

ABSTRACT OF OBSERVATIONS OBTAINED BY THE
SCIENTIFIC EXPEDITION SENT OUT TO ARABIA
PETRÆA AND WESTERN PALESTINE BY THE
COMMITTEE OF THE PALESTINE EXPLORATION
FUND IN 1883.

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THE Committee of the Palestine Exploration Fund, in the summer of 1883, resolved upon sending out an expedition to examine the geological structure of the Jordan Valley and Western Palestine, together with that of the Valley of the Arabah, with a view to determine the mode of their formation and physical history. It was also intended to connect the triangulation of the district of Mount Sinai (Jebel Musa) with that of Western Palestine along the district of the Wâdy el Arabah; and to determine the elevation above the sea of the watershed (or "saddle") of that valley, with reference to the practicability of the projected "Jordan Valley Canal Scheme." Several collateral objects were also kept in view—such as the investigation of the sites of Ezion Geber, Kadesh-barnea, and other localities connected with the Israelitish migration and history; but in this place only the scientific aspects of the Expedition will be referred to.

Besides the author, who was put in command of the Expedition, the other members were Major Kitchener, R.E., and Mr. Armstrong (formerly Sergeant-Major, R.E.), who joined us in Egypt; Mr. H. C. Hart, Trin. Coll., Dublin, who had been a member of Captain Nares' Polar Expedition, and now joined as botanist and naturalist; Mr. Reginald Lawrence, Associate of the Royal College of Science, Dublin who acted as meteorologist; and Dr. E. Gordon Hull, who was appointed assistant and medical officer.¹

The arrangements for providing camels, tents, food and supplies were undertaken gratuitously by the well-known firm of Messrs. T. Cook & Son, to whom it is only due to say that they did everything in their power for the comfort and safety of the members of the Expedition. A rendezvous of the whole party, including conductor, dragoman, and Arabs of the Towara tribe, took place at Cairo on the 7th November, 1883, and on Monday, the 11th of the same month, the party started for their desert journey from Moses' Wells (Ayun Musa), near Suez.

The route taken lay along the plain bordering the Gulf of Suez to Wâdy Gharandel, and thence by the Wâdies Hamr, Suwig, and Nasb, Bark, Lebwey, Berrah, and Es Sheikh, to the base of Mount Sinai (Jebel Musa). Thence, after a few days, in a north-easterly direction by the Wâdies Zelegah, Biyar, El Ain, Et Tihyah, and Ras en Nakb to Akabah.

Here the Arabs of the Towara tribe who had conveyed the party thus far were dismissed; and arrangements were entered into with the Sheikhs of

¹ Mr. Hart has considerably added to the recognised flora of the district traversed, and Mr. Lawrence has furnished a daily register of the temperature and aneroid readings. Dr. E. G. Hull brought home a large number of photographs.

the Alowins for a convoy along the Wâdy el Arabah to Petra, and the shore of the Salt Sea (Bahr Lut). This having been effected, the party left Akabah on the 3rd December; and after visiting Petra, Mount Hor (Jebel Haroun), and several of the branching valleys on either side, reached Es Safieh on the 17th of the same month, and camped by the village of the Ghawarnehs, where they remained ten days, including Christmas Day. Horses and mules having at length arrived from Jerusalem, accompanied by a small escort of Turkish cavalry, the party crossed to the western shore of the Salt Sea, and after examining Khasham (or Jebel) Usdum (the salt mountain), ascended by the Wâdy Zuweirah towards the tableland of Southern Palestine, camping successively at Wâdy el Abd, Tel el Melh, Bir es Saba (Beersheba), Tel Abu Hareireh, and reaching Gaza on the last day of the year. Here the party would have been obliged to remain in quarantine for fifteen days but for the friendly offices of Lord Dufferin, the British Ambassador at Constantinople, who procured their release on the morning of the fifth day. They then proceeded onwards by Jaffa to Jerusalem, from whence excursions were made to the Jordan Valley, and other places around, and by which two complete traverses of Southern and Central Palestine were effected. The whole distance traversed was about 700 miles, of which 500 miles were on camel-back, the remainder on horse-back. A final expedition through Northern Palestine was then arranged for, but was brought to an end by a heavy fall of snow, which covered the whole of the tableland of Palestine to a depth of 2 feet and upwards. The party left Jaffa on their return to England on Friday, 25th of January, Major Kitchener having previously returned to Egypt.

Scientific results.—Before proceeding to give an outline of the scientific results of the Expedition, the author desires to express his obligations to the writings of previous explorers in the same field, especially to those of Russeger, Fraas, Tristram, and of MM. Lartet and Vignes, of the expedition carried out by the Duc de Luynes.

1. A complete triangulation of the district lying between the mountains of Sinai and the Wâdy el Arabah, including that of the Wâdy el Arabah itself, bounded on the west by the tableland of the Tih, and on the east by the mountains of Edom and Moab. An outline survey along the line of route was also made, and has been laid down in MS. on a map prepared by Mr. Armstrong on the same scale as the reduced Map of Palestine, viz., $\frac{3}{8}$ inch to one statute mile, or $\frac{1}{1888000}$.

2. Some important rectifications of the borders of the Salt Sea, and of the Gulf of Akabah, were also made.

3. A geological reconnaissance along the line of route through the districts of Sinai, Akabah, and the Wâdy el Arabah, including the following particulars:—

(a) Collections of fossils from the Wâdy Nasb Limestone, in addition to those already made by Mr. Bauerman and Colonel Sir C. W. Wilson. These fossils (which are being examined by Professor Gollas) go to show that this limestone is of Carboniferous age; the Wâdy Nasb limestone was found to continue over a considerable region north of Mount

Sinai, and was again recognised amongst the mountains of Moab on the east side of the Salt Sea in the Wâdy el Hessi. As this limestone rests upon a red sandstone foundation, this latter may also be assumed to be of the same geological age, and therefore cannot be the representative of the "Nubian Sandstone" of Russeger, which (as Professor Zittel has shown) is of Cretaceous age. I propose to call this formation, therefore, "the Desert Sandstone." It forms with the limestone a strip along the borders of the ancient rocks of paleozoic or archæan age, and is about 400 feet in average thickness; the base is generally a conglomerate.

(b) Above the Wâdy Nasb limestone is another sandstone formation, of which a large portion of the Debet er Ramleh is formed. It is laid open in the Wâdies Zelegah, Biyar, &c., and along the mountains of Edom and Moab. Out of this rock have been hewn the ancient temples, tombs, and dwellings of Petra and the Wâdy Musa. It stretches along the southern escarpment of the Tih plateau, and forms the base of the limestone cliffs along the margin of the Wâdy el Arabah as far north as Nagb el Salni. This sandstone formation is soft, red, or beautifully variegated, and is in all probability of Cretaceous age, and therefore the true representative of the "Nubian Sandstone" of Russeger. It will thus be seen that there are two red sandstone formations, one below, the other above the Carboniferous limestone of the Wâdy Nasb.

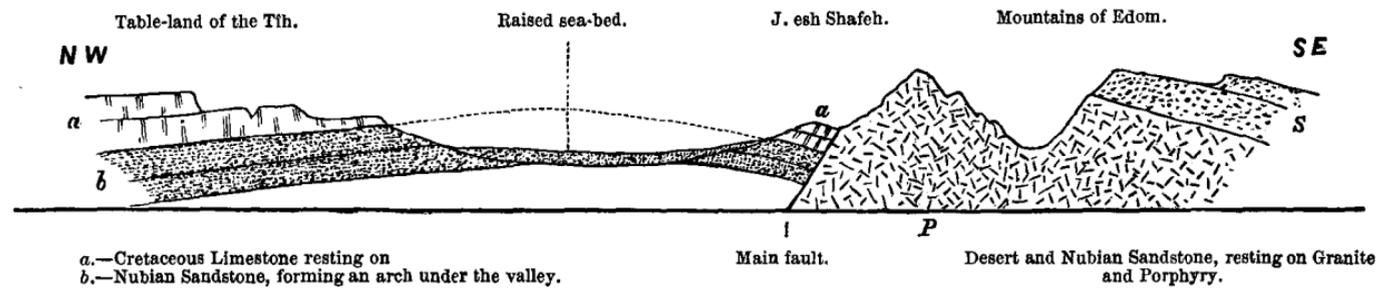
(c) The geological structure of the Wâdy el Arabah was examined throughout a distance of 120 miles from south to north. That it has been hollowed out along the line of a main fault, ranging from the eastern shore of the Salt Sea to that of the Gulf of Akabah, was clearly determined; and the position of the fault itself was made out and laid down on the map¹ in six or seven places, one being about ten miles north of Akabah, another near the watershed, in which places the limestone of the Tih (cretaceo-nummulitic) is faulted against the old porphyritic and metamorphic rocks. I here give two sketch sections to illustrate the structure at these points (see p. 163).

There are numerous parallel and branching faults along the Arabah Valley, but there is one leading fracture running along the base of the Edomite Mountains, to which the others are of secondary importance; this may be called "The Great Jordan Valley fault." The relations of the rocks in the Ghor and Jordan Valley have already been shown by Lartet, Tristram, Wilson, and others, to indicate the presence of a large fault corresponding with the line of this remarkable depression, and the author considers the fracture he has observed in the Arabah Valley to be continuous with that of the Jordan.

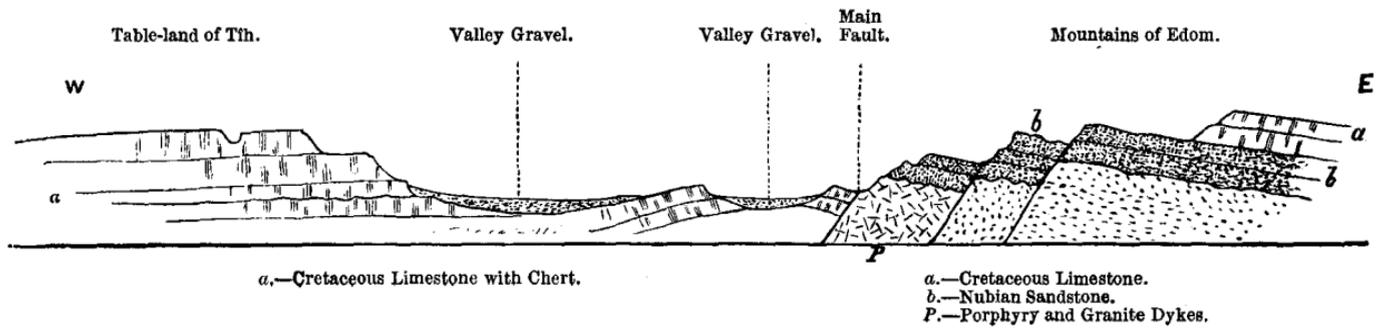
(d) The ancient rocks which form the floor either of the Desert, or Nubian, sandstone formations, consist of granite, gneiss, porphyries, and more rarely metamorphic schistose rocks—together with volcanic rocks, consisting of agglomerates, tuffs, and beds of felspathic trap. The author

¹ The map used was an enlarged plan from Smith and Groves' Ancient Atlas (J. Murray).

SKETCH SECTION ACROSS THE WÂDY EL ARABAH.



SKETCH SECTION ACROSS THE WÂDY EL ARABAH, SHOWING ITS STRUCTURE NEAR THE WATERSHED, OR SADDLE.



N 2

is disposed to concur with Dr. Lartet in considering the gneissose and granitoid rocks to be of archæan (or Laurentian) age, as they are probably representative of those of Assouan in Upper Egypt, which Principal Dawson has recently identified with those of this age. The granites and porphyries are traversed by innumerable dykes of porphyry and diorite, both throughout the Sinaic mountains and those of Edom and Moab; and the author considers it probable that the volcanic rocks which are largely represented along the base of Mount Hor, and of Jebel Somrah near Es Safieh, are contemporaneous with these dykes. As far as the author was able to observe, none of these dykes penetrate the Desert or Nubian sandstones, and if so, they may be considered of pre-Carboniferous age. The upper surface of the ancient rocks was extremely uneven previous to the deposition of the Desert sandstone, having been worn and denuded into ridges and hollows; over this irregular floor the sandstone strata were deposited.

4. The occurrence of terraces of marl, gravel, and silt, through which the ravines of existing streams have been cut at an elevation (according to aneroid determination) of about 100 feet above the level of the Mediterranean, was taken to show that the level of the Salt Sea (Bahr Lut) at one time stood about 1,400 feet higher than at present. These beds of marl were first observed at the camp at Ain Abu Beweireh; they contain blanched shells of the genera *Melanopsis* and *Melania*. The beds of marl were observed to be enclosed by higher ground of more ancient strata in every direction except towards the north, where they gently slope downwards towards the borders of the Ghor, and become incorporated with strata of the 600-foot terrace.

The author concurs with Dr. Lartet in thinking that the waters of the Jordan Valley did not flow down into the Gulf of Akabah, after the land had emerged from the sea; the disconnection of the inner and outer waters was very ancient, dating back to Miocene times.

The occurrence of beds of ancient lakes—consisting of coarse gravel, sand, and marl, amongst the mountains of Sinai, and in the Wâdy el Arabah, where now only waterless valleys occur, taken in connection with other phenomena, have impressed the author with the conviction that the former climatic conditions of Arabia Petræa were very different from those of the present day. Such terraces have been observed by Dr. Post in the Wâdy Feirân, and Colonel Sir C. W. Wilson in the Wâdy Solaf, and by the author in the Wâdies Gharandel, Goweisah, Hamr, Solaf, and Es Sheikh or Watiyeh. It would appear that, at a period coming down probably to the prehistoric, a chain of lakes existed amongst the tortuous valleys and hollows of the Sinaic peninsula. The gypseous deposits of Wâdy Amarah and of 'Ain Hawareh are old lake beds, and Mr. Bauerman has observed remains of fresh-water shells (*Lymnaea truncatula*) and a species of *Pisidium* in "lake or river alluvium" of the Wâdies Feiran and Es Sheikh. ("Quart. Journ. Geol. Soc.," Vol. XXV, p. 32.)

7. The author considers it probable that these ancient Sinitic lakes belong to an epoch when the waters of the Mediterranean and the Red Sea rose to a level considerably higher than at present, and when, consequently,

there was less fall for the inland waters in an outer direction. The evidence of a submergence, to a depth of at least 200 feet, is abundantly clear in the occurrence of raised beaches or sea beds with shells, corals, and crinoids of species still living in the adjoining waters. The raised beaches of the Mediterranean and Red Sea coasts have been observed by the officers of the Ordnance Survey, and by Fraas, Lartet, Schweinfurth, Post, and others. They were observed by the author at the southern extremity of the Wady el Arabah, and shells and corals were found round the camp of the 3rd December at an elevation of about 130 feet above the Gulf of Akabah.

These ancient sea beds are represented in the Egyptian area by the old coast line of 220 feet, discovered by Fraas along the flanks of the Mokattam Hills above Cairo, and recently described by Schweinfurth. (Über die geol. schichtunggliederung d. Mokattam bei Cairo; Zeit. d. Deuts. Geol. Gesel, 1883.) The period in which the sea rose to this level may be stated in general terms as the Pliocene, but it continued downwards till more recent times; and the author believes that at the time of the Exodus the Gulf of Suez reached as far as the Great Bitter Lake (*Quarterly Statement*, April, 1884), a view in which he is supported by Principal Dawson, F.R.S. It is scarcely necessary to observe that through the longer portion of this period of submergence Africa was disconnected from Asia.

8. The Miocene period is not represented by any strata throughout the district traversed by the Expedition. The author considers that in this part of the world the Miocene period was one of elevation, disturbance, and denudation of strata; not of accumulation. To this epoch he refers the emergence of the whole of the Palestine, and of the greater part of the Sinaitic, area from the sea, in which the cretaceo-nummulitic limestone formations were deposited. To this epoch also he considers the faulting and flexuring of the strata is chiefly referable; and notably the formation of the great Jordanic line of fault, with its branches and accompanying flexures in the strata—which are very remarkable along the western sides of the Ghor. These phenomena were accompanied and followed by extensive denudation and the production of many of the principal physical features of the region referred to.

9. The evidences of a Pluvial period throughout this region are to be found (*a*) in the remains of ancient lake beds, (*b*) in the existence of terraces in the river valleys, (*c*) in the great size and depth of many valleys and gorges, now waterless except after severe thunderstorms, and (*d*) in the vastly greater size of the Salt Sea (or Dead Sea), which must have had a length of nearly 200 English miles from north to south at the time when its surface was at a higher level than that of the Mediterranean at the present day. The author considers that this Pluvial period extended from the Pliocene through the post-Pliocene (or Glacial) down to recent times. As it is known, from the observations of Sir J. D. Hooker, Canon Tristram, and others, that perennial snow and glaciers existed in the Lebanon during the Glacial epoch, the author infers that the adjoining districts to the south of the Lebanon must have had a climate approaching that of the British Isles at the present day;

and that, in a region of which many parts are over 2,000 feet in elevation, there must have been abundant rainfall. Even when the snows and glaciers of the Lebanon had disappeared, the effects of the colder climate which was passing away must have remained for some time, and the vegetation must have been more luxuriant down to within the epoch of human habitation. The author's views generally coincide with those of Theobald Fisher, as extended by him to a much wider area. ("Studien über das Klima der Mediterranean Lander," Peterman's Mittheilungen, 1879.)

10. The author considers that there are reasons for concluding that the outburst of volcanic phenomena in North-Eastern Palestine in the region of the Jaulan and Hauran, &c., has an indirect connection with the formation of the great Jordan Lake of the Pluvial period. The presence of water in considerable volume in now recognised as necessary to volcanic activity, and the author submits that this interdependence was brought about when the waters of the Lake stretched as far north as the little Lake of Huleh. These waters, under a pressure of several hundred feet, would find their way into the interior of the earth's crust along the lines of the great Jordan Valley fault, and of its branches, and thus supply the necessary "steam-power" for volcanic action. The period when the volcanoes of the Jaulan and Hauran were in action appears to have ranged from the Pliocene through the post-Pliocene to the beginning of the recent; when, concurrent with the falling away and partial drying up of the waters of the great Lake, the volcanic fires became extinct and the great sheets of basaltic lava ceased to flow.

If these views are correct, it would seem that during the Glacial epoch, Palestine and Southern Syria presented an aspect very different from the present. The Lebanon throughout the year was snow-clad over its higher elevations, while glaciers descended into some of its valleys. The region of the Hauran, lying at its southern base, was the site of several extensive volcanoes, while the district around, and the Jordan Valley itself, was invaded by floods of lava. A great inland sea, occupying the Jordan Valley, together with the existing comparatively restricted sheets of water, stretched from Lake Huleh on the north, to a southern margin near the base of Samrat Fiddân in the Wâdy el Arabah of the present day, while numerous arms and bays stretched into the glens and valleys of Palestine and Moab on either hand. Under such climatic conditions, we may feel assured, a luxuriant vegetation decked with verdure the hills and vales to an extent far beyond that of the present, and amongst the trees, as Sir J. D. Hooker has shown, the cedar may have spread far and wide.

11. The author has not thought it necessary to go into the question of the origin of the salinity of the Salt Sea, as this question is now fully understood. He is obliged to differ with Dr. Lartet in his view of the origin of the salt mountain, Jebel Usdum,¹ which he (the author) regards

¹ Lartet regards the strata of this mountain as belonging to the Nummulitic period.

as a portion of the bed of the Salt Sea, when it stood about 600 feet above its present level. This level exactly corresponds to that of the terraces, both along the south and east of the Ghor, formed of lacustrine materials. The upper surface of Jebel Usdum was examined by Messrs. Hart and Laurence, of our party, but previous explorers have considered the sides inaccessible.

12. The author concurs with previous writers in considering that the Cretaceous and Tertiary periods succeeded each other over this region (at least as far as the marine deposits are concerned) without any important physical disturbances ; in consequence of which the limestone formations of these periods are in physical conformity and are generally incapable of separation. It seems probable, however, that while the Nummulitic limestones predominate in the Egyptian and Nubian areas, those of the Cretaceous period were more fully developed over the area of Arabia Petræa and Palestine.

The scientific results of which the above is a summary are intended to be published *in extenso* by the Palestine Exploration Fund, together with a geological map of the whole district, and one on a larger scale of Wâdy el Arabah. The popular narrative of the Expedition will appear before the close of the year.

NOTES ON THE JAULÂN.

THE map which accompanies these notes is the result of a flying survey made by my travelling companion, Mr. Schumacher, in the course of a short exploratory ride which I took with him up the valley of the Yarmuk, beyond the Baths of Amatha, as well as of a survey of the adjoining part of Jaulân, which he made with a view of investigating its practicability for a line of railway. As I did not accompany him upon this latter expedition, I will merely give the results of my observations of the valley of the Yarmuk. The hot sulphur springs of Amatha, with the remains which surround them, and which are mentioned by Eusebius as being second only in the estimation of the Romans to the Baths of Baice, have been visited and described by two or three travellers, and although a more accurate investigation of these interesting ruins would doubtless prove richly remunerative from an antiquarian point of view, my opportunities were too limited to enable me to add to the stock of existing information. So, probably, would be an examination of the impenetrable jungle of M'Khaibeh, with its extensive grove of date-trees, and its hot sulphur spring, which is situated on the other side of the river, and about two miles higher up it ; but it would require a stay of some days to make the necessary clearings, and cut paths through the vast thicket which is now the haunt of wild boar and other wild animals, which make their lairs amid the ruins that it no doubt conceals. Beyond this point, the