A Further Journey Through the Libyan Desert

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A FURTHER JOURNEY THROUGH THE LIBYAN DESERT:

A paper read at the Evening Meeting of the Society on 29 May 1933 by Mr. W. B. K. Shaw on behalf of

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SOME confusion of ideas seems to exist as to the extent and boundaries of the Libyan Desert, and as to its distinction from the Sahara. In the absence of any official definition, it is useful to consider the dividing line in the west as the belt of high ground Fezzan—Tibesti—Ennedi, and to limit the term Sahara to the French territory in the west. According to this description, then, the Libyan Desert covers one huge unbroken tract of true desert stretching from the foot of the high ground in the west to the River Nile in the east, a distance varying from 1100 miles in the north to 600 miles in the south. The southern boundary may be taken as the northern limit of annual summer rainfall, about lat. 18° N., so that the desert extends for about 1000 miles from north to south.

The whole area is almost uniform in character. With the notable exception of 'Uweinat there are no mountains worthy of the name, the surface consisting of gently tilted flats of bare rock, gravel, or sand, with low hills, falling steeply to lower levels by scarps sometimes over 1000 feet in height. Rain falls too seldom in any one place to support permanent vegetation other than an occasional plant of the specialized drought-proof variety. Scattered at intervals of several hundred miles lie the oasis-depressions, usually surrounded by cliffs, and deep enough to penetrate to the level of the artesian water which is the only permanent source of supply in the country. Over parts of the intervening desert great systems of sand-dunes have developed, and these, together with the long uninterrupted escarpments, form the principal obstacles to exploration; for, with modern cars, the lack of water is no longer a serious difficulty.

Prior to 1920 the Libyan Desert was the largest unexplored area in the world, but now, thanks to Hassanein Bey, the late Prince Kemal el Din, and others, the country has been covered by a network of travellers' routes. But many problems of this country are hard to solve, chiefly owing to the total lack of long-period observation in an uninhabited area; and each journey across the desert adds but a little to our knowledge of such questions as the frequency of rainfall both past and present, the origin and amount of the available artesian water, the cause, life history and organization of the great sand-dune systems, the ages and characters of the past human occupations of the country, etc.

On two previous journeys, in 1929 and 1930, which I described before this Society two years ago, we were able to obtain some knowledge of the sand-dune country between Siwa and 'Uweinat, and of the open desert between 'Uweinat and Wadi Halfa. With the Italian occupation and pacification of the interior of their province of Libya, there remained three large areas about which very little was known. First, the country between our 1930 route in the Sand Sea and Kufra Oasis; second, the Sarra Triangle or the tongue of Sudanese territory which juts out westwards to the Tibesti Mountains; and third, the country south of 'Uweinat between the French frontier and the line Malha—El Atrun (or Bir Natrun)—Merga. It seemed to us that by visiting the two latter areas

we should be putting our perhaps unique experience of very long-distance light-car expeditions to the best use, and at the same time we should gain a wider view of the Libyan Desert as a whole than has hitherto been possible. Mr. P. A. Clayton, of the Egyptian Desert Surveys, has been attacking the northern Sand Sea area this winter.

Four Ford car chassis were bought in Cairo and fitted out by Lieut. G. L. Prendergast and Lieut. R. N. Harding-Newman, of the Royal Tank Corps, on the same lines as for the 1930 expedition. The other members of our party were Mr. W. B. K. Shaw; Dr. K. S. Sandford; Major J. E. H. Boustead, of the Sudan Camel Corps; Captain V. F. Craig, Royal Engineers; Lieut. D. R. Paterson, Royal Corps of Signals; and myself. All the transport arrangements, including the maintenance of the cars during the expedition, were undertaken by Prendergast, Harding-Newman, and myself. Craig took on the food supplies and navigation, Paterson looked after the chronometers and took the wireless time signals nightly; he and Shaw made the daily astronomical observations; the latter was also responsible for botany and for the aneroid readings. Sandford dealt with geology and, with Shaw, with archaeology, and to Boustead and Prendergast are due our collection of birds, insects, etc.

We are indebted to Dr. James Breasted, the Director of the Oriental Institute of the University of Chicago, for a generous contribution to our expenses. The Royal Geographical Society gave us a similar sum—for half of which we have to thank Mrs. Patrick Ness—and lent us many instruments. The greater part of the cost however was shared among the members of the party. Our thanks are also due to the Director and officers of the Desert Surveys of Egypt and to the officials of the Sudan Political Service for the help which they so generously afforded us.

Our plan was to form, with our own cars, a large dump of petrol and food at 'Uweinat sufficient for (1) a 1200-mile journey westward into the Sarra Triangle; and (2) a journey of a possible 1400 miles from 'Uweinat south to El Fasher, the nearest point in that direction where further supplies could be got. For the dump at 'Uweinat it was arranged that the Shell Co. should send, with the assistance of the Governor of Halfa, a supply of 1000 gallons of petrol and oil to Selima Oasis which we would pick up and transport to 'Uweinat. This would entail on our part two complete double journeys of 600 miles each between 'Uweinat and Selima, but it was the most economical method by which we could get the supplies to 'Uweinat.

1. CAIRO—'UWEINAT—SELIMA

We left Cairo on 27 September 1932 with all the food and spare parts wanted for the whole journey. The cars had been stripped of every unnecessary part to save weight, and so the absence of mudguards made us avoid the mud road up the Nile valley to Asyut, whence the direct track to Kharga runs across the desert. Instead, we turned into the desert just south of the Faiyum, and ran south-west to meet the Abu Moharik dune belt along the side of which we proposed to run till near the Kharga cliffs, when we would strike south-east to the head of the Yabsa Pass. The going, on gravel and hard sand, was so good that we kept to the dune edge too long before turning eastward, with the result

that we became entrapped in a series of parallel wind-scored corridors in the rock, which led straight for the brink of the precipitous cliffs of the depression. The traverse eastward along the top of the cliffs to reach the Yabsa Pass covered the rockiest and worst country I have ever taken a car over. At times it seemed incredible that the chassis could hold together any longer. Fortunately we got through with nothing worse than burst tyres, and Wing-Commander Penderel, who happened just at that time to be flying out to Kharga and beyond, preparing dumps of petrol for a flight to 'Uweinat, was good enough to bring us out a supply of new tyres to replace the damaged ones.

From Kharga our proposed route lay almost in a direct line for 'Uweinat across the unknown country between the tracks of Mr. Harding King and those of Prince Kemal el Din. The going was on the whole good, though as far as Camp 7 the firm sand surface is spoilt in places by areas of waves sometimes 8 feet from crest to crest, which necessitate long spells of very low-gear work to spare the cars from excessive strain. As far as Camp 7, too, we passed a succession of shallow depressions containing pillars of mud as evidence of former mud-pans. Round the borders of these depressions Sandford and Shaw found stone implements of neolithic type and many querns and grinding-stones.

Shortly after Camp 7 we entered very broken country. The ground rose to over 2000 feet and the rocky hills about us were at least another 400 feet higher. We found ourselves in a valley at the bottom of which ran a dry water-course which we descended for more than 4 miles. The wadi showed obvious signs of having run with water within fairly recent years. After passing through a small gorge, where we had to do some road making, the wadi opened out into a wide empty basin disappointingly devoid of all signs of life. These sudden evidences of heavy rainfall are very astonishing, surrounded as they are by the almost limitless wind-eroded sandstone wastes without a single sign of any waterflow. It is curious that such a small change in elevation should make such a difference in the character of the country. Even the Gilf Kebir, 50 miles away to the west, is but 1000 feet above the surrounding plains, and yet great wadis have carried debris far out into the plains.

We then came on to a great sand-sheet which continued with few interruptions to within sight of 'Uweinat and Kissu mountains. There are many such sand-sheets, of varying size, by far the greatest so far discovered in this desert being that lying west and north of Selima. They appear to be a distinct sand phenomenon and can be recognized at once from other types of flat desert. The sand, instead of tending to accumulate to form dune colonies, seems to possess here some inherent tendency to flatness, as if oil had been poured over an ocean. Every feature disappears. The horizon becomes a hard straight line in every direction. Very occasionally one glides past a small group of pebbles, the last vestiges of a rock outcrop not yet utterly destroyed by erosion or submerged by the sand.

We steered straight for Gebel Kissu, where we had decided to make our dump. On the 1930 expedition we had left a broken-down car near 'Uweinat itself and a small dump of petrol and food. A few months later Mr. P. A. Clayton found them. The car had been shot at and damaged. This time we did not know if 'Uweinat was occupied or not, and thought it safer to leave our

precious petrol 20 miles away at waterless Kissu. However we found on arrival on October 5 that even our old camping site at Kissu had been picked over. Nothing remained of our rubbish except a short piece of string and a sardine tin. Notwithstanding, we dumped here all our food, water, spares, etc., and the remainder of our petrol, and drove across the intervening plain to 'Ain Duwa at the west end of 'Uweinat mountain. There were no signs of occupation. A broken wood crate proved no native had been here since an Italian patrol had left it behind. There was plenty of water in the pool.

Craig, Sandford, Shaw, and Prendergast remained at 'Uweinat with one car to visit the volcanic craters between 'Uweinat and the Gilf Kebir, which the Almásy-Clayton expedition had reported having seen from the air. The rest of the party with the other three empty cars left at once for Selima, 300 miles away to the east, for the first of the two 500-gallon loads of petrol and oil. We followed Mr. Beadnell's route for portions of the first 120 miles, but, avoiding his Bir Messaha, which was out of the direct route, struck through the big belt of *barchan* dunes just east of long. 27°, some miles farther south. This belt appears to be more than 100 miles long, for in 1930 we crossed a continuation of it far to the south. It is 7 or 8 miles wide, and consists of big *barchans* very close together but yet isolated from one another by narrow winding strips of the flat desert floor. The belt can probably be crossed anywhere south of lat. 22°.

The great Selima sand-sheet began before we reached this dune belt and continued without a break for 130 miles, to within 50 miles of Selima itself. It extends northwards as far as Bir Terfawi and southwards to somewhere about lat. 21°. Its area must be not less than 20,000 square miles. Motoring on it is terribly monotonous, and it is hard to keep awake. It could be crossed at 50 miles an hour. It is curious that the cars would go faster and use less petrol while crossing this area when they were heavily loaded with a cargo of 160 gallons of petrol each than when running empty. On each of the four journeys we made between Kissu and Selima a slightly better route was found across the other, rocky, portion of the desert. Finally the 300-mile journey was accomplished with fully loaded cars in one day of less than eleven hours.

Selima as a base for supplies for 'Uweinat and beyond is strongly recommended to any one who may be thinking of future expeditions.

During the four days they were alone at 'Uweinat the remainder of the party visited and fixed the position of the craters which Sandford was able to investigate geologically. Afterwards they made a tour of the 'Uweinat valleys at Karkur Murr, Karkur Talh, Karkur Ibrahim, and 'Ain Zuweia to collect botanical specimens and to verify that no traces remained of Herri and his little band of friendly Guraan who were still living in the mountain when we visited it in 1930. The whole mountain was very dry. All the vegetation was more withered than in 1930, and it seems that no rain has fallen since the floods of 1927, which Prince Kemal el Din reported as having covered the surrounding desert near 'Ain Duwa to a depth of 5 feet or more.

On October 8 and 9 an Italian military patrol arrived at 'Ain Duwa from Kufara in lorries, with Major Rolle, Governor of Kufara, in command. Lieut. San Severino, of the Royal Italian Air Force, accompanied him. They were followed by Colonel Lodi, chief of the Air Force in Libya, with two military

aeroplanes. Shortly afterwards Penderel also arrived in a big Victoria troop carrier, landed at Kissu, and camped with us.

Craig, Sandford, Prendergast, and Harding-Newman left for Selima on October 10. The others—Shaw, Boustead, Paterson, and I—after paying a visit to the Italians at 'Ain Duwa, set out for the summit of 'Uweinat. It was an arduous and very thirsty scramble. For the benefit of any survey party which may in future have to repeat the performance, our advice is to begin by approaching the foot of the Triple Peak by car from the direction of Karkur Murr, keeping close to the mountain. A good sandy wadi runs right up to the foot of the first 1000-foot rise. From the more obvious direction of Ras Rejm, due south of the Triple Peak, false ridges cut one off from the mountain itself. An easy way up the main cliffs can be found to the west of the Triple Peak up the neck joining it to the western of the two sandstone massifs. A series of deep narrow clefts through the maze of vertical pinnacles of eroded rock brings one out on to the slopes of the main dome, whence it is an easy walk to the top. A very liberal quantity of water should be taken.

On October 12 the second Selima party returned, and the following day we repacked and moved over to 'Ain Duwa, leaving 300 gallons of petrol and some food behind at Kissu for the journey south to El Fasher. After taking 100 gallons of water from the pool, the level was nearly 12 inches lower than when we first arrived. The area of water surface visible between the great granite boulders around the pool was now very small. The Italian party of thirty men must also have drawn on it considerably, but though they were still there ten days later on our return from the west, the level of the water had actually risen to within 3 inches of its original height. It seems therefore that there is little danger of future parties finding the pool dry.

2. THE SARRA TRIANGLE

We left for Sarra Well, 200 miles away, on the evening of October 13, following Prince Kemal el Din's tracks which led for the first 15 miles over an open plain of pebbles varying from 2 to 6 inches in size, resting on dried mud which here and there contained hollows with dead grass. The Prince's tracks had in some places sunk deep in this mud, and he had reported the hollows full of water. Well-worn gazelle tracks crossing the country in every direction prove that there is periodical grazing here, though the pebble surface now appears as dry and barren as any desert.

The Prince's map of this area shows a sudden change in the direction of the straight parallel lines of *seif* dunes which cross the country from north-east to south-west (Arabic *seif*—a sword). We turned northwards to verify the bearing of that portion of the dune field to the north-west of the Prince's bend. It is a fact that the southern edge of the dune field does actually change direction as he showed, the edge consisting of a continuous whaleback ridge of sand which hides the dunes inside from sight. But the dunes themselves are not parallel to it. They run more east and west on a bearing of 240°, almost parallel to the dunes which the Prince actually penetrated farther on beyond his supposed bend, and whose bearing he showed correctly.

We found here, on the south-east edge of the sand, a shallow depression containing a mud pan on which a large clump of several acres of trees and scrub

is still growing. The place was full of gazelle, two of which made a welcome change from our usual tinned food.

The dune field which we crossed gradually, slantwise, working westward as opportunity offered, consists of long lines of *seif* dunes very much like those in the southern part of the Sand Sea. The dunes lie directly on the desert floor or on a floor of continuous billowy sand. There are no whalebacks. The sand billows provide excellent going if one's tyres are suitably deflated. We took the Prince's more southerly route to avoid the second dune field which gave him much trouble in crossing, and on the 15th struck the Tekro–Sarra camel road about 15 miles south of Sarra. Fresh tracks of a caravan of camels and goats led us easily to the well, over an otherwise featureless sand-sheet. There is no vegetation at Sarra and no conspicuous feature nearer than the wall of the Sanya Dunes some miles to the west. The well might be difficult to find until the group of tiny *'alems* immediately surrounding it were picked up. Though Bruneau de Laborie, Prince Kemal el Din, and several Italians have been to Sarra, we appear to be the first British party to visit the well, although it has been shown as lying in Sudanese territory for many years.

The well itself is a rock-cut shaft some 6 feet in diameter and descends 195 feet to the water-level. The water is good, but very slightly sulphurous. The same rope and pulley were there that both de Laborie and the Prince had used. They were formerly maintained by the Senussi from Kufara. We found another Italian patrol from Kufara, under Major Lorenzini, camped at the well, and spent a very pleasant evening in his company. We saw with interest Hassanein's camera which he left at Kufara with the Senussi, and which Lorenzini, who was one of the first Italians to enter the place in 1931, found abandoned in a house. Before leaving the subject of Sarra I should like to pay tribute to the friendliness and generous assistance shown us both at 'Uweinat and Sarra by these Italian officers who placed everything they had at our disposal.

The great dune belt, called near here the Seif es Sanya, appears to stretch continuously along the west side of the Kufara—Sarra—Tekro caravan road from Bishara Well to far south of Sarra. Bruneau de Laborie shows it reaching almost to Tekro. It has never been crossed before. As with nearly all the big belts of *seif* dunes, the direction of the edge of the belt (which here follows that of the caravan road running about 200°) is no indication of the direction of the dune ranges themselves. These, we found, run at 240° and are arranged *en échelon*, so that, going south, one meets a succession of beginnings of fresh ranges. From a distance the dune barrier appears continuous and formidable. We entered it a few miles south-west of Sarra slantwise through a gap where one range overlaps the next, and were able to cross them almost due west by zigzagging up and down over cols in each successive range where there were no steep slopes of streaming sand. The belt is about 12 miles wide, but after some troublous hours spent in gaining experience of the general layout of firm and soft sand, we managed the last part of the crossing without difficulty.

For some time we followed a vague line of *'alems* westward. The ground rises gradually, and the surface becomes very rough, being composed of black jagged blocks of hard silicified sandstone. About long. 21° 20′, some miles east of Camp 20, the height reaches 2000 feet and the ground is dissected by

drainage runnels falling to deep narrow ravines. At Camp 20 we were on the highest part of a very boulder-strewn plateau over 2200 feet above sea-level, falling gradually towards Sarra in the east and abruptly to the west by a big indented escarpment 200 or 300 feet high. The ravines we had found probably drain round into the gulfs which run eastwards for long distances into the plateau. To the westward a sandy depression stretched away from the foot of the cliffs as far as we could see, and appeared to be a broad valley draining towards the north. The cliffs we were on ran to the north and south in a series of big headlands apparently rising in height to the northward.

We descended the scarp with some difficulty, being delayed by the exhaust pipe of my car getting carried away by a rock. Continuing westward across the sandy plain below, we were finally stopped by a new and very formidable sand-dune barrier of the type which occurs whenever a *seif* belt is checked in its progress by rising ground. Range after range is piled one on top of the other, forming a huge confused ridge of great height. We might have crossed it with much difficulty, but shirked the probability of having to recross both these dunes and the Seif es Sanya farther south, where they might both be more difficult still. So we followed the near edge of the dunes to the south-west. As before, the dune-edge ran much nearer south than the dunes themselves, which still kept to the general bearing of 240°. The cliffs on the east continued. The ground rose steadily till we reached 2340 feet but fell again to 2050 feet at Camp 21. Here we could see nothing in any direction except to the west, where the great peaks of Tibesti rose above the horizon. The dune belt on our right had ended, the sand-flow spreading out into a choppy sea of circular sand mounds 100 yards or so in diameter over which we ran without any trouble. Some were true *barchan* dunes, but most were plain mounds without the typical concave hollows in the leeward side. A quantity of grass had recently grown up and died in the sand, and in places there were quite thick tussocks, suggesting that some at least of the grass remained alive between the rare showers, continuing to grow in size when revived by rain.

Next day, October 18, we pushed on south-west for a further 25 miles, off the sand and on to rocky rising country which became so difficult that we decided to turn south-east and make for Tekro. The country here is scored into grooves 10 to 50 feet deep, each running in the south-west direction of the prevailing wind. Their bottoms are filled with sand drifts which, though very firm, are impossible to drive along owing to their surface being wrinkled up into corrugations several feet from crest to crest. The grooves and the corrugated sand in them resemble the hollow of the roof of a dog's mouth. We could not drive along the teeth of the rocks nor along the sand in between.

At this point, lat. 21°, long. 20°, we appeared to be on the top of an important ridge. Probably it agrees with the high ground marked vaguely on the French map. The height is about 2280 feet and the ground seems to fall to the west and south-west into the curious trough which runs along the foot of the Tibesti mountains absorbing all the eastern drainage.

To the south-east we soon found better going, being guided by Sandford's advice as to the most likely direction geologically in which to find the best and smoothest strata of the sandstone. Our course ran gently downhill for 120 miles to Tekro, which appears to lie in the trough just referred to. Before reaching

Tekro we should have recrossed the line of the Sanya dunes, but we saw nothing of them except once, when we crossed an area of sand mounds and undulations which may indicate the extreme end of the dune belt.

Tekro consists of a strip of sand-drifted scrub, mostly *Salvadora persica*, about 2 miles in length under a little scarp less than 100 feet high. There are no permanent inhabitants, but the French keep there a couple of natives from the nearest village of Unianga, who are relieved periodically, and whose job is to "look after the oasis." From the many tracks it seems that the road to Sarra and Kufara is still often used by caravans. Trade consists chiefly of small cattle going northwards to supply Kufara with meat, in return for European produce going southwards. The water in the small stone-lined well is within 3 feet of the surface. It is strongly sulphurous. From the cliff above the oasis it is possible to see a long way to the south and south-west. The country is flat and almost entirely covered with sand, which should provide good going for cars with suitable tyres.

We left Tekro north-east for 'Uweinat on the morning of October 20. After a few miles of ordinary desert with some rocks we came on to a wide smooth plain of sand which continued till, 40 miles from Tekro, we met a long cliff which must form the southern edge of the Jef-Jef Plateau indicated roughly on the maps. We ran east-north-east on very good going along the foot of these cliffs, which are about 100 to 200 feet in height. A few trees, mostly *tundub*, are growing in the sand here, and we saw some fresh gazelle tracks. Farther on, about halfway between Tekro and Camp 24, nestling under the cliffs of a bay in the plateau, which here corresponds perhaps with the Gebel Hadid of the Sudan map, was a mud hollow containing green trees in two big clumps, the whole covering some 50 acres. At first sight, an oasis! But it was soon quite clear that the area had been flooded some years ago by water from a heavy local storm but is now very dry indeed. Only one kind of tree, acacia, and only one kind of scrub still lives. Everything else is dead. The ground is nearly white with the little shells of one particular kind of freshwater shell-fish which must have multiplied in millions during the period when the area must have been a lake. The present desiccation cannot have lasted for very long, as the large numbers of empty lizard holes have not yet crumbled in. We found no trace of human visitation, no camel bones, nor any fresh tracks even of gazelle. But the place was full of big flies, which finally drove us away by their unwelcome interest.

At this point the cliffs of another plateau appeared to the east, and we ran between cliffs along a sort of corridor down which a veritable river of sand had flowed in huge billows. We drove over them for many miles as over a vast switchback. Forty miles on, the corridor narrows and then opens out, the cliffs falling away rapidly to the flanks. We here entered a sand sea of parallel *seif* dune lines, and met no more solid ground for over 50 miles. These dunes are evidently the south-western continuation of Prince Kemal el Din's dune field west of 'Uweinat, here very much denser and more spread out. We had no difficulty with them, as the lanes of billows between the dune lines ran almost in our direction. All we had to do was to work leisurely eastward across the lines whenever a chance came.

This area is full of ancient sites, whose age and type I will leave Shaw to

discuss. Almost every hollow in the dunes contains an untidy collection of shapeless broken stones, stone implements, and grinders. They lie in sand hollows, but not on hard solid ground, and always very near the dunes themselves. It is a very definite fact, both here and wherever we found these "dune sites," that the sand under the sites is far softer than elsewhere. Directly one leaves the scattered stones of the site the sand becomes firm again. On the south-east border of the sand the sites were particularly thick, in fact, one continuous site may be said to stretch all along. There were querns and grinders every 100 yards for miles together. But except for the "False oasis of J. Hadid" we saw no sign of vegetation on the whole journey between Tekro and 'Uweinat. We finally left the dunes receding away to our left, and entered a sand-sheet which reached as far as the Prince's Sandara Hill, within sight of 'Uweinat. At Sandara and in its neighbourhood Sandford found an area of volcanic craters similar to those recently found north of 'Uweinat.[1]

This round trip of 1000 miles was completed by our return to Kissu on October 22. Here all the remaining supplies were loaded up. We spent one night with the Italians at 'Ain Duwa, where we filled up with water for the long journey to El Fasher, and finally departed on the morning of October 23.

3. 'UWEINAT TO EL FASHER

West of the line 'Uweinat—Merga—El Atrun—Gebel Teiga, the desert as far as the French frontier had not previously been explored except for the Prince's triangular journey from 'Uweinat to Beacon Point and across to Merga; but a detailed survey of the French territory has been made by them. We therefore proposed to see as much of this unknown strip of desert as we could on our way south. It was not quite clear however whether the sudden fading out of all detail shown on the French maps just at the frontier was due to the presence of the frontier or to the fact that no detail existed, so we determined to touch the frontier at intervals on the way south.

We ran due south from 'Ain Duwa over flat and featureless sand, heading for Yerguehda Hill, mapped but not visited by Dr. Ball on the Prince's expedition of 1925. A strong east wind blew most of the day, driving a low cloud of sand over the surfaces of all the sand dunes we crossed, but there was no sand movement on the flat areas of sand-sheet. A small incident may emphasize the amazing flatness of these sheets. We halted for lunch and filled up the tank of one of the cars with petrol. Two square 4-gallon tins were emptied and thrown away. The wind caught them and tumbled them over on their successive sides. We watched them flopping slowly and steadily over and over along the sand almost side by side till with glasses we saw them disappear over the horizon.

Yerguehda Hill is the most conspicuous landmark in this country south of 'Uweinat. It stands quite alone, many miles south of the last hills of the 'Uweinat–Kissu group. Owing to a draughtsman's error it has been placed on published maps several miles west of its true position as fixed by Dr. Ball. Here stone implements were found and circular stone platforms at the base of the hill, and rock paintings on the northern cliff (see Section 8).

[1] These craters, and those to the north of 'Uweinat, have been described by Sandford in *Nature* of 14 January 1933, p. 46.

Just south of this hill a belt of low *seif* dunes runs across the plain from north-east to south-west. These were the last *seif* dunes seen by us in the Sudan, and except for some very small *barchans* in the Mourdi Depression, the last dunes of any kind seen on the journey south to El Fasher.

We continued south to lat. 20° 30′ and then turned south-west, heading for the corner of the frontier where the French had built in 1924 a small boundary cairn. The place has come to be known as "Beacon Point." The ground begins to rise to the south-west of Yerguehda Hill, and at lat. 20° reached 2500 feet. This high ground appears to be a spur of the Erdi Plateau which runs north-east from between Erdi Well and the Mourdi Depression to Beacon Point and on up as far as lat. 20°. We drove along the foot of the north-west cliffs of this spur, descending into a trough-like depression which runs into the main Erdi Plateau at Erdi Well. At Camp 28 we were in a basin not more than 300 feet deep quite devoid of vegetation but surrounded by boulder-strewn drainage wadis from the rugged cliffs above, on which presumably stood the cairn. But the upper country looked so rough that we gave up the idea of searching for the cairn and, ascending the cliffs farther south, turned eastward parallel to the Prince's track but to the south of it. The plateau here is composed of hard black sandstone blocks, but rapidly improves to the east. Very near long. 24°, and several miles south of Beacon Point, we came, to our surprise, on the actual French cairn, well sited on a prominent mound but certainly not where it should be. Our observations of its precise latitude agree well with the relative position of the Prince's track, which we located shortly afterwards. Our corrected aneroid readings show the height here to be about 2560 feet. This cairn is 6 miles too far south.

The next objective was the eastern end of the Mourdi Depression, which we reached by a detour eastward to avoid the rocky going over the plateau along the actual frontier. The country crossed consisted mostly of flat sand with sandstone outcrops. The general altitude is 2450 feet. Whether or not a downward scarp exists to the east I cannot say. Possibly the cliffs of the Mourdi Depression curl round and run northwards somewhere farther east, but they appeared to fade away not far to the east of our descent of them.

Here I must explain a cross current in our objectives. In order to make full use of our presence in this neighbourhood we were anxious to gain any possible information as to the whereabouts of the band of Guraan raiders who, under the leadership of a certain Gongoi, had for years been giving trouble in places as far apart as the Nile near Dongola, Sendia, north-west of El Fasher, villages in French Equatoria, and El Atrun Oasis. Rumour had it that two of their favourite haunts were the Mourdi Depression and the mouth of the Wadi Guroguro.

We had heard from the natives at Tekro that the band was last heard of in the Mourdi Depression, and so proceeded with caution. At Camp 29 an armed guard was maintained all night, and we moved off before dawn next morning, October 26. Descending the cliffs, which are here about 250 feet high, we turned west and ran down towards the French frontier. The deepest part of the valley is along the northern side beneath the cliffs. The ground here is composed of dark fertile-looking powdery mud strewn with pebbles. It was very soft, and we soon shifted across the valley to the gentle southern slopes of

smooth sand. With suitably soft tyres this sand proved excellent going. For the first time since leaving the Nile a month before, after a journey of more than 3000 miles, we saw fresh green rain-given vegetation. It was growing in the loose sand, very low and thin, but evidently quite fresh. The earth a short distance across the valley however was quite devoid of any sign of life. Some miles west of the frontier the sand became covered with large hummocks of grass, dead above ground, but presumably just alive somewhere and able to revive and grow after each rain. Game tracks abounded in the sand. We saw gazelle and one addax antelope, whose presence practically precluded the possibility of there being humans in the valley. From our most westward point we could look along the whole line of the Erdi cliffs, here very high and sheer.

We camped that night in the depression, and next morning, October 27, set out to the south-east on a reconnaissance of the unknown desert as far as long. 25°. The wide sandy southern border of the depression rose some 400 feet to a ridge of rock and drifted sand. We then descended till the rocky desert suddenly gave place to a flat sand-sheet which in turn soon changed to a vast sea of gently undulating sand billows with no visible bottom. We drove over this at a general altitude of 2050 feet for 60 miles, seeing nothing but sand. At long. 25° we halted and turned south-west, making for Wadi Guroguro. These sand billows evidently extend eastwards without interruption to near long. 26°, for we traversed the same type of country on our return journey northwards. Just south of lat. 18°, when signs of living vegetation had hardly begun to appear, was a small forest, 5 miles wide, of dead trees whose trunks, 10 to 12 inches in diameter, cut off at ground-level by the sand blast, lay strewn about over the sand.

Lat. 18° marks the end of the true "howling" desert of the north, at any rate as far as this pure sand country between long. 24° and 26° is concerned. South of lat. 18° the sand is covered either with a thin film of green shoots from this year's rain or with little dead or half-dead tufts from the rain of previous years. The first animals to be met with going south are gazelle and addax. On approaching long. 24° from the east the billowy sand ceases, giving place to low rock outcrops and small hills. The country was very green wherever the sand accumulations persisted. The land rises to the west very gradually with shallow indefinite little valley systems containing groups of fantastic pillars of sandstone like ruined towns. We found many rock pictures on the shady northern faces of these pillars. Again there was no sign whatever of present-day humans or of camels. Fresh game tracks abounded and also those of ostrich. Foxes sat up watching us over the edges of their little sandy lairs. Birds were plentiful. The vegetation increases very rapidly as soon as the land begins to rise. The country is green with acacia and other trees, grasses and scrub. The highest aneroid height which we reached with the cars was 2590 feet. There is excellent grazing in this Guroguro country, but we were unable to find the reported well of the Guraan, and unfortunately missed the other reported well, Haramba, owing to our being given a wrong latitude for it. It would be difficult for cars to penetrate much farther west on account of the size of the sand hummocks and the large areas of flat rock slabs separated by wide cracks.

On October 29 we set out on another detour to the east, this time to strike the Wadi Hawa and work back along it to the south-west before a final southward run to Kutum and El Fasher. The rolling sand began again in great waves averaging 200 yards from crest to crest. The sand was green with fresh plant life. Game in large numbers were passed. First nothing but addax and gazelle, then oryx in herds of twenty to fifty also accompanied by gazelle. The addax faded out at lat. 16° 45′, but the oryx continued far to the south. We first met ostrich at lat. 16° 30′, and soon afterwards found them in herds of forty to eighty. Except for the timid addax nothing seemed to be much afraid of us. The gazelle often did not bother to rise to their feet as we passed. In all this country there is no sign of recent human occupation, but obvious camel *baraking* places and old dung show that in some years at any rate the nomads have been as far north as this for the *gizu* grazing.

There was nothing to be seen except the rolling grass-covered sand downs until, 17 miles before reaching Camp 33, we came suddenly on to an apparently isolated area several miles in length of green spreading trees growing in a big mud pan surrounded by the sand. The altitude according to our aneroids is here 2300 feet—higher than the country either north or south.

Under one of the trees we found a nest of ninety-four ostrich eggs arranged in a circle about 12 feet across, and a central clutch of some twenty eggs upon which a bird was sitting. This was the only big nest we saw, but its size cannot be exceptional, for we saw later a pair of birds with a brood of more than fifty young chicks all about the same age. This rather disproves the statement in the *Encyclopaedia Britannica* that the outer ring of eggs are laid merely to provide food for the central hatching, for the latter could hardly contain as many as fifty eggs. But if the whole nest hatches out, as it appears to, it is rather difficult to see how the chicks can be of so uniform an age. In many other spots about the Wadi Hawa we saw little deserted groups of six to ten eggs, and in one such group the eggs were being broken open while we watched by a flock of vultures.

At Camp 33 the north bank of the Wadi Hawa was reached. The *wadi* consists of a thick belt of trees a mile or two wide, growing down the centre of a mud floor whose width averages about 4 miles. The banks are only just perceptible. The wadi emerges from the hills in the south-west and winds across the open rolling sand desert for more than 300 miles, rather as a flat sandless gap in the sand billows than a wadi. Except for the belt of trees one might easily drive across it without noticing anything particular. It falls in altitude from 2365 feet at long. 24° to 2085 feet at Camp 33, 1880 feet at Camp 46, and 1750 feet south of El Atrun Oasis, where it loses itself in the sands. We took several other aneroid readings along the wadi, and all the figures combine well to give a very steady fall.

West of Camp 33 there are areas in the mud floor which show signs of recent flooding. Wherever this has occurred all the vegetation, including the trees, has died. We saw nowhere however the smallest sign that any water has flowed along the wadi. West of Camp 34 there is undergrowth and grass. To the east, at Camp 46, where the rolling sand desert is far more barren both north and south of the wadi, the park-like quality of the green spreading trees and the neat white sandy floor give it a weird unreal appearance in contrast to

its surroundings. The question arises, whence do the trees derive their water? If, as seems obvious at first sight, there is an underground flow, at what depth is it? And could wells be usefully sunk? But the presence of the isolated area of the same trees to the north, growing on a mud floor exactly similar in appearance to the Wadi Hawa but as much as 300 feet higher in level, suggests another answer. If the river which once undoubtedly must have flowed in the wadi had deposited a considerable depth of suitable mud along its bed, the mud may retain enough water from local showers to keep the trees permanently alive. If this solution is correct, little or no flow of underground water down the wadi need take place. Another interesting problem about the Wadi Hawa is why, when the sand lies in huge accumulations for miles on either side of it, the actual bed is flat and devoid of sand drifts except in the extreme east, where it disappears.

Turning southward away from the Wadi Hawa not far from Sendia, we soon left the easy sand for a very difficult country of rocky hills separated by valleys of dried mud scored by the recent rains into vertical water runnels completely hidden by tall grass. The comfortable desert was at an end. From here to Kutum, life in the form of insects, thorns, and *heskanit* burrs made things decidedly unpleasant. There was still no water and no trace of human beings except for a vague camel track. The first man we saw had the blue head-dress of the Guraan; he was crouching behind a rock.

We headed first for Musbat, but the going became so bad that we sheered off eastward to more sandy open country. Due east of Musbat there were more definite signs of humanity. We met two Zaghawa women gathering some kind of fine dusty grass seed for food. The first village passed was Gomgom, at lat. 15°, but even here is no permanent water. The village gets its supply from Fugama Wells, 22 miles farther south; so that on this meridian a space of 250 miles exists between the northern edge of the vegetation and the northernmost permanent water.

The country north of El Fasher is not at all suitable for cars, except along the made road between Kutum and El Fasher. We reached El Fasher on November 3, having travelled 950 miles since leaving 'Uweinat.

4. EL FASHER TO CAIRO

We left El Fasher on the homeward journey on November 7 after a most welcome four days' rest during which we enjoyed the generous hospitality of the English residents. Boustead had to leave us at El Fasher to return to his Camel Corps at El Obeid, but his place was taken by Lieut. A. M. Finlaison, who came up from El Obeid by aeroplane to accompany us as far as Wadi Halfa.

The country north-east of El Fasher is much flatter and more open than that to the north-west, through which we had come. It consists of *gozes*, or big undulating downs of blown sand covered with grass and bushes and intersected by water gullies sunk to the level of the rock beneath. At intervals there are groups of jagged hills. The recently made car track keeps to the winding gullies owing to the heaviness of the going up on the *goz* country. I am not certain however if with modern balloon tyres run soft, and some knowledge of sand technique, the far more direct *goz* routes will not become preferred in

time to the present difficult, tortuous, and often rocky tracks along the watercourses. The only sand which we could not negotiate easily was the coarse grit of the watercourses which one has to cross and recross continually to avoid the rocks.

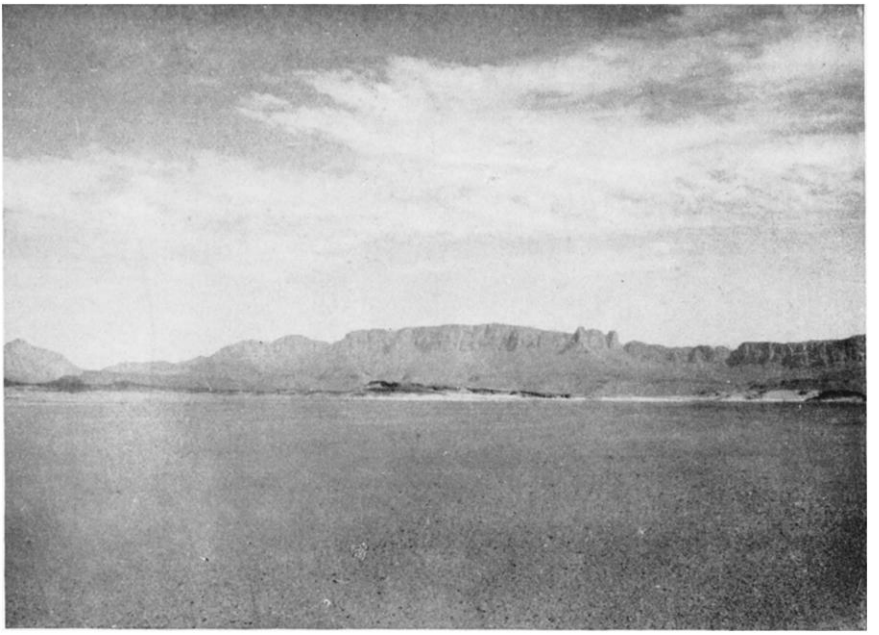
The track runs through Melit, Sayyah, Madu, and Malha. Beyond Melit the going is quite good all the way to Malha. But having no mudguards, windscreens, or other adequate protection from the showers of *heskanit* burrs thrown up by the front wheels, the two-days' journey through seemingly endless miles of *heskanit* grass was something of a nightmare. We had to stop at intervals to clear the seats of the cars of burrs and to extract their bundles of tiny needles from our clothes and bodies. It is extraordinary how even the lightest touch will cause these needles to stab right through one's skin.

The main features of this country north of lat. 14° are three big groups of hills whose peaks rise to 6000 feet. The Berti and the Meidob Hills are each inhabited by a people of the same name. The Teiga Plateau farther north is uninhabited and little explored, though I understand there are legends of its having been occupied not so long ago. The crater of Malha lies on the western edge of the Meidob Hills and is distinguished from outside only by the regularity of its low circular lip of lava and debris rising less than 100 feet above the parched brown plain which here shows practically no sign of human occupation.

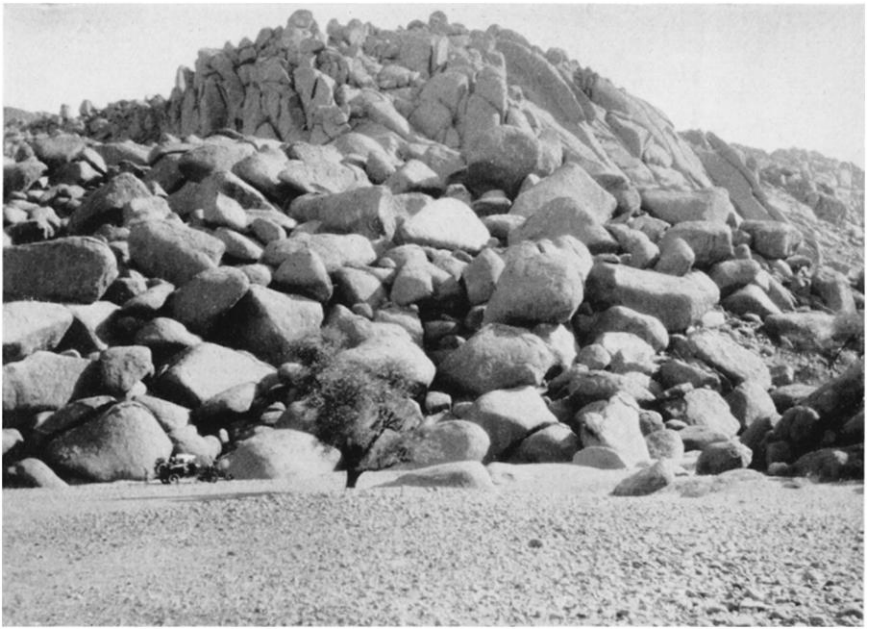
The sudden view down into the interior is indeed an astonishing one, especially in contrast to the barrenness outside. It is one of the chief watering-places of the isolated exclusive Meidob people, who inhabit the neighbouring hills. When we saw it, the whole of the bottom of the great pit about a quarter of a mile across was swarming with men, women, and children, and their cattle watering at the many springs. The final explosion of the crater has left the level of the pit bottom well below that of the underground water-level here, so that a circle of fresh water springs surrounds and drains into the central lake. The lake contains an oozy black liquid saturated with salts. The people wade into it up to their necks and scoop up from the bottom with their feet the black crystalline sludge which they dry and sell under the name of "gundoga" to the neighbouring Berti people and to the Arab nomads. It is regarded as a certain cure for all cattle diseases. There are tales that every generation or so some remaining volcanic action takes place, when the lake-level undergoes violent changes accompanied by rumbling noises. The people are non-Arab and very independent. They speak a language of their own and possess many ancient customs, including the matrilineal inheritance of property.

From Malha northward we still kept to the previous car tracks—those of the Motor Machine Gun Battery from El Fasher to Bir Natrun in 1931—along the banks of vertical-sided watercourses, hidden by scrub, which meander through flats of dry mud and cracked cotton soil. It was a great relief when this difficult country gave place to the open sand once more, covered though it was here by innumerable hummocks of dead grass over which it was necessary to drive very carefully in low gear.

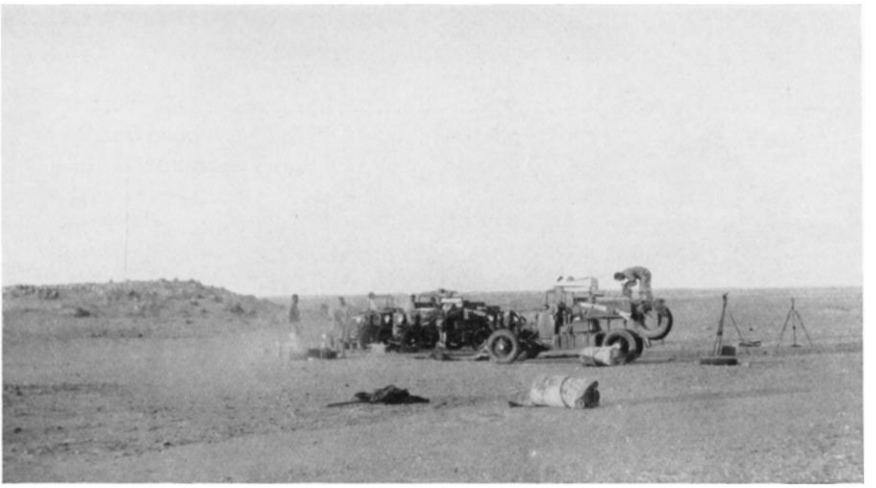
A feature of all the sand south of the Wadi Hawa is the extent to which it is impregnated with iron. Over large areas the bare sand, deep purple in colour, is consolidated by the iron till it is as firm as dried mud. We found in one place the remains of what may have been an ancient smelting establishment.



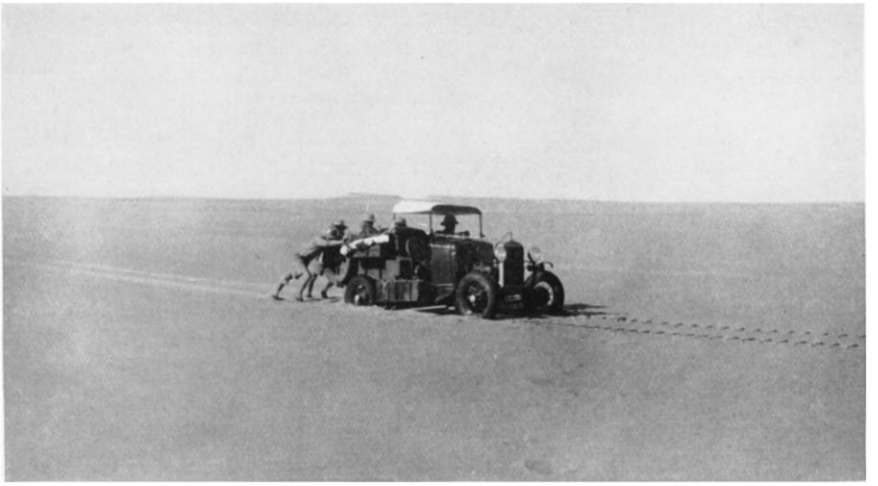
Gebel 'Uweinat from the south



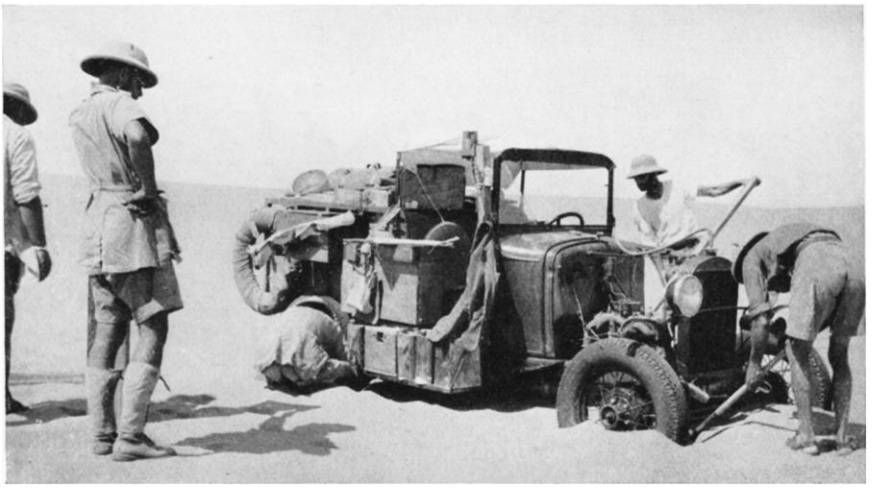
'Ain Zuweia at Gebel 'Uweinat, showing weathering of granite rocks



Camp west of Laqiya



"Unsticking" with steel channels and rope ladders



Extricating car from soft sand

Leaving the broken country of the Teiga Plateau well to the west, we returned at last at Camp 45 to the smooth rolling sand billows we had traversed north of the Wadi Hawa on the outward journey. The grass hummocks had shrunk away gradually till nothing remained but a thin crop of light dead grass varied by wide patches of colocynth whose dead dried shells, the size of small melons, popped and crunched under our tyres. Near here Harding-Newman picked up a complete tortoise shell apparently fairly freshly shed.

From here to the Wadi Hawa the billows of red sand were almost bare. We must have crossed the track of the old Arba'in Road somewhere in this stretch of country, but the only sign of it were two camel skeletons. The Wadi Hawa itself was not encountered till 13 miles north of its estimated position as marked on the Sudan map. Many archaeological sites are scattered along the low sand slope which constitutes its northern bank.

At Camp 46 the trees of the wadi spread out and a good deal of vegetation including trees appeared in the sand to the north. Secondhand Arab reports had mentioned the existence of a "Wadi Shekaya" running north and south somewhere to the west of El Atrun Oasis, and vegetation had been seen from the air by a patrol flying westward from El Atrun. Another flight had reported seeing what appeared to be the junction of the Wadi Shekaya with the Wadi Hawa somewhere about our Camp 46. We therefore turned north with the idea of following any visible vegetation line. Clumps of *hadh* and some trees grew along what seemed to be a chain of gentle hollows. After 30 miles the line of these clumps became more ill-defined, and it appears that the "wadi" is merely a wide area containing small groups of scrub with occasional trees. In one of the larger of these we found camp-hearths, bones, and other evidences of human occupation. The old guide Bidi wad Awad mentioned once that a well was known to the Bedayat and Guraan of a generation ago somewhere in this area, but that it has since been lost.

Near lat. 18° rain had fallen during the summer of 1932, for the sand downs were green and we saw a few addax. On the whole though, the 1932 rain seems to have been confined to the west side of the sand, and game was comparatively scarce to the east. At this point, lying upside down with its bottom just protruding through the sand, we found a large earthenware jar.

We were here on the eastern edge of the billowy sand country, 60 miles west of El Atrun, and turned eastward towards the oasis. A belt of *barchan* dunes reaches down from the north-east to this point. Probably it originates in the disintegration of the sandstone of the Merga Depression which lies almost directly to windward. We crossed another such belt of dunes just north of Camp 46 which may, in the same way, have come from the hollowing out of El Atrun Oasis. The two belts seem to be the southernmost dunes in the Libyan Desert.

Our route now lay through a succession of oasis-depressions, El Atrun—Merga—the Laqiyas—and Selima. El Atrun, which we reached on November 13, was found to be unoccupied. Usually the place is visited by caravans which come to collect salt. Now, possibly through fear of the Guraan raiders (a caravan was attacked and robbed twelve months before) the wells seem to have been deserted for some time. El Atrun Oasis has been much visited by Europeans of late. The fact has come to light that the name Bir

Natrun, which has been applied in the past to the whole oasis area by cartographers, is used by the Arabs to indicate only one particular well, the most northerly one. The Arabs call the whole oasis El Atrun, and it is surely high time that the correct native name appeared on the maps.[1]

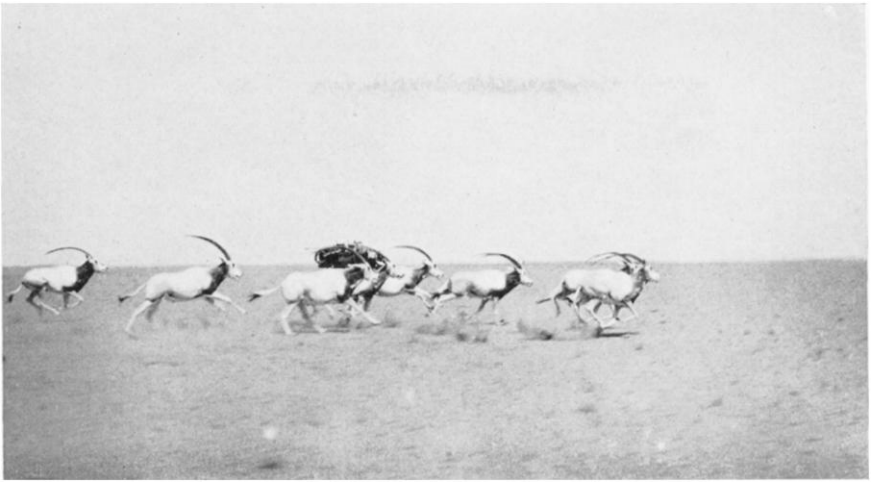
From here an afternoon's run brought us to Merga, visited and mapped for the first time by the late Prince Kemal el Din in 1925, and in the following year by Newbold and Shaw. We approached the nearest palm grove of Wa'arat el Abid with considerable caution, for here, if anywhere, the Guraan raiding party should be living. Merga has long been known to be an important raiders' camping place, especially in the summer and early autumn, when the heat and drought is too great for their animals elsewhere in the desert. Here they have unlimited water and some grazing, and can collect the autumn crop of dates of which there are considerable quantities. Merga alone of the northern Sudan oases might be able to support a small permanent population.

But Merga, like El Atrun, was empty. All we found was a group of well-built Guraan huts of grass and palm branch. Even the sacred tree to which they are supposed to sacrifice before their raids, and which Newbold and Shaw found in 1927, had been recently burnt to the ground by some unknown agency. After searching for further Guraan traces in all the palm groves of this large straggling oasis, we pushed on to the outlying depression of Wadi Hussein, first visited by Newbold and Shaw in 1927. It is a wide sandy hollow 16 miles long, full of half-dead grassy hummocks and one group of four sickly date palms: a truly dismal spot. Here also there were Guraan huts, but more ruinous and sand-invaded. There was every sign of a hasty departure a good many months previously, perhaps at the time when a single reconnoitring aeroplane had flown over the place. Scattered in the sand we found such things as Italian cartridge clips and food tins, pieces of Shell petrol tins, pieces of a British R.A.F. aeroplane which crashed at Merga in 1930, child's dolls of stuffed coloured rags on sticks, strips of cloth, date-cake and dried dates, a drum, a bag of herbs, baskets, bits of harness, leather bottles, rope, camel bones, and many very large heaps of ash indicating a prolonged period of occupation. We also saw large quantities of droppings resembling those of a cow. We collected some samples of these and afterwards showed them to badawin in Egypt, all of whom identified them as cow without hesitation. But how a large herd of cows could exist near Merga is a complete mystery. The name cow is applied by the Arabs to the antelope as well, but no addax or oryx would wander near a camping place at all events until it had been long deserted, and by that time the water-hole would have been filled in with sand.

There have been repeated rumours, reinforced by statements of the guide Bidi wad Awad, of a water-hole somewhere to the north, north-west, or north-east of Merga.[2] By the name of Bir Bidi it has even appeared on the latest edition of Philip's Atlas, but for some reason it has been placed south-west of

[1] Since the above was written I have been in communication with the Director of the Sudan Survey Department on this subject. It appears that opinions differ as to what the name of the place should be, and under the circumstances he prefers to retain the name of Bir Natrun which has been used on Sudan maps for many years. In order to avoid confusion, therefore, this name has been used on the map illustrating Major Bagnold's paper.—W. B. K. S.

[2] Vide *Geogr. J.*, vol. 72, p. 551.

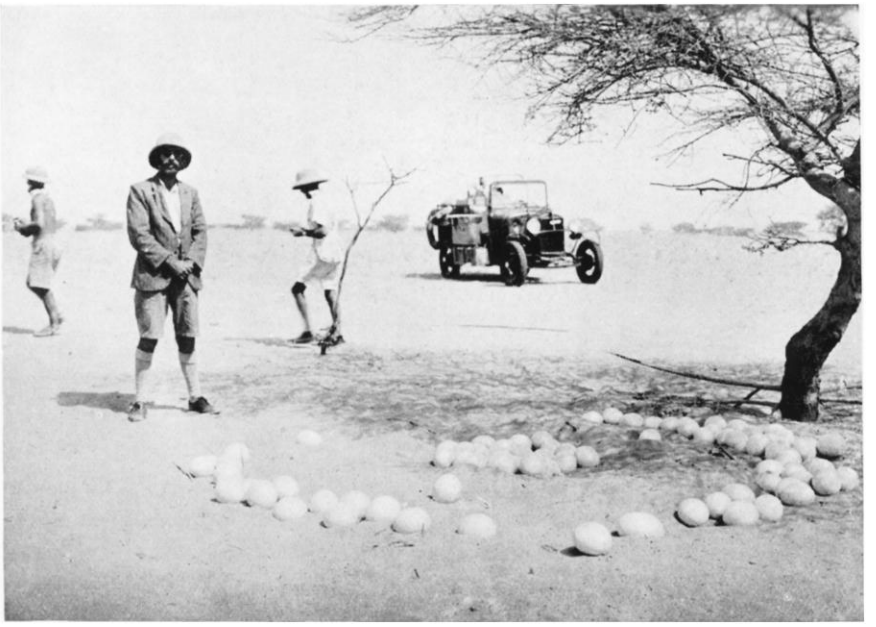


Oryx near the Wadi Hawa

The Wadi Hawa

Pillars of sandstone in the Wadi Guroguro

The Wadi Kutum



Ostrich nest near the Wadi Hawa

the oasis. Recent native reports, too, mentioned a place called Oyo where the raiders were said to be lurking. The most probable answer is that Oyo and Newbold and Shaw's Wadi Hussein are one and the same place, and that Bir Bidi, if it still exists, is merely a hollow in impervious rock where water collects underground for a year or more after rain and is not a new depression reaching down to the permanent artesian water-level. There are now five traversed routes diverging from Merga in northerly directions. Along each one the ground is found to rise sharply from Merga and Wadi Hussein without any indication of the presence of further depressions. It is likely that Bir Bidi, too, may be identified with the Oyo-Wadi Hussein Depression. For according to Dr. Ball, the Prince's guides, pointing eastwards after leaving Merga for 'Uweinat in 1925, indicated the direction of a well nearby which they said was discovered by a man named Bidi. But the Prince, having located and explored the main Merga Oasis, and thinking this to be but an outlying well, passed on without visiting it. Unfortunately Dr. Ball only heard this from the Prince afterwards. But now that the Wadi Hussein Depression has been traced westward by us to within a mile or so of the Prince's route, Dr. Ball's story seems to assist in the killing of Bir Bidi as a separate entity.

We cruised round far to the north-west and north of Merga without seeing any indication of another depression. The land is all more than 200 feet higher than Merga or Wadi Hussein, but we certainly did cross a very rocky plateau rising to 2000 feet in altitude where several small dried mud pans contained dead vegetation.

We now headed due east for the two oases of Laqiya, meaning to strike Laqiya Arba'in, but owing to the whole group being wrongly placed on the map we met the tracks of Colonel Wilson's 1930 car reconnaissance from Dongola, for which we were looking, not, as we reckoned, just south-west of Laqiya Arba'in, but actually south-east of Laqiya 'Umran. The chain of depressions containing the Laqiyas is a complicated series of winding gorges opening out into amphitheatres surrounded by cliffs 200–300 feet high. Some of the rock scenery is very fine. We actually arrived at Laqiya 'Umran thinking it was Laqiya Arba'in, and it was some time before we discovered our mistake. A good series of observations were taken by Shaw and Paterson for both longitude and latitude at Laqiya 'Umran and for latitude at Laqiya Arba'in which, combined with an accurate dead-reckoning between the two, should fix the true positions of the elusive Laqiyas fairly well. The whole group must be moved about 13 miles to the north-west and with it a large portion of the track of the Arba'in Road between El Atrun and Selima.

From the pool at Laqiya Arba'in the tracks and skeletons of the old road lead north-east up the head of a gorge almost blocked with huge sand drifts. I do not think there is much chance for cars to follow this very steep ascent, nor indeed for any easy car road to be found up the northern cliffs. We eventually succeeded in finding a possible route up the cliffs to the south-east of the depression and rejoined the Arba'in Road after an exciting bit of mountaineering with the cars round the eastern crests of the cliffs.

The Arba'in Road is here fairly distinct. It runs northwards through a difficult country of boulders, roughly following the line of big solitary *barchan*

dunes. North of Camp 52 the surface improves and soon becomes a flat sand-sheet in which the remaining signs of the road are lost. We left Laqiya on the afternoon of November 17 and reached Selima the next day, 150 miles. An easy run of the same distance the following day, the 19th, brought us to the banks of the Nile at Wadi Halfa, where we received every kindness from the Governor and the other residents. The whole journey from El Fasher amounted to 1100 miles.

The party broke up somewhat at Wadi Halfa. Prendergast left us to take up his new appointment with the Sudan Defence Force, taking one of the cars with him. Sandford and Finlaison also went south. The remainder of the party, after taking another 30 gallons of petrol on board each of the three cars, set out on November 22 for Cairo. The shortest and quickest route from Wadi Halfa to Cairo lies *via* Bir Murr and thence along the Arba'in Road to Kharga and on to Asyut, a distance of some 650 miles. But we decided that having travelled so far over new country we might as well try another new route back to Cairo *via* Bir Murr, Dakhla, and Bahariya. This was now possible since the Egyptian Government had just completed the construction of an ascent suitable for cars up the otherwise impassable limestone cliffs of the Kharga–Dakhla escarpment, to enable cars carrying the produce of Dakhla Oasis to reach the Nile direct along the old Darb el Tawil.

We covered the 300 miles to Dakhla without incident in three days. The new pass is a remarkable piece of work, but several of the pitches are still too steep for loaded cars to ascend without much pushing. From the top of the main pass we followed Mr. P. A. Clayton's tracks as far as the second scarp 60 miles farther north up which he has recently made another pass. Thence we struck out due northwards over a stony plateau containing several little clumps of scrub growing in small mud pans. At the top of the second pass the surface is scoured for several miles by vertical-sided water runnels suggesting very heavy rains not long ago. We reached Bahariya on November 27 and arrived back in Cairo on the 29th.

The whole journey totalled over 6000 miles, including the two runs from Kissu to Selima and back. Of this distance more than 5000 miles was over new country with no existing tracks. Much of it was very bad going for cars, being covered either with large stones and boulders, or, in the south, with hidden water runnels of hard mud. Apart from the cracking of one main engine-supporting bracket, which occurred within sight of the Tibesti Mountains and which was partly responsible for our decision not to go farther west, no serious fault occurred to any of the four cars, which at times were twisted and bumped about unmercifully. I would like to emphasize here that were it not for the great reliance which can be placed on these cars when driven and looked after by a party with real knowledge of their insides, no such small expedition as ours could safely penetrate far into the desert with but four cars and practically no load of spare parts.

Apropos of the size and cost of desert expeditions, it often astonishes people when I tell them that the gross cost per member of this type of expedition works out at about £20 to £30 per thousand miles, without allowing for any rebates, such as the proceeds of the sale of the cars afterwards.

5. SAND AND SAND-DUNES

In the Libyan Desert the free interplay of sand and wind has been allowed to continue undisturbed for a vast period of time, and here, if anywhere, it should be possible in the future to discover the laws of sand movement, and of the growth of dunes. Since we have now visited all but the north-western portion of the Libyan Desert, a brief summary of the sand-forms as a whole may not be out of place.

Desert sand is composed of hard mineral grains which are not easily fractured by impact. The grains are small enough to be moved about by the wind and yet large enough to prevent their suspension for long periods in the air and consequent dispersal as dust. In the Libyan Desert the grains consist almost entirely of quartz. They are driven by the wind sometimes for great distances over bare ground. Then, in certain spots which, except in the case of sand-drifts, have no obvious peculiarity to distinguish them from the ordinary landscape, the grains congregate to build up definite features which can be classified under four distinct heads:

Sand-drifts or Sand-shadows; Dunes; Whalebacks or Undulations; Sand-sheets.

Sand-drifts

Of the four classes of sand accumulation, these alone appear to be capable

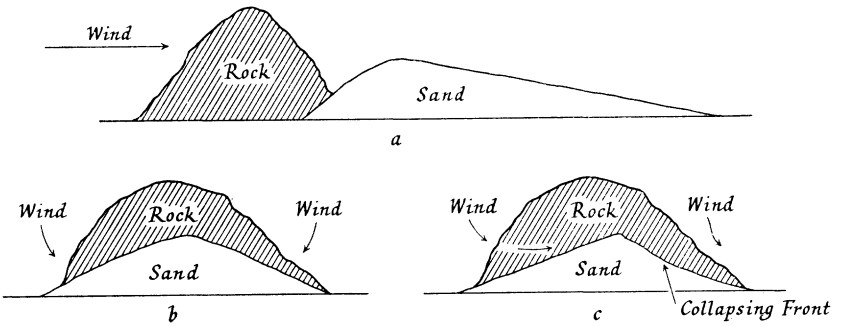


Fig. 1

of an obvious explanation. Sand driven by the wind will settle in sheltered places, gradually filling these up till the sheltered ground area is all occupied. In the case of a rock or solitary wind obstruction, a streamline sand-shape will form on the leeward side of it, provided the wind is laden with grains.

The size of the drift is limited by the area of ground over which the wind is prevented from sweeping, *i.e.* by the size and shape of the turbulent space behind the obstruction. The drift has no separate existence. If the rock is removed, the drift disappears. Fig. 1 (*a*) shows a section of a drift caused by a rock, viewed from the side. Fig. 1 (*b*) is a section looking up-wind, assuming the wind direction is constant. If the wind veers slightly, the drift tends to veer with it, and the ridge, veering faster than the base, will, if conditions are suitable and the drift be on a large enough scale, topple over, forming a "collapsing front," down which sand will slide. This is shown in Fig 1 (*c*). The steepness of the collapsing front is practically the same for all kinds of

sand, being about 33 degrees with the horizontal. No sand slopes can be steeper than this. Once the collapsing front is formed, the ridge, instead of being rounded as in Fig. 1 (*b*), is now a sinuous knife-edge.

It should be noted that the crest and general length of the drift lie roughly in the direction of the wind.

Dunes

Dunes are mobile heaps of sand whose existence is independent of either ground form or fixed wind obstruction. They appear to retain both their shape and identity indefinitely, and so to have an interesting life of their own. Contrary to common notions, there is no evolutionary connection between a sand ripple and a dune. The former is never more than a few inches in size and is merely a surface phenomenon, whereas it is doubtful if the latter is ever smaller than 20 feet across. There appears to be no upper limit to the size of a dune.

A good deal of confusion exists between a " dune," a "line" or "range" of dunes, and a "dune belt" or "dune field." A "dune" will here be taken to mean the smallest unit showing the type-form. There are two distinct type-forms. They are alike in possessing (1) a single summit, and (2) a collapsing front. In both forms the boundary between the dune and the ground on which it lies is very distinct. The sand gives the impression of having been swept up into the dune heap with a broom.

Type 1. The *seif* dune:

The individual *seif* dune has a form very like that of a sand-drift behind a rock, as just described. Its length or axis lies in the direction of the prevailing wind, and its long crest is a knife-edge ridge, one side of which is rounded and the other falls abruptly as a collapsing front. As with the sand-drift therefore the collapsing front faces a direction at right angles to the line of the dune and to the prevailing wind. The side on which the front occurs depends on the side to which the wind has temporarily veered out of its prevailing direction. The whole aspect of a *seif* dune may therefore change within a few days.

It is rare for a single *seif* to be found by itself. Normally these dunes grow end to end down-wind to form a range or line of dunes, all of exactly the same size and separated by the same interval between their summits. The interval varies with different ranges of dunes and may be anything from 60 to 600 feet. The range of *seif* dunes has one continuous ridge connecting the whole chain of summits, and this is its main distinguishing characteristic. Although the ridge may wind in curves between one summit and the next, the line of summits is amazingly straight. It is common for a single line to run unbroken for 40 miles or more without deviating more than one or two degrees from the axis joining its head and tail. Single lines of dunes over 60 miles long have been met with in the Sand Sea. Summits over 300 feet high above the base have been measured.

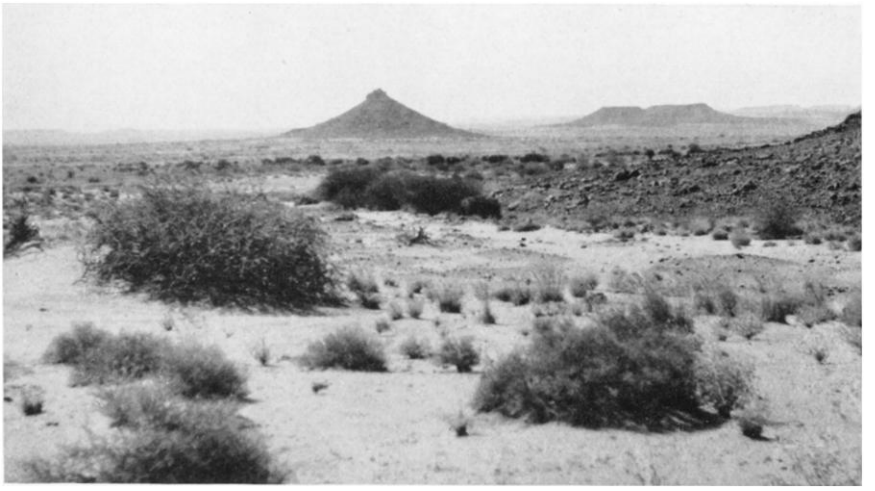
The line appears to grow by the formation of additional dunes at its leeward end, but very little information is available on this point. Nor is the rate of advance known with any certainty. Several observers hold that the advance is speeded up by the disturbance of the ground in front by car tracks, etc. As

Sub-desert country north-west of Kutum

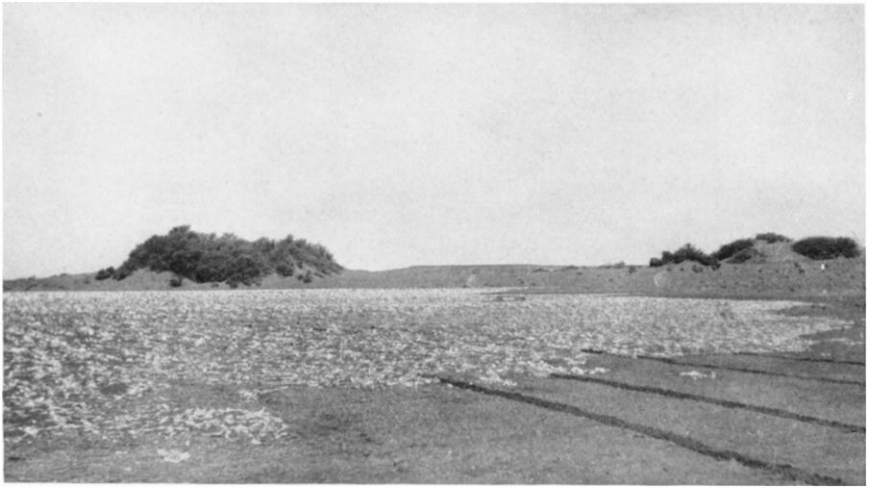
Inside the Malha crater

The Malha crater

Wadi Beida near Mellit



Remains of Nubian sandstone ridges in the country north of Malha



Salt pan at Bir Natrun

all the observed dune lines have been thus interfered with, it is difficult to guess at any rate for a dune line if left to itself. There is ample evidence of roads and car tracks having been pushed several hundred yards down-wind since 1920 by the advancing heads of the dune lines in the northern areas. There are three movements to be considered: the rate of advance of the head of the line, the rate of movement, if any, of the individual summits, and the mass-movement of the sand grains themselves.

It is usual for several *seif* dune lines or ranges to run parallel to one another, forming a dune field or dune belt. Here another type of repetition occurs, for each line is separated from its neighbour by a constant distance so that the landscape consists of a series of uniform parallel corridors. The distance between ranges varies in different areas, and may be anything from 400 yards to 5 miles. The floor of the corridor may consist of solid ground, either rock or shingle, or of undulating accumulations of sand.

Type 2. The *barchan* dune:

The individual *barchan* may be described roughly as a circular dome of sand, from the leeward side of which a big bite has been taken, leaving a collapsing front in the form of a hollow semicircle. The distinguishing feature of the *barchan* is this hollow crescent-shaped front, which faces directly down-wind instead of sideways as in the case of the *seif* (see Fig. 2).

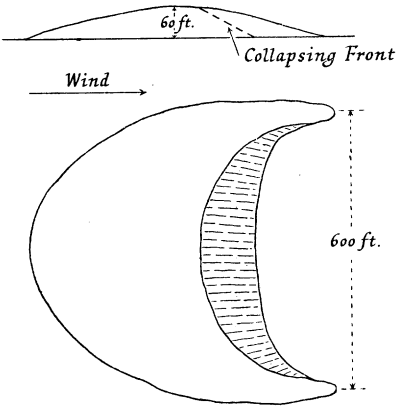


Fig. 2

As with the *seif* dunes, *barchans* congregate together. But owing to the transverse nature of the dune, no continuous straight ridge is possible, and a *barchan* line will be broad and ragged in configuration.

The dunes are usually arranged in echelon, sometimes so close together that the summits merge into one, the individuals being distinguished only by their crescent fronts, as in the left-hand side of Fig. 3. As with the *seif*, the *barchan* dune line stretches out in the direction of the prevailing wind. The line starts at the tail or windward end in the above close-packed manner, the individual dunes being of even size and evenly spaced, but the spacing increases towards the down-wind end till the individuals separate altogether. The line now carries on for a great distance as a well-drilled column of troops keeping regular echelon formation. The size of these individuals is of the order of 40 to 70 feet high and 100 to 400 yards wide between the horns of the crescent. The interval between dunes may be several miles. Sometimes a little dune 20 feet or so in width is found a few hundred yards to leeward of one of the horns of a big dune, as if some sort of reproduction is taking place.

A feature of the *barchan* is the tenacity with which it maintains its shape even when confronted with a formidable obstacle such as a small cliff, a village, or an area of rocks and boulders.

Curious cases of transformation occur. Although in the majority of *seif* dune lines the rear windward end rises abruptly to its full height in the open desert, there are some instances of short *seif*-like lines which seem to have started as sand-drifts under the lee of small hills and cliffs or even of mounds of vegetation, and crept out beyond the original sheltered area. But these lines never grow to any size. They are common near the oases of El Atrun, Merga, and Laqiya. More interesting are cases where the dunes at the head of a *seif* line suddenly alter their shape to rounded domes, and, less than a mile farther down-wind, separate out from one another, spread sideways to an echelon formation, and finally develop the typical *barchan* crescent. Instances of this can be seen north of the Gilf Kebir and at our Camp 21, 100 miles north-west of Tekro. In the depressions of El Atrun, Merga, and the Laqiyas there are cases of double transformations in which sand-drifts, starting at the foot of the cliffs, stream out across country for a mile or more as small *seif* lines and then change into true *barchans*. Apart from this, the *seif-barchan* transformation seems to be confined to the extreme down-wind ends of long *seif* dune fields, and is a sign that the field is coming to an end. The *barchans* continue only for a short distance before fading away into mounds and vague

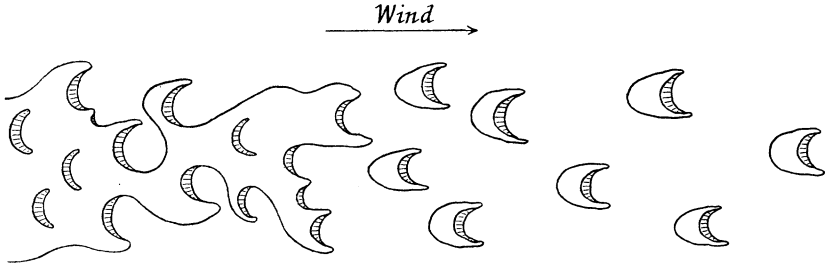


Fig. 3

undulations. No single case has been seen of any change in the reverse direction from *barchan* into *seif*.

The general effects of changes in the surface of the land on the dunes as they advance are difficult to determine. An up-gradient certainly causes a check and a consequent thickening and complication of the long *seif* ranges. In the Egyptian portion of the desert there is some evidence that a rocky broken surface is inimical to dunes, but in the northern Sudan, fields of both *seif* and *barchan* dunes are occupying country which is considerably broken. I think an area of rocks and small scarps will nearly always break up the continuity both of *seif* ranges and of closely packed *barchans*, and will in general diminish the density of a dune field so that large open spaces are found between the dunes, but it seems to take a very broken country with hills and high cliffs to check completely the advance of a large dune field. There are good examples of *seif* dunes existing in broken country in the big field south-west of 'Uweinat, and similar examples of *barchan* dunes immediately north of the cliffs of Laqiya, and in the depressions of El Atrun and Merga.

It is now possible to construct in outline a dune map of the Libyan Desert. Three striking facts emerge:

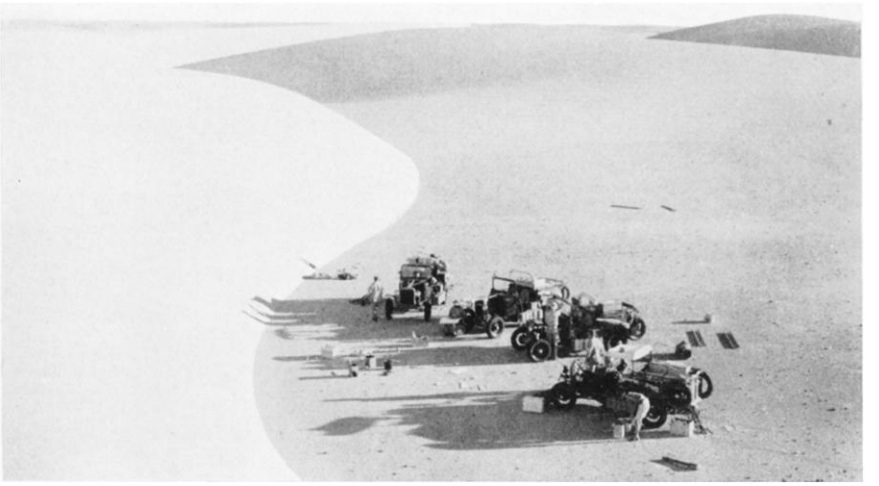
(1) There seems to be a single territorial boundary separating the desert

The lake at Merga

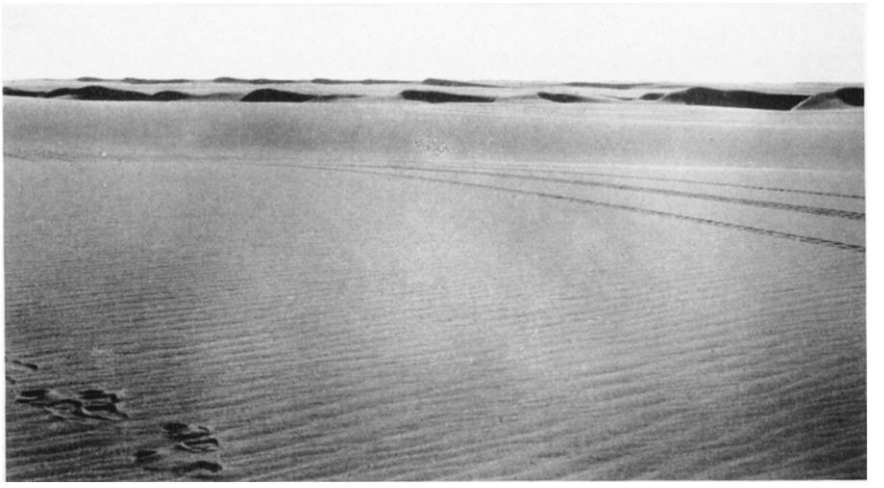
Looking east along the north scarp of the Laqiya depression

Wind-erosion of mud deposits in the Laqiya Umran depression

Selima Oasis from the south



Camp in lee of "barchan" dune near Bir Natrun



Lines of "seif" dunes in the Sand Sea

into two domains, each of which is occupied exclusively by one of the two dune types. Apart from the minor end-effects already noted, the whole of the north-western portion of the desert contains nothing but dunes of the *seif* type, while the smaller south-eastern section is reserved exclusively for *barchans*. The boundary seems to run from the Nile somewhere south of Asyut across to Kharga, and thence to Dakhla: thence south-west to the Gilf Kebir, and from there due south to meet the Wadi Hawa at lat. 17°. This boundary between dune types does not appear to coincide with any known division, either geological or orographical.

(2) All the dunes conform in direction to a single uninterrupted clockwise rotation about a centre somewhere near Kufara. The dune direction at any point on the map is presumably that of the prevailing wind also.

(3) True dunes appear to terminate about 100 miles before reaching areas where the rainfall is frequent enough to support grassy vegetation on the sand.

Whalebacks, and Undulations or Billows

A whaleback is a flat-topped ridge of sand anything up to 100 miles in length, of the order of half a mile wide, and up to 100 feet high. Like the *seif* dune range, it runs peculiarly straight throughout its length, but collapsing fronts are absent. The greater whalebacks are confined to the Sand Sea, of the northern portion of which they form the basic structure, the *seif* lines here being ranged along their backs intermittently.

Undulations are similar formations, but are shorter and therefore less definite in shape. They form the billowy surfaces between the whalebacks and *seif* ranges in the Sand Sea and in the big dune field south-west of 'Uweinat. Though so short that their general direction is often difficult to trace, they have a very uniform repetition distance of the order of 200 yards. They cover a very great area around lat. 18°, long. 25°, and thence south-east towards the Teiga Plateau. The big sand *gozes* of northern Darfur and Kordofan may possibly be of the same type. Both whalebacks and undulations appear to be "dead" or non-mobile as compared with dunes.

Sand-sheets

Except for small patches in the northern areas, sand-sheets are confined to the Nubian Sandstone country. They are characterized by their extreme flatness and by the almost entire absence of feature upon their surface, other than a fine ripple. The largest yet found lies due west of Selima, where it covers at least 20,000 square miles of country. Smaller sheets were found south and south-west of 'Uweinat, north of Tekro, and between Dakhla and 'Uweinat.

In addition to these four forms taken up by accumulations of real blown sand, there exist, especially in the Nubian Sandstone country, small objects which I will call "Grit-waves," since the presence of very large sand grains or small pebbles, too massive to be carried by the wind, is essential for their formation.[1] They occur either in sand-submerged areas, or by themselves on the surface of flat mud pans. Their shape is distinctive. They resemble giant ripples of the leaning-forward variety, *i.e.* with steep forward or down-wind slopes and gentle reverse slopes. The coarsest of the grit is collected along the crest of the

[1] See illustration *Geogr. J.*, July 1931, vol. 78, facing page 21.

wave, having evidently been driven there by a bombardment of small flying sand grains. In sand surfaces these waves occur either as raised structures whose bases are level with the sand surface, or as residues between hollowed-out troughs in the sand. Their chief distinguishing feature is the accumulation of coarse grit or pebbles along the crest. In size, these waves vary from a few inches in height to a maximum of about 2 feet. They are usually very firm and unyielding, and wave-infested areas present serious obstacles to motor transport.

[*The remaining sections of Major Bagnold's paper and a number of appendices will be published in the Journal for September.*]

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Homer speaks of the Libyan Desert as being a land of great fertility. That must have been long before his time and vague perhaps as the place and the date of his own birth. Whatever were the conditions in prehistoric times, it is safe to say that the climatic conditions in the Libyan Desert have not changed in the last four thousand years. Its history, to which I will refer later if opportunity offers, is of very great interest. In the last fifteen years it has been visited frequently. Hassanein Bey has been there often; Dr. John Ball, Prince Kemal el Din, who died last year and whose death was a great loss, Miss Caton-Thompson and Miss Gardner, and the Claytons. Lady Clayton, who is here to-night, came back only a few days ago.

This is the third journey that Major Bagnold has made into the Libyan Desert. Of the other two, one in 1929 and one in 1930, he gave descriptions which appeared in our *Journal*, and he has also lectured on them. Major Bagnold is a man who knows his business and chooses his men with a judgment that ensures success and really scientific production of what he discovers. It was therefore with great confidence that we were able in this Society to support him, both financially and by the loan of instruments. One of our Fellows, Mrs. Patrick Ness, with characteristic generosity, also helped him in his work.

Major Bagnold is not here to-night, having had to go to China to attend to his duties there. His paper will be read by Mr. Shaw, who accompanied him on this last occasion, as he accompanied him before. Mr. Shaw studied forestry at Oxford; he was then in the Sudan Forestry Service and left there, he tells me, because there were no more forests in the Sudan! Since then he has been working on archaeological explorations in the Near East. He made two previous journeys in the Libyan Desert, and on this journey he occupied himself chiefly with the survey and with the archaeology.

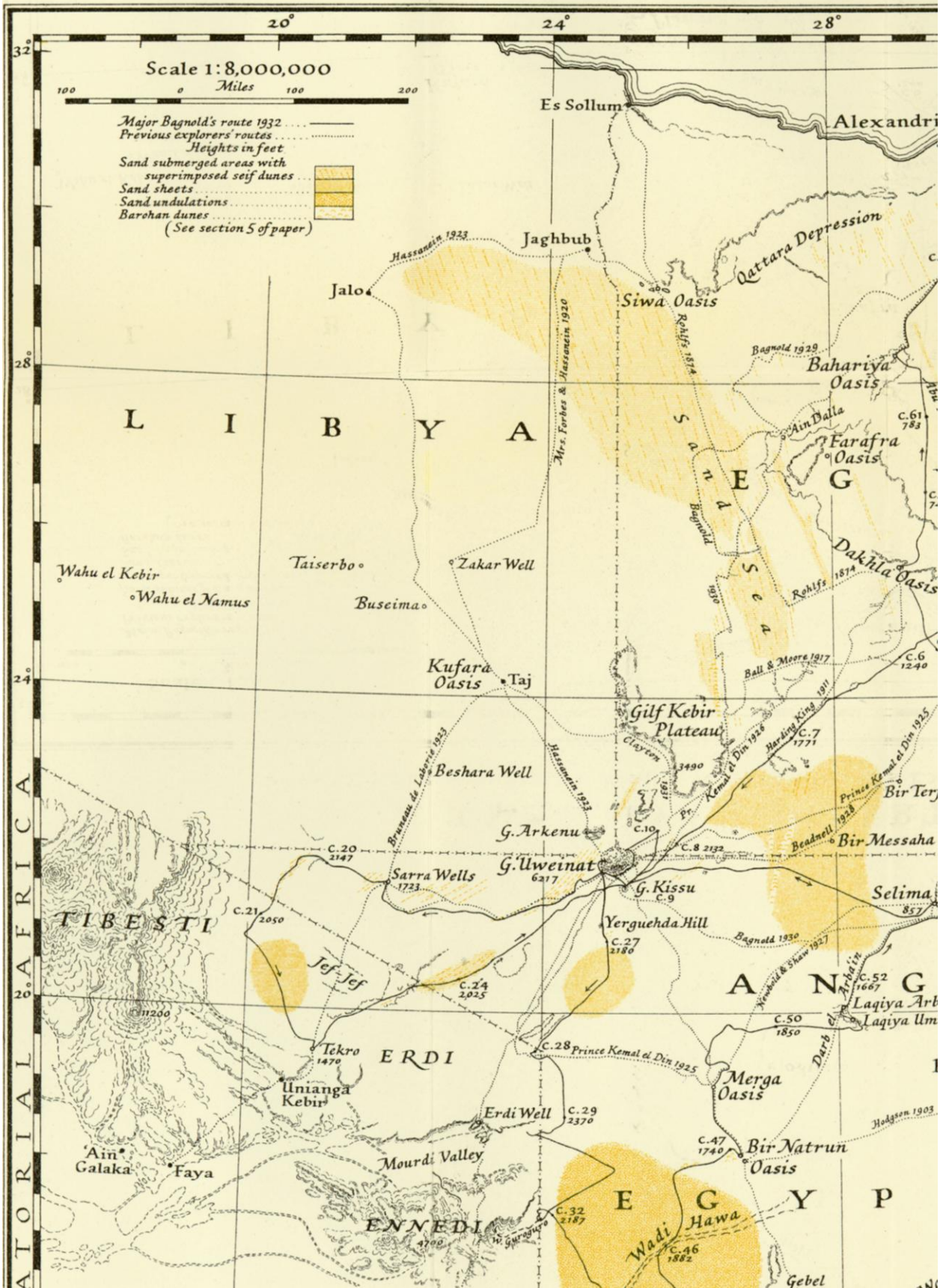
Mr. W. B. K. Shaw then read the paper printed above, and a discussion followed.

Dr. K. S. SANDFORD: From the slides that you have been looking at for the last hour you have probably gained the impression that the Libyan Desert, or at any rate the Southern Libyan Desert, is made up mostly of blown sand, or sand that will blow, or sandstone. That is sometimes regrettably true; but at the same time there is in fact an enormous amount of geological information to be gained from this country. Indeed it is in some parts a geologist's paradise, or it would be if he could stop there long enough. The difficulty is to maintain a party in some of these isolated pieces of country for any considerable time.

It is rather difficult to present many of the geological and pseudo-geological

THE LIBYAN DESERT

Showing the Routes of Major R. A. Bagnold's Ex



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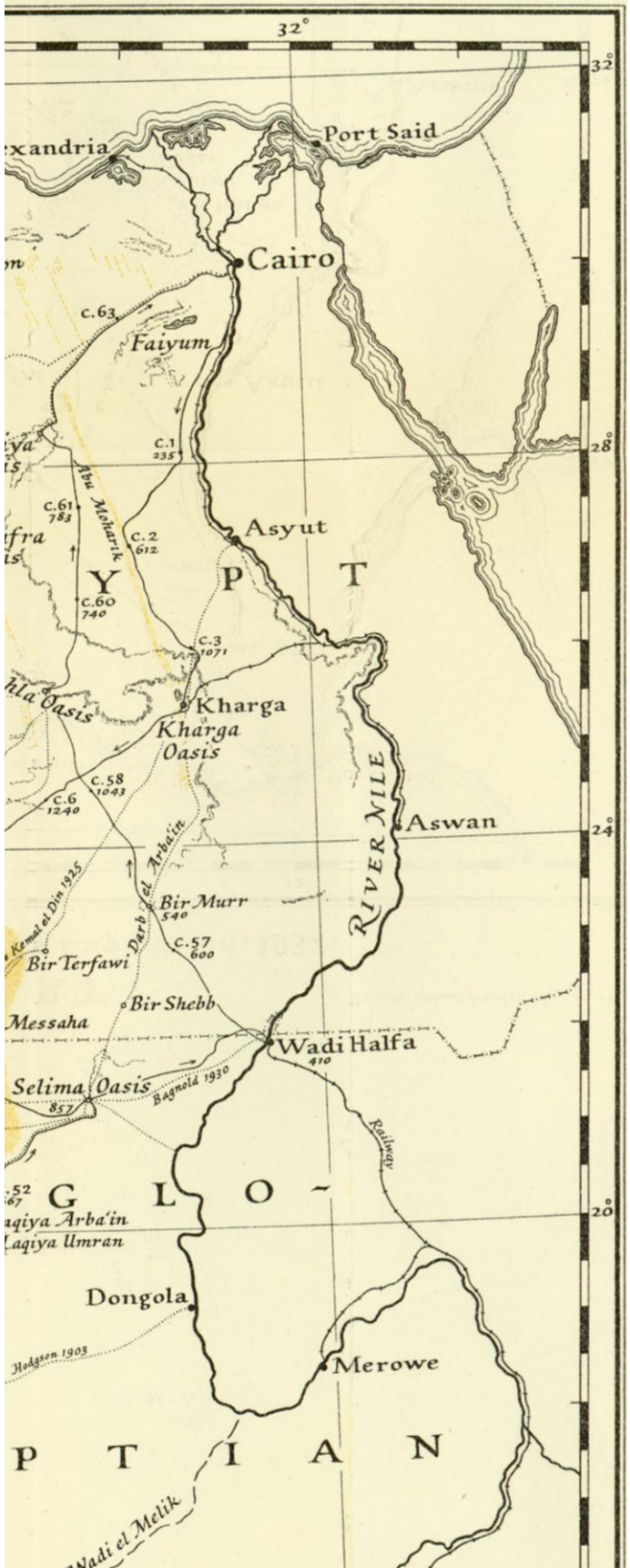

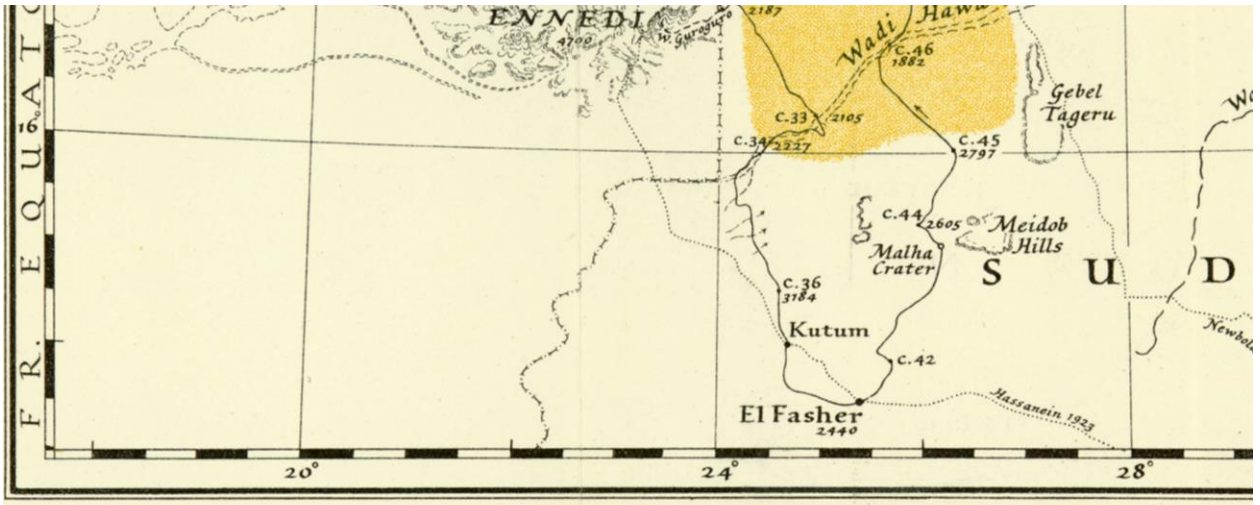

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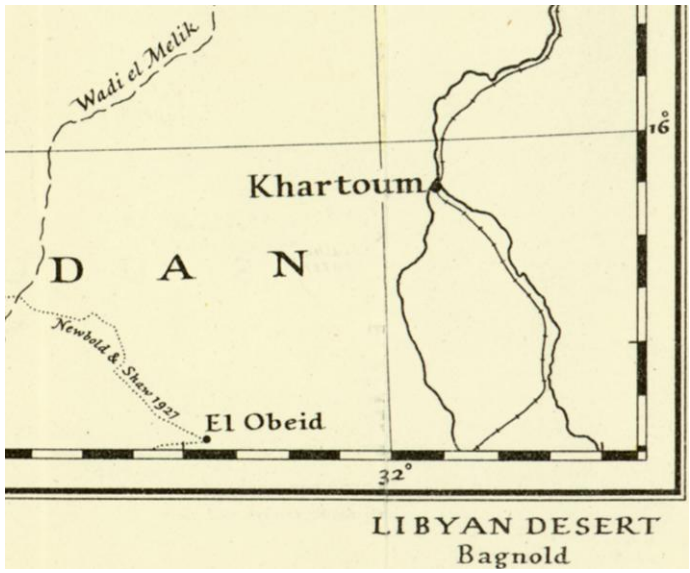
Wadi el Melik
16°
Khartoum
D A N
Newbold & Shaw 1927
El Obeid
32°
LIBYAN DESERT
Bagnold