

THE FRENCH SAHARA.¹

(1) **M. FOUREAU** has already told in a popular form the story of the expedition which he conducted with so much skill and success from the shores of the Mediterranean to the mouth of the Congo. Crossing the little-known country of the Touaregs, making the circuit round Lake Chad, descending the Shira and Ubangi Rivers, he had ample opportunity for examining the French possessions in Africa, and studying the prospects of their future development. During the six years that have elapsed since his return from this expedition he has been engaged in arranging and discussing the scientific results, some of which are now presented to the public. The first and second fascicules give details of the astronomical and meteorological observations, with a description of the water systems, the topography of the district, and the geological action of local winds. It is fortunate that the atlas of maps, which are drawn on a very elaborate scale, accompanies these handsome volumes. Since the geography of this part of Africa is somewhat uncertain, these are necessary in order to follow the exact route taken by the expedition.

M. Foureau is well known as an African explorer. For nearly thirty years he has traversed the Sahara in all directions, but his ambition to penetrate to the Sudan has always been foiled by the action of the Touaregs. In his many expeditions he has naturally been assisted by the Government and by learned societies, but he has never had at his command a force sufficient to overawe this warlike tribe and to make himself independent of its assistance or good will. In 1898, by a fortunate accident, he found himself placed in a more hopeful position. Through a legacy from M. Renoust des Orgeries to the Société de Géographie, a considerable sum of money became available for the purposes of exploration. The object of this bequest was to assist such expeditions as were undertaken with the view of bringing the independent tribes in the interior of Africa under the influence or protection of France, and which should by pacific measures tend to weld into a homogeneous whole the French possessions extending from Algeria to the Senegal and Congo. These funds were placed at the disposition of M. Foureau, who found himself in the autumn of 1898 at Wargla, at the head of a small army of some 300 men, a thousand camels, and the usual equipment of a well-organised expedition. M. Lamy, of the army of Algeria, was associated in the command of the expedition, and had charge of the military dispositions. Unfortunately, this energetic officer and able colleague, whose very ready assistance is warmly acknowledged, lost his life in an encounter with the natives.

The astronomical observations would perhaps be more fittingly described as geodetical, since they are naturally limited to the determination of the position of stations. The observations were made by M. Foureau and Lieut. Chambrun. For his longitudes, the former relied mainly on the methods used at sea, supplemented by a few occultations and pheno-

mena of Jupiter's satellites. The author carried four available chronometers, and remarks that the error in longitude arising from the accumulated error in the rate of the chronometers during 102 days amounts to only seven minutes of arc. It is not quite clear how this seven minutes is reckoned, but it certainly implies excellent performance of the watches and great care in their manipulation. It should be added, too, that wherever a comparison between the longitudes derived by different methods is possible, the agreement is quite satisfactory. M. Chambrun trusted to equal altitudes of moon and stars, and transits of the moon across the meridian. The latter, like some of the lunar distances taken by M. Foureau, were not found to possess sufficient accuracy. For latitudes both observers measured the altitude of Polaris and meridian altitudes of sun and stars. These results call for no remark, though it is impossible not to admire the energy which enabled these observers to prosecute their work after the fatigues of hard travel. M. Foureau also made some measures of the magnetic declination and horizontal force.

The meteorological or climatic observations are particularly welcome. These observations are, of course, spread over a large area, and it is not the climate of any one district that is presented. Con-

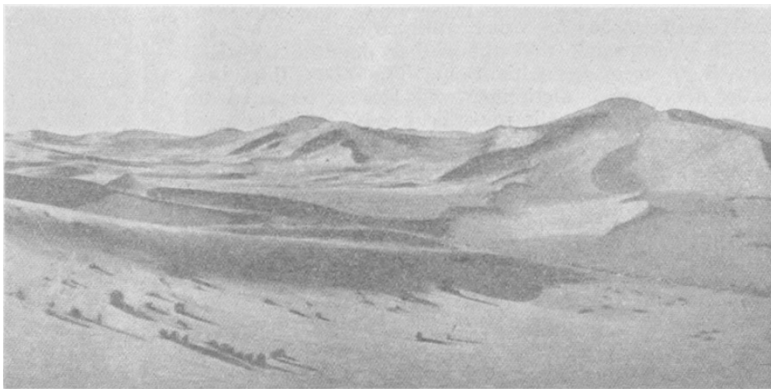


FIG. 1.—Large sand-dunes in the Erg region, Sahara.

cerning temperature, the author remarks that the thermometer fell below zero (C.) twenty-five times, the minimum reading being $-10^{\circ}.2$ (14° F.) at a height of 1144 metres. The highest temperature experienced was $48^{\circ}.3$ (119° F.), in March, 1900. Throughout the region the minimum temperature occurs about 5 a.m., and the maximum between 1 and 2 p.m. During the 645 days on which observations were possible, the sky was entirely free from cloud on 132 days, slight cloud was noticed on 227, while the sky was more or less overcast on 286. Dew was noticed on fourteen occasions, and rain fell on 116 days, but of these only forty-six were marked by severe storms; but violent atmospheric effects, whether of wind, or lightning, or sandstorms, were of frequent occurrence. In the Air highlands, almost every afternoon the sky was blackened, while violent thunder and lightning were experienced. The entire horizon would be continuously illuminated during whole minutes by brilliant flashes of lightning. Sudden hurricanes and appalling outbursts would keep men and animals in a state of tense excitement. Slight friction on the manes and tails of horses would bring forth, not electric sparks merely, but "des nappes de lumière."

The description of the Grand Erg and the character of the country through which the expedition passed,

¹ "Documents scientifiques de la Mission saharienne (Mission Foureau-Lamy d'Alger au Congo par le Tchad)." By F. Foureau. (1) Parts i. and ii., Observations, astronomiques et météorologiques. Pp. iv+551. (2) Part iii. Pp. 555-1210; with an atlas containing 16 maps. Geology, Petrography, Palæontology, &c. (Paris: Masson and Co., 1903-1905.)

its plateaux, its mountains, its profile, are all well brought before us, the illustrations are admirably reproduced, and the maps and plates make the text clear. Naturally M. Foureau had ample opportunity for studying the effect of wind erosion. On the Sahara its work is patent. The great variation in temperature by day and night brings about a constant cracking and crumbling of rocky corners, grinding each other into smaller fragments, which are ever being blown about by winds powerful enough to whirl along lumps of stone like feathers. Thus the constant manufacture of sand goes on, the friction of the particles of which gives to hard, compact rocks a polish like that of the lapidary's wheel. Other rocks of unequal consistency yield irregularly. The author traces the effects on various kinds of rock, granites, and sandstone, and shows the fret and honeycombing that follow. Having produced the sand by hard wear and tear, it is comparatively easy to construct the dunes, so conspicuous a feature on the comparatively level plains of the Sahara. Wherever obstructions intervene, such as prominent rocks, bushes, inequalities in the distribution of sand-level, a steep talus of grains gathers in the sheltered lee, while a more gentle sloping bank gradually rises on the windward side of the obstruction until this is finally buried. The weird

pronounced in the smaller body. M. Foureau directs attention to some very interesting points concerning the currents in this lake or in extensions of it, and discusses whether these currents are due to wind or evaporation; but into this, as into many other important points examined in these volumes, we have not space to enter. W. E. P.

(2) Now that so much new light has been thrown on North African geology by the explorations in the Lake region in the east, on the one hand, and in the territories of Germany, France, Great Britain, and the Congo Free State in the west, the largest of the unexplored tracts left of the once "Dark Continent" is that of the French Sahara, lying between Algeria on the north and the Congo territories on the south. Of this vast area a preliminary survey has been accomplished by the Mission Foureau-Lamy, which, setting out from Algeria in November, 1898, reached the Congo by way of Lake Chad in July, 1900. Ample collections were made along this almost unknown route, and detailed observations recorded on the topography, hydrology, and geology of the countries on the line of march. The results of the examination of the botanical, zoological, geological, and ethnological specimens, in the light of observations made during the journey, are

now published by the Geographical Society of France with the aid of subventions made by the French Government, the Academy, and the French Association for the Advancement of Science. Needless to say, the work before us (part iii.) has been issued in a form worthy of the highest traditions of French science, and with a great wealth of valuable illustrations.

In the geological notes made by the travellers along the line of route are found many very interesting observations on the mode of weathering of rocks in tropical districts. The illustrations reproduced are excellent examples of the action of sun and wind upon rocks in a desert region. The rocks passed over consist of granite, which appears to

occupy a very large area, crystalline schists, and sporadic masses of various volcanic rocks, with representatives of Silurian, Devonian, Carboniferous, and Cretaceous formations. In addition to these, there are sandstones of which the geological age could not be determined, and various superficial deposits.

The rock specimens were entrusted to M. L. Gentil, of the Sorbonne, a pupil of Prof. Lacroix, for description, and his report on the petrography of the regions traversed is a contribution of great value. Interesting laterites, diatomaceous earths, and travertines are among the most important of the materials of aqueous origin. The igneous rocks exhibit a great variety, and include, besides many varieties of granite, ophitic diabases, andesites, rhyolites, trachytes, phonolites, tephrites, and basalts. One very interesting feature exhibited by many of these rocks is their richness in the alkalis—the soda augites and hornblendes, like riebeckite, ægerine, &c., abounding in them. These facts, taken in conjunction with the studies by Mr. Prior, of the British Museum, on the rocks of the Lake district of Africa, of Prof. Bonney on those of Socotra, and of Prof. Lacroix in the Somali country and Madagascar, lend support to the view enunciated by the last-mentioned geologist that



Fig. 2.—Weathered pegmatite, showing the appearance of rock masses in the Sahara.

shapes into which this sand is blown, the strange curves it assumes, seem to be in many parts of the Grand Erg the only variation in a desolate landscape (Fig. 1). The author's description of Lake Chad is very interesting. This lake has about it something mysterious, and it is much to be regretted that the examination was not more thorough, with the view of unravelling what is obscure. To picture the lake as a compact sheet of water is quite inadequate. Whether the lake may be considered as containing an archipelago, or whether it runs away into numerous lagoons, creeks, swampy stretches, disconnected from the main body, is not yet cleared up. Whether these detached patches of water were originally parts of the lake, and now represent the deepest portions of the original bed, indicating that the lake is gradually disappearing, is one of those problems upon which more information is required. In these detached lakelets the water is brackish, but in the main body of the lake the water is fresh. The author raises the point whether some of these separate lagoons are not fed by subterranean water, which might explain the presence of salt. Where communication with the lake is probable or suspected there is very little salt in the water, but where the two are clearly distinct the presence of salt is very

a belt of alkaline igneous rocks surrounds the African continent.

The extensive collections of fossils brought home by the members of the Foureau-Lamy mission were placed in the hands of the late Prof. Munier-Chalmas for description, and on the lamented death of that palæontologist were transferred to his successor, Prof. Émile Haug. Valuable assistance in the work of determining and describing these fossils was received from Profs. Zeiller and Douvillé and from M. and Madame Ehlert. The result of these studies is to show that, in addition to the granitic and metamorphic rocks which at present cover such wide areas in the French Sahara, fossiliferous strata belonging to the Silurian, Devonian, Carboniferous, and Cretaceous systems also occur.

At a place called Tindesset, about 764 miles due south from Philippeville, there is found a series of

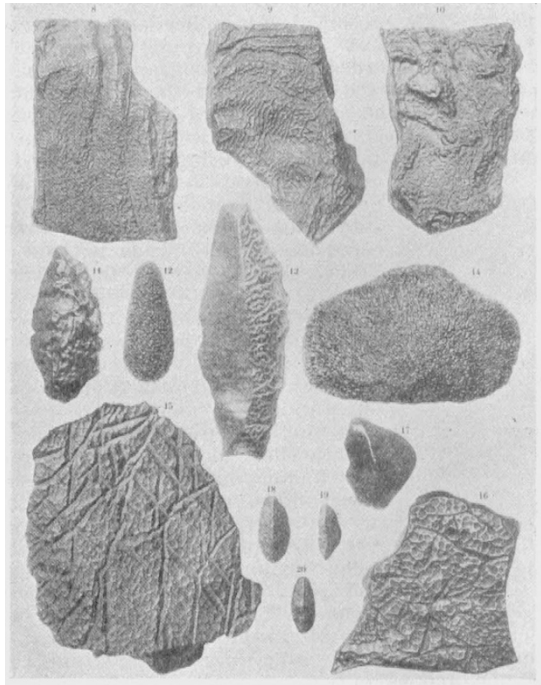


FIG. 3.—The larger specimens illustrate the fine fretted patterns produced on the surfaces of limestone rocks by the continued action of impinging sand grains driven by the wind. The four smaller specimens (17, 18, 19 and 20) illustrate the wearing down of fragments of siliceous rock, acted on by the natural "sand-blast." These are similar to those described by Mr. Enys from New Zealand.

shales cropping out from below the Devonian sandstones. The point at which they occur is nearly 4000 feet above the sea, and was reached with great difficulty by the members of the expedition. On splitting specimens of these shales that were brought home, the late Prof. Munier-Chalmas found undoubted examples of graptolites belonging to the genus *Climacograptus*. At that time strata of Silurian age were not certainly known to exist in the Sahara or in any part of northern Africa, but subsequently M. Flamand described graptolite shales as occurring in the Sahara at a locality about 250 miles north-west of Tindesset. As these belong to the Llandovery (Gothlandian) stage, the fossils of Tindesset may not improbably be referred to the same age.

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The Devonian strata cover a wide area in the northern part of the district traversed by the mission. Strata of this age were recognised by Overweg so far back as 1850, the fossils being determined by Beyrich. In the district of Tassili they form a plateau consisting of sandstones passing into quartzites. Besides the obscure fossils referred to, Spirophyton, *Arthropycus*, *Nereites*, *Crossopodia*, *Nemertites*, and *Medusina*, undoubted examples of *Homalonotus*, *Melocrinus*, and various brachiopods occur, which justify the placing of these strata at the very base of the Devonian. In addition to these, a number of separate valves of a lamellibranch shell, mineralised by hæmatite, were found. These are referred by Munier-Chalmas to a new genus (*Desertella*), and the beds containing them are doubtfully assigned to the Middle Devonian.

The Carboniferous system, also first recognised in North Africa by Overweg and Beyrich, has been found at many points in the Algerian Sahara, and a fairly large series of fossils (principally plants and brachiopods) was brought back by the members of this mission. The strata of sandstone and limestone appear to rest quite conformably upon the Devonian sandstones, and to represent low horizons in the Carboniferous system (Uralian and Moscovian). As is well known, Upper Carboniferous strata also occur over considerable areas in North Africa.

The Cretaceous strata consist of the widely-spread beds of limestones forming extensive plateaux, and containing *Ostrea columba* with other characteristic Cenomanian fossils. The escarpments formed by these limestone plateaux have a height of from 300 feet to 350 feet, and at their base it has long been known that variegated clays with beds of gypsum occur. Up to the time of the dispatch of the Foureau-Lamy mission, however, no fossils had been found in these beds, and their age remained doubtful. The discovery of the remains of Cretaceous types of *Ceratodus* with other fishes and some reptilian bones led Munier-Chalmas to assign these strata to the same age as our Gault.

In addition to the fossiliferous rocks referred to above, tracts of sandstone strata, which yielded no trace of fossils, were found, and the exact geological age of these must remain for the present in doubt.

Two plates of the work are devoted to illustrations of the structures developed in limestone rocks by æolian action—the impinging on rock-surfaces of sand grains driven by the wind. These are well known to all geologists who have studied desert formations, but the examples so beautifully figured in this work are of exceptional interest (see Fig. 3).

In the ethnographical section of this volume, which is very full and admirably illustrated, facts of very considerable geological interest are recorded. Most important of these is the account of the occurrence of implements formed of sandstone and quartzite, which are of undoubted Palæolithic types. The whole of the ten examples appear to be of the large, elongated, and pointed form so common at Saint-Acheul, none of the smaller oval type having been found. Neolithic types of both polished and unpolished implements abound, and are very fully illustrated.

Both the authors and publishers of this very important work are to be heartily congratulated on the discoveries made and the manner in which they are given to the world.

J. W. J.