ruptions, extend to Murzuk (Morzúḳ). To the south of the hammada of Murzuk the dunes of Murzuk stretch away south-east. Looked at in its entirety, this series of tracts may be called the northern zone; it forms a kind of bow, with its extremities respectively at the Atlantic and the Libyan Desert and its apex in the south of Tunis. In the south are the Juf, @@1 covering a vast area to the south-east of the middle portion of the Igidi, another area between the Adghagh plateau and the Tasili wan Ahaggar, and a third between Air and Tibesti. Away to the east in the Libyan Desert is a vast region of dunes of unascer­tained limits. It must be borne in mind that the sands do not entirely cover the areas assigned to them in the ordinary maps, which are of too small a scale to show the interchange of different kinds of surface. In the Eastern Erg especially the dunes lie in long lines in a north-north­west and south-south-east direction, presenting a gradual slope to windward and an abrupt descent to leeward. There they are generally about 60 or 70 feet high, but in other parts of the Sahara they are said to attain a height of upwards of 300 feet. The true dune sand is remarkable for the uniformity of its composition and the geometrical regularity of its grains, which measure less than ·03937 inch. @@2 While individually these appear crystalline or reddish yellow (from the presence of iron), they have in the mass a rich golden hue. According to M. Tissandier’s examination, animal organisms, such as the microscopic shells of *Rhizopoda,* so abundant in sea-sand, are strik­ingly absent. Under the influence of the wind the surface of the dunes is subject to continual change, but in the mass they have attained such a state of comparative equilibrium that their topographic distribution may be considered as permanent, and some of them, such as Gern (Peak) al-Shúf and Gern Abd-al-Kader, to the south of Golea, have names of their own. The popular stories about caravans and armies being engulfed in the moving sands are quite apocryphal, but there is abundant evidence against the theory of M. Vatonne as to the dunes having been formed *in situ.* To understand their origin it is necessary to glance at the general geology of the Sahara, which, however, in this aspect, is only known in detail to the south of Algeria and along the routes of the Rohlfs ex­pedition (1873-74, Dr Zittel) and that of Dr Lenz (1880).

Granite, which, along with gneiss and mica schists, seems to be the prevailing rock in the highlands of Air (Von Bary), comes to the surface more or less sporadically in the neighbourhood of Al- Eglab and in the Adrar districts in the south-west. Gneiss and mica schists are probably the main materials of the Ahaggar plateau. Volcanic rocks (basalt, &c.) form the mountain masses of Jebel es-Sóda and the Haruj ; in Air they break through the granite and other rocks in a very erratic fashion. Slates and quartz­ite (possibly Silurian, according to Lenz), which play so great a part in Senegambia, appear to the north of the Senegal, along the edge of the desert, and crop out again in Adrar, on the eastern borders of the Juf, and to the east of Wady Sus. An immense tract from Adrar north-east to the borders of Algeria seems to be occupied by Devonian and Carboniferous formations, the character­istic fossils of which frequently show on the surface ; farther east these rocks are covered by Cretaceous and Quaternary deposits, though they again appear in the Muydir and Tasili plateaus (M. Roche s report @@3 ). The development of the Cretaceous system is altogether one of the most striking features of Saharan geology, its extreme limits being the coasts of the Atlantic and the Red Sea, and the area occupied by it in the Algerian Sahara alone being equal to the whole of France. In the Algerian Sahara the Cretaceous rocks are covered by no later sediments, with the exception of certain Quaternary deposits, but in the Libyan Desert Tertiary deposits are abundant, though, according to Zittel, there is no sharp distinction between Cretaceous and Tertiary, the one seeming

(certain palaeological characteristics apart) to pass gradually into the other. Eocene limestones, rich in nummulites and operculines, stretch south and east from the oasis of Síwa and are well seen in the cliffs enclosing the depressed oasal areas which sink down to the Cretaceous rocks. To the south of Farafreh extends a vast tract of Nubian sandstone.

In all parts of the Sahara there is evidence of denudation carried out on a scale of unusual magnitude. The present surface of the desert has been exposed to the protracted wear and tear of the elements. But to determine the exact method by which the ele­ments have done their work has hitherto proved beyond the power of science. The superficial observer is at once tempted to accept the theory of *submarine* denudation : the Sahara is still the “ dried bed of a sea ” in even such text-books as Professor Huxley’s *Physioyraphy* and Stanford’s *Compendium of Geography.* The sand-dunes, the salt efflorescence and deposits, and the local occurrence of certain modern marine molluscs all go to help the hypothesis of a diluvial sea. But a more extensive acquaintance with Saharan character­istics shows that such a sea for the Sahara as a whole is impossible. The denudation must probably be explained as due to the combined action of fresh water and atmospheric agencies. Even at present the Sahara is not so destitute as has been supposed of fresh water. Though rain is one of the rarest phenomena of the lowlands, the mountains on its northern borders and the central highlands are both regions of precipitation, and discharge their surplus waters into the hollows. A glance at a good physical map of the Sahara shows in fact the skeleton of a regular river-system. From the north side of the Atakor-’n-Aliaggar, for instance, begins Wady Igharghar, which, running northwards between the Tasili plateau and the Irawen Mountains, appears to lose itself in the sands of the Eastern Erg, but can be distinctly traced northwards for hundreds of miles. Its bed contains rolled fragments of lava and freshwater shells *(Cyrena* and *Planorbis).* In a line almost parallel to Wady Ighargliar Wady Mya descends from the plateau of Tademayt, and shows the importance of its ancient current by deep erosion of the Cretaceous rocks, in which a large number of left- hand tributaries have also left their mark. Away in the far east of the Libyan Desert Dr Zittel discovered stalactite caves in the limestone. The question arises, What has become of the abundant water-supply which filled the wadies and hollowed out the caves ? Recent discoveries in the Algerian Sahara suggest that part of the water circulation has become subterranean. The streams from the Atlas which seem to be absorbed in the sands of the desert evidently find a series of underground reservoirs or basins capable of being tapped by artesian wells over very extensive areas. As Olympiodorus (quoted by Photius) mentions that the inhabitants of the Sahara used to make excavations from 100 to 120 feet deep, out of which jets of pure water rose in columns, it is clear that this state of matters is (historically) of ancient date. Since 1856 the French engineers have carried on a series of borings which have resulted in the fertilizing of extensive tracts; between 1856 and 1879 155 wells were bored in the province of Constantine alone. In Wady Rir’, which runs for 80 miles towards the south-west of the Shott Melrir (comp. *infra),* the water-bearing stratum is among permeable sands, which are covered to a depth of 200 feet by impermeable marls, by which the water is kept under pressure. The wells, varying much in their discharge and “head,” give a total of 3·5 cubic metres per second at an average temperature of 25°T Fahr. A similar artesian zone exists between Negussa and Wargla. Connexions probably exist with subterranean water-sup­plies in the mountains to the north. That in some way the water in the artesian reservoirs is kept aerated is shown by the existence below ground of fishes, crabs, and freshwater molluscs, all of which were ejected by the well called Mezer in Wady Rir’. Hitherto those subterranean basins have been verified only in a comparatively limited area (the whole expanse of the Sahara being considered); but the same phenomena are probably repeated to some extent in other regions.@@1 The oases are of course proofs of the presence of a steady supply of underground moisture, for vegetation under the Saharan climate is exceptionally thirsty.

Everything considered, it may therefore be assumed that tho desert formerly possessed a surface circulation of water capable of aiding in the processes of disintegration, removal, and deposition. Since the water disappeared other agencies have been at work. The surface of the rocks, heated by the sun and suddenly chilled by rapid radiation over night, gets fractured and crumbled ; elsewhere the cliffs have been scored and the sand thus formed is at once turned by the wind into an active instrument of abrasion. In many places it has planed the flat rocks of the hammada as smooth as ice. Elsewhere it has scored the vertical faces of the cliffs with curious imitations of glacial striation, and helped to undercut the pillar- or table-like eminences which, under the name of *gurs* or “witnesses,” are among the most familiar products of Saharan erosion. The softer quartz rocks of the Quaternary and Cretaceous

@@@1 This name, meaning the “depression,” has long been in use, but appears to be a misnomer ; the lowest point in Lenz’s route, which, however, only crossed the east end of the Juf, was 400 feet above the sea.

@@@2 See Rolland, in *Bull, de la Soc. géol. de France,* 1881, and *Revue Scientifique,* 1881.

*@@@3 Comptes Rendus, Acad. des Sciences.*

@@@4 See Rolland, “ Le régime des eaux artésiennes de l’Oued Rir et du Bas Sahara,” in *Comp. Rend., Acad. des Sc.,* Sept. 1885.