
The Egyptian Wilderness

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THE EGYPTIAN WILDERNESS

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*Read at the Meeting of the Society, 20 June 1921. Map on Plate
following p. 260.*

THE prevalent idea of the desert is doubtless that of a vast sand-covered flat expanse, but few realizing that the steep rocky ranges they see rising on either hand when travelling up and down the Gulf of Suez equally form part of the arid wilderness. The reason for the popular conception that the desert is a waste of sand is obvious to all, for there is no question that Egypt displays its richest sand treasures in those localities where they are most visible to the new-comer. The low coast-line near Alexandria suggests its presence, the long line of dunes east of the Suez Canal and flanking the Wadi Tumilat from Ismailia to the Delta bears witness to its importance. The traveller to Upper Egypt is impressed with the golden-yellow sand-drifts which fill the hollows or cover the slopes of the scarps bordering the Nile Valley.

Yet to those who penetrate deeper into the desert the lesson is soon brought home that its surface is not in the main one of sand, but of the sun-split solid materials from which all the finer dust and sand has been swept away to repose in the wind-sheltered spots.

Though sand plays a less important part in the desert than is usually imagined, occupying as it does but a small fraction of its vast area (one-ninth according to Zittel), its significance as a geographical factor must not be minimized. It does, in fact, become a dominant geographical feature in the parallel ridges and depressions of the Mariut Province west of Alexandria; the coastal dunes of the Delta; the sand waste of Northern Sinai; and the longitudinal dunes of the Libyan Desert. The characteristics of each of these will be briefly considered.

The Parallel Ridges of Mariut.

One of the most marked of the features in the Mariut Province west of Lake Maræotis is the series of ridges and depressions which has a striking parallelism to the Mediterranean coast-line. Immediately adjoining the shore is a belt of brilliant white sand-dunes, consisting of rounded oolitic

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grains composed of carbonate of lime. These never rise much beyond 20 feet above sea-level, and their extension beneath the sea is the cause in all probability of the beautiful blue colour which the latter displays in this region.

A narrow depression separates these dunes from a higher ridge (over 100 feet above sea-level in some places), the dune origin of which is not evident at first sight. This ridge extends for many miles, being of great length but small breadth. Its summit is formed of a hard compact limestone. Its uniform outline remains almost unbroken except where stand the old Roman lighthouse and Ptolemaic temple of Abu Sir. On the slopes are cultivated plots of ground, but in the parallel depression (some 4 miles in breadth) which follows to the south, the ground sinks again to sea-level. In these valleys brine is very near the surface, and only salt-loving plants flourish.

Once again a parallel ridge rises to the same level as the one to the north, its regularity being broken by a series of quarries, from which was derived the stone used by the Romans for their constructions. These quarries supply evidence as to the nature and origin of the ridges. In them it is clear that the material is of similar oolitic nature to that already mentioned. Here, however, a familiar chemical reaction has come into play. The winter rains fall on the dunes, the carbonic acid they contain uniting with the carbonate of lime of which the latter are composed and producing the soluble bicarbonate of lime. This is subsequently drawn to the surface under the influence of the sun's heat and evaporated, the extra carbonic acid being liberated. As a result the carbonate of lime is deposited as a cement round the oolitic grains near the surface of the dune, giving rise to the compact layer of limestone.

Further to the south this alternation of definite ridge and depression is replaced by the undulations of the Mariut uplands, in which the valleys are now in all probability largely filled with wind-blown shore sands. The precise limits of this type of country to south and east have not been determined.

The Coastal Dunes of the Delta.

The region of the Delta is divisible into three well-defined areas of very different magnitudes and types. There is in the first place the highly cultivated region, the richness of which is due to the deposition of the rich Nile mud. Every visitor to Egypt is familiar with its characteristics, its abundant canals, the constant succession of towns or large villages, rising amid fields of cotton, wheat, clover, etc., which spread continuous to the horizon. These are the centres, where an industrious population is constantly at work, while the many roads which follow the canals and connect the principal cities are thronged with an ever-varying procession of pedestrians, alternating with strings of loaded camels, or riders on small donkeys.

Such is the familiar Delta, but as we pass from Cairo northward to Alexandria or Port Said, the scene gradually changes. If it be the season when cotton is at its prime, it is not difficult to note the progressive deterioration seaward, both of the size and yield of the plants. Finally we pass into the second region, that of the lakes which spread from Lake Maræotis near Alexandria, through Lakes Idku and Burullus, to Manzala near Port Said. The borders of these great lakes are broad saline wastes, the surfaces of which glitter with innumerable crystals of selenitic gypsum, or are bright with a green growth of salt-bush. Villages become fewer and more widely scattered, the population is sparse, flamingoes and water-fowl of various kinds being the main living things visible.

But there is a third area, small in extent, and easily accessible only in recent years through the development of such important irrigation enterprises as the Burullus Drain. This is the strip of coastal sand-dune which follows the extreme northern shore of the Delta, and is best developed near the town of Baltim and along the northern edge of Lake Burullus. These dunes are mostly of anchored type, rising to 60 or 70 feet above sea-level, and have developed crescentic forms under the influence of the north-west wind. Palm-groves are hidden in their hollows or follow their slopes, while excellent grapes, water-melons, etc., are also grown as the result of the absorption of rain by the dune sand. Though mapping during successive years has shown that the movement of the dunes is slight, it has in not a few cases been sufficient to bury palms and overwhelm cultivated spots.

The dunes are formed of very fine quartz sand, probably derived from the Nile, and swept eastward by the current trending in that direction which is characteristic of this coast.

Sand-Dunes of North Sinai.

Of far greater importance is the sand-dune area of Northern Sinai, the existence of which will have intensified the conception that the Egyptian desert is a vast sand waste. Thousands of gallant men have toiled across this inhospitable land in the advance on Palestine, and will have spread the report of its great aridity and monotony throughout the English-speaking world. Great dunes often rising well over 100 feet above surface-level follow each other in grim succession, their steeper edges facing north-eastward and indicating the activity of the south-westerly winds. They extend in a broad fringe between the slopes of the northern Sinai hills (Maghara, etc.) and the Mediterranean, and even penetrate into the depressions which separate the ranges. Not only do they follow the northern coast, but they extend in longitudinal lines to the east of the Gulf of Suez, making the crossing from the Sinai uplands to Ismailia, such as was undertaken by myself in May of last year under sandstorm conditions, an experience which does not call for frequent repetition.

For nearly three days of camel march there is nothing in sight but

sand, either in definite dunes or spread as a pall over the undulating surface. Of larger vegetation there is not the slightest trace, yet some memories of the spring rains remained in little tufts of flowers, which blossomed in spite of their inhospitable surroundings.

It may seem strange to many to hear that this sand, so conspicuously a feature of aridity, should nevertheless save the areas occupied by it from being utterly barren and uninhabited. The war has brought home this fact in a most striking manner to all, though the Mariut region and the Delta coast-line had already borne witness to it. When examining the question of water-supply in North Sinai for the military authorities, I was struck by the fact that so many of the important wells, such as Bir Mahadat, were situated at or about sea-level. Further study indicated that this was a general rule in the sand-dune area bordering the Mediterranean, it being especially noticeable where wells were sunk in areas at a considerable height above sea-level. Thus at Rafa, Khan Yunus, and Beni Sela, where the heights are over 40, 100, and 200 feet above sea-level, the depth of the wells is respectively over 40, 100, and 200 feet.

When Mr. Hughes and I commenced the investigation of the soils and water-supply of the Mariut province in connection with irrigation questions submitted by Mr. Tottenham, Under-Secretary for Public Works, we were naturally deeply interested to see whether similar conditions held as regards water-distribution in this region. The result was an absolute confirmation of the general truth of the observations previously made. On the higher levels the wells were found to be at depths closely approximating to the heights above sea-level, the results being given in detail in a memoir we now have in the press. At these deeper wells there are scenes of great animation at watering times, hundreds of sheep being collected together, while men and women seize the rope which brings up the water-bucket.

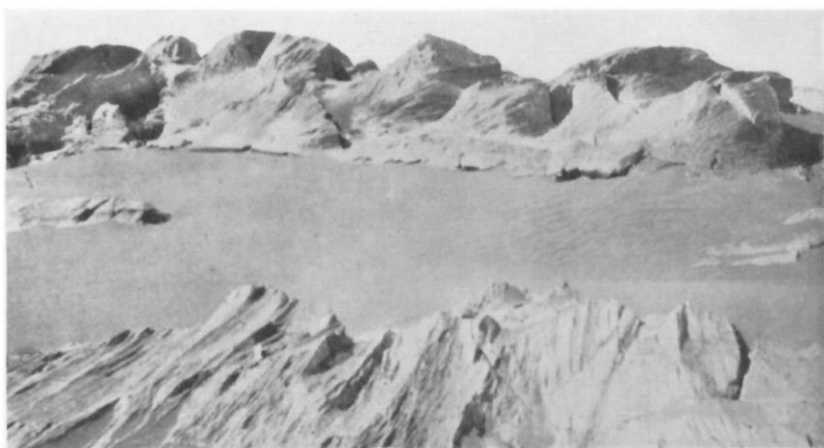
It is therefore to this rain-absorbing property of sand that we may ascribe the flourishing Roman colonies of Mariut, the presence of a small population in the northern Delta, and the relative ease with which great armies passed across North Sinai, in spite of its markedly inhospitable conditions. The sand-deposits of Mariut and the Delta are obviously connected with the present Mediterranean; those of Sinai may be partly from that source and partly of desert origin.

Longitudinal Dunes of the Libyan Desert.

These have in general a very definite starting-point, beginning in large measure from the remarkable depressed area which extends from the Moghara Oasis (80 miles south-west of Alexandria) to Siwa Oasis. This lies south of the high limestone-crowned Cyrenaic plateau, the southern slopes of which are composed of a thick series of sands. The depression is itself near the *zero*, or ground-water level. Though a fuller study of the starting-point of the dunes is desirable, it is a fair presumption that the



**RIVER-BORDER DUNE ON EAST BANK OF NILE BETWEEN WADI HALFA
AND SARRAS, NORTHERN SUDAN**



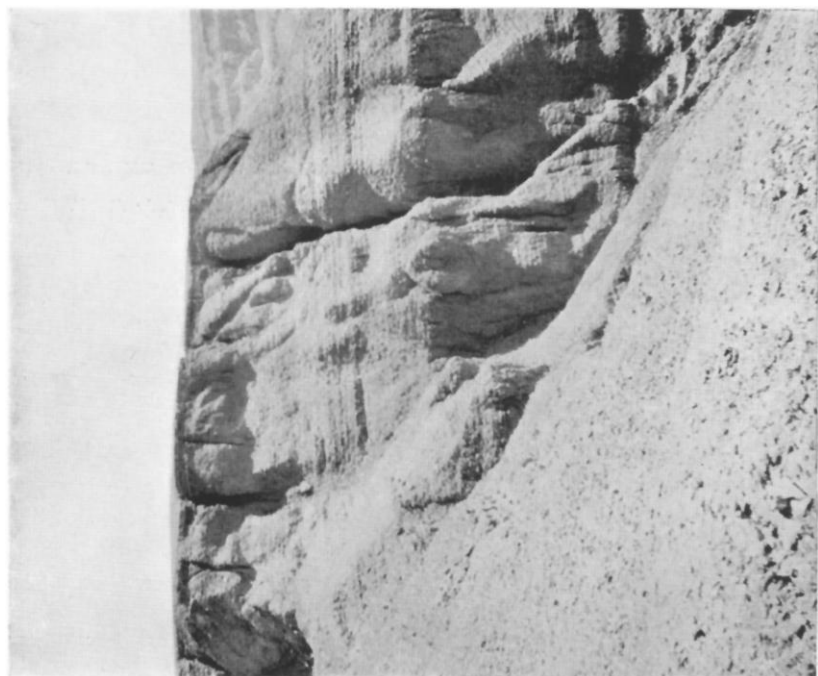
**SAND EROSION OF LIMESTONE AT UM SHERSHER, ON THE ARBAIN
ROAD SOUTH OF KHARGA OASIS**

Phot. by F. W. Green

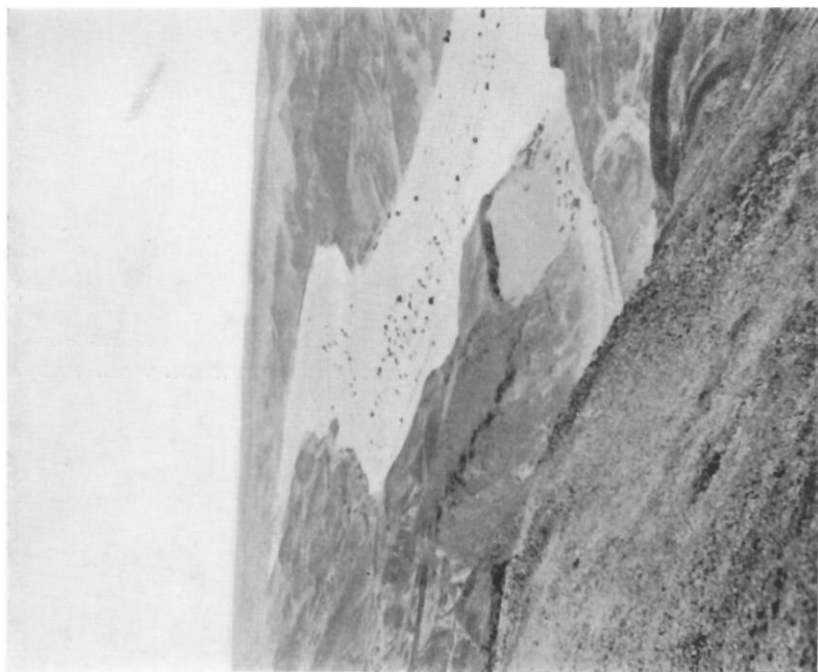


**SAND DRIFT IN WADI ETHEIL, TOWARDS GEBEL RAHA, NORTHERN
SINAI**

Phot. by H. Sadek



CLIFFS IN WADI GURDI, MAAZA LIMESTONE PLATEAU



WADI HABIB: A DESERT VALLEY IN THE MAAZA LIMESTONE PLATEAU

material composing them is mainly derived from the sandy beds exposed in this region. Once started the dunes extend in the direction of the prevailing wind. They are asymmetric in character, uniform in texture, their outlines being determined by the angle of rest of the sand and velocity of the winds, both general and temporary.

The precise distribution of these dunes has been clearly indicated in a map prepared by Ball from the military surveys of the Libyan Desert, especially those made by Partridge and Williams in motor-car expeditions. At the same time it is difficult at first sight to account for their position, rising as they do high above the surface of the plain, under circumstances where their existence might have been deemed impossible owing to the sweeping action of the wind. Yet not only are they of considerable height, often rising over 100 feet above the flat surface around them, but they also frequently attain a remarkable length in a N.N.W.-S.S.E. direction. The most notable of these dune-lines is the Abu Moharik series to the east of the oases, which is said to commence in $29^{\circ} 45' N.$ lat. at Arus-el-Buqar, some 50 kilometres south-west of the Moghara swamp, and thence extends southwards for over 7° of latitude in the direction of Kharga Oasis. Its average breadth is only some 4 miles, whereas the series of dunes composing it has a length of approximately 400 miles. As stated by Harding King, "these belts consist almost entirely of crescent-shaped dunes. In places these dunes are scattered and stand isolated from each other, with areas of sand-free desert between them. In other parts the dunes are more closely packed; many of the crescents join together to form large clusters; and the spaces between the dunes are also sometimes covered with sand."

There seems little doubt that there is also close connection between the distribution of the dune-lines and the relief of the ground. The western desert is by no means an even surface. There is a very marked fall from the eastern edge of the Bahariya Oasis, over 700 feet above sea-level, to a depression under the 300-foot contour. All the main dune-lines are massed on the slope between them. In the same way the chief sand deposits on the Kharga railway are just eastward of the top of a ridge. This certainly suggests that the south-west wind, so active an agent in the greater sandstorms, plays an effective part in dune formation. Winds from this direction would carry sand from the great sand sea to the west, and from Bahariya Oasis, over the high ridge to the east of that depression. On crossing it the blown material is somewhat protected in its wind-shadow, and thus tends to be deposited on the long descending slope. A certain part may also rest in the centre of the depression, but most of it would be piled on the further or western slope of the gravel ridge which extends to the Nile Valley, if it were steep enough. As it is, the remainder is carried over this elevation to the Nile Valley, and blown over the cliffs of its western border, forming the golden-yellow drifts so familiar to all visiting Egypt. Desert dunes may be divided into wind-shadow and slope-

piled varieties ; those east of Bahariya Oasis belong to the first-named category, while the dune-lines massed on the slopes between the Suez Canal and Sinai Hills represent the second.

In the discussion which took place at this Society a few years ago (*Geographical Journal*, vol. 51, No. 4, April 1918, p. 252), Mr. Godfrey Sykes suggested that sand will move much more freely over other sand than it will over the bare ground upon either side. "Thus, given a strong wind from one general direction, the tendency would be to heap up the sand into a long and gradually extending line rather than spread it. Also, as the wind varies slightly and blows upon either quarter, it too tends to pile the sand back upon the wind-row rather than diffuse it." This shepherding effect of a wind a point or two off the normal, as also emphasized by Mr. Hinks, is no doubt of great importance in determining the longitudinal character of a dune-belt.

The manner of the formation of sand-dunes has been a subject of interest since Mr. Vaughan Cornish brought the subject prominently before this Society. To him the eddy in front of the obstacle or the initial sand-mass is an important factor, tending to restrict the forward advance of the dune, causing a rise in the crest, while to windward the sand tails away in a long slope. The material blown up this inclined plane is partly arrested by the eddy and partly carried forward by the wind, coming to rest where the air-current bends down towards the ground surface beyond the vortex area. Thus originates first the individual dune, and then a series of them in line, separated by broad spaces clear of sand.

The discussion above mentioned indicated that many keen observers could not agree that eddies played the important part assigned to them in dune-formation by Mr. Vaughan Cornish. I have myself found pleasant shelter during a heavy sandstorm under the lee of a crescentic dune near Semna. Mr. Oldham admits the occasional presence of an eddy under the lee of the dune crest, but when noted it was always of small dimensions. The extreme diameter was about 20 feet, and the usual size was much smaller. This effects the deposition of sand to leeward in small dunes, but when the latter rise to heights of from 10 to 15 feet the eddy ceases to be important. This probably explains the variety of opinion which has arisen on this subject. In small dunes a horizontal eddy is formed leeward by air working round the corners, but in the larger ones the eddy between the horns no longer exists ; only small ones are formed in the prolongation of the direction of the horns, giving rise to smaller dunes in front of the main sand deposits. A simpler explanation than that of dune-formation in line by air-waves is given by Mr. Harding King, who regards the wind as sweeping in a simple curve over the dune. It bends down after passing it, and strikes the ground at a given distance beyond it, depending on the height of the dune. I have not studied these dunes in sufficient detail to pronounce a definite opinion on the point in dispute.

There are several agencies which diminish the facility of movement of dunes, and, if sufficiently developed, cause them to become anchored instead of mobile. Rain falling on them sinks in, and, where abundant, may form a zone of permanent saturation. On the other hand, surface crusting may have a similar retarding effect. We have already seen that carbonate of lime plays this part to an exceptional extent in the Mariut district, and it must certainly be effective wherever limestone grains form any noticeable percentage of the sand mass. Of these as much as 7 per cent. has been noted even as far south as Kharga Oasis. Near the northern lakes salts of various kinds must play the main part in crust formation.

In the course of the discussion at this Society on sand-dunes in 1918, Dr. Mill found a difficulty in explaining the persistence of the crust in a travelling dune, and of its rapid restoration when broken. The explanation I would suggest is that there is a solution highly charged with bicarbonate of lime close beneath the surface. If the protective layer be removed evaporation at once takes place, and normal carbonate of lime is deposited as a cementing substance.

Apart from the major sand deposit previously considered, there are some minor ones which have forced themselves on one's attention in the course of desert study. One of the most interesting of these is a strip of sand-dunes, crowned by sellim (*Acacia Ehrenbergiana*, Hayne) bushes, which extended for many miles along the west bank of the river at Amara, in the North Sudan. On the one side it was bounded by the steep scarp bordering the stream, and on the other commanded a broad wind-swept and rock-floored plain. In such a situation it seemed more natural to expect that the sand would be blown over into the river, but it seems most probable that the humidity of the Nile mud bordering the river has had an arresting effect. The high dunes south of Wadi Tumilat, near Ismailia, would belong to the same moisture-held type. It was also noticed that, whenever we approached areas of certain granitic types in the eastern Desert, the hollows of the denuding hills were filled with blown sand; but, apart from the striking occurrences we have mentioned, the Egyptian wilderness, whether west or east of the Nile, is relatively sand-free.

Character of the Western or Libyan Desert of Egypt.

To determine the true character of the western Desert a series of traverses has been undertaken by me in past years.

1. A visit was made with Mr. F. W. Green to Bahariya Oasis by a road leading from the Nile through Moela Oasis [Wadi Muelih on map], the return journey being by the northern edge of the Faiyum.

2. A second traverse was undertaken from Ibrim through Dunqul Oasis to the southern end of Kharga, the return journey being to Kurkur Oasis, and thence within the desert area to Edfu. The Rev. Ivo Carr-

Gregg accompanied the expedition as a volunteer, keeping temperature records, etc. This journey was one of the greatest interest, because the guide left the usual roads to try a short cut. The razor-edge country traversed caused the experiences to be also of a more exciting nature than usual.

3. The third crossing was made with Mr. F. W. Green from Edfu to Um Shersher, on the Arbain road, and thence northward through Kharga Oasis, the return to the Nile being by the railway.

4. A very interesting motor-car journey was also made with Major Montefiore from Shusha towards Bahariya Oasis in connection with the water-supply for the desert railway, over 200 miles of desert being traversed.

The following remarks are based on the experiences thus obtained, as well as on a study of results due to others, necessitated in connection with the preparation of the geological map of Egypt published in 1912.

We have already noted that the western Desert is by no means a uniform or horizontal plain. It is in reality a broad plateau attaining a maximum height of over 2000 feet west of Esna, the highest portion being thus between 24° and 26° N. lat. It then slopes gradually northward, falling to levels of 200 to 400 feet, though there seems to be a higher ridge between Bahariya Oasis and Cairo.

It is soon evident that the desert floor varies greatly according to the rocks composing it. To east and west of the Nile near Cairo extends an elevated region which is covered with countless rounded highly polished pebbles of brown flint or white quartz, materials brought down by ancient streams and spread out near the former shore-line. All the finer particles have been carried away by the wind, and temperature variation effects are common, the flints being split into angular fragments which give its character to this desert surface, known to the Arabs as *Serir*. Nor is this portion of the desert flat, our camel party after passing us usually disappearing rapidly into some shallow hollow.

Immediately we pass outside the long belt (which rapidly narrows southward) where these conditions prevail, and enter on those portions of the desert formed of limestones, the scene changes. Where the rock is relatively soft it breaks up into a series of irregularly shaped fragments, which lie strewn over the surface. On the other hand, if the limestones are compact they form huge flattened slabs with roughened surface and gnarled edges, separated from one another by broad cracks.

Whatever the character of the desert it is subject to the sand-blast, often with marked geographical effects. The formation of conical projections on hard rocks facing the prevalent wind direction is a well-known feature, as also the standing out of hard pebbles and fossils, the latter on stalks of the limestone which they protect from erosion.

There are, however, wider features developed by sand-wearing. Among the most interesting of these are the fossil-strewn floors which cover

considerable areas of the western desert. Of such a character are the expanses of whitened coin-like nummulites of large size near Moela Oasis, which, when first seen from a distance, were thought to be extensive salt-pans. Further to the south, in journeying from Kharga Oasis to the Nile, areas were passed over covered with thousands of sea-urchin spines or accumulations of small oysters, which give rise to a smooth, almost buoyant surface, hailed with pleasure after wearying tramps over furrowed and warped limestones.

In the Eastern Desert, east of the Nile, a series of strata are exposed containing huge flint concretions, often near 2 feet in diameter. In the Western Desert (especially east of Kharga Oasis) the more easily denuded limestones have been swept away, leaving the ground strewn with these harder melon-shaped bodies. Such areas are known to the Arabs as Battikh, or Melon Country.

Still more remarkable surfaces are met with when we cross the desert south of the dune-lines. It is evident that the sand-scour is effective far beyond the areas of sand deposition, for the hard limestone has been grooved by it into a series of ridges and furrows. This sand-cut hummock country extends across the plateau to the cliff-edge dominating Kharga Oasis, while the cliff summit itself has a jagged saw-like appearance, owing to the gaps formed in it by sand-erosion.

A remarkable region was traversed when attempting the short cut from Kharga to Kurkur, the limestone plateau being scored over wide areas on a small scale. The ridges were only a couple of inches or less in height, but with sharp crests. So bad was the ground that the speed of the camel train was reduced by nearly one-half. The fullest development of sand-cut scenery was noted at Um Shersher, where a ridge of limestone has been hollowed and carved into striking form.

Further south, in the northern Sudan, where sandstone dominates, the conditions are again different. Here everything is swept away down to a harder surface, the result being tremendous plains such as have been recently described by Mrs. Forbes north of Kufara. Sometimes relics of an earlier plane are preserved as pyramid or flat-topped hills rising from the flat surface. Such scenery can be seen from the railway window as one travels from Halfa to Abu Hamed on the road to Khartoum.

Yet again we pass into areas where huge rounded boulders rise above the wide expanse. If these be more closely examined, they are found to be granite or gneiss—no longer the familiar hard rock, but a loose aggregate of the component minerals resulting from the disintegrating action of variation of temperature. In addition large cavities have been formed, due to the sand-blast as indicated by the sand lying in the hollows. Sooner or later the whole of the material is broken up and carried away.

The Oases.

These great depressions, gems of fertility set in the most desolate surroundings, must always be of the greatest interest to the geographer. They are of two types, closed oases, such as Bahariya, which are almost entirely enclosed by scarps; and open oases, such as Kharga and Dakhla, which are bounded by steep cliffs on one side, but on the other have only a long, sloping, dip-slope rise.

In the case of Bahariya, there seems no doubt that it lies on the summit of an anticline, which, though small in height, would have been greatly affected by marine erosion as it rose from beneath the sea. To this agency we ascribe the disappearance of the capping of limestone which once extended across the area. With its removal softer strata were exposed, which, becoming subject to wind-action and sand-abrasion, were eroded more rapidly than the harder limestone flanks. In this way, according to Beadnell, arose the characteristic inner depression, which has been described in detail on several occasions.

Bahariya differs from the other oases in the marked evidences of former volcanic activity which it displays, columnar lavas forming a high plateau between Bawiti and Zabū, its two northern villages. Their presence indicates that the region was already in a zone of disturbance early in Miocene times. There is every indication that the rise above sea-level took place at the close of the Eocene, for the oasis is bordered by shallow-water deposits which have since been eroded into the depression already referred to, while in the north is a dark mass of iron ore forming a striking feature, and in all probability of fresh-water lake formation.

In the preceding pages I have sought to describe such features as have come more especially under my notice, and briefly to mention such theoretical views as seem to offer the best explanation at the present moment.

So far we have considered the western Desert from a physiological or geological standpoint. There is a danger that familiarity may make us miss recording the essential features which strike the imagination at a first visit. Emphasize the variations in level as we may, the main characteristic of this desert is its uniformity, especially to the south. As soon as the plateau scarp is ascended, as far as the eye can reach there is nothing visible but plain, unbroken by any conspicuous elevation, a plain of bare limestone rock or of strewn quartz and chert pebbles shimmering in the sunlight. Every form of life is almost totally absent, being mainly limited to the most inconspicuous plants, or to animals like the small rapidly running brown mantid, *Eremiophila*, and the ubiquitous ant. Apart from these, in some of the expeditions no living thing was seen, while between Kharga and Kurkur a dead gazelle beneath a dry bush, and two horned vipers under a stone, represented the total.

The meteorological conditions naturally vary greatly according to the

time of year in which the traverses are made. Our coldest experience was met with on our journey from Kharga to Kurkur, when the temperature fell to 23° Fahr. The water in the waterskins was frozen, and the camel-men and camels suffered greatly from the bitter cold. During the previous crossing from Dunqul to Kharga, the temperature fell every night to freezing-point, although we were then well within the tropics. On the other hand, the height of the plateau was nearly 2000 feet above sea-level.

The other extreme is to be met with during sandstorm periods. An exceptionally severe disturbance of this character caused us to lose our camp in the desert north of Bahariya, no shelter being obtainable under the lee of a small boulder. On the return journey we were caught by one in the open plain, and had an excellent opportunity of studying the cyclonic character of these storms. It began by heavy sand-driving wind from the south-west, which soon blotted out our view of the camp which we had left a short while before that morning. Fortunately the camel-party joined us before the view was completely shut out by driving sand, which would have effectually prevented our forward movement had we been advancing against the wind instead of with it. As it was, we were forced to depend entirely on the compass for our bearings. The wind gradually veered round to north-west, when the wind-blown sand swept down on us in one continuous blast, and it was only towards evening that we found a slight depression where our tents could be set up, and anchored by means of water-tanks.

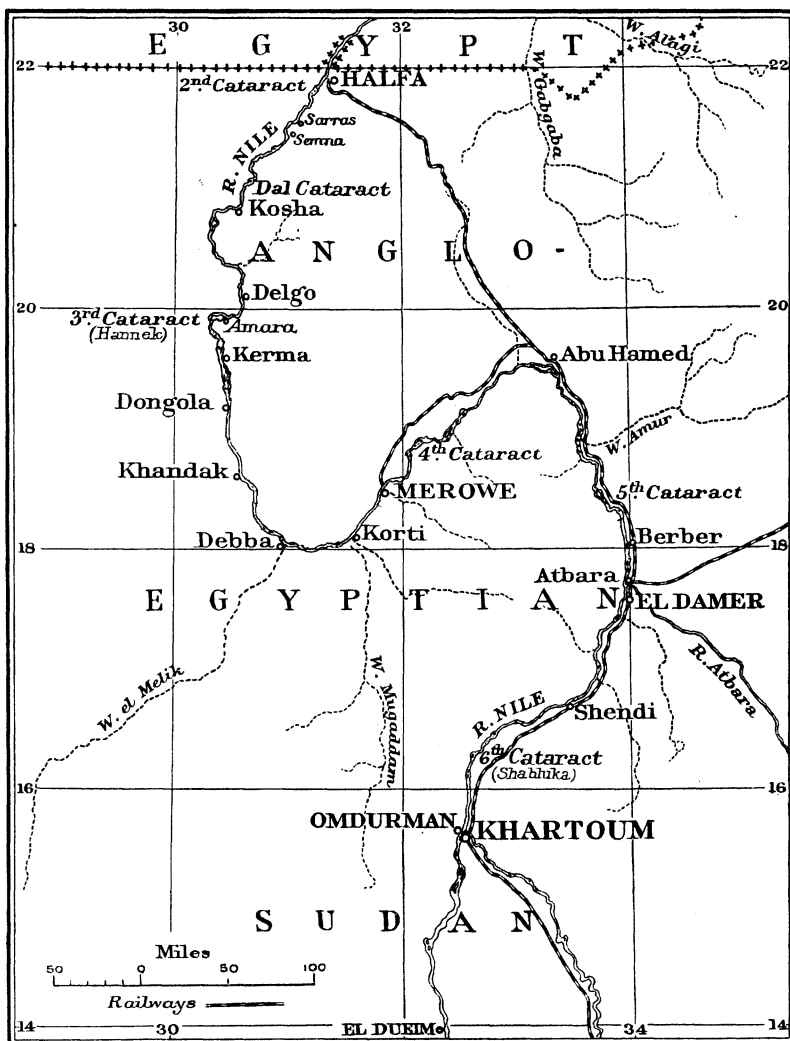
The method of survey adopted was much on the same lines on each expedition. The instrument used was the plane-table, distance being determined by measuring-wheel, pedometer, or camel-pace. When Mr. F. W. Green was with me he undertook the surveying, leaving me free for geological and other observations. The Serir plateau was crossed at a speed of 20 miles a day, the party walking from point to point. Heights were determined by barometer readings, compared with those taken at the nearest meteorological stations available.

We usually took the local guide with us for the earlier part of the day, the baggage party packing up and following. When it reached and passed us the local guide went ahead with it, the leading of our party falling to an Ababda from the eastern Desert of Egypt, who had been with me since 1898, and had proved his exceptional ability as a tracker. We were thus for most of the time in the remarkable position of having no one present who had been in that portion of that desert before; yet throughout our journeyings we only once lost our camp, and that through bad leading on the part of the local Arab during a heavy sandstorm.

The Nile Valley.

There has been little advance in the general knowledge of this important geographical feature since Colonel Lyons published the 'Physiography of

the Nile Valley.' There has, however, been a collection of considerable material by the Survey Department of Egypt, most of the principal cataracts having been surveyed in detail. To my own lot fell the geological examination of these areas in connection with the question of

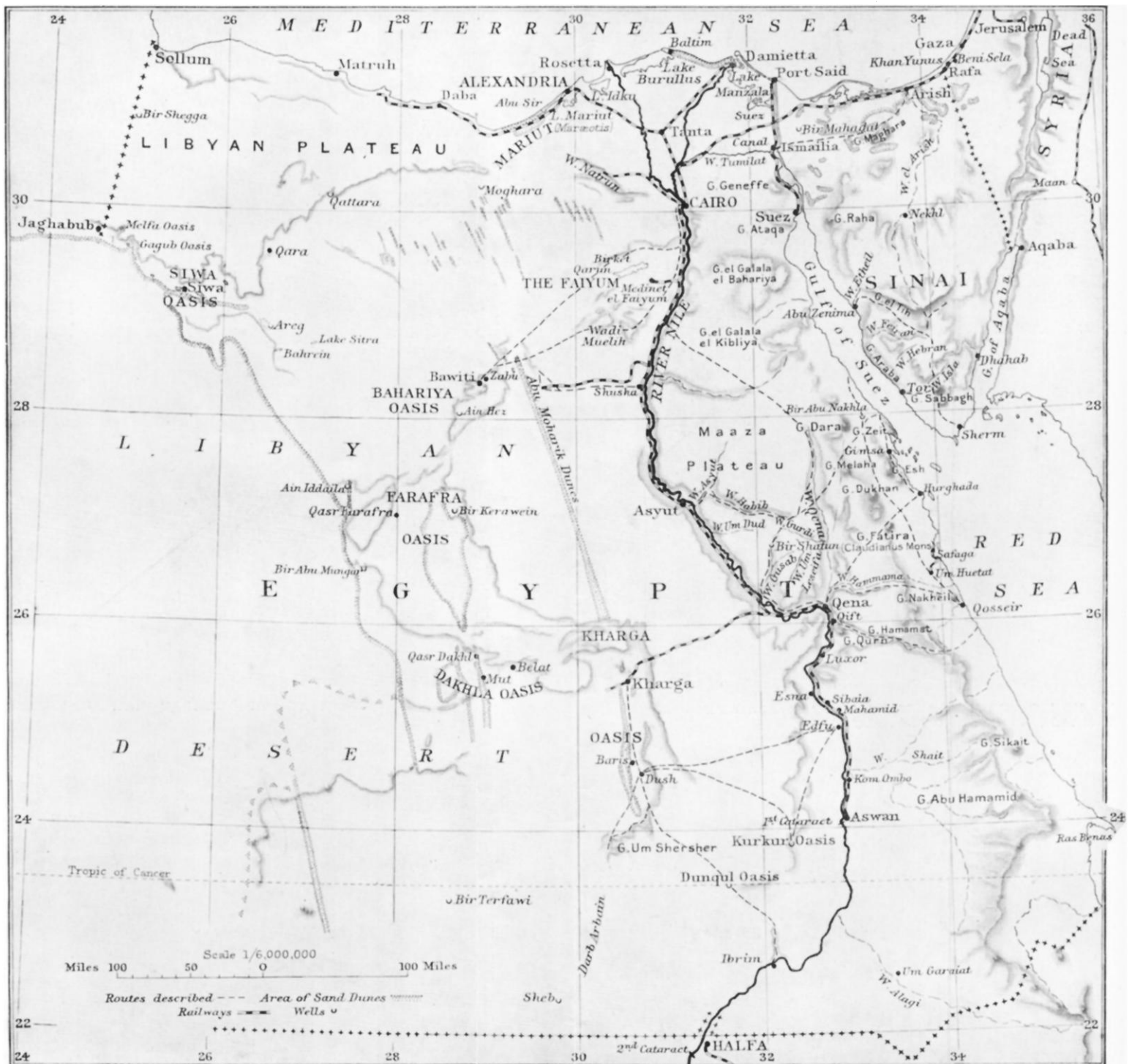


The Nile Cataracts.

the construction of a barrage alternative to the raising of the Aswan dam. What is chiefly required at the present time from the geographical standpoint is a careful survey of wide regions east and west of the Nile. Only in this way shall we be able to understand the meaning of the great S-shaped bend of the river which is its most characteristic feature in the

Sketch Map of Egypt to illustrate the paper by Dr. Hume

THE GEOGRAPHICAL JOURNAL, OCT., 1921.



Published by the Royal Geographical Society.

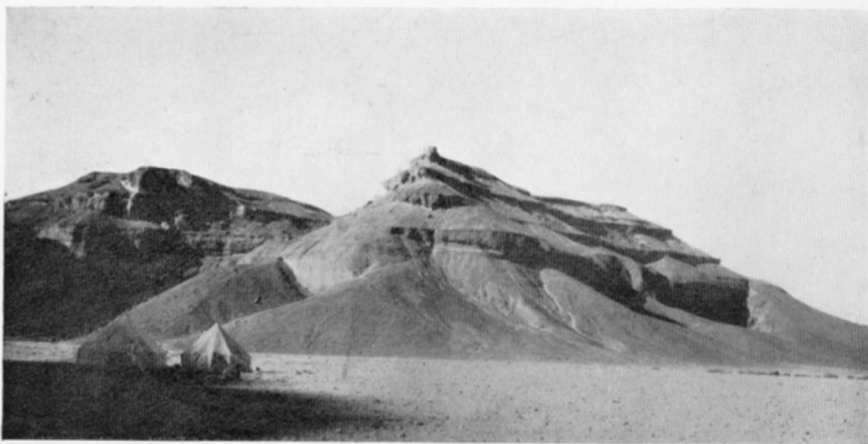
EGYPTIAN WILDERNESS
Hume



THE DOME OF GEBEL FAHDI RISING FROM MAAZA LIMESTONE PLATEAU



FIRST STAGE IN EROSION OF SEUI PLATEAU ON UPPER ROAD FROM BIR SHEITUN TO AMIRI, MAAZA LIMESTONE PLATEAU



EROSION IN WADI UM LESEIFA MAAZA LIMESTONE PLATEAU



THE



GRAN



OASIS OF MURI
CEOUS LIMEST



ONE PLATEAU



AD FROM BIR



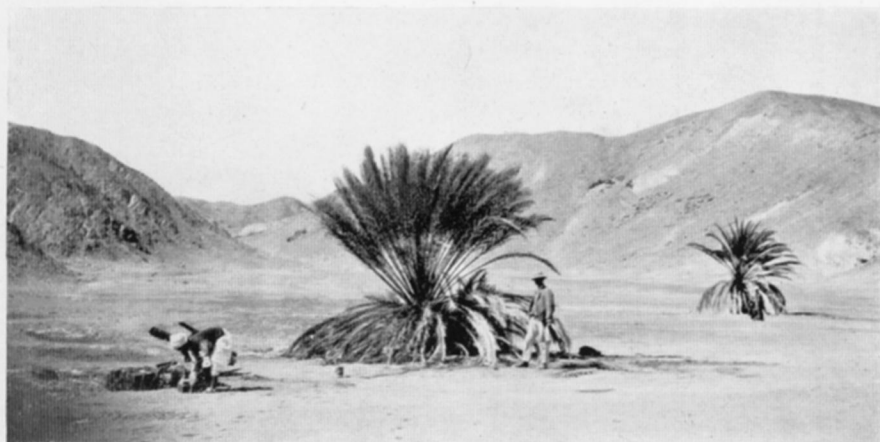
LATEAU



THE GEBEL MELLAHA, RED SEA HILLS, FROM THE EAST



GRANITE RANGE OF GUBERAT RHANAM, RED SEA HILLS



OASIS OF MURER AT JUNCTION OF IGNEOUS ROCKS ON LEFT AND CRETACEOUS LIMESTONES, RED SEA HILLS

Northern Sudan. Large folds naturally suggest themselves, but evidence is wanting as to their presence, and as to the reasons why barriers of igneous and metamorphic rock suddenly appear at various points along the course of the curve, rising through the superincumbent sandstone. Wherever this takes place the change in the scenery is striking. In the sandstone areas the river flows quietly along, often between palm-groves. Immediately it enters the region of the igneous rocks its whole character changes. In the mouth of the Sixth or Shabluka Cataract the river flows in a channel having an almost uniform depth of about 50 feet, between high banks of ancient lavas showing columnar structure. Further north in the Fourth Cataract the scenery is one of tumbled granitic boulders, while the water-channels between the large islands have made their way along veins of softer rock (porphyrites) which penetrate the granites in lines parallel to the river's course. It may be of interest to note that the man who supplied our camels was the son of the one who murdered the party returning from General Gordon in Khartoum.

The prosperous province of Dongola is again in sandstone country, but immediately the ancient gneissose rocks reappear begins the Third or Hannek Cataract, which was visited throughout its course. Here the rapids appear to be due in every case to bands of granite which rise through the more easily eroded gneiss, and then extend into the desert on either side as boulder masses. Here and there in the desert itself rise flat-topped hills nearly 1000 feet high, which are often formed by a cap of columnar sandstone, with dark slopes of basaltic rock, by the invasion of which the sandstone has undergone the alteration noted.

From this point onward rapids begin, to follow one another in quick succession. At Dal the river has cut its way through the joints in the granite masses, which form picturesque islands almost filling the river channels. Round the smaller islets grow thick clumps of willows, where at the time of our visit the hippopotamus still found a home. Owing to the destruction wrought by this animal on the growing crops, it was killed by the villagers. The crocodiles also flourish in this neighbourhood, and these animals were frequently seen basking on the sand-banks in the stream. They seemed to arouse but little dread; a couple of natives would swim to each islet with the measuring staff, though they somewhat disliked going to those where the willows were thickly clustered.

It would be wearisome to re-describe this wild country in detail, seeing that General Butler has already done so in connection with the British advance southward under Sir G. Wolseley, when a note of deep human interest enriched the narrative. As I am now putting together a detailed geological account of these cataract areas, fuller description will be reserved.

There is, however, one point which deserves special mention. Soundings taken downward of several of the important cataracts (Aswan, Semna,

Dal) have revealed the presence of channels over 100 feet in depth. It seems scarcely probable that scour alone would produce such a result, and suggests that true waterfalls were far more common in the earlier days of the Nile Valley than they are at present. Another feature of interest is the spreading plains which frequently border the Nile, and appear to be ancient lake-basins formed at a period when the barriers across the river were as yet not fully opened. Among the most important of these is the plain behind Wadi Halfa, and especially the well-known one at Kom Ombo, which has now developed into a large agricultural centre. The latter may have been formed behind the rock barrier at Silsila, in which are some of the best known of the early Egyptian sandstone quarries.

Dealing with the Nile under more general aspects as one has seen it in the course of the work undertaken, undoubtedly one of the most interesting of its features is to be observed where the Blue and White Niles join. The conduct of the discharge operations in 1902-1903 brought home the relations of the two rivers very forcibly. The means adopted for measuring the discharges were as follows: A rope was stretched across the stream from bank to bank, and definite intervals marked on it by knots of string. The measuring party in a boat moved from point to point thus determined, observations being made in each case for depth by throwing the lead, and for speed of current by a current-meter lowered to a depth which by previous study was regarded as giving the best mean result. With breadth, depth, and speed of current obtained by these means, the total discharge was calculated. The four localities originally adopted for these observations were a spot a little above Khartoum on the Blue Nile, another on the White Nile above the junction of the two rivers, a third at Kereri below the junction, and a fourth at Duem, 100 miles up the White Nile. During the early summer months the proceedings were somewhat monotonous in character, but when the floods began on the Blue Nile in late July, conditions became exciting. The rope hitherto in use was snapped by the violence of the stream, the sailing-boat wrecked by the heavy wind, and while no readings at all could be obtained, telegrams were arriving from headquarters asking for bi-weekly instead of weekly observations at each station. Matters were growing desperate, as failure at this stage would have meant the loss of two years of study. The problem was solved by hiring the gunboat *Fateh*, and buying up the thin steel rope that one of the local engineering companies was able to supply. The new thick rope purchased in the open market had proved utterly useless for the purpose. By this means success was finally achieved.

Before the floods began, so many sandbanks appeared in the river at the Kereri station that it was necessary to seek for a new one further downstream. No suitable position as regards breadth could be found until the entry of the Shabluka gorge, when the section already mentioned

proved satisfactory in every respect. When examining portions of the Fourth Cataract, the study of the river had to be made under somewhat unusual conditions. The region is a very wild one, and the only means of communication between the two banks is by means of primitive canoes made from the stems of the dom palms, or more usually by swimming on inflated skins. It is most difficult for a beginner in this latter method to obtain the right balance, and for my own passages to the various islands I had two skins bound together by ropes, on which I was supported. The local guide, to whom the rapids were familiar, swam in front, a short rope connecting us. From time to time we and another swimmer became involved in oily-looking whirlpools, but any idea of danger was lost in a sense of exhilaration. Further north in the Second Cataract we were mostly able to visit the numerous islands by means of rafts, propelled by sturdy natives accustomed to such work.

There have been certain minor geographical changes of late years resulting from the raising of the Aswan dam. The great sheet of water so produced at certain seasons of the year has had the effect of destroying the picturesque palm groves which once spread along the narrow strip of cultivation fringing the river. The Berber inhabitants have been forced to build their stone residences higher up on the desert slopes, and have felt keenly the loss of the river border, the rich mud of which enabled them to raise satisfactory crops.

Before leaving these cataract regions, attention may be directed to the picturesque effects which result from the handiwork of man. It must not be forgotten that they continued to be strongholds of monastic Christianity for nearly nine centuries after the Moslem conquest of Egypt. Not only therefore have we such well-known architectural features as the rock-cut temple of Abu Simbel and the fort of Ibrim in the reach between Aswan and Wadi Halfa, or the two temples of Kumna and Semna flanking the Semna cataract bar on either hand, but there is a whole series of monastic dwellings built on the islands or perched high on crags above the stream. Frequently vague memories of the castles of the Rhineland are recalled as these castellated edifices appear into view. Probably the most valuable contribution now being made to the geography of the Egyptian portion of the Nile Valley is the aeroplane survey undertaken by the Survey Department of Egypt. When the data obtained have been interpreted, they will give a basis for an advance of a most important order.

Ma'aza Limestone Plateau.

There is one portion of the Nile Valley and its borders which has received special attention of late years, and in which the effects of erosion appear to be much more marked than elsewhere. This is the region bounding the river both to east and west from Luxor to Assiut. Mr. Craig and I suggested at the British Association meeting at Portsmouth in 1912

that the characteristics observed might be due to the rain-laden westerly winds which now fringe the Mediterranean coast having been driven five degrees of latitude southward during the period of greater glaciation.

One of the most notable features on the east bank of the Nile is the great size of the bays which form the terminations of many of the larger valleys (Wadis Asyut, Um Dud, Gusab). The valleys themselves have a considerable extension inland, and one of these was ascended for 50 miles before there was any possibility of mounting from it on to the plateau. The successive phases of the erosion are very clear and of much interest. The highest portion of the plateau to the west and south of Wadi Qena is typical "serir," a broad expanse in which sun-fractured flints are often cemented into hard mosaic floors by re-deposited carbonate of lime. The streams first cut shallow valleys into the strata rich in nummulites which form the surface beds, the hard flinty concretions remaining behind, just as the "melons" do in the western desert (see p. 257). Immediately they penetrate to certain nodular beds underneath, a vertical-sided ravine is at once formed, bordered by undercut white cliffs, the undercutting being due to the splitting off of layers by crystallization of salt.

While there is perfect freedom of movement on the high plateau, it rapidly passes by this denuding action into a ravine-intersected or *nullah* country, from which there is no easy exit until the drainage lines open into the Nile Valley.

As the valley deepens it passes from the nodular limestones into a bastion series. Here the cliffs become still more conspicuous, weathering into bold reddish-tinted battlements, such as determine the impressiveness of the Thebes area at Luxor. The strata here are marked by the close-set parallel flint-bands, while rock-falls being frequent, these portions of the valleys are strewn with gigantic boulders. Finally, in their lower courses the valleys become true cañons, with steep vertical walls in the upper part of the cliff. Lower down every hard band forms a ledge, while the softer ones give rise to talus slopes on which lies the débris fallen from above.

For this region of cañon valleys and the high plateau into which they penetrate, I propose the name of the Ma'aza Limestone Plateau, as being within the sphere of influence of the Ma'aza tribe. With Mr. F. W. Green (who joined me in a volunteer capacity and undertook the mapping, leaving me free to study the geographical and geological details) I examined the whole area in some detail during portions of two seasons, while in a third expedition I crossed the area from Asyut as starting-point, going up the full length of Wadi Habib, the main southern tributary of Wadi Asyut, and descending to Wadi Qena by its main eastern feeder, Wadi Gurdi. This formed part of a traverse to the Red Sea which was intended to cover as much little-known ground as possible. In it I was accompanied by Captain Davidson, who took an excellent series of photographs (used to illustrate the lecture) and interesting observations of

temperature variations in rocks of different character and position in relation to wind direction. Fuller details of this region will be given in a work on the 'Physical Characteristics of Egypt,' lately prepared by me for publication.

While crossing the plateau, we were much struck by the sudden rise out of it of domed hills in which the strata dipped outward in every direction. They mostly occur on the borders of the area, and are four in number, the principal being Gebels Fahdi and Fertila. These remarkable features were first considered by me as being due to underground igneous activity, but lately another suggestion has presented itself, the result being possibly due to compression of horizontal strata. Bailey Willis, in his well-known experiments, has shown how such sharp upfolds are produced on the small scale.

The suggestion of greater rainfall in the past in this portion of Upper Egypt is emphasized by the development of important masses of travertine or tufa in the Western Desert, especially in Kharga, Kurkur, and to a less extent in Dunqul Oases. There are also similar travertines in some of the valleys of the Ma'aza limestone plateau (Wadi Gusab) and in the Nile Valley itself at the same latitude. These deposits could only have taken place from streamlets charged with carbonate of lime, at a time when rain was much more plentiful than at present.

Great Age of Egyptian Desert Erosion.

The very ancient character of the Egyptian desert land area is clearly indicated by the vast amount of erosion of which its present scenery gives evidence. The great length of the valleys (such as Wadis Qena and Shait) which enter the Nile Valley on its eastern flank bears witness to the activity of rainfall in the past. The longitudinal valley of Wadi Qena has been deeply cut into the Nubian Sandstone for nearly 200 miles, its eastern border being formed by a high and precipitous limestone scarp which can only be scaled at one or two points in a distance of probably over 100 miles. On the east this expanse (which is practically a plain) is bounded by the complex Red Sea hills, where paths are relatively few and often steep and difficult. Between the limestone scarp and Wadi Qena lies a somewhat confused country, including vast, gently undulating stretches of white chalk. These were traversed under trying circumstances, the shade temperature being 104° Fahr., with no shelter available. At the same time the intense glare was most trying. Indeed, the mapping in this region was not free from some anxiety, as camels had to be sent for water to far-distant water-holes in the Red Sea hills, the party being absent for four days from our camp. Had there been any delay in its arrival, there was no water-supply available within over 100 miles on every side.

South-east of Qena the region occupied by these soft strata becomes one of typical bad land scenery. Every important hard bed tends to form a plateau, but as the softer formations are rapidly denuded from beneath,

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the unsupported portions are speedily broken off and carried away during storms. Thus the topography becomes of remarkable complexity. The arid marly ridges capped by flat surfaces rise steeply from narrow cañons, while their sides are scored by innumerable miniature gullies, which have arisen along every joint-plane or other line of weakness. These major gullies are separated by long steep slopes extending from the main plateau, which in their turn are seamed by miniature erosion grooves which cut deep into the soft and often almost powdery strata. The whole scene leaves on the mind a deep impression of barren loneliness and utter instability.

Wherever Nubian Sandstone is present, it is eroded far more rapidly than the harder limestones overlying it and the granites which lie beneath it. Consequently, where it forms the surface rock the dominant features are depressions or plains, except where, as in the larger valleys descending from the Red Sea hills, these have cut across it, producing relatively shallow ravines. These always offer grateful shade to the traveller, and are pleasing to the eye by the cheerful brightness of their tints.

Further south, as on the railway between Wadi Halfa and Abu Hamed, the production of plains as smooth as billiard boards may be seen in full development. One vast plane surface has been broken through, and can be seen from the train forming the summit of low flat-topped hills which rise out of a monotonous expanse where the mirage is ever present. This is the type of country which, advanced a further stage in erosion, has recently been described by Mrs. R. Forbes as so widely spread north of Kufara.

Erosion Effects in the Red Sea Hills.

This portion of Egypt is one of great topographical complexity, owing to the long period during which rain erosion has been active. Where the granite has been but lately overlain by sandstone, it at first presents plateau features, but rapidly passes by temperature-scaling and rain-weathering to the rounded forms which characterize some of its principal hills (Um Disi, Dara, Kassala). As the erosive attack continues, the rain-water acting along joints and soft dykes brings out the deep-seated differences in rock structure, and produces the diversity of form so characteristic of the region. The hard red dykes of felsite stand out as brightly tinted crests, the soft veins are worn away in steps, giving rise to dark and forbidding gullies. These frequently offer considerable help in ascending the hills, but usually terminate at a pass dominated on each side by forbidding precipices.

The fullest effects of denudation by water are seen in the highest ranges of the central hills, where the main mountain masses rise in abrupt slopes from the plains at their feet. Their summits are usually long jagged crests, often so narrow that only the most surefooted of mountain goats can pass along them. Down their sides descend steep torrent grooves,

filled with boulders rolled from the heights above, and often in their recesses there are temporary water-pools formed during storm. True springs are but rarely met with, and then usually in the most picturesque surroundings.

Rain Erosion Effects in Schist Country.

The greater part of the Red Sea hills are divided as regards rock structure between the granites and schists. The change from the one to the other is marked by a complete alteration in the character of the scenery. Where the schists appear the hills lose their bold form and the valleys their brightly tinted floors. Arid dull green ridges, with conical or rounded summits, follow one another in uninteresting succession, the dreary slopes are covered with broken fragments or split into sharp-edged slabs, while the valleys are waterless, stony, and bare. The long period of erosion to which these ancient strata have been subject has caused them to assume their present complicated topography, in which no single ridge dominates those which surround it.

The Red Sea and its Associated Gulfs (Suez and Aqaba).

For some time we had been disposed to regard these depressions as far younger in age than the Egyptian mainland, but recent studies tend to indicate that they were already in existence in early Miocene times. There may be a considerable difference in actual years, but not a large one in the geological period. It seems probable that the nature of their origin may yet become a subject of considerable controversy, the first ranging of the combatants having begun.

For many years the conception of Prof. Suess that the Red Sea and the depressions associated with it were tension rifts has remained unchallenged, and was re-emphasized by Prof. Gregory in the pages of this journal ("The African Rift Valleys," *Geog. Journ.*, vol. 56, No. 1, July 1920, pp. 13-47). There had, however, been a growing doubt on this subject, which found vigorous expression in a letter from Dr. Ball (*Geog. Journ.*, vol. 56, No. 3, September 1920, p. 234). For him rifting or tearing action, such as the rift theory required, had not played an essential part in the geological history of the region; on the contrary, he considered that compressional folding of the crust had been the chief cause of the faulting observed, and that the present surface configuration had resulted mainly from denudation and erosion acting subsequently on the folded and faulted areas. Unfortunately, both writers quoted me during the correspondence that ensued. Hitherto I had been content to carry on detailed investigations, and as each district was examined my colleagues and myself also indicated the theoretical conceptions which seemed best to satisfy the facts. Memoirs by Messrs. Moon and Sadek on North Sinai, and by Mr. Madgwick on the Suez area, have been handed in to the Egyptian Government for publications written on these lines,

and it is quite conceivable that statements in them may be found to be at variance with the views now suggested. Geographers will fully appreciate the desire one has not to hamper workers in the field by pressing on them one's own conceptions; but at the same time we read these reports through together before I left Egypt, and any differences would be due to further thinking during my absence on working leave in England.

The attitude of several leading geologists, as of myself, to this question has been indicated in a recent discussion (June 8) which took place at the Geological Society, and in opening it I dealt with certain points which, being of general geographical interest, may be referred to here.

We may briefly consider three areas: (1) The northern portion of the Red Sea proper; (2) the Clysmic Area; (3) the depressions within the Sinai Peninsula parallel to the well-known major one outside it, which includes the Gulf of Aqaba, Dead Sea, and Jordan Valley.

The Northern Red Sea (Western or Egyptian Coast).

This coast has only been explored in a very cursory manner since the Admiralty landed its surveying parties, but with the oilfield investigations now proceeding its characters will soon become more widely known. Members of the Department of Mines and of the Geological Survey of Egypt have, however, visited the coast wherever entry could be made into the small harbours, protected by coral reef, which are found from time to time along it. This frequently involved bold and skilful navigation, but Captain Morewood, then in command of the small but useful Government steamer *Menagem*, apparently enjoyed being put to the test. It was often a happy experience for our parties, after tossing for hours on the troubled waters of the Red Sea, suddenly to enter some peaceful, almost land-locked bay, where we lay at rest, surrounded by the manifold richness of life associated with coral reefs. Hunts for crayfish and edible oysters or excellent bathes were occasionally the lighter occupations of the cruise. The coast from Qosseir to Ras Benas is geographically simple in its structure, as only a thin fringe of low hills (seldom as much as 10 miles in width, and consisting of limestones and gypsum) extends between the sea and the more prominent ranges of the Red Sea hills. These consist of granites, gneisses, or schists, and have the surface features which characterize the particular rocks determining them. They are usually overlain on the seaward side by an ancient coral reef, which plunges steeply beneath the gypsum.

From what had been previously written by Suess and Blanckenhorn, I had expected to find evidence of marked fractures at the junction of the igneous hills with those of sedimentary character. No such evidence has been obtained, and in the discussion at the Geological Society above mentioned I have pointed out that the Red Sea may have originated from direct erosion of an arched portion of the Earth's crust without involving any conception of tension cracks. The great width

of the Red Sea as compared with the minute nature of the elevations on its flanks, makes it unnecessary to call in vast physical changes on the facts at present known to us.

The Clysmic Area.

The above name (derived from Clysma, the Roman name for Suez) has been adopted to avoid confusing this wider region with the Gulf of Suez, which occupies a small part of it. The Clysmic Area may be defined as the expanse of lower confused hills and plains which, with the shallow Gulf of Suez, lies between the northern Red Sea hills, the two Galalas, Ataqa, and Geneffe ranges on the west and the marked scarps of western Sinai on the east.

Often when standing on the deck of a steamer, while passing along a portion of the west coast of Sinai, I have been impressed by the wild confusion of the white limestone hills in the foreground, behind which rises the great granite scarp, capped by Carboniferous sandstone, looking as in absolute repose. Or again, further south, by the long, low ranges of El-Melaha and of Zeit on the Egyptian side and of Araba on the Sinai coast, rising to such uniform heights of about 1400 feet above sea-level, while behind tower the Red Sea hills or mountains of Sinai, where the ranges rapidly reach heights of from 5000 to over 8500 feet above sea-level. In this region the more detailed study undertaken over wide portions of the area suggests to me that these surface differences, while emphasized by erosion, are nevertheless based on fault movements. The deeper-seated solid granitic masses undergoing uplift would produce the effects observed. Again, as in the Red Sea, the minute nature of the elevations in relation to the breadth of the area makes it difficult to explain the features observed as resulting from tension. While the Red Sea might be more purely derived by erosion, there seems no doubt that the Clysmic Area (in which the boundaries with the igneous hill ranges are marked by the most striking faults) is of a fault-controlled type.

The region is a very windy one, especially during the spring. A few months ago a Belgian professor, acting for an oil company, called upon me and inquired whether this characteristic was a usual one, or whether he had been there for an exceptional season. His attention was called to the "Meteorological Notes" in the memoir by the late Mr. Barron and myself on the 'Eastern Desert of Egypt,' 1902, p. 95, where reference was made to the heavy sandstorm at Abu Nakhla, which rendered the putting up of tents an impossibility, the sand and gravel sweeping in a continuous stream from the north-west. The party sat with heads enveloped in rugs, and ate cold tinned soup mixed with sand as the evening meal. Planes blown upside down, and incidents of like nature, are common occurrences when working in this area.

Southern Sinai Peninsula.

Space forbids dealing in any detail with a district in which nine months was spent of deeply interesting research, the results of which have been described in the late Mr. Barron's memoir on Western Sinai, and mine on the south-eastern portion of the peninsula. In its general characters the highland portion of the south agrees with the Red Sea hills in Egypt. But erosion does not seem to have been so long in action. The valleys are deep and relatively long, but the hills are not worn down to the roots to so marked an extent.

The region is more subject to rainfall than is the case in Egypt, violent thunderstorms being frequent in the winter. Nearly every year snow falls on the higher summits, and on 1 January 1899 we ascended Gebel Sabbagh (over 7000 feet high) with snow filling every cleft and hollow. As a consequence vegetation is more frequently met with, and there are small perennial streams for short distances and almost jungle growth in some of the main valleys, such as Wadis Isla, Feiran, and Hebran. The leopard still lives in these mountain fastnesses, and conies run among its rocks. The hyæna makes its home beneath granite boulders, while the ibex is frequently met with. The latter, when disturbed, always makes for the highest summits, while the graceful Dorcas gazelle, of which fifteen were seen together at one time, generally keeps to the valleys.

There are certain narrow valleys in the eastern portion of this area which are of the deepest geographical interest. They are long narrow depressions parallel to the Gulf of Aqaba, and obviously connected with faulting, as Cretaceous limestones and Nubian sandstone occur along their course between walls of granite. These softer materials have been largely removed by rain erosion, so that the valleys are fault-controlled rather than fault-determined. Their closer study will have a very direct bearing on the origin of the longer Jordan-Dead Sea depression, which seems to us to be of the same nature, but developed on a larger scale. In their characters they approach most nearly to one's conception of a "rift," and the idea of opening under tension in connection with their formation was very present to my mind. Indeed, I thought of them as cracks produced in the granite as the result of local tension developed during general compression, but final conclusions must be reserved until the area has received closer attention than has yet been possible. It was hurriedly examined by my companion, the late Mr. H. G. Skill (who fell gallantly fighting for his country in France during the late war) and myself at the close of a very tiring season and in the heats of May. Mr. Skill's great desire was to be a member of the Royal Geographical Society, and his wish was gratified at the close of an expedition which reflected the highest credit on his work and devotion.

We broadly conclude, in connection with the present controversy on the rift question, that

(a) The northern portion of the Red Sea shows no evidence of large faulting, and can be easily explained by erosion of a fold.

(b) The narrower Clysmic Area is both folded and faulted to a remarkable extent, differing most markedly from the Red Sea region. The boundary between them is marked by a line which prolongs that of the Dead Sea and Gulf of Aqaba depression, on the northern side of which lie the land surfaces of the Clysmic Area and the shallow waters of the Gulf of Suez (25 to 40 fathoms deep), while to the south are the several hundred fathom depths of the Red Sea. To this line I specially call attention, though not professing to explain its reason.

(c) The very narrow valleys in south-east Sinai and presumably the Dead Sea-Jordan depression are obviously fault-controlled in origin, and close study is required to indicate what part tension or compression have played in determining them. Erosion is the cause of the actual valley character.

I have avoided bringing the question of isostasy into consideration, because we have as yet no data which enable us to discuss these features from this point of view.

The Industrial Development of the Egyptian Wilderness.

At first sight it would appear as though these desert regions would make but little appeal to man, and would indeed remain outside the sphere of his main activities. This, however, has not been the case. In very early times there were wanderers over the plains of the Western Desert and the plateaux east of the Nile, their presence being borne witness to by the frequent finding of flint implements in most unexpected localities.

It had a curious fascination for the early Egyptian monarchs, who spread their explorations far and wide south of lat. 26° N., though extending their sphere of operations but little north of that line. The region bounding the Qena-Qosseir road and that east of Edfu received particular attention. All the important gold-mines of the eastern desert probably date from this period, the quartz veins being pursued to their narrowest limits in order to obtain the gold, which is often most richly developed in the smaller stringers.

The emerald-mines of Sikait are well known, as also the quarries of green slate and breccia verde antico, at Hamamat, on the Qena-Qosseir road, the age of which is indicated by the abundance of hieroglyphic inscriptions on the rock faces.

Whereas the Egyptian clung to the Upper Egyptian Desert, the Roman extended his activities far and wide. The Egyptian built his temples at the northern end of Kharga Oasis; the Roman emperors were not content till they had also built theirs at the extreme southern end, in the little oasis of Dush. The latter developed the wonderful underground water-channels of Kharga and Bahariya Oases, as well as many of the wells to which these in part owe their fertility.

Surveyors sent out by the emperors Claudius, Hadrian, and Trajan searched the wild hills for ornamental stone; and to their activities we owe the discovery of the beautiful Imperial porphyry of Gebel Dukhan and the grey granite of Mons Claudianus, both localities situated well to the north of lat. 26° N. Roads were established from the Nile to these working centres, a series of Roman stations with baths being built at convenient distances. The workings must have come to a somewhat abrupt end, as there are huge granite pillars lying in the valley at Mons Claudianus ready for transport, and a large sarcophagus has been partly cut out of the rock in the same district.

From the Roman period onward the desert seems to have lapsed into silence, except in the extreme north, where monks founded the earliest monasteries of St. Antony and St. Paul at the foot of the southern Galala hills. Sinai also became an important monastic centre, the Emperor Justinian founding the famous monastery at the foot of the traditional Mount of the Lawgiving.

There is little evidence of any attempts at development of the desert resources during the period of Arab and Turkish domination. A new era opened during the middle of last century, when the great Khedive Mohammed Ali had explorations undertaken by various European explorers, among the most notable being Figari Bey. A long list of British, French, Italian, and German explorers could be given on whom the desert exercised peculiar attractions. By their efforts the traces of the early Egyptian and Roman activities were rediscovered and described.

When the British occupation of Egypt took place after the events of 1882, the desert studies became more systematic. Colonel Lyons, following on his well-known patrol expedition through the oases, became head of the Geological Survey in 1896, and both in that capacity and subsequently as Director-General of the Survey Department gathered round him a band of earnest workers who considered the various problems presented to them in a scientific spirit.

Messrs. Barron and Beadnell, the first members of the Geological Survey, were deputed to examine the borders of the Nile Valley, and before the season was out the late Mr. Barron announced the discovery of phosphate beds in Gebel Qurn, near Qift. In the following year he and I were associated in the wider exploration of the eastern Desert, and while studying the region east of Qena, examined a small plateau 20 miles eastward of that town in Wadi Hammama. To our deep interest Mr. Barron re-discovered the phosphates at this spot, while practically at the same moment I found a specimen of the Cretaceous cephalopod *Plythoceras*. This absolutely fixed the position of the strata in the geological scale; we traced the phosphates across the Egyptian Desert, finding them developed near Qosseir and at various points in the neighbourhood of Safaga. Samples obtained at surface indicated an average of 45 per cent. of tricalcic phosphate.

The discovery aroused the interest of those engaged in the phosphate industry, and Mr. Crookston, of Glasgow, sent Mr. Theodore Greaves to look into the matter from a commercial standpoint. The latter found by trenching that the surface phosphates were associated with and hid a far richer 70 per cent. variety at Um Huetat, near Safaga, this finally leading to the foundation of the important enterprise which has its centre at Safaga, whence railways penetrate into the interior. Various other localities recorded by us were soon submitted to examination, an Italian industry springing up in this way at Gebel Nakheil, near Qosseir.

Meanwhile it had been obvious to us from the geological structure of the country that the phosphates must somewhere approach the Nile, and when travelling to Khartoum for the discharge operations I noted Mahamid station, in Upper Egypt, as the place from which operations should commence. I was surprised one day to receive a letter from Mr. Monson, then agent for Boghos Pasha Nubar, asking me to supply him with (if I remember rightly) 25,000 tons of Egyptian phosphate. In reply it was pointed out that these had still to be obtained, and in further correspondence Mahamid was mentioned as a starting-point. Mr. Monson acted on the suggestion, and before the season was over had located the phosphate deposit at Sibala, the station north of Mahamid, where the bluff containing these beds comes down to the river. This led to the foundation of a second area of the phosphate industry, which as developed in Egypt is an excellent example of co-operation between scientific study and commercial enterprise. In the same way the manganese ore discovered by Mr. Barron in Western Sinai is now being exploited by a large company with its port at Abu Zenima, about midway up the eastern side of the Gulf of Suez. Another period of great activity occurred in the eastern Desert of Egypt when the Department of Mines was founded under Mr. John Wells in 1905, gold and petroleum being the products which attracted the main attention. Some very rich gold ore had been found in the mine of Um Garaiat, near the great Wadi Alagi in the desert south-east of Aswan, this leading to the exploitation of many of the gold-mines worked by the Egyptians. On the other hand, the proof by the Department of Mines that a light oil was present at Jemsa led to the dividing up of part of the coast-line of the Gulf of Suez between a number of companies.

In April 1908 the first oil-well was bored at Jemsa, yielding a petroleum rich in benzene, and several of those which followed were equally successful. From an early period (January 1908) in this development the Egyptian Government had appointed an inspector under my supervision to collect samples and watch the progress of the work. Shortly after this general inspection was taken over by the Department of Mines under Mr. Greaves, while a series of topographical and geological surveys of the adjoining regions were commenced. When Colonel Lyons left Egypt, the work thus begun was continued under Mr. E. M. Dowson, the

field-work being confided to Dr. Ball and the present writer. As a general statement of the results has been lately published by Mr. E. M. Dowson, the Acting Financial Adviser, in a 'Note on the Programme and Policy of the Egyptian Government with regard to the investigation and development of the Petroleum Resources of Egypt,' these need not further be referred to. The arduous work undertaken by many of the companies would afford material for an equally interesting account, but their records are not as a rule made public.

When the members of the Geological Survey first wandered over the desert in 1897, the region was barren of all human industry. Strains of music from a P. and O. liner passing along the great highway to India occasionally reminded us of the larger world outside. To-day we can put into the flourishing ports of Abu Zenima, of Hurghada, Safaga, Qosseir, or Jemsa, where the most hearty hospitality is extended to the visitor by the companies. Many of these employ scientific men, who gladly welcome their co-workers in the Government service, and seek with them not only to advance general knowledge but to aid in commercial expansion.

Before the paper the President said: The lecturer this evening upon the Egyptian wilderness will speak to us with great authority, because he has spent many years in Egypt and is now Director of the Geological Survey. I will ask Dr. Hume to give us his lecture.

Dr. Hume then read the paper printed above, and a discussion followed.

Colonel H. G. LYONS: Dr. Hume has spent upwards of a quarter of a century in Egypt, and a considerable part of each year in traversing the desert on geological work. Therefore he speaks with an authority, and with a wealth of illustration of the physiography of the desert, with which I do not think any others can compete. He has put before you this evening, in a most perfect manner, I think, the varied character of the desert of Egypt—I may rather say of north-east Africa—and he has done so with characteristic accuracy and without exaggeration. Those long sand-dunes he pointed out in the western desert are most interesting. I do not quite follow his calling in the aid of the south-west wind: but never mind. When we were out there first in 1896, and were crossing that desert to and fro without any definite knowledge of how far these longitudinal dunes extended, it was not infrequently a most unpleasant surprise when coming back towards the Nile, rather short in water and supplies, and with tired camels, to see in the morning sunlight that hard white line on the horizon which meant sand-dunes, with a complete ignorance as to whether they were going to take hours or days to get across them, and whether or not a laden camel might not break his leg. There are possibilities of that sort always present to any one working with a small geological party in the desert. I can remember more than once being in a state of very great anxiety for days at a time, when news of one small band or another did not arrive. A small party usually meant only two Englishmen and such camel men as they had with them. It is a fascinating area to work over. You are free to go where and when you like; and if you are geographically or geologically interested you have an infinite wealth of problems to solve; and therein lies one of the very great difficulties, both geographical and geological. You lay out your plan to