

centre of gravity, and of course, as a consequence, the greater is the displacement of the ocean. It may be observed also that, other things being equal, the thinner the solid crust or shell is, and the greater the difference in the density of the fluid materials in the interior, the greater will be the extent of the displacement of the ocean, because the greater will be the displacement of the centre of gravity.

It follows that if we knew (1) the extent of the general submergence of the Glacial epoch, and (2) the present amount of ice on the southern hemisphere, we could determine whether or not the earth is fluid in the interior.

IV.—GEOLOGICAL NOTES FROM THE NEIGHBOURHOOD OF CAIRO.

By JOHN MILNE, F.G.S.

THIS neighbourhood has already been described by several authors, —the most complete account of the Tertiary beds being by Dr. Fraas, *Aus dem Orient*, 1867. Dr. Figari Bey, in vol. i. of *Studi Scientifici sull' Egitto*; H. Bauerman, Esq., and Dr. C. Le Neve Foster, in the *Quart. Journ. Geol. Soc.* 1869, vol. xxv. p. 40, have also written on the district, the latter observers referring especially to the occurrence of Celestine in the Moccattam quarries.

The surroundings, of Cairo, being by no means a geological *terra incognita*, there will perhaps be but little to be gleaned in the way of additional particulars respecting this district from the following brief communication; it is therefore hoped it will be accepted rather as a note to accompany the few specimens collected¹ than as an independent paper.

Middens or Rubbish Heaps.—Outside Cairo, and noticeably so between its N.E. and S.W. sides, there are a number of dark-coloured low hills, forming a range about four or five miles in length, with an undulating surface,—in contour not unlike the Downs of our southern counties. In places these approach so closely to the city as partially to bury the walls with which it is surrounded, above which they rise rather steeply, at an angle of 25° to 28°, to a height of from 100 to 125 feet. On the opposite side, that is, towards the S.E., they slope more gradually, descending by a series of undulations and small valleys of the same depth as the hills are in height. The summit of these hills, which may be averaged at a quarter of a mile in width, and which, with the lateral ridges, is sufficient for the accommodation of numerous windmills, affords an extensive view towards the S.W. across Cairo to the Pyramids of Gizeh, and towards the E. over the plain in which are situated the Tombs of the Caliphs to the range of Moccattam. This view is represented as a diagram, in order to show the relation of the Red Hills to the Limestones of Moccattam, and also the dip of the strata. (See Woodcut, Fig. 1.)

It is not until these hills are approached and closely examined that their nature can be determined, after which one contemplates them

¹ The specimens referred to, have been presented by the author to the British Museum.

with astonishment, and marvels that such an immense amount of material, sufficient to build many such towns as the one from which it was derived, should have all been accumulated by human agency.

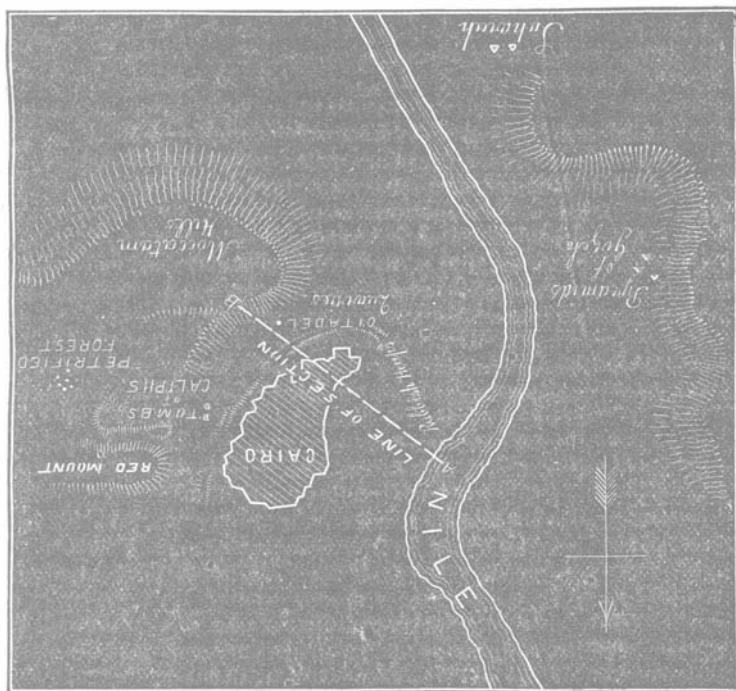


FIG. 1.—Sketch-map of the neighbourhood of Cairo.

Similar heaps to these are to be seen marking the position of many other cities, as at Memphis, where they may perhaps even exceed those at Cairo. No careful investigation of these vast Refuse Mounds appears at present to have been made. This Egyptian darkness may, perhaps, in part be removed by an archaeological exploration of their contents, pottery and coins being interpreted by the antiquary as fossils are by the palæontologist.

On approaching these heaps from the end of the principal street in Cairo, "the Mosque," a definite dip at an angle of 4° or 5° , is seen towards the S.W. along a line about fifty yards in length.

Behind some limekilns at this point, about twenty-five feet above the base of the heap, there is a cutting in the side of the slope, about thirty feet in length and ten feet in height. The materials in this exposure are arranged in distinct layers, the chief constituents being comminuted fragments of brick and mortar, black soil, broken crockery, charred wood, fragments of bones, and a few land-shells, (*Helix*),—the pieces of wood and bones marking what may be termed the stratification, in which they are aided by a corresponding horizon-

tality in all the pieces of crockery ware, which either fell in the position they now occupy, or else have gradually acquired it.

Many pieces of the pottery are highly coloured, rich greens and blues being common. On some of them designs, such as patterns of flowers, are noticeable. Small pieces of granite and quartz are also met with, and near the surface heads of old pipes and date-stones.

Bits of Nummulitic Limestone and detached Nummulites have travelled from the adjacent hills, to be imbedded with the rest; and on the eastern side of these heaps, near the summit, at about two or three feet from the surface, and occasionally on the surface itself, there are many recent shells.

The material covering the sides and tops of these ranges of hills only differs in being coarser than the rest, most of the finer débris having been washed down into the valley during rainy seasons, where it has accumulated and forms a fine mud-grit.

Plain of the Tombs of the Caliphs.—Lying between these rubbish heaps and the range of Moccattam Hills there is a narrow sandy plain, about a mile and a half in width. At the N.E. end of this, opposite Jebel Achmar or the Red Mountain, numerous small excavations have been made beneath the surface (which has a crispness, from the salt it contains), in order to obtain a fine greenish-grey gritty sand used for domestic purposes. In these openings numerous skulls and other human bones are seen strewn over the ground.

Not far from these small openings a trench, from fourteen to sixteen feet deep, had been excavated, about 300 yards in length, in the direction of the waterworks, giving a good superficial section of the desert, but not sufficiently deep to reach the limestone seen in the adjacent heights. For six feet from the surface there is a coarse sand, with occasional fragments of pottery, and innumerable human bones—skulls, femora, tibiae, ribs, and in fact many almost perfect skeletons. Judging from the number of these remains, the way in which they are confusedly heaped together, and the wide extent of ground over which they extend, they probably resulted from some great epidemic, such as the plague, which may have visited the city long ago.

Looking at the depth at which these remains occur, and remembering that in Eastern countries it is customary to bury barely beneath the surface (?), it may be inferred, from the accumulation of sand and other materials above these relics of humanity, that a considerable time has elapsed since their interment.

Below six feet no more pottery exists, and excepting the fragment of a shell, only sand, containing innumerable flints and pieces of silicified wood, is to be seen.

Moccattam Quarries.—These truly historical quarries form a long line of cliffs, overlooking the eastern and south-eastern side of Cairo, the height of which above the Nile is about 800 feet, and above Cairo 525 feet, as will be seen in the accompanying sketch section, the elevations on which were approximately obtained by several aneroid observations. (See Woodcut, Fig. 2.)

The general dip of the beds forming this escarpment is towards

the N.E., at an angle of from 4° to 5° , diminishing in height towards the north, in which direction they pass beneath the red quartzose hills of Jebel Achmar.

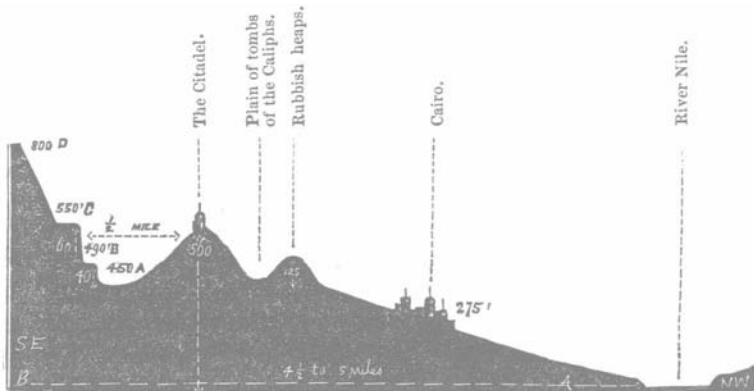


FIG. 2.—An approximate section along the line A-B on Fig. 1.

The section of these quarries is the largest and most noticeable excavation along the entire range, being worthy of a visit, if only to see the magnitude of the works which for past ages have been and still continue to be carried on. The quarries are situated behind the Citadel, a general plan of which is seen in Fig. 3, and in section Fig. 2, and Sketch-map Fig. 1.

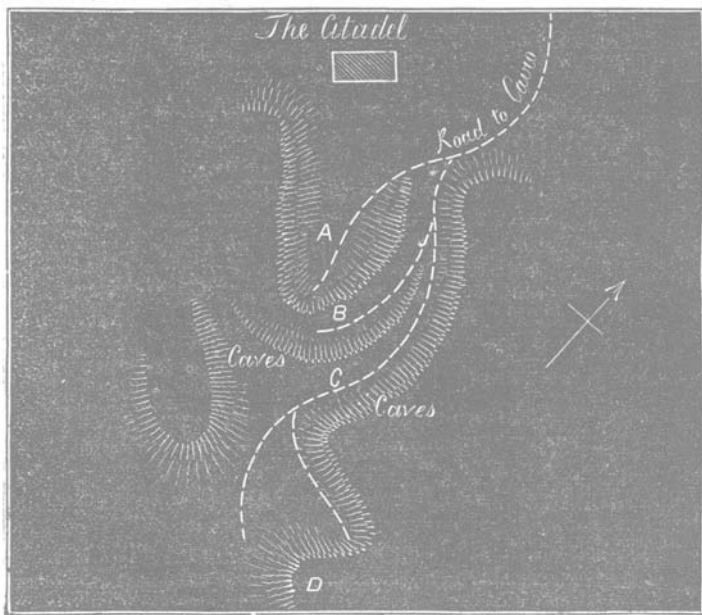


FIG. 3.—Plan of the Great Moccattam Quarries behind the Citadel, Cairo.

Reckoning from the walls of the Citadel, near which the excavations originally commenced, the hill has been cut back for a distance of about half a mile. The workings of the quarry are carried on along the face of three scarps, which, in conjunction with its semi-circular form, give to it the appearance of an amphitheatre. Entering the quarries from the rear of the Citadel, the road divides; the lower branch leading into what might form the arena of a theatre (Fig. 3, A.), the lowest part of the quarry, 350 feet below the summit of the hill; the upper branch, after running a short distance towards the rear of the quarries, in its turn also splitting into two branches; one of which (Fig. 3, B.) leads along the base of the second scarp, forty feet above the lowest part of the quarry; whilst the other (Fig. 3, C.), after winding round the end of the quarry at from 80 to 90 feet above its lowest point, turns to the left, and passing through a narrow valley opposite to the Citadel, gradually ascends to the summit of the hill.

These different roads and levels are referred to in Section Fig. 2, and Plan Fig. 3, by corresponding letters.

A striking feature in this quarry is the immense blocks of stone which are scattered about in all directions. One of them, in the upper road C, in measurement was found to be 57 feet long, 18 feet high, and 18 feet thick, representing about 1400 tons of stone; and from one point on the road I counted upwards of forty blocks approximating to, and in many cases perhaps exceeding, the dimensions of the one just quoted. These blocks, which have been obtained by the undermining of the cliff, aided by natural vertical joints, now form small quarries in themselves, being more readily worked and broken in upon than the upright face of the cliff from which they were detached. Where these cliffs have been worked in upon, several large caves have been produced, the positions of which are indicated in Plan, Fig. 3. One of these shows a flat roof, about 30 or 40 feet in height, and 90 feet in an unsupported span.

Standing at a distance, and looking at the range of hills in which these quarries occur, it will be seen that there is a marked difference in colour between the rock forming the cap or head of the mountains and that exposed in the cutting below—the upper strata being reddish, whilst the lower ones are white, which at once suggests the idea, which has been followed out by previous observers, of dividing the beds, according to their physical aspects, into Brown Beds and White Beds. The thickness of the former beds behind the Citadel, as estimated by aneroid, is about 125 feet; whilst the exposure of the White Beds, from the junction with the Brown Beds above to the foot of the quarry, is about 225 feet.

These measurements may be compared with those of a section of the same beds taken about a mile and a half to the north, given in the paper by Messrs. Bauerman and Foster previously mentioned, from which it will be seen that behind the Citadel the Brown Beds have in so short a distance more than doubled their thickness.

Looking at these Brown Beds generally, it will be seen that their surface is much weathered and decomposed, and forms a reddish soil,

which in places is clayey, this latter appearance being probably due to the decomposition of certain bands rather than to a breaking up of the whole. The White Beds are the well-known Nummulitic Limestone. This is soft, easily worked, and, when freshly broken, is perfectly white; but on exposure, it becomes slightly yellowish. Standing a short distance away from the face of this rock, a division in the beds is to be seen, marked by yellowish horizontal lines, which are in certain cases somewhat siliceous. In addition to these markings, there are others, more strongly defined, indicating fissures and cracks, which are often filled with a yellow oxide of iron, in certain cases of a sufficiently good quality to be used for a pigment.

Commencing at the summit of the hills behind the Citadel, the general succession of beds in their descending order is represented as follows. The letters refer to the fossils.

I.—*Red Beds.*

- A. 1.—The capping beds here consist of a coarse limestone, almost wholly made up of shells. It is much weathered, and its surface is strewn with dark-coloured stones, the angles of which are much rounded. Externally these are very vesicular, like a hard burnt cindery slag; but on being broken, they are seen to be more compact, showing transverse sections of shells. These probably formed portions of still higher beds, which have been by a subaerial degradation carried away; their vesicular character being due to the dissolving out of a portion of the shelly matter of which they are almost wholly made up.

These top beds are traversed in various directions by a few small veins of gypsum, which are generally not more than a quarter of an inch in thickness.

- B. 2.—About 30 feet below these beds of limestone we get a reddish yellow band of soft calcareous sandstone. In places this is siliceous, and from its friability almost becomes a sand, whilst in its lower portions it resembles a loam. It contains but few fossils, but in one portion it is full of numerous small nests of crystallized carbonate of lime. These crystals are small, but all more or less assume the same geometrical form,—that of a scalenohedron, terminated by the planes of an obtuse rhombohedron.
- 3.—At the base of this there is a band apparently wholly made up of Oyster-shells.
- C. 4.—Below this there are six feet of a yellowish earthy band, which is followed by a three-foot band of Oysters.
- D. 5.—Still lower we come on more yellow sandstone and a thin band of shells, the base of which is about 60 feet from the summit of the hill.
- E. 6.—Below this 60-foot level the sides of the hill are covered with a soft earthy mass of sand, produced by the disintegration of the rocks above, which to a great extent conceals the underlying strata. A slight efflorescence of salt, giving a whitish appearance

to the ground, together with a few veins of fibrous gypsum coursing upwards, is all that is observable.

A few yards to the N.E. side of the road a cutting about 20 feet in depth has been made, exposing compact beds of yellowish sand. Running through the face of this there are five almost horizontal bands of gypsum, under one of which, and almost in contact with it, is a narrow band of Oysters, which, being more compact than the beds of sand, stand out to form a small ledge. The largest of these bands is not more than three inches in thickness. Between them, imbedded in the sand, several hollow and angular shallow forms, composed of sand cemented with carbonate of lime, and lined with small crystals of calcite, were observable, probably pseudomorphs after Celestine.

The base of this cutting is from 75 to 80 feet from the summit, and appears to be the lowest exposure of the Red Beds.

From this point there is a descent of about 50 feet down a bank of earth-sand, covered with fragments of gypsum, the result of the disintegration carried on up above to the Limestones or White Beds in which the quarries are.

From these notes it would appear that the characteristic feature of these upper or Brown Beds is the number of bands made up of fossil *Ostreæ*. At a short distance in many places these appear like a shale, and it is not until a close inspection is made that their real nature can be seen, which in some cases bears a striking resemblance to the beds of *Ostrea distorta* in our Purbeck series.

Imbedded with them are other shells, which may be easily detached; but the Oysters themselves are so matted and friable that it is difficult to obtain single specimens.

II.—White Beds.

F. These commence 125 feet from the summit of the hill, and lithologically are very similar down to the lowest point yet excavated, 225 feet still lower, the lower beds differing from those above them in perhaps being more compact and of a fine texture. In places the rock is visibly almost wholly made up of fossil remains, these being more apparent in the upper than in the lower beds.

7.—At 160 feet from the summit on the north side of the road there is a concretionary band of limestone, the nodules of which are discoidal, about the size of a potato, but not noticeably elongated.

On this level, which is that of the road marked C on Plan, Fig. 3, numbers of minute Nummulites are visible, together with species of *Echini*. This is also an horizon of the beds containing Celestine, specimens of which may be seen in radial forms imbedded in the white limestone. When they fill the chambers of some fossil, as a Nautilus, perfect, well-defined, and brilliant faces of crystals are to be seen,—the various forms and combinations of which are described in the paper already referred to by Messrs. Bauerman and Foster (*ante* p. 353).

G.8.—Lying along the line of the second road, in Plan marked B, are many blocks that have fallen from above, and are seen to be full of Celestine. Here the rock is more compact than above, and the fossil remains are not so distinct, with the exception of certain Crustacea, which are remarkably well defined, the species *Lobocarcinus Paulino-Wurtembergensis* being very common. In the face of this scarp there is a noticeable yellow band, containing Oysters and Nummulites.

H.9.—The line of the lower road, marked A upon Plan, leads into the lowest part of the quarry, 350 feet from the summit. Celestine is also found here; but it apparently differs from that found above in being massive, one piece showing an exposed surface 1 ft. 9 in. wide, perfectly transparent, and of a light yellow colour,—no transparent colourless crystals or opaque bluish white stellar forms, like those described by Bauerman and Foster, being found.

About 12 feet up the face of this scarp there is a bed exceedingly full of Nummulites, corals, and other fossil-remains, together with some remarkably well-preserved casts of a spiral shell, probably a species of *Turbo*.

In travelling towards the north, in the direction of the Tombs of the Caliphs, owing to the dip of the beds in this direction, newer beds, corresponding to the second and third scarps of the Citadel Quarries, are met with, sections of which may be observed in the many valleys entering from the N.E.

Immediately outside the quarry in this direction numerous shark's teeth are met with, which are followed by large *Nautili* and other fossils. In the quarries behind the Tombs of the Caliphs Crustacea and casts of *Turbo* are again met with in abundance, beyond which, on crossing a small valley, you come to Jebel Achmar, or the Red Mountain.

Jebel Achmar.—This mountain or chain of hills is about 225 feet above Cairo. At a distance they appear to be very red; but on nearing them this is seen to be partially superficial, the exterior colour being due to an oxidation through exposure of the iron contained in the rock, which is a moderately fine-grained yellowish quartzose sandstone.

The texture, however, varies, portions having quite a conglomeratic aspect,—white quartz pebbles about a quarter of an inch in diameter being inclosed in a red base.

The fine parts of the rock are quarried for grindstones and mill-stones, which are manufactured in Cairo.

Petrified Forest.—This interesting deposit of silicified wood having been already described by Mr. W. Carruthers, F.R.S. (GEOL. MAG. 1870, Vol. VII. p. 306), it will be well not to run over old ground, but rather to describe the road leading to the so-called "Forest," than to speak of the Forest itself.

Leaving the Red Hills upon the left, the track towards this Forest enters the second valley counted in the direction of the Citadel, crossing the entrance to which, and also running up it for a short distance, is a tramway for fetching stone.

The entrance to this valley is narrow, being bounded on the right and left by cliffs of limestone, which dip at a low angle up the valley, those on the right being about 50 feet in height, and those on the left from 20 to 30 feet. As the valley gradually widens, to a breadth of about half a mile, the cliffs and hills which form a scarp to it become lower. Covering the ground over which you walk are fragments of gypsum sparkling in the sand, as mica often does in the gravels of our streams, which probably indicate the presence at some point higher up the valley of the sand-beds seen above the Citadel Quarry. Opposite to the termination of the tramway, which is about half a mile up the valley, upon the right-hand side of the road, there is a knoll of black stones, in the distance something like a low volcanic cone. This is made up of a similar but darker coloured rock to that of Jebel Achmar, and in fact apparently marks the eastern boundary line of this red quartzose formation, which forms several outcrops, and appears to run up the right-hand side of this valley.

Keeping to the right hand at all junction of tracks, you pass along the foot of the limestone hills, whilst opening out upon the left there is a wide flat plain, which shortly narrows into a flat valley. Near the head of this, many black masses of quartzite, similar to the one just mentioned, are seen, covering portions of the hills. If a line were drawn passing through these heaps of *débris*, it would take a N.W. direction towards the Red Hills.

At the first of these mounds there is a ridge of the material, which is apparently turned on end, the left-hand side of which is quite a dark-coloured flint; whilst the right-hand side cannot be distinctly seen, from the quantity of *débris* which has fallen from above upon it, amongst which there are several large fragments of silicified wood.

Standing up from a sandy rock on the west or Cairo side of this ridge, there are a number of short cylinders, averaging six inches in length to one inch in diameter, formed of concentric layers of sand, the structure of which is seen in a transverse fracture.

Near the head of this valley, at the entrance to a small cutting into the hills upon the right, the relation of the limestones to one of these siliceous ridges is to be seen. This, like the others, strikes in the direction of the Red Hills, dipping at an angle of about 80° to the N.E., upon that side it is a fine-grained siliceous rock, from which it graduates in a thickness of only two feet through a pudding-stone, into a soft quartzose sandstone upon the N.E.

Coming down the cutting upon this side are some narrow bands of limestone, overlying beds of sand, also dipping to the N.E., but only at about 5° or 6° , which, but for the intervention of a few feet of sandy material, would apparently be seen to abut against the up-turned ridge.

A short distance beyond this last-mentioned ridge the track turns sharply to the right, and enters, between sloping masses of red rock, into a large opening, resembling a shallow sand-pit, above which is the Petrified Forest.

Generally speaking, this consists of fragments of silicified wood about six inches in length, which are strewn over about four miles of desert. Where the trunks from which they have been derived are shielded from the sun by lying buried in the sand, and have thus been protected from sudden changes of temperature, they are often preserved in pieces several yards in length. When fissured, they do so rather down the trunk than transversely to it, which would seem to contradict Gardiner Wilkinson's suggestion,¹ referred to by Mr. Carruthers,² that there are "some jointed stems resembling bamboo or *Equisetum*." In the same paper it is stated that no branches were observable, which appears to be the case; but I was assured on good authority that at the New Petrified Forest a tree with the limb of a large branch may be seen. The larger trees referred to may be seen by taking a S.E. course towards a distant bluff across this desert. After about a mile you reach the north end of a line of low sand and gypsum hills, keeping along the eastern side of which you shortly come upon numerous trunks lying in the sand, some of which are 40 feet long and two feet in diameter.

Beyond these, still continuing in a S.E. direction, through a gap in the low sand-hills, for a quarter of a mile across the next open valley, some extensive Oyster-beds are reached, from which some perfect specimens may be obtained.

On the opposite side of the Nile to that on which Cairo stands are corresponding hills to those of Moccattam, in which are the ancient quarries of Sattanah. At the Pyramids of Gizeh, which are built of Nummulitic Limestone, the Sphinx is seen cut out of the solid rock, and exhibits in the material composing it a natural N.E. dip and the eroding effects of tens of centuries of sand-blast.

V.—NOTE ON THE RED CHALK IN YORKSHIRE.

By the Rev. J. F. BLAKE, M.A., F.G.S.

IN mapping the boundaries of the Lias in that part of Yorkshire where the Cretaceous rocks overlap the Jurassic, the Red Chalk becomes extremely useful as a guide, especially as the springs constantly break out beneath it, and give good opportunities for its examination and that of the subjacent strata. Some points of interest have thus obtruded themselves upon one's notice. Its range in Yorkshire may be described as first northwards and then eastwards. Though much covered by Boulder-clay in the latter portion, it may be traced almost step by step along the former, except where it appears to be absent.

Mr. Judd³ has drawn attention to the unconformity between the Upper Cretaceous and Neocomian series, with which latter beds he includes certain ferruginous pebbly beds which lie below the Red Chalk, and are generally unfossiliferous, but which contain towards

¹ Gardiner Wilkinson in "Murray's Handbook for Travellers in Egypt" (1867).

² W. Carruthers, "On the Petrified Forest near Cairo," *op. cit.* p. 307.

³ Quart. Journ. Geol. Soc. vol. xxiii. p. 242, etc.