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Recent Surveys in Sinai and Palestine

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Now the question may be asked: *Cui bono* all this toil of analysis and research devoted to a document so unimportant in size and of such limited contents? The facts may answer for themselves.

1. If the realities which have been here laid bare had been detected any time during the last three centuries and a quarter, so that the site of the lost East Colony of Greenland had been proved to demonstration instead of being a matter of opinion,* the Kings of Denmark would have been spared the necessity of sending out a great number of unsuccessful expeditions: and

2. A number of learned disquisitions by some of the most illustrious *literati* in Europe would have been rendered superfluous.

3. The Zeno document is now shown to be the *latest* in existence, as far as we know, giving details respecting the important lost East Colony of Greenland, which has been so anxiously sought for.

4. It is the *latest* document in existence, as far as we know, giving details respecting the European settlers in North America—although a century before Columbus's great voyage across the Atlantic—and showing that they still survived at that period.

5. The honour of a distinguished man, whose only faults as regards this ancient story, fruitful in mischief as they have been, were that he did not possess the geographical knowledge of to-day, and that he indulged in the glowing fancies and diction of his sunny country, has been vindicated: and

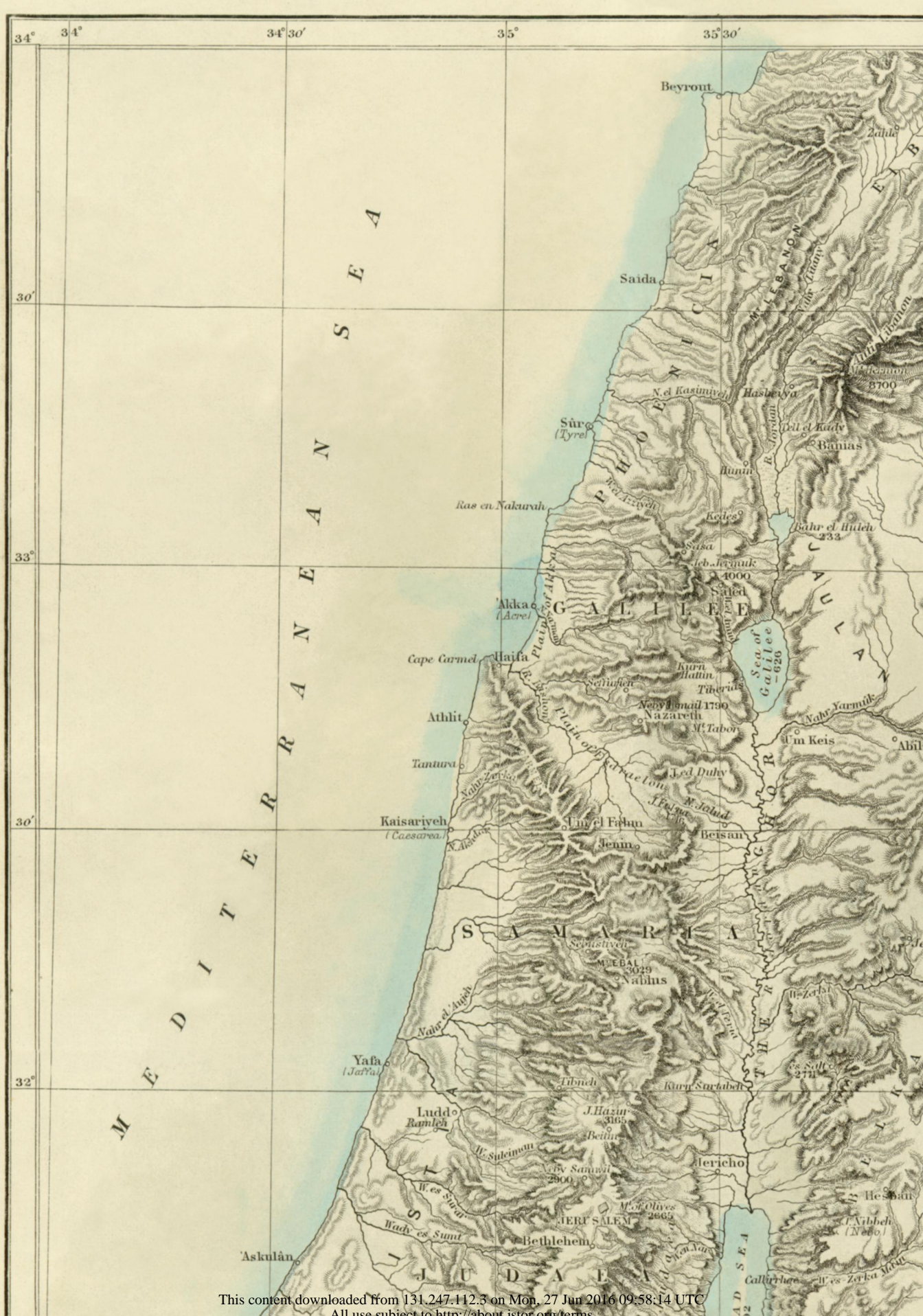
6. The book which has been declared to be "one of the most puzzling in the whole circle of literature" will henceforth be no puzzle at all.

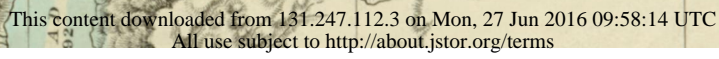
IX.—*Recent Surveys in Sinai and Palestine*. By Major C. W. WILSON, R.E.

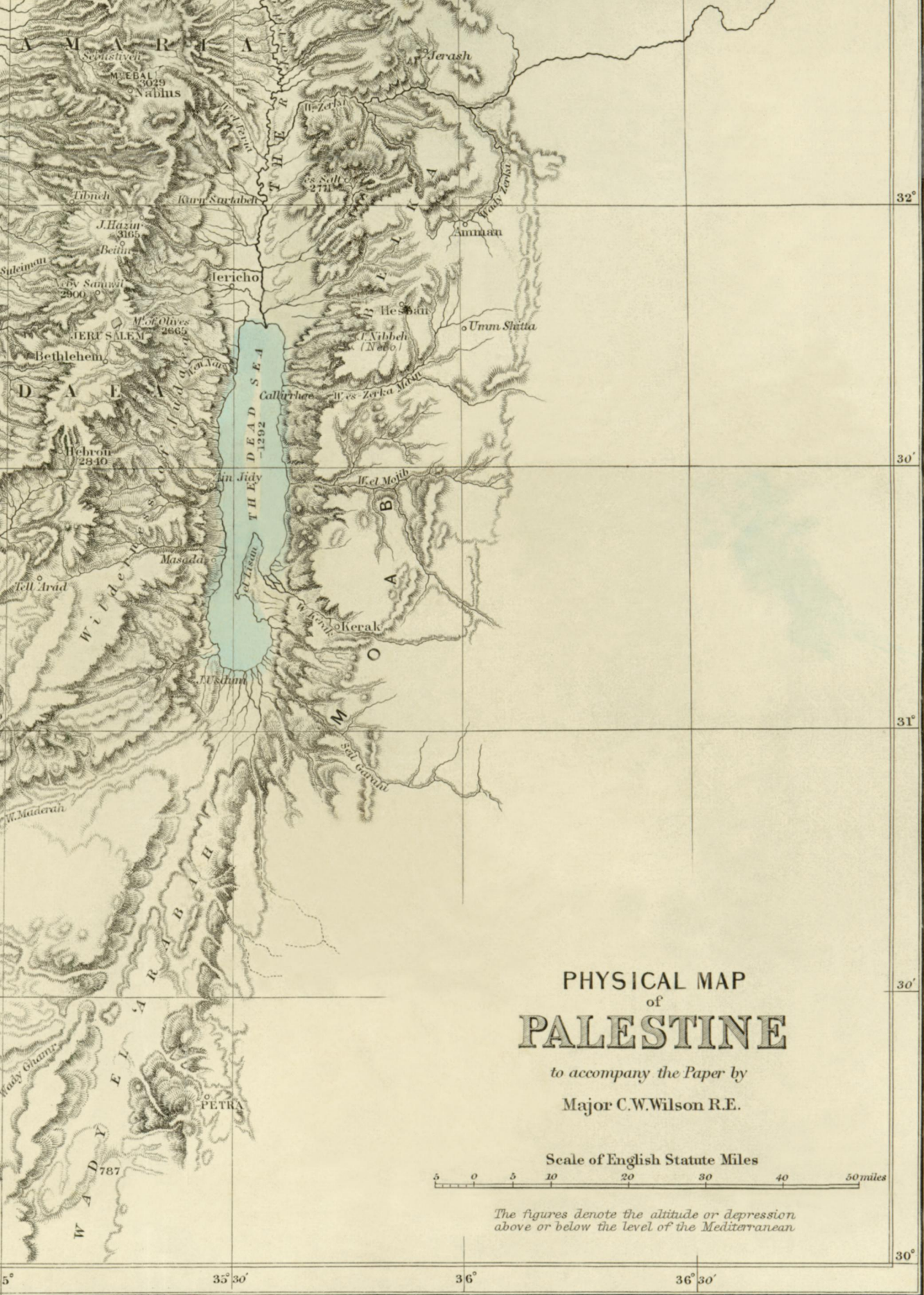
[Read, June 23rd, 1873.]

THERE are few countries in the world which, within the same area, present so many features of general interest as Sinai and

* There can be no better proof of the correctness of this statement than the fact that while the true site was correctly believed in by Eggers in 1794, Captain Graah was sent out in 1828 to learn, if possible, whether the site were on the east or the west coast; and even though he himself correctly believed in the true site, his pleas, on behalf of his convictions, were so inconclusive, that the learned author of 'Iceland, Greenland, and the Farøe Islands,' in 1840, after well weighing the arguments, says: "For these reasons we are disposed to regard this point not only as still undecided, but one on which without more evidence it would be premature to come to any conclusion."



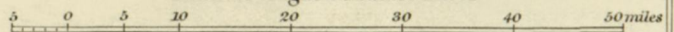




PHYSICAL MAP
of
PALESTINE

to accompany the Paper by
Major C.W. Wilson R.E.

Scale of English Statute Miles



The figures denote the altitude or depression
above or below the level of the Mediterranean

Palestine, yet it is only within the last few years that any attempt has been made to submit them to that thorough and systematic examination which is alike demanded by the geographer, the geologist, the archæologist, and the Biblical student. This work has been undertaken by the Palestine Exploration Fund, and other kindred societies, and the following paper has been prepared with a view of drawing attention to what may be called the geographical results of their labours, and more especially to the progress of the Trigonometrical Survey which was commenced in 1871.

The field of operations may be said to extend from Mount Hermon, in lat. $33^{\circ} 26' 10''$ N., on the north, to Rás Muhammed in lat. $27^{\circ} 43' 20''$ N., on the south, and from the Mediterranean on the west, to the longitude of Damascus, $36^{\circ} 18' 24''$ E., on the east—an area of 40,000 square miles.

For the present, however, various considerations, principally those arising from want of funds, have induced the societies to confine their attention to Palestine proper, which includes an area of about 12,000 square miles.

At Rás Muhammed the great fissure of the Red Sea branches off to the right and left, one arm forming the Gulf of Suez, the other, under the several names of the Gulf of 'Akabah, the Arabah, the Ghor, and the Bukäa, stretching northwards to the vicinity of Antioch. At the southern extremity of the peninsula of Sinai rise the Sinaitic Mountains, a vast crystalline mass, similar in character to the adjoining mountains of Africa and Arabia; on the east they descend abruptly to the Gulf of 'Akabah, whilst on the west they are flanked by an arid plain, which extends almost without interruption to the Mediterranean, and, for some distance north of Tur, is separated from the Gulf of Suez by a low range of hills of tertiary sandstone. Northward, a broken sandstone district, sometimes known as the Debbet er Ramleh, separates the Sinaitic Mountains from the limestone plateau of the Tih, a dreary desert, that falls gradually towards the north, and is chiefly drained by the great Wády el Arish, the River of Egypt of the Bible.

To the plateau of the Tih succeed, on the north-east, the limestone hills of Judæa, rising near Hebron to a height of 2840 feet. This mountain range, which has been aptly called the "backbone" of Palestine, runs north to Esdraelon, with slightly varying altitude, and then, after throwing out a spur westward to Carmel, is linked to the Lebanon by the Hills of Galilee, which attain their culminating point in Jebel Jer-muk, 4000 feet high. West of this central range extend with varying breadth the maritime plains of Philistia and Phœnicia,

whilst on the east lies the depression of the Jordan, forming a natural separation between Palestine and the great eastern plateau, which stretches away almost to the Euphrates.

The peninsula of Sinai has been well described as a "desert of rock, gravel, and boulder, of gaunt peaks, dreary ridges, and arid valleys;"* it is extremely wild and rugged, and is intersected by one of the most complicated systems of drainage in the world. The great crystalline mass which forms, as it were, the "core" of the peninsula, is split up into innumerable peaks, that attain a considerable altitude—Jebel Zebir, 8551 feet; J. Katerin, 8536 feet; J. Umm Shomer, 8449 feet; J. Músá, 7375 feet; and J. Serbál, 6734 feet—and present views of the most grand and impressive character. The sandstone district, rich in antiquities and mineral wealth, is broken up into quaint forms, which, combined with the rich covering, give a peculiar charm to the scenery; in the cretaceous and tertiary districts, on the other hand, the features are devoid of interest, and the scenery is monotonous, except when lighted up by the rich glow of the rising or setting sun. The wádies, or valleys, are deeply cut, and descend rapidly to the sea; they frequently take their rise in open plains, or "fershs," that lie at the foot of the peaks, and form one of the most interesting topographical features of the interior. The valleys appear to have been formed by the action of water, and in many places along their sides are lofty banks of alluvium, which, according to some writers, mark the existence, at a remote period, of inland lakes. The water supply is more abundant than has generally been supposed, and in the mountain districts, especially in the vicinity of Jebel Músá, there are several small perennial streams, and numerous springs of good water. The sandstone and limestone districts are badly supplied, and the water found in the latter is brackish and has a purgative effect.† There is one hot spring at the foot of Jebel Hammám Far'un; the temperature is 157°.

The vegetation is sparse, but there are not wanting indications that it was formerly more plentiful; even now there is, at certain seasons of the year, a considerable amount of vegetation on the upland plains, and in addition to the well-known oasis of Feirán there are several others scattered over the peninsula. The climate is very variable; in the higher districts the cold in winter is severe, and the peaks are frequently covered with snow; in the lower districts the heat is intense, and, when the

* Capt. Palmer, in 'Ordnance Survey of Sinai,' vol. i, p. 17.

† This arises from the large quantities of carbonate of soda and other salts held in solution.

khamsein blows, almost unbearable. The air is dry, clear, and bracing, and there is always a great difference between the night and day temperature; the average rainfall is small, but the country is subject to local storms of great violence, which produce the "seils," or floods, so much dreaded by the Bedawín. One of these has been graphically described by an eye-witness, Mr. Holland;* it will suffice to mention here that on this occasion the bed of the great Wády Feirán was at one place washed out to a depth of 8 feet; and that in the gorge of Wády Sigilliyeh the water rose to a height of 30 feet, and then, after running nearly 20 miles over the dry desert of El Ga'ah, entered the sea near Tur a broad river from 3 to 4 feet deep.

One of the most striking features of Palestine proper is its natural division into four parallel strips—the Coast Plain, the Hill Country, the Jordan Valley, and the Eastern Plateau. The Coast Plain, from 10 to 20 miles wide, extends without a break from the desert on the south to Mount Carmel on the north; beyond Carmel lies the Plain of Acre, about 20 miles long and 4 to 6 wide, and this again is separated from the narrow Plain of Phœnicia by Rás en Nakúrah, better known as the Ladder of Tyre. The greater portion of the plain is fertile and cultivated, but north of the Nahr Anjeh there are low hills of tertiary sandstone, which check the drainage from the mountains, and give rise to several large swamps; these were formerly drained by tunnels or drifts cut through the hills, which are now choked with rubbish. The Hill Country commences about 50 miles south of the Mediterranean, and, interrupted only by the Plain of Esdraelon, traverses the country from south to north. The hills are broad-backed, and there is no marked grandeur in their physical features, but every here and there rounded summits rise above the general level of the range, and afford striking panoramas of the surrounding country. The average altitude may be gathered from the following heights:—Hebron, 2840 feet; Mount of Olives, 2665 feet; Neby Samwil, 2900 feet; Jebel Hazur, 3165 feet; Mount Ebal, 3029 feet; Jebel Fukua, 1716 feet; Neby Ismail (Nazareth), 1790 feet; Jebel Jermuk, 4000 feet.

The main road from Jerusalem to Nablus, Nazareth, and Banias follows the line of water-parting, and in close proximity to it were the most important cities of Judah and Israel. On the east the hills descend rapidly to the Jordan, and are furrowed and cleft by deep, wild torrent beds; whilst on the west they fall, at first abruptly, and then pass, by a series of low, undulating hills, the "Shephelah," or "low country" of

* 'Royal Geographical Society's Journal,' vol. xxxviii. p. 148.

Scripture, to the Maritime Plain. The valleys for the most part take their rise in small upland plains, and, preserving generally an east and west direction, debouch, after an infinite variety of windings, on the Coast Plain and the Jordan Valley.

The Jordan Valley runs nearly parallel to the coast from the base of Mount Hermon to the Dead Sea, which occupies its deepest portion. South of the Dead Sea the valley rises gradually for about 68 miles to the water-parting which, at an altitude of 781·4 feet, separates the waters of the Dead Sea from those of the Gulf of 'Akabah. This water-parting, which links the Tih to Arabia, is, according to M. Lartet, a cretaceous barrier separating in the most complete manner the two slopes of the district. The cretaceous strata are covered with their own débris, and show no trace of any water-course in the direction of the Red Sea.

The Eastern Plateau attains its greatest altitude at Es Salt, 2771 feet; it is tolerably uniform in its characteristics, and maintains, as far north as Banias, a general altitude of about 2000 feet. At this point the grand peak of Hermon rises to a height of 8700 feet, and forms the commencement of the range of Anti Lebanon. On the north the great plateau is covered by the basalts of the Jaulan, and east of them lie the volcanic hills of the Hauran and Ledja.

The one great river of the country is the Jordan, a river which, as Ritter justly observes, is wholly unique: "There is no other like it on the whole face of the earth; a purely inland river, having no embouchure on the sea, and closing its course at the very deepest part of the Old World, and far below the level of the ocean." After the junction of the three streams, which rise respectively at Hasbeiya, Tell el Kady, and Banias, the Jordan spreads out into the lake El Huleh, and thence descends rapidly to the Sea of Galilee; from this lake it follows for 66 miles a tortuous course, wholly below the level of the Mediterranean, to the Dead Sea. From Tell el Kady to El Huleh there is a fall of 328 feet in 11·9 miles, from El Huleh to the Sea of Galilee a fall of 898·75 in 11·1 miles, and from the Sea of Galilee to the Dead Sea a fall of 665·75 feet in 65·9 miles. From the Dead Sea to the water-parting there is a rise of 2073 feet in 67·9 miles, and from the water-parting to the Gulf of 'Akabah there is a fall of 781 feet in 40·7 miles. The Jordan has several tributaries, of which the most important are the Yarmuk and Zerka on the east, and the streams in Wadies Jalud and Feriá on the west; in addition to these, Wadies Rubadiyah and Hammám discharge their waters into the Sea of Galilee, and Wadies Zerka Main, Mojib, Kerak, and Ahsi into the Dead Sea. There are also several

streams running westward to the coast, as the Litany (Leontes), Naman (Belus), and the Kishon, north of Carmel; and the Belka, Zerka, Akhdar, and Aujeh, to the south. There are numerous springs of good fresh water, and several hot springs, of which the principal are those near Tiberias (132.2° to 142.2°), those near Umm Keis (Gadara), 110° ; and those at Callirrhoe, in W. Zerka Main, 120° .

Palestine was evidently at one time thickly covered with forests, but they have entirely disappeared, except in a few places on the mountains and along the sea coast, and the only existing traces are the roots, that form one of the principal sources from which charcoal and firewood are obtained. The plains and rocky hills are, in spring, carpeted with herbaceous plants, but they soon disappear under the burning sun of summer, and the country then assumes a dreary, monotonous aspect. Though most of the country lies waste at present, it was at one time highly cultivated, and the art of "terrace culture" seems to have been brought to a state of great perfection. On every hill, remains of the ancient terraces can be traced rising one above the other, and even far to the south of Beersheba, Professor Palmer found long swathes of stones on the hill-side, marking the presence of former vineyards.

From the peculiar formation of the country, there is a great variety of climate; that of the Lebanon may be compared with that of the Alps; that of the Hill Country with Italy, and that of the Jordan Valley with the tropics. In summer, from local causes, the towns and villages are subject to fever, but the climate is generally healthy, and the bracing air of the Lebanon is always within easy reach. The most unhealthy periods of the year are May and October, when the country is visited by the khamsin winds, which frequently last for several days at a time. In connection with this wind, Dr. Chaplin has noticed the fact that it is entirely destitute of ozone. The rainy season commences at the end of October or beginning of November, and lasts till March; it is not a continuous rain, but a succession of heavy showers, with intervening periods of fine weather. The average rainfall at Jerusalem during the seven years from 1860 to 1867 was 19.62 inches, the maximum being 22.9 inches in 1860-61, and the minimum 14.8 in 1864-5. There are occasional falls of snow, and one at Jerusalem in April 1870 was 2 inches to 5 inches deep, and lay on the ground for three days. The country is still subject to those sudden storms which are so frequently alluded to in the Bible, and they are accompanied by a sudden fall in the temperature; on one occasion the temperature fell in a few minutes from about 75° to below freezing-point. In summer the dews are very

heavy, penetrating the tent, and wetting everything within it. There does not appear to have been any great change in the temperature, to that, at the date of the kingdoms of Judah and Israel; there may have been a slight decrease in the rainfall, but the existence of the conduits, pools, and cisterns for the water supply of Jerusalem, and the numerous aqueducts and cisterns for irrigation, show that there must always have been a deficiency of water, and the fact that the fruits grown at the present day, are those mentioned in the Bible would seem to confirm it.

Such are the principal features of the country in which the operations of the British and American societies are being carried on. Before, however, alluding to their labours, it will be well to give a brief account of the results obtained by previous travellers.

The publication, in 1835, of Berghaus's map ("Karte von Syrien"), with an accompanying memoir of great value, may be said to mark the commencement of a new era in the geographical investigation of Palestine, for it was the first serious attempt to classify and portray in a careful and systematic manner the results obtained by the earlier travellers of the present century.*

The winter of 1836-7 is marked by Von Schubert's travels, and his account of them contains much that is new, relating to the natural history of the country, as well as some vivid descriptions of the scenery.

In 1838 Russegger travelled through the country, and collected a mass of information, especially with regard to the geological character of the districts he passed through.

In 1838 also, Robinson and Eli Smith made their first journey through Sinai and Palestine, and the former published the result of their labours in a work, 'Biblical Researches in Palestine,' which still forms the text-book of all students of Scripture geography. Robinson was the first traveller who conceived the idea of writing such a book from personal observation on the ground itself. He prepared himself for his work by a course of arduous study, extending over a period of fifteen years, and reaped his reward in a series of important discoveries, which at once placed him in the foremost rank of travellers in the Holy Land. Provided only with a large compass, his numerous and careful bearings, and his strikingly accurate measurements and topographical descriptions, afforded such voluminous data that Professor Kiepert, of Berlin, was enabled to construct

* Clarke, Ali Bey, Seetzen, Burckhardt, Richter, Irby and Mangles, Legh, Richardson, Buckingham, Hogg, Catherwood, Marmont, Laborde, Ruppell, Wellsted, Moresby, &c.

a new map, which almost entirely superseded that of Berghaus.* Commencing at Sinai, Dr. Robinson travelled northwards to Damascus, collecting information at every step, and keeping a minute itinerary of his route, whilst his companion, Dr. Eli Smith, supplied lists of Arabic names, which have been of the greatest service to Biblical students.

In 1852 Dr. Robinson paid a second visit to Palestine, and was again accompanied by Dr. Eli Smith. Landing at Beyrout, they passed through Galilee to Acre, and thence through Galilee and Samaria to Jerusalem; from Jerusalem they turned northwards to Beisan, the Sea of Galilee, Hasbeiya, and Damascus, whence they crossed the Lebanon to Beyrout. Their route on this occasion passed through those districts which had not been previously examined, and an account of their journey was published in the '*Later Biblical Researches in Palestine*,' which contained a new map by Prof. Kiepert.

In 1841 Lieut. Symonds, R.E., was enabled to make a triangulation of the country between Jaffa and Jerusalem, and thence to the head of the Dead Sea, on the south; and from Cape Blanco to Safed and the Sea of Galilee on the north; these two main series of triangles being connected by intermediate triangles. By this triangulation the level of the Dead Sea was fixed at 1312·2 feet, and that of the Sea of Galilee at 328·9 feet below the Mediterranean. The triangulation was made with an 8-inch theodolite from bases measured near Acre and Jaffa, but there were no astronomical observations. Some portion of the details of the northern sheet was filled in, but the whole was in too fragmentary a state for publication. For this service Lieut. Symonds received the Patrons' Gold Medal of the Royal Geographical Society in 1842.

From sketches made in 1840-41 by Scott, Robe, Wilbraham and Symonds, Major Scott prepared a map in three sheets; in this, however, Symonds' triangulation underwent much modification, instead of being used, as it should have been, as the basis for the construction of the map.

In 1846 Lepsius visited the peninsula of Sinai, and in addition to his archæological researches, collected much valuable information on the topography of Jebels Músá and Serbál.

In 1847 Lieut. Molyneux, R.N., made an adventurous descent from the Sea of Galilee to the Dead Sea, which unfortunately terminated in his premature death from exposure to the fierce rays of an autumnal sun.

* Prof. Kiepert's map was accompanied by an excellent memoir, which is published in vol. iii. of the '*Biblical Researches*.'

In 1848 Lynch descended the Jordan from the Sea of Galilee to the Dead Sea in two boats, and spent fifteen days on the latter lake. The results of his expedition were, a sketch of the course of the Jordan, which, considering the manner in which it was executed, is of great accuracy, and has never been superseded;* a very exact chart of the Dead Sea, with soundings, and the determination of its depression, by a line of levels carried up Wády en Nar to Jerusalem, and thence by the ordinary road to Jaffa. The sketch of the Jordan showed that in a direct distance of 60 miles, the length of the river was 200 miles, whilst the soundings gave the Dead Sea a maximum depth of 1308 feet, and the levels fixed its surface at 1317 feet below the Mediterranean. The instrument used in levelling was one of Troughton and Sims' spirit levels.

In 1850-51 M. de Sauley visited the western and southern shores of the Dead Sea, Kerak, and Moab, and travelled northward through Palestine, collecting material which was embodied in a map published to illustrate his travels.

In a second journey, made in 1863-4, M. de Sauley was accompanied by Capt. Gélis of the *État Major*, and the route sketches made by this officer from Jaffa to Jerusalem and Hebron, and from Jerusalem northward by Jifna, Mozaré, Tibneh, Nablus, and Jenin to Nazareth form a valuable contribution to Palestine topography. The account of the journey was also accompanied by special plans made by Capt. Gélis, of Ebal and Gerizim, Jericho, Amman, Hesban, Arak el Emir, &c.

In 1851-2 Van de Velde travelled through Palestine, and the result was his first map published on a scale of $\frac{1}{315000}$. Van de Velde used a 7-inch compass with two levels, a cross-threaded plunging telescope, and vertical semicircle; he had no aneroids or other means of determining altitudes. The map was based on Symonds' triangulation, and compiled from his own observations, with the compass bearings, itineraries, and astronomical observations of others; it was accompanied by a memoir, containing a rich store of authentic and well-arranged data.

After a second visit to the country in 1861-2, Van de Velde published a new edition of his excellent map, which, until the recent publication of Mr. Murray's Atlas, was the best map of Palestine.

In 1853, and again in 1862, Dean Stanley visited Palestine,

* The accuracy of Lynch's work has sometimes been questioned, but the position of one important point, the embouchure of Wády Zerka, which Van de Velde considered to be in error, was found to be quite accurate by Lieut. Anderson and myself.

and published the result of his travels in a book, 'Sinai and Palestine,' which has perhaps created greater interest in Biblical geography than any work that has appeared on the subject.

1850-55.—In his work 'Five Years in Damascus,' Mr. Porter gives a map embodying the results of observations made during his five years' stay in the country. The map contains much new and interesting information on the Ledja, Hauran, the Lebanon, and the water system of the Plain of Damascus, but unfortunately a mistake was made in the application of the variation, so that the relative positions of places are somewhat distorted. Bearings were taken with a compass, and altitudes with an aneroid.*

1855.—In a paper read before the Royal Geographical Society, Mr. Poole communicated the results of an examination of the western and southern shores of the Dead Sea and the Lisan. He made the depression by aneroid 1313·5 feet.†

1857.—In a paper read before the Royal Geographical Society, Mr. Cyril Graham gave an account of his travels in the Hauran and the district of El Harah, which had not previously been visited. His paper was accompanied by a route map containing a large number of new names of towns and villages.‡

1858.—An important journey in the Hauran and Ledja was made by the Prussian Consul at Damascus, Herr Wetzstein, who published an account of it in 1860, which was accompanied by a map by Kiepert. The instruments used by Wetzstein were a 7-inch sextant, a box chronometer, and a Schmalkalder's compass; his latitudes are from observations of the pole-star and circum-meridians of the sun; and the map contains much authentic information of the districts that he visited, which were previously little known.

In 1860-61 advantage was taken of the presence of French troops in Syria to make several reconnaissances, which were afterwards embodied in the "Carte du Liban," a beautifully executed map, published on a scale of $\frac{1}{200,000}$. The detailed features of the country are correctly given, but the latitudes of many of the places are in error, and the work bears the appearance of being a series of military reconnaissances fitted together; unfortunately no memoir was published with the map, from which its claim to accuracy might be judged. To the same period belongs M. Renan's expedition to Phœnicia, the account of which is accompanied by some beautiful topo-

* 'Royal Geographical Society's Journal,' vol. xxvi.

† Ibid., vol. xxvi.

‡ Ibid., vol. xxviii.

graphical maps and plans by Captain Gélis and other French officers.

In 1860-62 an Admiralty Survey of the coast of Palestine and Syria was made by Captain Mansel, R.N., assisted by Masters Hull and Christian, and a triangulation was carried over a portion of the country. During the progress of the Survey, Alexandria was connected with Malta for longitude by electric telegraph, and by 8 or 9 meridian distances by 13 chronometers carried round from Malta to Beyrout, Jaffa, and Alexandria, the results being most satisfactory. An astronomical base was measured between Hassan Cove, Beyrout, and the south point of Jezireh Island, Saïda. The longitude of Beyrout was fixed from 3 chronometric meridian distances between Alexandria and Beyrout, and that of Saïda from 4 chronometric meridian distances between Beyrout and Saïda. The latitude was in each case fixed with the sextant by numerous observations of stars north and south of the zenith. The northern minaret of the Great Mosque at Damascus was connected with Hassan Cove, Beyrout, for longitude, by electric telegraph, and the latitude of the minaret fixed with the sextant. This placed the minaret in lat. $33^{\circ} 30' 30''$ N. and long. $36^{\circ} 18' 24''$ E. In addition to the accurate delineation of the coast line, and the preparation of charts on a larger scale of the harbours, a large number of points in the interior were fixed by astronomical observations and triangulation; the variation of the compass was carefully observed, and numerous altitudes were determined by barometer and angles of elevation and depression.

In 1863-4 Dr. Tristram visited Palestine, and published the results of his travels in the 'Land of Israel,' which was accompanied by a general map of the country, and a special map of the Dead Sea, that adds much to our knowledge of the topography of its western shores. In 1872 Dr. Tristram again visited Palestine, and spent some time in an examination of Moab; his account of his journey is now in the press, and the map which is to accompany it will give many new details of the topography of that district.* Dr. Tristram was fortunate enough during his visit to discover the remains of a remarkable palace at Umm Shittah, not far from the Damascus Haj route.

In 1863-4 the Duc de Luynes conducted an expedition to Palestine, the entire cost of which was defrayed from his own private means. He was accompanied by Lieutenant Vignes of the French Navy, and an accomplished geologist, Monsieur

* This work has since been published under the title of 'The Land of Moab.'

Lartet. These two gentlemen spent a month—8th March to 7th April 1864—in examining the Dead Sea, with the aid of a boat carried in sections from Jerusalem. They afterwards passed up the Jordan valley to Jisr Damieh, and thence passed by way of Amman, Hesban, Moab, and Petra, to the 'Arabah, which was carefully examined. Owing to the lamented death of the Duc de Luynes a full account of the expedition has not yet been published, but we already have an excellent map by Lieutenant Vignes, of the Dead Sea and its vicinity, including the 'Arabah, on a scale of $\frac{1}{240000}$; and M. Lartet has published a work on the geology of Palestine which is of the highest value. His paper on the Dead Sea treats the whole question of its origin, and the geological formation of its basin, in the most able manner, and his examination of the water-parting in the 'Arabah has shown that there is no ground for supposing that the waters of the Jordan ever entered the Gulf of Akabah.

In 1867 the Rev. F. W. Holland spent some time in exploring the peninsula of Sinai, and communicated an account of his journey, as well as of a former one in 1861, to the Royal Geographical Society in a paper published in Vol. xxxviii. of the 'Journal.' Mr. Holland's journey was performed on foot and alone, and he was enabled from his itineraries and numerous compass-bearings from the peaks, with barometrical and hypsometrical observations of their altitudes, to construct a map of the entire peninsula, which is inserted in Vol. xxxix. of the Society's 'Journal.' This map, when tested afterwards by the closer examination of the Survey of 1868-69, was found to be very accurate, and was of great use to the expedition; it was the first map upon which any attempt had been made to show in detail the peculiar topographical features of the peninsula, and is remarkable as the work of a single, unaided explorer.

In 1870 Captains Mieulet and Derrien, of the French *État-Major*, proceeded to Palestine with a view of constructing a map of the country; they commenced operations on the 10th May and worked till the 10th August, when they were recalled to France. A base line was measured on the plain of Acre, and from this, 21 stations were fixed by triangulation with a theodolite; the altitudes of 500 separate points were fixed, and more than 1000 square miles surveyed. The field sketches were made on a scale of $\frac{1}{100000}$, and contain all towns, houses, tombs, ruins, wells, springs, woods, &c.; the hill features are shown by contour lines, and the names are written in French and Arabic. The map is at present being prepared from the field sketches.

In 1871 Captain Burton and Mr. Drake made an exploration of the Tulúl el Safá, the volcanic region east of Damascus, and an account of their journey by Captain Burton has been published in No. 2 of Vol. xvi. of the 'Proceedings' of the Royal Geographical Society. A fuller account was published under the title 'Unexplored Syria,' with a map by Mr. Drake, which adds much to our knowledge of the Trachonitis.

In 1871-2 an Admiralty Survey of the Gulf of Suez was made by Captain Nares, R.N., in H.M.S. *Newport*, and the first sheet, extending from Tur to Rás Muhammed, has already been published.* In addition to the hydrographical features the charts show many new and important topographical details, especially with regard to the coast range running northwards from Tur, and the hills in the vicinity of Wády Gharandel.

The present year has been marked by the publication of the northern sheet of Mr. Murray's new map of Palestine, which is beautifully executed, and contains information derived from the most recent surveys and expeditions.

This portion of the subject can hardly be closed without alluding to the works of Thomson, Tobler, and Ritter, as well as to the articles by Mr. Grove in the 'Dictionary of the Bible,' all of which have largely contributed to our knowledge of the physical features of Sinai and Palestine.

I now pass to the more accurate surveys which have recently been made, commencing with that of Jerusalem, which may in some measure be said to have given rise to the subsequent operations. Early in 1864 the sanitary state of Jerusalem attracted considerable attention, and several schemes were proposed for its improvement by providing an adequate supply of pure water for the inhabitants. The Baroness Burdett Coutts, having been informed that it was necessary in the first place to obtain an accurate plan of the city, at once placed a sum of 500*l.* in the hands of a committee of gentlemen interested in the subject, for that purpose. The committee requested Lord de Grey, then Secretary of State for War, to allow a survey to be made by a party of Royal Engineers from the Ordnance Survey under the direction of Sir Henry James, and obtained a favourable answer. It was, however, stipulated that Government should be put to no expense, and that an officer should accompany the party at his own cost, as the funds were not sufficient to defray his expenses. The survey was made by myself and five non-commissioned officers of the Royal Engineers, and on our return to England the cost of publication was

* The remaining charts of the Red Sea have since been issued.

defrayed by a grant from the Treasury, which has been more than repaid by the sale of the plans, photographs, &c. The plans are now so well known that it will be sufficient to mention here that they were made on the same scale and with the same accuracy as the Parish Plans of the Ordnance Survey, $\frac{1}{2500}$. Before the party left England, some doubt was entertained as to the possibility of making a close-contoured survey, which necessitated constant trespass on private property, of a town in which there was such a large Moslem population; but with a little care and management the difficulties soon disappeared.

The ground covered by the survey was triangulated with a 7-inch theodolite, and a chain survey then made of the whole, a 5-inch theodolite being used to lay out the longer and more difficult lines. The base was measured three times with a standard chain, and the mean of the three measurements, which had a range of half a link, was used for calculation. A traverse survey was made of the city and Haram Area with a 5-inch theodolite. The chain survey was plotted at Jerusalem, and traces made of the work, which were carefully examined on the ground, any inaccuracies or omissions being at once corrected. The ground was contoured at 10-foot intervals, with the exception of the city itself, in which the streets were levelled, and bench marks were cut at frequent intervals. The hill features were then sketched in on the ground, and plans of the most important buildings made. Such of the subterranean passages as were accessible were examined, and a few excavations made at important points. The plans were brought home in a finished state, and consisted of—

$\frac{1}{2500}$ plan of Jerusalem and vicinity,	with 10-foot contours
$\frac{1}{10000}$ ditto	with hill features.
$\frac{1}{500}$ plan of Haram Area.	
$\frac{1}{200}$ and $\frac{1}{500}$ plans of Church of Holy Sepulchre and other buildings.	

Whilst at Jerusalem I was requested to carry a line of levels from the Mediterranean to the Dead Sea, and from Jerusalem to Solomon's Pools, the funds in one case being provided by the Royal, and Royal Geographical, Societies, and in the other by the Syrian Improvement Society. After a careful reconnaissance of the intervening country, the line selected, as that which would give the best results, was one following the camel road up Wady Suleiman to Jerusalem, and thence the usual road to Jericho and the Dead Sea. As the expense of running two independent lines of levels would have been very great it was decided to run a single line with two instruments and two observers. The back and forward staves were read twice by each observer, and the results compared on the spot; if they lay within a certain limit, the instruments were moved to

another station, if not, the readings were taken again. From a comparison of the two sets of levels, it is certain that the limit of error in the ascertained depression of the Dead Sea does not exceed 4 inches. The rate of levelling varied according to the nature of the ground; the average number of stations in a day was 89, and the greatest interval between the staves was 8 chains, 4 on each side of the instrument. 35 bench marks were cut between Jaffa and the Mount of Olives, and 18 between the latter place and the Dead Sea, where a stone was sunk in the sand. These bench marks have been connected with the triangulation of the survey now in course of progress, and have enabled the surveyors to check the altitudes of many of their trigonometrical points. The party suffered considerably from the intense heat and the bad water. The depression of the Dead Sea was found to be 1292·13 feet on the 12th March 1865, but it was ascertained that in early summer the level of the sea is at least 6 feet lower; this would make the depression 1298 feet, and it is probably never greater than 1300 feet. An examination of the drift-wood on the shore of the lake showed that the water had stood $2\frac{1}{2}$ feet higher during the winter, or at 1289·6 feet; there is thus a range of 10·4 feet, but whether it is an annual variation, or not, we had no means of ascertaining. This represents an enormous amount of evaporation, and it is to be hoped that advantage may be taken of the present survey, to establish a gauge by which we may arrive at the annual rise and fall. The Jordan is subject to two annual freshets, one during the rainy season, the other when the Lebanon snows melt, and at this time the supply far exceeds the evaporation; the highest level of the lake would probably be in January, the lowest towards the end of October. It may not be uninteresting here to give the results obtained by previous travellers:—

	Feet.		Feet.
Ordnance Survey, by levelling ..	1292·13	Russegger, barometer ..	1430
Lynch, by levelling* ..	1316·7	Von Wildenbruch, barometer	1441
Symonds, by triangulation ..	1312·2	Schubert, barometer ..	638
Lieut. Vignes, by barometer ..	1286·15	Bridges, barometer ..	1367
De Bertou, barometer ..	1377	Poole, barometer ..	1316

The success which attended the Jerusalem Survey showed that the time had arrived when it would be possible to carry out a systematic examination of the whole country, and at a meeting held on the 22nd June 1865, an association was

* Lynch's line of levels was run in May, and from indications in his map the water appears to have been at that time very low. A small tongue of land shown by him as connected with the shore was in 1865 an island separated from the shore by water 6 or 7 feet deep.

formed for this purpose under the name of the Palestine Exploration Fund. Her Majesty graciously consented to become the Patron, and a committee was appointed to arrange matters of detail. A prospectus was prepared by Mr. George Grove, the indefatigable Honorary Secretary, to whose unceasing exertions much of the success of the Fund is due, and in this, the object was said to be the examination of the archæology, the manners and customs, the topography, the geology, as well as the botany, zoology, meteorology, &c., of the Holy Land. The committee decided that, in the first place, an expedition should be sent out "with the view of making such a general survey of the country as would enable the promoters of the Fund to fix on particular spots for further examination, and also to collect such special information as was compatible with the larger purposes of the Expedition, and would throw light on any of the points mentioned in the programme of the Exploration Fund." The committee did me the honour to offer me the command of the Expedition; and, accompanied by Lieutenant, now Captain, Anderson, R.E., and one sergeant R.E., I left England in November 1865. Landing at Beyrout we proceeded to Damascus, and after determining the position of the lakes to the east, proceeded to Banias; thence we travelled southwards to Hebron, and afterwards made an excursion along the Maritime Plain to Athlit. In some excursions which I had made from Jerusalem in 1864-65 I had been much struck by the character of the country as affecting its survey; the clearness of the atmosphere and extensive views from many points offer great facilities to the surveyor, whilst on the other hand the deep transverse valleys prevented free movement over the country, and the absence of spires or prominent points in the villages, combined with the uncertain character of the population, made it difficult to establish fixed trigonometrical stations. As under the circumstances of the Expedition it was impossible to carry out a satisfactory triangulation, I determined to make a reconnaissance of the country passed through, observing at the principal stations for time and latitude, and connecting them by azimuth lines with some known point. The results of the Expedition, which remained in the country about 6 months, were briefly as follows: Observations for time and latitude at 49 different stations; a line of azimuths from Banias to Jerusalem giving independent determinations of longitude for the points used, Mansel's position for the Dome of the Rock at Jerusalem being adopted as a fixed point; a reconnaissance on a scale of 1 inch to a mile of a district extending from Banias to Hebron, and embracing the whole backbone of the country; a reconnaissance of a large portion of the Maritime Plain; special surveys of the Sea of

Galilee and vicinity, Samaria, Beisan, and Mounts Ebal and Gerizim ; an examination of the French map of the Lebanon, in which many errors were found ; more than 50 plans of synagogues, churches, temples, tombs, &c. ; and a number of tentative excavations at various points which yielded good results. A large number of photographs were taken, and two questions of some importance to the geography of the country were settled : one the point at which the stream from Wády Zerka enters the Jordan, the other the correct course of Wády Surar. There is not space to enter into the details of these and other results which have been published from time to time by the Fund. The method of conducting the reconnaissance will be best understood from a short description of its commencement ; the latitude of Banias was carefully fixed by astronomical observations, and a similar determination was made of the junction of the Jordan and Banias streams, about 5 miles distant. These two places having been connected by compass bearings, a base was obtained on which to frame the triangulation to the mountains on both sides of the valley. Explorations on horseback were made in different directions over the valley, and the position of all the important points fixed by compass bearings to points previously determined. From Banias an azimuth line was observed, with a 5-inch altitude and azimuth instrument, to a prominent peak about 10 miles distant on the west side of the valley, and the latitude of our camp, pitched close to this peak at the village of Hunin, was determined astronomically, and the connection accurately made with the different places visited during the exploration in the valley, including the last camp at Banias. At Hunin we were on the water-parting, which was explored about 8 miles further north, to the great bend of the Leontes. From Hunin the water-parting was followed to Jerusalem, and this afforded great facilities for topographical reconnaissance, as a clear view was always obtained to great distances both on the east and west, and all important places visible within 8 or 10 miles fixed by triangulation. From Hunin the line of azimuths was carried to Jerusalem, the principal points used being Banias, Hunin, Alma, Sasa, Safed, Nazareth, Jebel Duhy, Mount Ebal, Mount Gerizim, Jebel Hazur, Jerusalem. At every camp the chronometers were carefully rated and compared ; for latitude 10 observations of a north and 10 of a south star were made, and for time 5 observations of an east and 5 of a west star ; the sun was rarely used, as we were generally reconnoitring or excavating during the day ; the azimuth lines were run with a 5-inch alt. azimuth instrument, and the principal triangulation made with the same. Heights were determined by

aneroid.* The observations at Banias are given as an example for latitude and time,† and an example from the Sinai Survey is given for the method of reducing the azimuths.‡ The reconnaissance was carried out by Captain Anderson. The constant day and night work was very trying, but a short rest at Jerusalem soon restored the party to perfect health.

On our return to England I submitted a scheme for a regular survey of the country, but the committee, taking into consideration the extreme interest felt by everyone in Jerusalem, determined to devote their attention, for the time being, to excavations in the Holy City. In accordance with this decision an expedition was sent out in January 1867, under Captain Warren, R.E., neither Captain Anderson nor myself being able at the time to return to Palestine. The difficulties which Captain Warren had to encounter and the remarkable results which he obtained by his excavations are well known, and they hardly come within the scope of the present paper. He was, however, able whilst in Palestine to carry out some important reconnaissances, which have added much to our knowledge of the topography of the country. The reconnaissances of Captain Warren (since embodied in Mr. Murray's map of Palestine) were made at intervals during the excavations at Jerusalem, and were conducted in the same manner as those of the Expedition in the previous year.

They consisted of about 650 square miles in the Plain of Philistia, about 300 square miles on the west bank of the Jordan to the north of the Dead Sea, and about 1050 square miles to the east of the Jordan, as far as the Haj route in the desert. In addition, a sketch of the hills about the Jordan Valley was made as far as the Sea of Tiberias, including the plain of Beisan, a geographical description of the western side of the Dead Sea, also an account of Mount Hermon, together with plans, &c., of all the temples in Cælo-Syria as far as at present known.

Capt. Warren was usually accompanied by a photographer (Sergeant Phillips, R.E.), or by other non-commissioned officers of Royal Engineers, and plans were made of all the ancient buildings and ruins met with; among others Nebo, Amman, and Jerash, together with photographs both archæological and geological, and illustrative of the manners and customs of the people.

* The Expedition was but poorly furnished with instruments, the only ones supplied being 1 8-inch sextant; 1 5-inch alt. azimuth instrument; 1 large azimuth compass; 1 prismatic compass; 4 pocket chronometers; 2 chains; 1 syphon barometer; 3 aneroids; 2 thermometers; 1 hygrometer. Three of the chronometers proved to be reliable instruments, and were found to have accumulated only errors of 2 and 3 minutes in 7 months.

† Appendix I.

‡ Appendix II.

I may mention photographs of the ruins of Marsada, Amman, and Jerash, also the hill desert of Sacha, and about the Dead Sea. Advantage was taken of Jacob-es-Shellaby's presence on Mount Gerizim to photograph the Samaritan colony, both in camp and when assembled for prayer on the evening before the Passover. These are the only photographs of the Samaritans known to exist.

Captain Warren came to the conclusion that, taking cost for cost, the results of reconnaissances in a country like the Holy Land (where every ruin is of importance) was not to be compared with the results to be obtained from a systematic trigonometrical survey, forming at the very least a skeleton outline, the substance of which could be filled in at any future period; and he urged upon the Committee the necessity for the survey which has now happily been commenced under such good auspices.

In Philistia, Ramleh being taken as a fixed point, a triangulation by means of true bearings and latitudes was carried down to Gaza, and as far east as Neby Samwil, thus checking the longitude of Jerusalem.

The principal heights and latitude and longitude of about 300 villages and ruins in this plain were obtained, and published in the papers of the Palestine Exploration Fund. It was observed that this fertile plain is being threatened by vast sand-hills, gradually advancing from the sea, put in motion by the prevailing surface wind; whole villages have been engulfed, and instances have been found where some landowners, more industrious than the rest, have from year to year patiently carried the advancing sand away from their plots of ground, until at the present time they are situated far below the surface of the sand, and entirely surrounded by it. The only chance of arresting the advancing enemy is united action on the part of the inhabitants, and the planting of pine trees (as at Beyrout).

In making this reconnaissance of Philistia, the existing maps were of no assistance, for though externally accurate in parts, with regard to the relative position of certain ancient towns one to another, the general positions were entirely wrong; thus clearly showing the necessity for a correct outline of the country on which the ancient ruins found from time to time by travellers could gradually be filled in.

Three separate expeditions were made when filling in the 1350 square miles about the Jordan Valley. The reconnaissances extend from the edge of Captain Anderson's survey of the water-parting between Jerusalem and Nablus to the Jordan, and then across Gilead to the elevated Plain of Arabia, as far as the Haj route, being from north to south 30 miles, to east of

Jordan 30 miles, to west 15 miles. The greater portion of the country had not been mapped on the ground before, the portion to east of Jordan, shown in Van de Velde's map, having been constructed by him at Jerusalem from the itineraries of travellers and information obtained from natives.

This work was performed by Captain Warren at a time when the Bedawin he was with, were up in arms against an invading Turkish army—a price being placed on the head of the Sheikh who accompanied him. They were obliged to retreat suddenly from Jerash, the Turkish troops occupying that ruin on the following day.

The ruined town of Nebbeh, close to the Springs of Moses, was discovered; it is near the mountain of the same name, and thus helps to settle the site of Nebo, discovered independently a year or two previously by three distinguished explorers.

The heights of several hundred places have been obtained and published, together with a list of Arabic names met with; the latitudes and longitudes have also been worked out, but it has not been considered necessary to publish them, as the American Expedition is in possession of the reconnaissance sheet, and will be able to work out the positions with more accuracy by a trigonometrical survey, than they could be, obtained astronomically with the instruments used. Captain Warren is the first who has been enabled to examine and describe the whole Jordan Valley from Tiberias to the Dead Sea (Lynch's survey, having been of the river and its banks). In February 1868 he, with a party, traversed the western side as far as the Jisr Mejamia, returning by the eastern side, and continuing as far as Callirhoe; he was arrested in the journey to Kerak by the illness and death of one of the party. The overflowing of the banks of the Lower Jordan was witnessed, by which operation whole tracts of corn were irrigated and the land fertilised.

The excursion to Marsada and Jebel Usdum was made in mid-summer, under a tropical heat, the thermometer on one occasion registering 110° after sunset; nevertheless some good photographs were taken, and the Serpents' Path at Marsada, described by Josephus, was discovered and scaled.

In the Lebanon, the old idea that Mount Hermon was the Kibleh to which all the temples were turned, was disproved, it being ascertained beyond doubt that the entrances of all the temples were eastward. A plan was made of the summits of Hermon, together with the sacellum and ancient ring or *towaf*.

In 1868 a fund was raised, principally by the exertions of the late Mr. Pierce Butler, for an examination of the peninsula of Sinai, and Sir H. James was requested to undertake the direction of the Survey. The premature death of Mr. Butler when

on the eve of starting for the East, caused some delay, but everything was arranged by the 24th October 1868, when a party, consisting of Captains Wilson and Palmer, R.E., Rev. F. W. Holland, and five non-commissioned officers Royal Engineers from the Ordnance Survey, sailed from Southampton. The Expedition was joined in Egypt by Mr. E. H. Palmer and Mr. Wyatt, the former an accomplished Arabic scholar, the latter a naturalist. The Expedition was actively employed in the desert for five months, with the following results:—

At 36 encampments there were 83 sets of observations for determining the time, 3 for longitude and 201 for latitude. The direction of the true meridian was determined at 6 different stations, and miscellaneous observations for azimuth and magnetic variation were taken at 24 points of the survey.

Two special surveys, upon a scale of 6 inches to a mile, the one of Jebel Músá and its vicinity, the other of Jebel Serbál and its vicinity, and respectively 17 and $13\frac{1}{2}$ square miles in extent, were completed, and the plans drawn. In the execution of these surveys, two base lines were measured, and the relative positions and altitudes of 68 trigonometrical stations determined by triangulation. The stations, 55 of which were observed from, ranged up to an altitude of 2700 feet above the base line at Jebel Músá, and 4800 feet above that at Jebel Serbál.

The special surveys likewise comprised 63 miles of traversing, 45 of levelling, and $4\frac{1}{2}$ of contouring, and were completed by hill sketches. They were connected by a traverse survey 29 miles long, and accurate models have since been made from them.

The relative position and altitude of 56 mountain peaks were determined by triangulation from 25 selected points. A series of barometrical and hypsometrical observations were taken at Suez, and at the camps of the Expedition, as well as on many of the peaks themselves, so as to enable their levels to be referred to that of the Red Sea. Seven hundred miles of route survey were made, extending over many parts of a district which may be roughly described as bounded at its four extreme points by Suez, Ain Hudherah, Jebel eth Thebt, and Tur, and embracing an area of 3600 square miles—about twice that of Kent.

The instruments used in the special surveys were the 5-inch theodolite and 8-inch spirit-level; the hill sketching was filled in with $2\frac{3}{4}$ -inch prismatic compasses and small aneroids. For the general survey 8-inch and 6-inch sextants, a 6-inch altitude azimuth theodolite, one box and three pocket chronometers, a 5-inch prismatic compass on stand, 5-inch theodolites, pocket compasses, barometers, hypsometers, &c.

The maps which have been published, are, special surveys of Jebels Músá and Serbál, on a scale of 6 inches to a mile, in outline, and with hill shading; a map of the general survey, on a scale of 2 miles to an inch; and a map of the peninsula, on a scale of 10 miles to an inch.

The difficulties of carrying out a chain survey in a country such as Sinai, with lofty mountains of bare rock, were of no ordinary character; cairns had to be erected on the summits of peaks so difficult of access that it was sometimes a good day's work to get to and from a single station, and on a few occasions the instruments had to be hoisted up the steep ledges by ropes. Nor was the actual observing an easy matter, for often after reaching a cairn, in a violent perspiration from the intense heat of the sun in the sheltered valleys, the fingers became so numbed by the keen wind on the heights that they could hardly work the screws of the instruments.

On reaching Suez it was at once apparent that the labour and expense of connecting Suez with the Sinaitic Mountains by triangulation would be very great, and it was decided to adopt a similar plan of operations to that followed in the Palestine Survey of 1865-6, viz. :—

1st. To establish the position of at least one series of selected peaks between Suez and Jebel Músá by observing the latitude of the peaks, and their reciprocal true bearings from one another; this—Jebel Serbál being one of the peaks as well as Jebel Músá—would give the true position of the special surveys and of several points between them and Suez.

2nd. From the points thus fixed, and also from the principal trigonometrical stations in the special surveys, to extend a triangulation as far as possible right and left of the main line of peaks.

3rd. To fill in the topographical details by route and reconnaissance surveys, checked by bearings to known points, and observations for latitude at the camps. This plan was adhered to throughout.

The mode of determining the differences of longitude between the points in the series between Suez and Jebel Músá is given in Appendix II.

The altitudes of the two permanent camps at Jebels Músá and Serbál were determined by a careful comparison of a long series of observations made at them with a Gay-Lussac barometer, with a series made at Suez by Mr. Andrews, of the P. and O. Company; and to these altitudes all other observations in the peninsula were referred. The instruments used in the field were 1 Gay-Lussac barometer, 8 aneroids, and 3 hypsometers; and a comparison of the 9 barometers was made by myself

every morning and evening when the regular meteorological observations were made; the aneroids were also compared by the officers using them on leaving and returning to camp. As I believe it to be one of the most complete series of barometrical readings which has been made on an expedition of this kind, I have given in Appendix III. a note on the subject by Captain Palmer, R.E., taken from the published account of the survey, which is not within every one's reach.

Meteorological observations were made at Suez, and at the camps at Jebels Músá and Serbál, and the results are published in the account of the survey.

In addition to the survey, special plans were made of all ruins met with, the numerous cells and tombs examined, impressions and photographs taken of the Egyptian remains and inscriptions, and several small excavations. Geological, botanical, and natural history specimens were collected, and, thanks to Mr. Palmer, the native names and traditions were obtained in the most authentic and complete manner. Mr. Palmer was also able to set at rest for ever, the questions connected with the Sinaitic inscriptions, and by the discovery of several in bilingual characters, to form a complete alphabet. The inscriptions throw little light on the history of the peninsula, but are of great value to philologists; they date from about the 1st century before Christ to the 3rd and 4th A.D.

On the return of the Expedition to Egypt, careful measurements were made of the Nilometer and the base of the Great Pyramid.

In November 1869 Mr. Palmer was sent out by the Fund to explore the Desert of the Tih and part of Moab, and he was accompanied on his journey by Mr. C. F. Tyrwhitt Drake. Leaving Suez, Mr. Palmer proceeded, in the first instance, to Jebel Músá, and thence to Ain Hudherah; from this point he proceeded up Wády Byar, and ascending the Tih by a pass not previously known crossed over to Nakhl. From Nakhl Mr. Palmer travelled northwards to Beersheba and Hebron, visiting *en route* El Aujeh, S'baita, Khalasah, and other places of which little was previously known; plans of these places were made, photographs taken of the ruins, and a large amount of valuable information collected. From Jerusalem Mr. Palmer travelled southwards to Hebron, and thence for the greater part of the way by an entirely new route through the Negeb to Petra; on this occasion he was fortunate enough to discover the ruins of Abdeh, the ancient Eboda, and came upon several traces of the old Roman road from Gaza to Petra. From Petra, near which a new rock-hewn town was found, he proceeded up the 'Arabah to the Dead Sea, and after an examination of the Lisan

ascended by Shihan to Moab; here he spent some time examining the country with a view of discovering inscriptions, and then crossed the Jordan to Jerusalem. The whole of Mr. Palmer's journey was accomplished on foot in native costume, and a careful sketch of his route was made with a prismatic compass, and by pacing; the accuracy of the work may be judged from the fact that on closing on Hebron the amount of error was only $4\frac{1}{2}$ miles. The geographical results of the journey are very valuable, and the discovery of traces of extensive cultivation, principally vine culture, in former days to the extreme southern limit of the Negeb is especially interesting. Of great value also, is the collection of the correct nomenclature and native traditions, a work for which Mr. Palmer was so eminently qualified; and his account of his journey is one of the most interesting and valuable papers which have been contributed to the quarterly publication of the Fund.

Having failed to obtain permission to excavate in the Haram Area at Jerusalem, the attention of the Committee was turned to the survey; it was felt that Biblical research had reached a point at which an accurate map was indispensable for its further progress, and that the strong tide of Western civilisation which had recently set in, would sweep away for ever many old names, traditions, and relics of the past, if they were not rescued by the speedy completion of an accurate and systematic examination. A resolution was therefore passed at the Annual General Meeting of the Fund in June 1871, that immediate steps should be taken to complete the survey of Palestine.

At the same meeting it was announced that a Palestine Exploration Fund had been formed in America to co-operate with the English Fund, and that an arrangement had been made by which the English party was to survey the country west of Jordan, whilst the Americans took the east.

Captain Stewart, R.E., was appointed to the command of the English party, and two non-commissioned officers, good observers and surveyors from the Ordnance Survey, were selected to accompany him. Mr. Tyrwhitt Drake, who was at the time in Palestine, also consented to join the party and take charge of the nomenclature, traditions, natural history, &c.

The objects of the Expedition, as embodied in Captain Stewart's instructions, were briefly:—

1. To obtain an accurate map of the country, on which, in addition to the topographical features, should be laid down the sites of all towns, villages, roads, &c.

2. To collect, as far as possible, the native names and traditions connected with the various places.

3. To make tentative excavations where necessary.
4. To carry on a series of meteorological observations.
5. To make such notes as might be possible on the geology of the country, its botany, zoology, &c.
6. To take any opportunity which might offer of making excavations at Jerusalem which would lead to decisive results.
7. To examine and make plans and drawings of interesting archæological remains in the country.

8. To carry out generally the scheme which had been proposed in the several prospectuses issued by the Committee.

The scale approved by the Committee for the general map was 1 inch to a mile, whilst plans of localities having a special interest, and of important buildings, were to be made on such larger scale as circumstances might require.

The projection selected was Sir H. James's Rectangular Tangentive Projection, and a series of sheets were prepared by Captain Bailey, R.N., embracing the whole country. Each sheet contains 20' of lat. and 30' of long. As the same projection and arrangement of the sheets has been, I believe, adopted by the Commander of the American party, there will be no difficulty in combining the results of the two surveys. The coast line was laid down on the sheets from the Admiralty Survey, and Captain Mansel's longitudes of Jaffa, Acre, and Beyrout were taken as correct.

The instructions for the survey pointed out the vicinity of Ramleh, on the plain east of Jaffa, as the most suitable locality for the measurement of a base, and recommended the connection of the base as early as possible with a common point of the Admiralty Survey at Jaffa, and with the triangulation of the Jerusalem Survey. When this was completed the triangulation was to be carried northwards and checked by the measurement of a second base on the plain of Esdraelon.

Under ordinary circumstances the whole country would have been triangulated, and the points laid down before the survey was commenced; but in the present instance it was, for several reasons, deemed advisable to fill in the details as the triangulation proceeded. The instruments supplied for the triangulation were one 7-inch and two 5 inch theodolites.

Some years previously, meteorological observatories had been established by the Fund at Beyrout, Nazareth, Jaffa, and Gaza, whilst an observatory under Dr. Chaplin's care had been in full work at Jerusalem since 1864. A full set of instruments, with a portable observatory designed by Elliott and Co., were supplied to Captain Stewart, and he was requested to make arrangements with the other stations for making, as far as possible, simultaneous observations.

Mr. Glaisher very kindly undertook the direction of the meteorological work, and has contributed some valuable papers on the results already obtained, to the quarterly publication of the Fund.

On the 8th November 1871, Captain Stewart landed at Jaffa, and he and his party immediately set to work on the necessary preparations for the conduct of the Survey. A camp was established at Ramleh, a base line measured, and the first points for the triangulation selected, when, on the 25th November, Captain Stewart was unfortunately attacked by a severe illness which compelled him to return to England. In consequence of Captain Stewart's sudden illness, the duties connected with the Survey devolved upon the two non-commissioned officers he had taken out with him—Serjeant Black and Corporal Armstrong—and I would take this opportunity of speaking in the highest terms of the general accuracy of their work and of the judgment shown in the selection of points for the triangulation. On the 17th December Mr. Drake arrived from Damascus, and taking over the charge of the Survey from Captain Stewart, joined the camp at Ramleh. The varied nature of the duties which Mr. Drake was suddenly called upon to perform, may be gathered from the programme of the Survey, and the Committee are deeply indebted to that gentleman for the able manner in which he carried on the work, and for the readiness with which he undertook the responsibility attached to it. On the resignation of Captain Stewart, which followed his return to England, Lieutenant Conder, R.E., was appointed as his successor, and assumed the charge of the Survey on his arrival at Nablus on the 17th July 1872. Since this date the progress of the Survey has been rapid and steady, and some idea of Lieutenant Conder's exertions since he joined, may be gathered from the fact, that, in addition to many beautiful sketches, we are indebted to him personally for the delineation of the hill features of the area surveyed, and for a geological map of the same district.

The base selected near Ramleh was measured three times with a common chain which had been compared with a standard; the three measurements agreed well together, and gave a mean length of 22183·8 feet, or 4·2 miles, the accuracy of which was tested by one of the usual methods. The position of the base with regard to the meridian was determined by observations of Polaris, and a series of observations for latitude were made at Ramleh, giving results which agreed excellently with those derived by triangulation from the Admiralty latitude of Jaffa.

By the end of January, Serjeant Black was able to report that

the triangulation had been carried away from the base line in a series of well-shaped triangles extending over 100 square miles, that 80 square miles had been surveyed and laid down on the sheets, and that a connection had been made with a common point of the Admiralty Survey at Jaffa, and with a bench mark on the line of levels from Jerusalem to Jaffa. During February and March, 100 square miles were triangulated and surveyed, and a complete connection established between Jaffa and the triangulation of the Jerusalem Survey.

Mr. Drake, very justly deeming it unadvisable to expose men new to the climate, to the great heat of the maritime plain in summer, determined to push the triangulation northwards over the hill country towards Nablus, and by the 17th July, when Lieutenant Conder arrived to take charge of the Survey, 560 square miles, partly of the most difficult country, had been triangulated, surveyed, and drawn on the sheets.

In September a second base, 23810 feet, $4\frac{1}{2}$ miles long, was measured on the flattest portion of the great plain of Esdraelon, and connected with the triangulation. It lies within 4° of north and south, and its ends have been marked in a most durable fashion by cairns of stone set in a sort of mortar of fresh-slaked lime. This base was also measured three times, and further checked by observations from its ends and from a point near its centre. Considering the many difficulties attending the work the calculated length of the line agrees well with the measured one.

From this base the triangulation was extended to the north and west, picking up several points used in the reconnaissance of 1865-6, and by the 20th January of this year (1873), Lieutenant Conder was able to report, that the triangulation had been carried to Haifa and Carmel, and that 1250 square miles had been completed and drawn on the sheets. The diagrams which I exhibited to the Society showed the principal triangulation and the area which has been surveyed and plotted; the original plans were in Palestine, but the tracings sent home by Lieutenant Conder were lent for inspection by the Palestine Fund.

The Survey is now in progress between Carmel and Jaffa, and Lieutenant Conder hopes before the hot weather sets in to complete this portion of the work.*

In addition to the triangulation, observations for latitude have been made at the principal places, and it is satisfactory to

* The Survey now extends over 1800 square miles, $\frac{1}{11}$ ths of the whole area of Palestine, whilst the monthly rate has been increased to 180'89 miles, being an increase of nearly 30 per cent. on the maximum attained before Lieutenant Conder joined the Survey. Twelve special surveys have also been made of important localities, and the geological map has been continued.

find that where these can be compared they agree well with Captain Mansel's observations, and that the position of Acre, as derived from the triangulation, differs but slightly from that laid down on the Admiralty chart. The altitudes are determined by reciprocal angles of elevation and depression, as well as by aneroid barometer, and frequent observations are made for variation. On the original maps the hills are properly hachured according to a scale of shade, the principal slopes being taken with an Abney's level. Lieutenant Conder and Mr. Drake are not, however, content with making a mere modern map; they are intent upon making a thorough examination of the whole country. To these additional labours only a brief allusion can be made here.

Not only is every ruin, however small, visited, but a description of it is written on the spot, plans and sketches made of it, if of sufficient importance, and occasionally slight excavations. The result of this is a mass of most interesting plans and papers, some of which have already been received in England; the greater portion, however, are still in Palestine, Lieutenant Conder being unwilling to trust such valuable documents to the post-office; but it is hoped that Mr. Drake, who is expected home shortly, will bring them with him. In connection with this subject it may be mentioned that the old Roman roads through the country are carefully traced out and laid down on the map, and from this source alone we may hope to recover many lost sites.

Meteorological observations are made at all the camps under instructions supplied by Mr. Glaisher, and at times, as nearly as possible, the same as those of the fixed observatories. This will give valuable information on the climate of Palestine.

Geological specimens are collected, and a geological map of the country is being prepared, by Lieutenant Conder; amongst the results already obtained are the discovery of several basaltic outbreaks previously unknown, and some ancient mines in the vicinity of Carmel.

The names of all ruins, valleys, hills, and other natural features are collected by Mr. Drake, whose long residence in the country, and familiarity with the native character and Arabic language, renders him peculiarly well fitted for this important and difficult task. He has already succeeded in identifying several lost Biblical localities, and we may expect a rich harvest from his exertions.

Mr. Drake also collects all native traditions, and is a close observer of the existing manners and customs of the people. He is also engaged in forming a collection of botanical and zoological specimens.

The difficulties which the surveying party have had to encounter have been by no means inconsiderable: the work has been carried on in one of the most trying climates in the world, and in the midst of a turbulent population with but slight support from the local government; cairns have been pulled down as soon as erected, and in some places the opposition of the natives has taken the form of open hostilities. The results which have been obtained are largely due to the tact which the officers have shown in their dealings with the natives, and under such control we may hope for a successful completion of a work which has well been described as "a new phase in geographical research."

In conclusion it may be mentioned that, according to the latest reports from Beyrout, Lieutenant Steever, of the United States Engineers, had completed the outfit of his party and had left for the country east of Jordan. We may thus hope to obtain at an early date interesting details of the progress of the American Expedition.*

APPENDIX I.

CAMP XII.—BANIAS, December 31, 1865.

South Star, "Sirius," for Latitude.

Observed Meridian Double Altitude.										Observed Times.		
°	'	"								H.	M.	S.
80	28	30	..	..	..	..	..	..	..	9	30	21.6
80	28	20	..	..	..	..	..	..	..	9	30	26.0
80	28	20	..	..	..	..	..	..	..	9	31	29.6
80	28	20	..	..	..	..	..	..	..	9	31	38.0
80	28	20	..	..	..	..	..	..	..	9	32	36.0
80	28	10	..	..	..	..	..	..	..	9	33	08.0
80	28	0	..	..	..	..	..	..	..	9	33	47.6
80	28	05	..	..	..	..	..	..	..	9	34	19.6
80	28	00	..	..	..	..	..	..	..	9	34	32.4
80	27	55	..	..	..	..	..	..	..	9	35	29.2

* By recent accounts the American party had measured a base line on the plains of Moab, and 400 square miles had been triangulated and filled in. The archaeological and scientific departments of the expedition had also been very successful.

North Star, "Polaris," for Latitude.

Observed Double Altitude.										Observed Times.		
°	'	"								H.	M.	S.
67	31	25	..	..	..	..	..	..	..	8	40	20·4
67	30	50	..	..	..	..	..	..	..	8	41	03·6
67	30	25	..	..	..	..	..	..	..	8	41	30·6
67	30	00	..	..	..	..	..	..	..	8	42	18·4
67	29	25	..	..	..	..	..	..	..	8	42	52·4
67	28	50	..	..	..	..	..	..	..	8	43	34·4
67	28	20	..	..	..	..	..	..	..	8	44	12·4
67	28	10	..	..	..	..	..	..	..	8	44	48·0
67	27	25	..	..	..	..	..	..	..	8	45	26·4
67	27	00	..	..	..	..	..	..	..	8	46	18·4

South Star ° 33 ' 14 " 38·4

North Star ° 33 ' 14 " 53·1

Mean determination ° 33 ' 14 " 45·8

"Procyon" for Time (West Star).

Observed Double Altitude.										Chronometer Times.		
°	'	"								H.	M.	S.
103	50	0	..	..	..	..	..	..	..	8	32	56·4
104	0	0	..	..	..	..	..	..	..	8	33	28·0
104	10	0	..	..	..	..	..	..	..	8	33	59·2
104	20	0	..	..	..	..	..	..	..	8	34	29·6
104	30	0	..	..	..	..	..	..	..	8	35	01·2

"Aldebaran" for Time (East Star).

Observed Double Altitude.										Chronometer Times.		
°	'	"								H.	M.	S.
105	0	0	..	..	..	..	..	..	..	8	49	57·2
104	50	0	..	..	..	..	..	..	..	8	50	22·0
104	40	0	..	..	..	..	..	..	..	8	50	47·0
104	30	0	..	..	..	..	..	..	..	8	51	12·0
104	20	0	..	..	..	..	..	..	..	8	51	36·4

	H.	M.	S.	
West Star, Chronometer slow	..	2	25	40·43
East Star	..	2	25	42·02

	H.	M.	S.		H.	M.
Mean Chronometer error =	2	25	41·23	at	11	38 M. T.

APPENDIX II.*

Longitude.—The differences of longitude between the points selected as initial stations of the Survey were determined as follows:—

Let A and B be two stations on the surface of the spheroid visible from one another, A P = ψ , B P = ψ' their observed colatitudes, the angles A and B their reciprocal true azimuths, and A P B the required angular difference of longitude. Then, by spherical trigonometry,†

$$\cot \frac{1}{2} P = \frac{\cos \frac{1}{2} (\psi' + \psi)}{\cos \frac{1}{2} (\psi' - \psi)} \tan \frac{1}{2} (A + B), \quad (1)$$

which determines P.

But, as the angles at A and B may not have been measured with perfect accuracy, it is necessary to compute the small quantities by which the observed azimuths must be corrected. The following method of doing so has been kindly suggested by Lieut.-Col. A. R. Clarke, C.B., R.E.:—

Let λ be the latitude of A, λ' the latitude of B, the angles A and B the true azimuths, n n' the normals at A and B. Also let k be the chord line joining the two stations A and B, and μ μ' the angles made by this chord with the normals at A and B, so that $90^\circ - \mu$, $90^\circ - \mu'$ are the mutual depressions of those points.

Then, from formula (7), page 231 of the 'Account of the Principal Triangulation of the Ordnance Survey,' in which a a' , $\frac{a}{\Delta}$ $\frac{a'}{\Delta}$ correspond respectively to A B, n n' in this statement of the problem, and ω is the difference of longitude, we get—

$$\frac{\sin \mu \sin A}{\sin \mu' \sin B} = \frac{n' \cos \lambda'}{n \cos \lambda}.$$

But, from the two last equations on the same page,‡ it may be proved that μ and μ' are so nearly equal, that we can put $\frac{\sin \mu}{\sin \mu'} = 1$ without appreciable error. Hence,

$$\frac{\sin A}{\sin B} = \frac{n' \cos \lambda'}{n \cos \lambda} = m \text{ (say)}. \quad (2)$$

$$\therefore \sin A = m \sin B. \quad (3)$$

Suppose α and β to be the observed azimuths, and let x y be the corrections to be applied to them. Then, by (3),

$$\sin (\alpha + x) = m \sin (\beta + y);$$

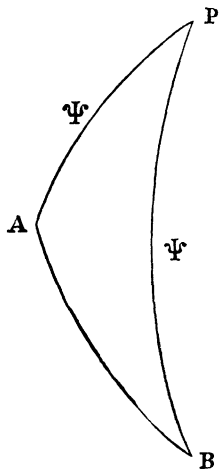
and, since x and y are small,

$$\begin{aligned} \sin \alpha + x \cos \alpha &= m \sin \beta + m y \cos \beta \\ &= m \sin \beta + \frac{\sin \alpha \cos \beta}{\sin \beta} y \end{aligned}$$

* From Ordnance Survey of Sinai.

† Equation (1) is true for the spheroid as for the sphere.

‡ See also examples, lines 9 and 10, page 235 of the same work.



Mansel's longitude of Suez Hotel, $32^{\circ} 33' 29''$ E.; this was found by telegraph, and depends upon the longitude of Alexandria Lighthouse being $29^{\circ} 51' 40''$ E.

Three values for the difference of longitude between Suez and Jebel Músá were obtained by the method described above; they are,

Difference of Longitude.					Longitude of Jebel Músá.			
1st Value	..	1	25	30	E. equivalent to	33	58	59 E.
2nd "	..	1	25	32	"	"	33	59 1
3rd "	..	1	25	34	"	"	33	59 3
Mean	..	1	25	32	"	"	33	59 1

This value was checked by observations from Jebel Músá and Jebel Abu Mes'úd to Jazirat Tírán in the Gulf of 'Akabah, with the following results:—

Difference of Longitude.					Longitude of Jebel Músá.				
1st Value	..	0	33	35	E. equivalent to	33	59	5	E.
2nd „	..	0	33	27	„	„	33	59	13
Mean	..	0	33	31	„	„	33	59	9

For final result,

					Longitude of Jebel Músá.		
Mean from Suez	..	..	..	..	33	59	1 E.
" " Tírán	..	..	..	..	33	59	9
Mean longitude of Jebel Músá	..	..	..	..	33	59	5 E.

This value has been adopted, and it is probably within 5" of the truth.

APPENDIX III.

DETERMINATION OF ALTITUDES.

The altitudes of a large number of points in the peninsula—214 in all parts of the country, besides the 68 trigonometrical stations in the special surveys—have been determined by various means and with various degrees of accuracy. The greater number of the results are contained in the Tables; all of them, with three or four exceptions, have been written on the maps and plans. The datum-level, to which all the heights refer, is that of mean tide at Suez. One mountain barometer and two Gay-Lussac barometers, eight aneroids, and three hypsometers, were used in the determinations. One Gay-Lussac was left, with other meteorological instruments, at Suez, and registered daily, A.M. and P.M., by Mr. Andrews, of the Peninsular and Oriental Company. The mountain barometer was unfortunately injured beyond hope of repair, on the way from Suez to Jebel Músá, by the conduct of a refractory riding-camel, which succeeded in bringing the instrument and the corporal carrying it, to the ground. The Gay-Lussac happily suffered no harm, and became the standard at our permanent camps, to which, in connection with the Gay-Lussac at Suez, all other barometric readings were ultimately referred. The whole of the barometric and hypsometric observations have been reduced at Southampton by Quartermaster James Steel, R.E. He has brought great experience to bear upon the subject, and we are indebted to him for a laborious and, as far as could be, successful analysis of a very puzzling and complicated mass of

figures. I will endeavour to indicate the means by which the various results were arrived at, and the general conclusions to be drawn from them.

1. The Gay-Lussac barometer was kept stationary at the special survey camps—six weeks at Jebel Músá, followed by ten weeks at Feirán, and then a second period of five weeks at Jebel Músá. It was registered daily, at times to correspond with the registers at Suez, and all aneroids in camp were constantly compared with it. The altitude of each permanent camp was thus concluded from a comparison of long series of readings of the two standards. The formula used in the reductions was—

$$H = 60345 \cdot 5 \left\{ [\log B - \log b (1 + 0000897 (\tau - \tau')) \times [1 + \cdot 0010652 (t + t')] \right. \\ \left. \times [1 + \cdot 002695 \cos 2 \phi] \right\},$$

where H represents the difference of height between the two stations, ϕ the latitude midway between them, and B, b, τ, τ', t, t' , the heights of barometers, temperatures of mercury, and temperatures of air, at the lower and higher stations respectively.

In the reductions of the aneroid readings taken in the course of the general survey, it was considered sufficiently accurate to use a mean latitude (ϕ), a mean pressure (B), and mean temperatures for the whole. A table of altitudes for every $\frac{1}{10}$ " of pressure, from the sea level to 8,500 feet above it, was calculated with these data. The aneroid readings were corrected for index error, and for any deviation at the time of reading, from the mean pressure both at Suez and at the permanent camp, and the altitudes were then obtained from the table by interpolation.

2. The lines of levelling and the computed relative heights (by vertical angles) of the trigonometrical stations in the special surveys were all referred to the levels of the respective permanent or special survey camps, and their true altitudes thence obtained. Then, from these trigonometrical stations, we determined by vertical angles the altitudes of the greater number of the peaks of the general triangulation, the cluster about each special survey being computed separately.

3. During the geographical survey, aneroids had mainly to be depended on. They were observed at our camps and latitude stations, at the crossings and mouths of wádies, at watersheds, and on all the peaks we ascended. The registers of the different instruments were at first very perplexing and did not seem likely to lead to good results. The readings of three out of the eight for some time defied all attempts to harmonise them; but it was at length discovered, on close investigation, that their index errors had been effected by a uniform law. The Gay-Lussac had been the means of furnishing trustworthy altitudes of the two permanent camps, and a comparison of the index errors of the three aneroids at these stations with their errors at the sea level pointed to the conclusion that these errors varied in direct proportion to the pressure. This was verified by a scrutiny of the aneroid readings at the higher trigonometrical stations (of known altitude), when the same law was found to hold good. It thus became possible to compute a sliding-scale of approximate index error for each instrument, by which its reading at any altitude from the sea-level to 8500 feet could be corrected. The errors did not all increase in the same direction. Two aneroids gave the low plus value at the sea-level, the high value on high ground; but, with the third, the error varied in the contrary direction, and so tended to correct the others when used in connection with them. The results from these three aneroids served to check those from the other five, the index errors of which, did not appear to have been regulated by any known or discoverable law.

By this means fair determinations were no doubt obtained in the majority of cases. The value to be attached to them was tested in several instances by

reference to the aneroid readings at points of known altitude.* In eight out of twelve such comparisons it was found that the results, after being corrected by the sliding-scales of error, agreed pretty closely with the trigonometrical heights, the differences varying only from + 48 to - 34 feet. In the other four instances the discrepancies were larger, but this was probably owing to the fact of the weather having been on those occasions stormy or unsettled.

4. Hypsometers were tried on many occasions, but nearly always with discordant and unsatisfactory results. Out of thirteen comparisons of hypsometric heights with those found by the Gay-Lussac and vertical angles, in two only was there close agreement. In the remainder the hypsometric values varied from 54 to 133 feet below, and from 184 to 383 feet above, the true altitudes. They differed in the most irregular and unaccountable manner, and no weight has been attached to them.

It will have been seen from the foregoing description that the opportunities this survey afforded of testing the values of aneroids and hypsometers for determining altitudes have been more than usually numerous and favourable. The instruments were by the best makers, and good of their kind; there was a fair supply of them; they were used in a systematic manner, and tried over a considerable range of heights. The series of results is very numerous, and perhaps more comprehensive in its character than any yet given to the public. The conclusions to be drawn from them, cannot but be valuable. These conclusions appear to be—(1) that at high altitudes hypsometers are not to be depended on for any but the roughest approximations; (2) that aneroids are, *per se*, almost worthless for absolute determinations, and are only of service when used, as at Sinai, in direct connection with standard mercurial barometers at various heights, or for filling in details of a survey between datum-points of known altitude. If it had not been for the data at Feirán and Jebel Músá afforded by the Gay-Lussac, the sliding-scales of index error could never have been hit upon, and the correct reduction of the aneroid readings would have been hopeless; and, as it was, the index errors of five aneroids out of eight could not be depended on, when they were carried to any great height above the highest Gay-Lussac datum in Wády ed Deir. It is difficult to say whether, if taken independently—that is, without the incidental help of the Gay-Lussac—the aneroid heights would have been more or less trustworthy on the whole, than those given by the hypsometers. But there can be no doubt that our best determinations are those of the two permanent camps and of the trigonometrical points in and about the special surveys.

X.—*Recent Elevations of the Earth's Surface in the Northern Circumpolar Regions.* By HENRY H. HOWORTH.

AMONG the phrases we owe to the ancients, there are few we use more frequently than that of *terra firma*; and among the prejudices common to untutored man there are few more justifiable perhaps than that of the stability of the solid earth when compared with the mobility and restlessness of the water. Yet at a very early date the inhabitants of some areas of the world must have been impressed that there were considerable exceptions to the rule, that in the neighbourhood of Etna and Vesu-

* The highest point where aneroid observations were made is about 8,526 feet above the sea.