

and although the ore can be mined at these places rather cheaply, the handling and further treatment required to free the sulphur from the worthless material is expensive. Furthermore, a good deal of the sulphur is not extracted by this rather crude method of treatment, and hence the difference between the original sulphur content of the ore and the quantity of sulphur recovered in practice is often very great.

Most of the companies producing small quantities of sulphur are developing localized deposits that seem to be more or less intimately connected with the dying out of volcanism or solfataric action. The richer parts of the deposit on a single property are therefore rather irregularly distributed and usually cover only a small area. The sulphur content is usually greatest in the surface portions, although in places the sulphur-bearing formation is reported to be as much as 40 feet thick.

SULPHUR DEPOSITS RECENTLY INVESTIGATED BY GEOLOGICAL SURVEY.

In the chapter on sulphur in Mineral Resources for 1916 all the known deposits of sulphur in the United States were described. In the similar chapter for 1917, a few additional sulphur localities were listed, among others one near Jemez Hot Springs, in New Mexico. Practically nothing was known regarding the value of this deposit as a source of sulphur, and accordingly Geologist George R. Mansfield was detailed to make an investigation of it. His report, which has already appeared in several of the technical papers, follows:

NEW MEXICO.

SULPHUR IN JEMEZ CANYON, SANDOVAL COUNTY.

By GEORGE R. MANSFIELD.

Small deposits of sulphur have long been locally known in Jemez Canyon, Sandoval County, N. Mex. Early in 1918 the suggestion was made that these deposits might be a source of commercial sulphur. Reconnaissance reports already available at the United States Geological Survey indicated that the deposits were probably of slight extent or value, but in order to obtain more detailed information a geologist was sent from the Survey to examine them. The examination confirmed the unfavorable reconnaissance report and showed that the deposits are not of commercial value.

The deposits occur at two places, one in the Canyon de San Diego grant, about 5 miles above Jemez Springs, nearly three-fourths of a mile below the forks of the creek; the other at Sulphur Springs, in the Baca location, about 14 miles above Jemez Springs. Inquiries at Jemez Springs elicited no information concerning any other deposits in the region comparable with these two. The nearest railroad points are Bernalillo and Albuquerque, on the Atchison, Topeka & Santa Fe Railway, about 45 and 60 miles, respectively, south of Jemez Springs, by the wagon road. The road for much of the way is heavy with sand.

San Diego deposit.—The sulphur ore at the deposit, which may be called the San Diego deposit, consists apparently of residual material

from Carboniferous limestone leached by acidulated waters and permeated by sulphurous vapors, which have deposited free sulphur in the crevices and pores of the upper few feet of rock.

The sulphur-bearing mass is about 700 feet long and 150 feet wide, occupying a lenticular area of about 1 acre. Two smaller areas, 50 feet or less in diameter, were noted in branches of a small tributary canyon about three-fourths of a mile to the northwest. The writer spent nearly three days in mapping, exploring, and sampling this deposit in association with Linus Shields, superintendent of the Canyon de San Diego grant. In this exploration, six prospect cuts were dug, exposing fresh sections ranging in depth from 2 feet 1 inch to 13 feet 6 inches. From these cuts numerous measurements were made and 11 samples were obtained for analysis. The sulphur is irregularly deposited and is in a relatively thin deposit, measuring only 2 feet 4 inches to 3 feet 4 inches in thickness in four cuts in the more promising parts of the area. In one cut the deposit was not penetrated at a depth of 4 feet 2 inches. The sulphur ore contains from 15 to 39 per cent of free sulphur and from 6 to 8.5 per cent of sulphur combined as sulphate. The rock under the ore contains no free sulphur, but about the same percentage of sulphur combined as sulphate.

Deposit at Sulphur Springs.—The deposit at Sulphur Springs is similar, except that it occurs in rhyolite, a volcanic rock. The rocks at this locality are at some places still warm to the touch, and there are numerous vents in them from which hot acidulated waters and sulphurous vapors are now being emitted. Some of these vents are being utilized for the hot water and vapor baths that make Sulphur Springs a local health resort. The escaping vapors have deposited sulphur on the walls of the vents, lining them with beautiful acicular or stout yellow crystals.

One day was spent in the trip to Sulphur Springs, where the deposit occupies about 9 acres in a small basin eroded in the rhyolite. A number of low slopes between drainage lines are covered with white debris and some yellowish spots suggesting sulphur ore, the presence of which was confirmed by making small pits, but pits in other areas disclosed no sulphur.

Sixteen years ago M. S. Otero, former Delegate to Congress from New Mexico, built at Sulphur Springs a mill equipped with a boiler, engine, pump, and two retorts of about 1-ton capacity each, for producing sulphur. The retorts were filled with ore and steam under pressure of about 30 pounds was led into them and the melted sulphur was drawn off below. On the death of Mr. Otero, two years later, the mill was closed and the property passed into the hands of his sons. According to A. T. Otero, who furnished the above data regarding development, the ore treated ran about 60 per cent sulphur and the total production amounted to about 200,000 pounds, of which 150,000 pounds were sold at Albuquerque, the rest being sold in small lots to local purchasers.

The ore used by the mill had been taken from an entry, now caved, on a low ridge that forms the southeastern extension of the deposit. A shallow cut, 4 feet 10 inches long, made on the side of this tunnel, showed seams of good sulphur in cracks, but the material as a whole did not run so well and seemed poorer toward the bottom. The crushed and quartered sample representing the entire

cut contained 31.85 per cent of free sulphur and 2.09 per cent of sulphur combined as sulphates.

All the sulphur at Sulphur Springs was apparently deposited in vents, cracks, and pores within a few feet or a few inches of the surface. The available sulphur in this area is apparently not large in quantity and is irregularly distributed.

About 2 miles above Sulphur Springs and at several places in Jemez Canyon between Sulphur Springs and the San Diego deposit, hot springs or leached rocks indicate similarly active waters and vapors on a smaller scale. Hot sulphureted water occurs at Jemez Springs. These phenomena occur in a zone more than 15 miles in length along the general line of Jemez Canyon, and suggest the occurrence of a deep fracture or group of fractures in the earth's crust along which acidulated waters and sulphurous vapors have risen here and there and deposited sulphur. No evidence was obtained that the deposits are connected with one another.

Conclusions.—The examination led to the following conclusions: (1) The deposits are local and were formed independently along one or more deep fractures in the earth's crust; (2) the San Diego deposit covers about 1 acre, and the Sulphur Springs deposit covers 9 acres, though it includes numerous barren areas; (3) the sulphur ore is irregularly distributed and is relatively thin, being only 2 feet 4 inches thick at four measured cuts; (4) the quantity of available sulphur is too small to be of commercial importance, especially in view of the inaccessibility of the deposits.

ALASKA.

Deposits of sulphur have long been known in the vicinity of several of the volcanoes of the Aleutian Islands and the Alaska Peninsula. Several of these deposits were noted in the chapter on sulphur in *Mineral Resources for 1916*. During the summer of 1917 the deposits on Unalaska and Akun islands and near Stepovak Bay, Alaska Peninsula, were visited by A. G. Maddren, of the United States Geological Survey. A complete report¹ of his observations has been prepared, but the following summary is quoted from a preliminary announcement of the investigation and its results.²

The examination showed that although there is some sulphur at each place examined there is little probability that any of the deposits can be profitably mined at present or in the immediate future, for they are not of large area, most of them are probably shallow and contain only disseminated sulphur, supplies and labor are not obtainable near the deposits, the open season is short, the work of transporting the sulphur from the mines to the ships would be difficult, and the haul to the larger markets would be long. However, these deposits form part of America's sulphur reserves, and similar deposits undoubtedly occur at many other places in the volcanic belt of southwestern Alaska. When material and labor are more easily and cheaply obtainable, when transportation is cheaper, and when the demand for sulphur on the Pacific coast is larger, the sulphur deposits in Alaska can doubtless be mined profitably. The area within which workable deposits of sulphur may be found in Alaska is large and most of it is unexplored, so the place at which sulphur can be first and most profitably mined is not certainly known.

Sulphur claims have been staked on deposits in the crater of Makushin Volcano, on Unalaska Island; on Akun Island; and near Stepovak Bay. No sul-

¹ Maddren, A. G., Sulphur deposits and beach placers of southwestern Alaska: U. S. Geol. Survey Bull. 692—E, 1919.

² U. S. Geol. Survey (unsigned), Sulphur deposits of Alaska: U. S. Geol. Survey Press Bull. 372, July, 1918.

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