a slight northerly dip, they seem to be traversed by lines of fault, running approximately north and south, and east and west, which sometimes change the relative positions of the beds. On the Arabian or Eastern side of the river, the beds have probably been supported by the subterranean extension of the old crystalline rocks of the hills between the Nile and

[1] See Prof. J. Milne, "Geol. Mag." 1874, pp. 353–362; and review of Zittel's recent work, "Geol. Mag." 1884, pp. 172–179.

the Red Sea, and are consequently more firm and regular. On the Lybian side they are more disturbed, and probably somewhat thrown down and fractured. This is well seen at Cairo and Gizeh on the opposite sides of the river. At the former place the beds seem undisturbed. At the latter they are much shifted by faults, so that in places the newer members of the series are brought down to the level of the middle portions. To the north, where the crystalline rocks terminate, the east-and-west fractures become more pronounced. A very important one seems to pass through the Wady Dugla, behind the Mokattam hill, extending thence eastward towards the Red Sea. The north-and-south fractures have no doubt exercised an important influence in determining the position of the river valley; and their comparative absence on the eastern side has tended to give greater continuity and elevation to the cliffs on that side as far up as Thebes.

Schweinfurth's map and section of the Mokattam hill may be summarized as follows, in descending order,[1]—

Upper Eocene.

(*a*) Brown arenaceous sandstone at summit of the ridge 640 feet above the sea. Characteristic fossil, *Echinolampas Crameri*; contains also *Nummulites Beaumontii*.

(*b*) Ochraceous Marl, with clay ironstone, and abounding in fossils. The upper beds contain many bivalves, especially a Lucina. In the middle beds *Plicatula polymorpha* and *Ostrea Clotbeyi* abound, and the latter, with species of Turritella and Callianassa, is still abundant in the lower beds. Some small Nummulites also occur.

These Upper Eocene beds have an aggregate thickness of nearly 200 feet.

Lower Eocene.

(*c*) This, which attains a thickness of about 300 to 400 feet, is essentially a limestone formation, usually white, and rich in Nummulites and in some beds composed of small Foraminifera. One remarkable band is made up of Bryozoa. Among its characteristic fossils are the Cairo crab, *Lobocarcinus Paulo-wurtemburgensis*, the great *Cerithium giganteum*, and a variety of Echinoids belonging to several genera. This is the great limestone of the Nile valley, and constitutes the greater part of its boundary cliffs, the lowest Eocene beds appearing from under it far up the river in the vicinity of Thebes.

[1] "Proc. German Geol. Soc.," 1883.

At Thebes, the upper beds correspond with the middle and lower parts of the Mokattam series, but are underlaid first by Lower Eocene marls and clays and next by Cretaceous beds (Nos. 6 and 7 *infra*). The succession at and about Thebes may be stated as follows, in descending order :[1]—

(1.) Limestone with flint—*Ostreæ flabellata*, small Nummulites (*N. Thebaica*.

(2.) Marls and Limestones—*Schizaster*, *Amphidotus*, *Lucina squamula*, *Crassatella tumida*, *Nummulites*.

(3.) White Limestones with flints, *Lucina inflata*, *Cardita*, *Venus*, *Turritella*, etc.

(4.) Chalky White Limestone, foraminiferal. In this are the tombs of the kings.

(5.) Grey Marls, ostracoids, foraminifera, and shells of Lower Eocene types.

(6.) Chalky Cretaceous Limestone and plant-bearing series, clays and sands of Edfou (Upper Cretaceous).

(7.) Nubian Sandstone.

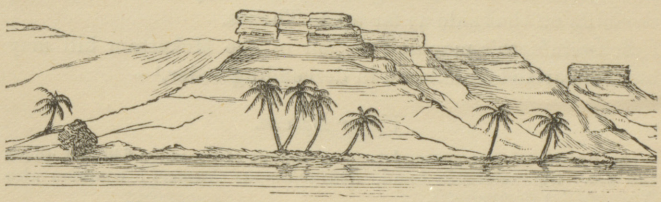

FIG. 6.—CRETACEOUS BEDS ABOVE SILSILIS.

In the beds at Edfou (No. 6 above), borings made for coal have ascertained the existence in clays and sandy beds of carbonized wood, striated leaves, and stems resembling those of reeds. The Cretaceous formation does not, however, attain to so great a development in Egypt as in Syria; and this, I think, is an important point with reference to the attempts which have been made to correlate the rocks of the two regions. We shall best understand their true relations by studying a section geographically intermediate, which we may find on the shores of the Red Sea, sixty miles to the eastward of the great Mokattam section, near Cairo.

Tracing the Mokattam range to the eastward, in Jebel Attaka on the Red Sea, it rises to a considerably greater elevation, and while its upper part consists of Eocene limestone, with

[1] Delamare, "Comptes Rendus," 1868.

Nummulites[1] and other characteristic fossils, its lower part is Cretaceous, and holds *Hippurites* and *Ostrea larva*. The Cretaceous here consists of hard limestones, not, in so far as I know, found in the Nile valley, but comparable with those seen farther east and north in Judea and the Lebanon, while the Eocene beds appear to be less highly developed and less purely calcareous than on the Nile. The structure of Jebel Attaka, in short, appears to afford a clue to the apparent anomalies of the distribution of the Cretaceous and Eocene in Egypt, Arabia, and Syria. It would seem that while in all these countries the Cretaceous and Eocene are conformable, and closely associated with each other, they have from the first

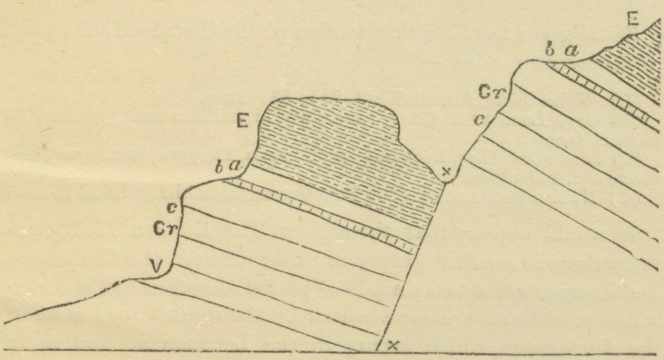

FIG. 7.—SECTION AT JEBEL ATTAKA (partly after Le Vaillant).
(E) Eocene: (Cr.) Cretaceous, including (*a*) White Chalky Limestone; (*b*) Red and Greenish Marl; (*c*) Hard Limestone and Dolomite with *Hippurites*, *Ostreæ*, etc.; (v) Position of Quarry; (× ×) Supposed Line of Fault.

been unequally deposited. The calcareous members of the Cretaceous, slenderly developed in Egypt, increase in volume on the Red Sea, and attain their maximum in Syria, while those of the Eocene show their greatest thickness in Egypt, and become depauperated farther to the east. This is at least what appears to me the obvious explanation of the difficulties

[1] It has been stated that *Nummulites* do not occur here; but I was so fortunate as to find specimens of coarse limestone full of them.

which have occurred in correlating the Cretaceous and Cocene beds of these countries.

M. Le Vaillant[1] has given a detailed section of the beds of Jebel Attaka, of which the following is asummary, in descending order:—

Eocene	Dolomitic Limestone—*Potamides* and *Cerithium* (Holds also *Nummulites* and various Eocene bivalves)	150	mètres.
	White Chalk	50	,,
Cretaceous	Red Marly and Gypseous Band	7	,,
	Alternations of Chalk and Dolomite	109	,,
	White Chalk	2	,,
	Dolomite — 2 species of *Hippurites*, *Ostrea larva*, *Janira sexangularis*, *Exogyra*	53	,,
	Total.....	371	

Zittel gives the following section of the Cretaceous of Lybia, n descending order:—

(1.) White Chalk, foraminiferal, 20 to 50 mètres.
(2.) Grey Laminated Clays, sometimes bituminous and gypseous, 30 to 80 mètres.
(3.) Limestone, Clay, Rock Salt and Gypsum, *Exogyra*, fossil wood, fish, teeth, etc., 150 mètres.
(4.) Nubian Sandstone. (The Palestine sections will be found below.)

It would appear that throughout the Eastern Mediterranean there is no stratigraphical break between the Cretaceous and Eocene, while two periods of partial elevation and shallow-water conditions are represented by the lignitiferous zone of the Cretaceous, which occurs in the Lebanon as well as in Egypt, and by the argillaceous and gypseous beds near the top of the Eocene in Egypt. The periods of greatest limestone deposition would seem to have been in the Middle and Upper Cretaceous in Syria, and in the Middle Eocene in Egypt. These facts serve to illustrate the importance of a detailed study of rocks and fossils in each locality, before instituting comparisons of horizons. The difficulties hitherto experienced in this have also arisen, in part at least, from a too close adherence to European distinctions, which may not be strictly applicable in the East, though the general order of succession of fossils is no doubt similar in both.

[1] "Bulletin Geol. Soc. of France."

The question of the age of the Nubian sandstones is at present somewhat difficult, and has recently been ably discussed by Hudleston[1] and by Hull. On the Nile it succeeds at Silsilis the Cretaceous beds above referred to, in descending order, and apparently conformably, and forms an east-and-west ridge, through which the river passes in a narrow gorge. In this outcrop are the celebrated quarries from which so much of the stone of the Egyptian temples was derived. The Silsilis exposure is, however, limited in breadth, and south of it beds similar to those on the north recur, leading to the supposition that there is here an east-and-west fault or roll of the strata, repeating the beds, or else that there are two distinct sandstones. I had not opportunity to work out this point satisfactorily, but believe that there is little reason to doubt the existence of a downthrow fault, repeating the Cretaceous beds, at the south of the Silsilis ridge. A little below Kom Ombos the sandstone reappears, and continues all the way to Assouan. At one point in this section two distinct beds are seen, the upper a ferruginous irregular sandstone and the under grey and laminated. They appear, as seen from the river, to be unconformable, but this may be merely false bedding. At another place the sandstone is seen to be shallow, a mass of dark-coloured crystalline rock appearing below it. At Assouan, however, where it reposes on the Laurentian and Granitic rocks, it appears in some places to be at least 100 feet in thickness.

The conformable manner in which the Nubian sandstone underlies the Cretaceous, and the occurrence of a few Cretaceous fossils in its upper part, have induced Zittel and others to consider the whole of it as merely a lower member of that formation. Of this, however, there is no distinct evidence in regard to its lower part; and the only determinable fossil hitherto obtained in this part of the formation—a species of *Dadoxylon*

[1] As Hudleston has remarked, Bauerman's section of the Tih escarpment exhibits a lower sandstone, in connection with which the fossils regarded as Carboniferous occur; while higher in the series there are other sandstones associated with calcareous beds holding undoubted Cretaceous fossils. "Geology of Palestine, Proc. Geol. Assoc.," vol. viii. See also Hull's Report.

(*D. Ægyptiacum* of Unger) — has a Palæozoic rather than Mesozoic aspect. Specimens of this wood have been obtained at Assouan and Kom Ombos; and Newbold mentions[1] the discovery of coniferous wood at Ipsambul, in Nubia, which must also have been in this formation. On the other hand, *Nicolia* is also stated to have been found in it; but this I suspect to be an error. In any case the Nubian sandstone is the oldest formation on the Nile next to the old crystalline rocks, to which it clings all along their margin, and from whose waste it is obviously derived. It may not improbably be a Palæozoic deposit, the upper part of which has been *remanié* and mixed with the early Cretaceous beds. This would imply a remarkably undisturbed condition of the Egyptian area in the later Palæozoic and earlier Mesozoic periods. There is, however, a similar case in the Triassic red sandstones of Prince Edward Island in the Gulf of St. Lawrence, which rest so conformably and continuously on the upper red sandstones of the Permo-Carboniferous from which they are derived, that it is almost impossible to separate them.[2]

If we appeal in this case to the so-called Nubian sandstones of the Sinaitic peninsula, we find that there Bauerman and others have found animal fossils of Carboniferous species as well as *Sigillaria* and *Lepidodendron*.[3] Of these I have seen only the specimen of *L. Mosaicum* in the collection of the Geological Society, which is in a hard grey sandstone, and has a decidedly carboniferous aspect. The sandstones of Wady-Nasb, which have afforded these fossils, are connected by a continuous line of outcrop with those of the east side of the Dead Sea, which underlie the Cretaceous of that region, just as the Nubian sandstone does in Egypt. It will be seen in the sequel that Hull has separated the lower sandstone under the name of Desert Sandstone; and Schweinfurth has recently found palæozoic fossils in the Nubian sandstone of the Red Sea border. The species are not named in his memoir, but

1 "Quart. Journ. Geol. Soc.," 1848, vol. iv. pp. 349–357.

2 Acadian Geology.

3 Tate, "Quart. Journ. Geol. Soc." 1871, vol. xxvii., p. 404; Hudleston, "Address to Geologists' Assoc.," vol. viii. 1883, pp. 1–53.

Beyrich seems inclined to refer these to the Devonian; they may, however, be Lower Carboniferous.[1]

On the other hand, I have studied certain sandstones associated with the lignitiferous zone of the Lebanon, and which have been correlated with the Nubian sandstones; but these are stratigraphically included in the Cretaceous limestones, and contain *Ostrea succini* and other Cretaceous fossils. They hold also fossil coniferous wood, which I have not yet examined microscopically, but it has a decidedly Mesozoic aspect. These Lebanon beds I would correlate with the similar beds above referred to, near Edfou in Egypt, rather than with the Nubian sandstone.

On the whole, therefore, it would seem that we have in Upper Egypt and in Sinai an upper palæozoic sandstone, supporting a not dissimilar sandstone of Lower Cretaceous age; and that the deposits which have been known by that name in the Lebanon are altogether distinct, and belong to a Cretaceous lignitiferous zone of Upper or Middle Cretaceous age. We shall further discuss this question under the geology of Palestine. I may add here that in Egypt there are sandy beds containing Cretaceous fossils, or alternating with fossiliferous limestones and marls above the horizon of the Nubian sandstone properly so called.[2]

4. *The Crystalline Rocks of Upper Egypt.*

A sudden and great change takes place in the geology of the Nile valley in approaching the First Cataract, where we pass from the unaltered and nearly flat Nubian sandstones to rocks highly crystalline, greatly disturbed, and penetrated with multitudes of igneous veins.

The gneisses and schists associated with granite and diorite at Assouan and its vicinity, though they have attracted the attention of the most unscientific travellers, have apparently as yet been little studied in detail. They have, however, been described by Lieut. Newbold in the "Journal of the Geological Society of London," vol. iii., and in the same Journal, vol. xxiii.,

[1] "*Bulletin de L'Institut Egyptien*," 1886.
[2] Ibid.

Mr. Hawkshaw has given a good map of their distribution, and has noticed most of the kinds of rock, though without inquiry as to their precise age or general mode of arrangement. Lartet has given in his "Geology of Palestine," a summary of the observations of Russegger, Rivière and Figari Bey on the crystalline rocks of the Nile; and the allied rocks of the Sinaitic peninsula have been described by him, by Bauerman, and by Holland, and more recently by Hull. All these authors have noted, more or less distinctly, a series of gneisses and micaceous and hornblendic schists, associated with intrusive granites and diorites, as the oldest rocks of these districts, and succeeding these in geological age, certain slates and

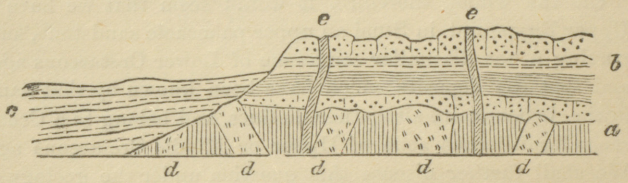

FIG. 8.—CRYSTALLINE ROCKS AND NUBIAN SANDSTONE AT THE ISLAND OF BIGGEH (Ideal Section).

(*a*) Older Crystalline Series (Laurentian). (*b*) Second Crystalline Series. (*c*) Nubian Sandstone. (*d*) Dykes of Granite and Diorite. (*e*) Dykes of Felsite and Basalt.

associated rocks, with porphyry and basanite in beds and veins.

The town of Assouan is situated at the northern end of a ridge of crystalline rock, which runs about south ten degrees west, along the side of the river towards the Cataract. South of the town a cutting has been made across this ridge for railway purposes, which affords a good opportunity for studying the structure of the formation. The following section is exposed in this cutting, beginning at the western end, the beds being nearly vertical, and with strike E. ten degrees north:—

Micaceous and hornblendic schists, with many red granite veins, one of them holding nests of broad-leaved magnesian mica	66 paces.
Dyke of coarse-grained hornblendic granite, with reddish orthoclase	6 „

Schists, as before, with large granite veins	53	paces.
Gneiss, with granite veins	7	,,
Schist, with much black mica	23	,,
Coarse orthoclase gneiss, with beds of schist	20	,,
Micaceous and horblendic schists	7	,,
Gneiss and schist	3	,,
Schists and gneiss	7	,,
Orthoclase gneiss	7	,,
Hornblendic and micaceous schist, with veins of coarse granite	41	,,
The same, with veins of red felspar	37	,,
Micaceous and hornblendic schists, much weathered at the surface	34	,,
Total	311	paces.

Eastward of the cutting the ground becomes flat, and does not afford a continuous section; but the decayed edges of micaceous and hornblendic schists, and thin-bedded gneisses appear at intervals for about 800 yards, after which they are overlain by the base of the Nubian sandstone, which farther east rises into the table-land of the Arabian desert.[1] The base of the sandstone at this place shows a thin bed of conglomerate, and upon this some soft calcareous layers, above which is the ordinary grey sandstone.

The above section represents at least two thousand feet in thickness of crystalline schists and gneiss, with granite veins. To the latter category belongs the huge dyke of granite at the north end of the ridge, in which are the principal Egyptian quarries, though there are other ancient quarries in granite, diorite, and sandstone in several places in this vicinity. One of the diorites has a porphyritic character, caused by crystalline patches of white felspar, and this stone appears as a material of statues and other objects in all parts of Egypt. Two sphinxes from Pithom, now in the square of Ismalia, are of this material. There are also dykes of a black basaltic rock. No crystalline limestones were observed, but from the manner in which the surfaces of the gneiss and schist are disintegrated, it may be inferred that the outcrop of limestones, if present, would be deeply eroded and concealed. It would seem from this disintegration that the climate here has

[1] In approaching the sandstone, the strike of the schists changes to about N. 7·0 degrees E.

not always been so rainless as at present. Possibly, also, some of the now crumbling rocks may have resembled the coarser earthy limestones or calcareous gneisses of the Laurentian of Canada, which, when weathered, present a very similar appearance.

Many of the granite dykes extend in the plane of the stratification, and for this reason it is not always easy, without careful observation, to distinguish them from the beds of gneiss. They are, however, generally coarser, and not laminated, and can be observed to send off branches into the adjoining beds. The mica present in the schists seems to be in all cases biotite rather than muscovite. The distinctly bedded character of the schistose rocks at Assouan is quite as manifest as in the case of the Laurentian of Canada; and the fact that the schistose structure is not an effect of pressure or crushing is manifest from the want of such structure in the true dykes.

At the Island of Biggeh, above the Cataract, and near to Philæ, there appears to be a second crystalline formation, resting in a horizontal position on the older gneiss and schists, and itself overlaid by the Nubian sandstone. The precise arrangement of these rocks could not be seen so clearly as was desirable, owing to the *débris* which covered the sides of the cliffs; but on the island of Biggeh their order appeared to be as follows, in descending series:—

(1.) Coarse dark-coloured porphyritic rock with large crystals of deep red felspar, darker in colour and more opaque than that of the lower series. This rock breaks into cuboidal masses, giving the cliffs composed of it a remarkable castellated appearance.
(2.) Fine reddish gneissose rock.
(3.) Black fine-grained coarsely laminated beds.
(4.) Coarse porphyritic rock (porphyritic granite), resembling No. 1. Below this are the schists of the lower series, in a position nearly vertical.

The whole thickness of this upper series appeared to be about a hundred feet. On the mainland east of Biggeh it forms a high ridge stretching to the eastward. These rocks are certainly not ordinary aqueous deposits, and would rather seem to be a series of bedded igneous rocks, ejected over the edges of the older series, and subsequent to its disturbance

and metamorphism, but before the deposition of the Nubian sandstone. Whatever the origin of these rocks, they appear to overlie unconformably the lower series, and they did not appear to be penetrated by the great granite veins. They are, however, traversed by veins of red felsite and of a black igneous rock, having the appearance of basalt.

Rocks of the character above described might of course admit of different interpretations as to their relations and origin; but as seen on the ground, they undoubtedly have the aspect of an overlying, unconformable stratified formation, and their crystalline character must be due to the conditions of their formation, and not to any subsequent mechanical action. They are, therefore, to be regarded as igneous or aqueo-igneous deposits.

Above the Cataract the river passes through a gap in the rocks above described, between the island of Biggeh and the eastern shore, and runs over the older series, the granitic dykes of which project in prominent masses above the softer schists, as may be seen in the rocks of Konosso, and the eminence on the west end of Philæ. In cutting back its channel, the Nile must originally have formed its First Cataract at the ridge of Silsilis, about forty miles below Assouan, and its waters were then dammed up so as to flood much of the river valley between Silsilis and the present site of the First Cataract. At this time the Nile probably flowed along the old channel east of Assouan; but so soon as the channel was cut back through the Silsilis ridges, it would rapidly extend southward through the softer beds to Assouan, and on reaching this place, the river would begin to remove the Nubian sandstone capping the crystalline rocks at the site of the present cataract. This process would seem to have disclosed an ancient break or soft portion in the underlying formation, enabling the present channel to be cut, and this has been done mainly by removal of the sandstone and of loose fragments of the second crystalline formation above referred to.

In so far as the locality at the First Cataract is concerned, we have no precise measure of age for the crystalline rocks. There is reason to believe that in the range of similar for-

mations extending northwards between the Nile and the Red Sea, beds occur of ages intermediate between those of the rocks of the Cataract and the Nubian sandstone; but the precise ages of these intermediate rocks are as yet uncertain. In these circumstances mineral character becomes our only guide. But this is by no means uncertain in its testimony. The schists and gneisses of the older Assouan series are identical in mineral character with those of the Grenville series of the Canadian Laurentian; and they have already been compared by Drs. Liebisch and Hochstetter with the rocks of the same age in Scandinavia.[1] In like manner, the second or overlying series has two points of similarity with the felsitic series found in America to occur at the base of the Huronian, which has been named by Hicks the Arvonian series, and to which the Swedish geologists have given the name halleflinte. I think, therefore, we may be justified in regarding these old crystalline rocks as African representatives of the Laurentian, and one of the succeeding crystalline formations; and of course the same conclusion would apply to the wide extent of similar rocks in this part of Africa, and to the southward as far as the Cape Colony, and which recur in the peninsula of Sinai. In any case, it is very interesting to find the oldest rocks of Africa presenting the same mineral characters with those of Europe and America.

Assuming the lower Assouan series to be Middle Laurentian, the next rocks to be expected in ascending order would be the Upper Laurentian and the Huronian. To the former the second Biggeh series bears no resemblance; but there are known to be in the Arabian chain, and probably associated with the equivalents of the Assouan rocks, Norian rocks of the character of anorthosite gneiss, a rock which was used by the ancient Egyptians for statuary, but is generally called diorite by antiquaries, though it differs very much from the true diorites of the country.

Dr. Schweinfurth has sent me, from the districts of the

[1] "Geological Society of Germany, Jahrbuch," 1877. I have placed a suite of specimens in the hands of Prof. Bonney, F.R.S., whose notes on them will be found below (Section II.).

Arabian chain north of Assouan, a rock similar to the more compact variety of the dark Biggeh rock, which he states forms ridges parallel to the main chain of crystalline rocks. Newbold refers to greenish and chocolate-coloured schists and quartzite, as bordering the older schists and granites, and Lartet notices talcose and chloritic slates with granulite in a similar relation, crowned by the celebrated green conglomerate and breccia of Kosseir and Gebel Doukhan. Further, Russegger connects the red porphyry and petrosilex porphyry with large felspar crystals of Gebel Doukhan with this second series, and Lartet has described the quartziferous porphyry of Mount Hor as lapping around the granite nucleus of that mountain.

It would thus appear that the Laurentian gneisses and schists of Upper Egypt and its eastern mountain chain are succeeded by formations which may be held to represent the Upper Laurentian and Huronian series at least; and I would regard the Biggeh formation, or second Assouan series, as consisting mainly of bedded volcanic material, representing some portion of the Huronian, a formation which would seem to have been more largely developed, or to be better preserved in some parts of the Arabian chain to the north and east where it is also overlain by slaty rocks, and by the green conglomerate which either constitutes an Upper Huronian series, or may represent the Animiké and Kewenian formations of America. There would seem in this district, as in Palestine, to be a great geological hiatus between these old rocks and the Nubian sandstones.

The rocks quarried by the ancient Egyptians at Assouan or Syene, for buildings, obelisks, and statues, seem to have been principally the red granite and different varieties of dioritic rocks; and the latter they obtained not so much from regular quarries as from projecting masses, the ruins of dykes exposed by denudation, and which had the double advantage of being free from cover, and of consisting of material of proved durability. Illustrations of their working such exposed masses may be seen in several places near Assouan. The thick granite veins often contain, as is not unusual in such masses,

G. M. Clark

APPENDIX

TO

MODERN SCIENCE IN BIBLE LANDS.

BY

SIR WILLIAM DAWSON, LL.D., F.R.S.

With Map.