

*NOTES ON NATIVE SULPHUR IN TEXAS.*

ABOUT 40 miles northwest of Pecos City, and 20 west of Guadalupe station on the Pecos Valley Railroad, are some deposits of sulphur, a short account of which may be of interest to the readers of SCIENCE.

These deposits occur in the 'Toyah Basin' (or its extension), referred to by Prof. R. T. Hill in his report on the Artesian waters of Texas. This basin is one of a series of lacustrine formations occupying valleys eroded in the plains or enclosed by mountain blocks, the underlying and enclosing formations being the Red Beds and the lower strata of the Comanche series of the Texas geologists.

To the northwestward of Guadalupe station, and distant some fifty or sixty miles, the Guadalupe mountains (of Paleozoic rocks) end with a perpendicular escarpment of at least a thousand feet in height, forming a conspicuous as well as a most beautiful feature of the landscape. Twenty-five or thirty miles west of the station a range of hills two to five hundred feet in height, with increasing altitude towards the west, and composed of the yellowish calcareous sandy rocks, probably of the Comanche horizon, makes the first interruption to the monotony of the plain in this direction. From the station out to these mountains and hills, and to the southwestward, beyond the limits of vision, the country is in general terms a level plain; in detail, a succession of low ridges and shallow ravines or 'draws,' the result of the erosion of the original plain. The region is practically destitute of trees, but there is on the elevations a scanty growth of yucca, dwarf mesquite, cactus and similar desert plants, to which in the lower and moister places there is added a dense growth of grasses, and in places a few stunted cedars.

The shallower ravines expose only the materials of the basin formation, coarse sand loosely cemented by lime; silt, usually

pinkish or light chocolate brown in color, water-worn siliceous pebbles; and 'tierra blanca,' a white chalky calcareous material possessing some hydraulic properties (Hill). In the deeper ravines erosion has laid bare the underlying formations, which are, according to locality, the red or dark purple clayey materials of the Red Beds or the sandy yellowish limestones of the Comanche. In these deeper 'draws' are a few springs of gypseous water which flow off in rather bold streams, to be speedily absorbed by the porous soils. Two of these, the Screw Bean and the Maverick springs, are between the station and the sulphur deposits. Besides these there are several springs whose waters are strongly impregnated with sulphur, and where the pools of water stand for some time they become briny, leaving, upon evaporation, a thick crust of salt. The level country between the limestone hills above mentioned possesses somewhat similar characters, and in the plain enclosed by these hills there is a fine spring of slightly gypseous water some five miles to the westward of the farthest of the sulphur localities. This is at the Tierman ranch where the water has been used to some extent in irrigation around the ranch.

At the three places visited by me the sulphur was found below bare, apparently wind-swept, spots, its presence being usually indicated either by clusters of gypsum crystals in the soil, or by an outcrop of the sulphur itself, sometimes tolerably pure, sometimes cementing the surface pebbles into a conglomerate. When further exposed by pits, the sulphur is seen to occur in nests and irregular veins filling small fissures or crevices in the soil, the sides of these fissures being often lined with well-developed sulphur crystals up to one-fourth of an inch in size. The whole of the earth, to the depth of ten feet or more at the three localities visited, appeared to be im-

pregnated with sulphur, sometimes almost imperceptible to the eye, but oftener in minute crystals concentrated along irregular lines. Where thus generally disseminated through the brown or chocolate-colored earth, the sulphur makes some 10 or 15 per cent. of the whole weight, but where concentrated along the lines above mentioned the percentage of sulphur goes up to 40 or 50 and even higher, for not infrequent is the occurrence of sulphur in the massive form, very light yellow in color, opaque, and of earthy aspect, resembling a yellowish meerschaum, but of exceptional purity, several analyses of average samples showing 97 per cent. sulphur. The average content of sulphur in the material penetrated by the several pits which were examined by me could not be far short of 50 per cent.

In the immediate vicinity of one of the occurrences the surface soil is highly charged with gypsum, which appears in small crystals and in large groups of crystals imbedded in the white calcareous sandy material rendered strongly acid by the decomposition products of the sulphur. At one place the sulphur beds rest upon an impure limestone which has been so greatly corroded by these acids as to be very difficult of identification.

Upon exposure to the air the sulphur rapidly undergoes alteration, being in great part finally converted into sulphuric acid, but becoming first opaque and soapy. From this cause the heaps of nearly pure sulphur piled around the mouths of the prospecting pits, rapidly disintegrate and disappear. In many cases, however, this waste has been partly due to the mechanical action of floods which, by reason of the occasional heavy rainfalls, sweep down the generally dry 'draws,' carrying everything before them. The sides of the pits and the materials thrown out of them exhale a peculiar odor (sulphury), and are so strongly acid as to destroy quickly the clothing and other

organic matters brought in contact therewith.

The sulphur beds do not appear to underlie uniformly the whole basin, for in the region indicated, within a radius of twenty miles, only three places are as yet known where they occur. The actual outcrop by natural or artificial exposure will here cover some four or five acres, but the probability is that the sulphur in each of the localities underlies a much larger area, for wherever penetrated by borings or pits the sulphur-impregnated earth has been encountered to a depth of at least ten feet, and a deposit of this thickness could hardly be conceived to thin down so rapidly as to limit the occurrence of the sulphur to the small area in which it has actually been exposed.

Nor, on the other hand, are the sulphur deposits of Texas confined to the particular region designated in these notes, for there are well authenticated reports of their occurrence both to the westward and to the northward, the former from cowboys, through whose representations attention was first directed to the beds above described, the latter upon the authority of Capt. John Pope, who had charge of one of the divisions of the survey of the railroad routes to the Pacific. Along the banks of Delaware creek he collected a sample of earth which contained 18.28% of sulphur, and he comments also upon the frequency of sulphur springs in the same region. Delaware creek rises among the Guadalupe mountains and flows into the Pecos river some fifty miles to the northward of Guadalupe station.

The materials filling the basins of the Trans-Pecos region have very generally been considered as of lacustrine origin, and of the truth of this supposition we have very good proof in the great number of fresh-water diatoms discovered in the sulphur-impregnated earth submitted by me to Mr. K. M. Cunningham, of Mobile, for

microscopic examination. The basin formation is considered by Mr. Hill to be of Pleistocene age, but somewhat more recent than the Llano Estacado.

In regard to the origin of the Texas sulphur beds, the most significant of the associated materials are the beds of gypsum which a few miles to the northeast are of commercial importance because of their great thickness and purity; the springs of sulphur water which are abundant along all the deeper drainage ways; and the ancient lake deposits which practically make the country. These deposits contain much organic matter along with calcareous and siliceous sediments.

The sulphur deposits of Sicily have probably received more careful study than any others, and they are generally thought to be derived from springs charged with calcium sulphide or sulphuretted hydrogen and carbonate of lime, resulting from the decomposition of gypsum in presence of organic matter. The decomposition products of the sulphur, in turn, acting upon calcareous matters, yield gypsum, thus completing the cycle.

Without enquiring into the origin of the great gypsum deposits of this section, I think we must consider the sulphur as one of its products, though due more immediately to the oxidation of sulphuretted hydrogen.

If these deposits were more accessible there could be no question as to their commercial importance. They are twenty miles from railroad lines, and in a country destitute of fuel and with scanty supply of surface waters. On the other hand, there would be no difficulty in the way of constructing a railroad or tramroad, which could be built out to the sulphur beds almost without grading, and that a supply of water could be had by artesian borings is as good as certain, for further down the basin near Pecos City abundance of water is obtained from

borings of 200 to 300 feet. The nearest source of fuel would probably be the Texas coal fields.

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#### CURRENT NOTES ON PHYSIOGRAPHY.

##### THE ADIRONDACK MOUNTAINS AND VALLEYS.

A FEW pages in the account of Essex county, N. Y., by Kemp (Rept. State Geol., N. Y., 1893, 438-441) describe the Adirondack ridges thereabouts as trending to the northeast, Lake Champlain rounding their ends in a series of bays. The longitudinal valleys are said to be chiefly due to faults, and the mountains are regarded as of the tilted-block type; the evidence of the faults being found in breccias and shear zones (as of Avalanche lake, Amer. Journ. Sci., Aug., 1892), and in the narrow 'passes' which are said to be evidently produced by fault scarps. Moreover, the ridges are commonly abrupt on one side and slope more gradually on the other, as in Knob mountain. A later report by the same author states that the relief of the region is not caused entirely by erosion, but that it is 'in a large part due to block faulting' (Bull. N. Y. State Museum, III., 1895, 328). It is further concluded that many of the valleys must have been outlined in pre-Cambrian times; for small areas of Potsdam sandstone occur in the depressions far within the mountains.

##### TOPOGRAPHIC FORMS PRODUCED BY FAULTING.

THE context of the above extracts seems to indicate that their author infers an ancient date for the faults mentioned, and a considerable amount of erosion subsequently in the excavation of the valleys; yet the hasty reader might gather the idea that the forms now visible were directly initiated by faulting of comparatively recent date. It is not decidedly stated whether the faults lately produced the ex-