I am doubtful whether the great accuracy and rapidity of this class of work has yet been recognised by any section of thinking men. The best features of the work are that it cannot get out to any great extent, so that it may be carried for hundreds of miles with the same limit of error. For example, the extreme points in this Reconnaissance are Jerusalem and Gaza. In each of these cases the limit of error in latitude is 3 seconds, and in longitude respectively 11 and 13 seconds. I am not aware that there is any record of so large a number of points being accurately fixed over so extended a tract in so short a time; the average day's work included the surveying from 50 to 70 square miles, and fixing the latitude and longitude of eight places.

The accuracy of this Reconnaissance was so little comprehended ten years ago that when I brought it forward it was distrusted because it was so unlike all the work that had been done before. At that time I asserted positively that Maunsell's longitude of the Dome of the Rock was nearly a minute too far to the west, and published my longitude in the P.E.F. Quarterly, 1871, p. 162, but finding that the former longitude was preferred to mine, I said I should be content to wait for the Trigonometrical Survey to decide between us, which it has now done in my favour.

THE SULPHUR OF THE VALLEY OF THE JORDAN.

(*From the Zeitschrift of the German Palestine Association.*)

By Dr. Oscar Fraas.

Some time ago I received an account from Herr Charles Paulus, sen., of the sulphur found in the Jordan Valley, which confirmed the result of observations previously made. Herr Paulus writes that some young men of the Temple Colony in Jerusalem made an excursion to the Dead Sea in the spring, and brought back with them "some specimens of a mineral substance they had found there. These specimens consist of a fine grey clay containing sulphur. The clay itself is good pottery clay, such as is found, not only in the neighbourhood of the Dead Sea, but which also exists in great quantities all over the chalk mountains of Palestine. . . .

"This sulphur consists for the most part of roundish lumps varying from the size of a pea to that of a walnut; it is of a whitey yellow colour, earthy, very brittle and apt to lose its colour. Each of these sulphur balls is enclosed in a larger kidney-shaped lump of clay that forms as it were the shell containing the sulphur kernel. The clay in which small crystals are to be found, dissolves in water. Sulphur was also discovered in the cracks in the larger crystals (calcareous spar ?).

"The sulphur ground lies from 1 to 2 km. distant from the right bank of the Jordan, and a short German mile from the Dead Sea; its surface is in some places flat and in others hilly. Several of these heights rise 100 feet above the level of the plain. The sulphur ground stretches out towards

the north, but how far is as yet unknown. The travellers thought it extended as far as they could see. The air is pervaded by a sulphurous smell, which indeed clung to the specimens brought to me. All vegetation ceases in this ground. A slow combustion is apparently going on in the air during the normal state of the temperature, and is betrayed by the smell. The friable earthy character of the mineral forbids the assumption that it had been brought down by means of water from some distant place as for instance, from the volcanic region of Hawrah; it is far more probable that the sulphur was thrown up in the very spot where it now lies, or, at least, was brought from somewhere in the immediate neighbourhood by an irruption of mud."

Robinson mentions the sulphur collected by the Jehalin Bedaween, for the purpose of making gunpowder at the northern end of the Dead Sea in his Palestine II, pp. 454, 469, and III, p. 8. Herr Schick, to whom I applied for further information on the subject in 1865, wrote that Herrn Palmer and Schneller were of opinion that no real sulphur was to be found at the Dead Sea, but that they had picked up some whitey coloured sulphur amongst the hills to the north of the sea which surround the bed of the Jordan and lie at a good quarter of an hour's distance from the bank. They considered that these hills were raised by the action of water, and left it an open question where the sulphur came from and how it got there. Herr Schick went on to say that the hills seemed to him like the bank of an old lake or river, for the ground below them was 30 or more feet lower than the terrace on the other, or western side of the hills. Thus the hills were hills when regarded from the east, while, when seen from the west they were on a level with the plain. The sulphur was formed at the edge of the dried up watercourse.

Ten years later, in December, 1875, I received a box from Herr O. Kersten containing, amongst other things, some specimens of oolitic sulphur from "Khan Hadjla." Now as "Kalaat Hadjla" is placed by Lortet in his map half way between Riha and the northern end of the sea, it must undoubtedly be the same place as that described by Herr Schick and Herr Paulus.

Herr Paulus maintains that this sulphur cannot have originated in sulphur springs, because each lump is enclosed in a shell of clay, and because there are no sulphur springs on the right bank of the Jordan. There are such springs on the left side of the river, but he does not see how the sulphur could get across the water to the right side; unless, indeed, it be maintained that the Jordan ran formerly in a more westerly direction, which is not impossible, but then, in that case more sulphur would have been found on the right bank, and also near the springs where it is unknown. Herr Paulus goes on to connect the presence of the sulphur with a volcanic irruption in the Jordan Valley, and ascribes it to that convulsion of nature which caused the destruction of Sodom and Gomorrah.

I have geological reasons for denying the volcanic origin of the sulphur most emphatically. It is true that there is a volcanic sulphur generated

in the craters of volcanoes and by subterranean fire. But such sulphur can only be regarded as the direct or indirect sublimate of pure sulphur already in existence, or of such combinations as decompose thereinto at a high temperature. Sulphur, like phosphorus, is a *product of the organic world*, of the vegetable as well as the animal world. Still plants do not possess nearly so much sulphur as animals. Wherever organic bodies have been decomposed in great numbers, as for instance in old sewers and such like excavations, sulphur crystals have been found. Sulphur chiefly appears in the later formations of the earth, viz., in the tertiary, because there was a greater mass of organic remains during that period than before. It is there found in combination with clay and gypsum. Gergenti in Sicily, Conil near Cadiz and Ternel in Aragon are rich in sulphur. The tertiary slime of Radoboj in Croatia, celebrated for its fossil plants, insects, and snails, is full of yellow and brown sulphur. In other places where sulphur is found, as for example, in the neighbourhood of Jebel Zeit, there is in addition to decomposed animal and vegetable matter, bitumen, rock oil, and asphalt, or again in contact a decomposition of gypsum and other salts of sulphuric acid.

The origin of the sulphur indigenous to Hadjla is the same as this. A few kilometers to the west of this place is Nebeg Musa with its well-known Moses Stone, a calcareo bituminous stone cut and carved by the Bethlehemites. Bitumen and asphalt extend from Mount Quanantanca to Rasel-Feshka into the old chalk strata, and the waters which have been and are collected there become, through the decomposition of the bitumen, sulphur springs, such as are of frequent occurrence on the eastern side. One will not be far from the truth if one concludes that the oolitic earthy sulphur of Hadjla originated in old dried-up sulphur springs. The theory just propounded by Herr Paulus, and then dismissed, in consequence of his prepossession in favour of the volcanic origin of the sulphur is certainly correct. The clay shell surrounding the sulphur is a proof of this origin, for the water that decomposed the bitumen washed the clay out of the bituminous chalky marl with which it was incorporated, after which it clung to the sulphur thrown off by the spring. The fact that there are no sulphur springs to the right of the Jordan at the present day is no disproof of this, nor yet that the springs on the left side of the river have not a sulphur deposit, such as is to be seen at Hadjla. The precipitates of springs and deposits they may form are in a great measure dependent on factors, such for example, as the presence of free carbonic acid in the water, which lying beyond human reckoning, are rooted in minute chemical processes.*

* While this paper was in the press, I received a small bag of the sulphur in question from Herr Chr. Paulus, an exact analysis of which proves the truth of my conjecture. Professor Bronner undertook to make a chemical analysis of one of these pieces of sulphur, and his report is as follows: "The substance does not consist simply of sulphur and gypsum as it appears to do. It is rather a combination of sulphur, carbonate of calcium and gypsum, with smaller quantities of sulphite of calcium, silicate of aluminium (clay) and boracic acid.