SALINES.

SURVEY PUBLICATIONS ON SALINES, INCLUDING SALT, BORAX, AND SODA.

The more important publications of the United States Geological Survey on the natural lime, sodium, and potassium salts included in this group are those listed below.

These publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ARNOLD, RALPH, and JOHNSON, H. R. Sodium sulphate in Soda Lake, Carriso Plain, San Luis Obispo County, Cal. In Bulletin 380, pp. 369–371. 1909.

BREGER, C. L. The salt resources of the Idaho-Wyoming border, with notes on the geology. In Bulletin 430, pp. 555–569. 1910.

CAMPBELL, M. R. Reconnaissance of the borax deposits of Death Valley and Mohave Desert. Bulletin 200. 23 pp. 1902. 5c.

——— Borax deposits of eastern California. In Bulletin 213, pp. 401–405. 1903. 25c.

CHATARD, T. M. Salt-making processes in the United States. In Seventh Ann. Rept., pp. 491–535. 1888.

DARTON, N. H. Zuñi salt deposits, New Mexico. In Bulletin 260, pp. 565–566. 1905. 40c.

ECKEL, E. C. Salt and gypsum deposits of southwestern Virginia. In Bulletin 213, pp. 406–416. 1903. 25c.

——— Salt industry of Utah and California. In Bulletin 225, pp. 488–495. 1904. 35c.

KINDLE, E. M. Salt resources of the Watkins Glen district, New York. In Bulletin 260, pp. 567–572. 1905. 40c.

PACKARD, R. L. Natural sodium salts. In Mineral Resources U. S. for 1893, pp. 728–738. 1894. 50c.

PHALEN, W. C. Salt and bromine. In Mineral Resources U. S. for 1909, pt. 2, pp. 661–684. 1911.

——— Potash salts, their uses and occurrence in the United States. In Mineral Resources U. S. for 1910.

RICHARDSON, G. B. *Salt, gypsum, and petroleum in trans-Pecos Texas.* In Bulletin 260, pp. 573–585. 1905. 40c.

SCHULTZ, A. R. Deposits of sodium salts in Wyoming. In Bulletin 430, pp. 570–588. 1910.

YALE, C. G. Borax. In Mineral Resources U. S. for 1909, pt. 2, pp. 631–632. 1911.

SULPHUR AND PYRITE.

SULPHUR DEPOSITS NEAR SODA SPRINGS, IDAHO.

By R. W. RICHARDS and J. H. BRIDGES.

LOCATION.

Five miles east of the town of Soda Springs, in T. 9 S., R. 43 E., in Bannock County, Idaho, on the Oregon Short Line, is a group of sulphur springs and associated deposits of native sulphur. An attempt was made to work these deposits in the late nineties and a considerable amount of sulphur was produced in 1901 and 1902, but the attempt was finally abandoned and the plant was being dismantled during the fall of 1910. The character of the deposits is of sufficient interest, however, to warrant a brief description.

TOPOGRAPHY.

The springs are situated at the mouth of Sulphur Canyon, a short gulch formed by the junction of North, Middle, and South Sulphur canyons. The surrounding hills stand from 1,500 to 2,500 feet above the rather broad canyon bottom and the area as a whole is situated on the western flank of the Aspen Range.

GEOLOGY.

The geology of the area (see fig. 58) involves old sedimentary rocks of several formations and a minor amount of igneous rock, all of which owe their present relations to one another mainly to faulting. The springs themselves are located along a northwest-southeast fault zone with rocks of early Carboniferous age to the east and Triassic rocks to the west. The Carboniferous sediments of the area range from the Madison limestone (Mississippian) to the Park City formation (Pennsylvanian), and include an unnamed upper Mississippian interval and strata of Pennsylvanian age which are believed to represent the Morgan formation[1] of northeastern Utah and the Weber

[1] Blackwelder, Eliot, Bull. Geol. Soc. America, vol. 21, 1910, p. 529.

quartzite. The Triassic(?) is represented by the Woodside shale[1] alone, the overlying formations to the south and east (Thaynes limestone and Ankareh shale) not being recognized. The igneous rocks consist of pre-Cretaceous white volcanic tuff (ash) intimately associated with the sulphur deposits and basaltic flows of probably early Quaternary age. Tertiary lake beds, travertine, hill wash, and alluvium abound and obscure the relations of the older formations. The faults associated with the sulphur deposits are normal and are presumed to extend to considerable depths and to afford passages for the sulphur-bearing gases or solutions. The waters supplying the

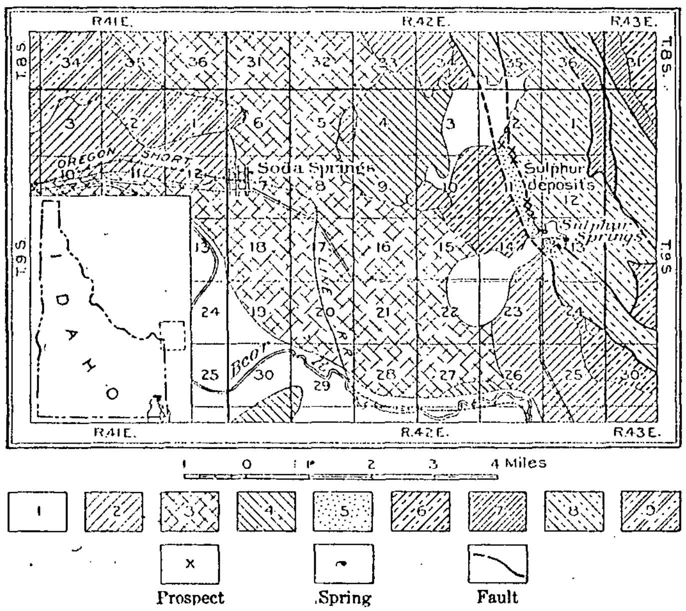

FIGURE 58.—Geologic map of the sulphur-bearing area near Soda Springs, Idaho. 1, Alluvium; 2, travertine; 3, basalt; 4, lake beds; 5, agglomerate (Cretaceous?), made up of tuff, Carboniferous limestone and quartzite, and Triassic limestone; 6, Woodside shale (Triassic?); 7, Park City formation (Pennsylvanian); 8, Weber quartzite to Madison limestone (Pennsylvanian-Mississippian); 9, undifferentiated Mississippian to Cambrian rocks.

springs are doubtless derived from the catchment areas of the Aspen Range. The nearest hot spring is Steamboat Spring, on Bear River, about 2 miles west of Soda Springs, and the nearest center of recent volcanic activity is the group of craters about 9 miles northwest of the sulphur deposits.

DESCRIPTION OF THE SPRINGS.

The springs vary in size from holes comparable to a wash basin to some that are large enough for a good-sized swimming pool. The milky or cloudy color of the water, which is cold, is due to the presence of free sulphur. The cloudiness is more intense in some of the springs than in others, and there is a noticeable variation in the amount of gas exhausted and the rate of its expulsion in bubbles through the water. These variations are not constant for any particular set of springs, but shift about from one group to another, owing to some undetermined cause. The springs are very numerous and no attempt was made to determine the actual number. Many small ones are concealed in the marsh. The following paragraphs give a description of some of the most characteristic springs examined.

[1] Boutwell, J. M., Jour. Geology, vol. 15, No. 5, 1907, pp. 446-447.

On the south side of Sulphur Canyon, in the SE. ¼ NW. ¼ sec. 13, are two groups of springs. The largest spring of the western group has a surface area which at the time examined was estimated at about 500 square feet. The water is very milky and a large amount of gas, carbon dioxide and hydrogen sulphide, is discharged both through the water of the spring as bubbles and through the gravel and holes higher on the hillside to a distance of some 150 feet from the spring.

The eastern group is between 300 and 400 feet northeast from this one and consists of smaller springs, in which, however, the gas is discharged with greater force, as is indicated by the greater height to which the water is lifted by the bubbles. The same gases, carbon dioxide and hydrogen sulphide, are exhausted by these springs and also through crevices and holes in the ground over an area possibly half an acre in extent. At this point the cementation of the gravel by the deposition of sulphur in the interstices can be seen in process.

The marsh group, in the SW. ¼ NW. ¼ sec. 13, includes a great number of springs, which occupy a zone of 150 feet or more in width between Sulphur Canyon and the group on the north side. A sample of water taken from one of these springs gave a strong acid reaction with litmus and had the bitter, repulsive taste which is characteristic of the water in all the springs.

The largest of the springs on the north side of Sulphur Canyon, in the NW. ¼ NW. ¼ sec. 13, has an estimated surface area of about 2,000 square feet and is probably the remnant of the lake mentioned by Peale.[1] The water is extremely cloudy and the deposition of sulphur in the small ditch which takes the overflow can be seen at the present time. E. W. Largilliere, of Soda Springs, reports that the best quality of sulphur obtained in this vicinity was taken out of this spring.

SULPHUR DEPOSITS.

Sulphur deposits have been mined on the north side of Sulphur Canyon in the SE. ¼ SW. ¼ and the SW. ¼ SE. ¼ sec. 2 and the NE. ¼ NW ¼ and the NW. ¼ NE. ¼ sec. 11, and on the south side of Wood Canyon in the SE. ¼ SE. ¼ sec. 11 and the NE. ¼ NE. ¼ sec. 14. A small amount of prospecting has been done in sec. 13, but apparently no

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., [illegible]

sulphur has been mined. The greater part of the excavation in both groups of workings has been done 50 to 200 feet above the level of the present springs. Both quarrying and tunneling were employed in developing the deposits. About 2,000 cubic yards had been excavated in the open work. The condition of the tunnels was such that an examination of them was impossible, so that no idea was gained of the extent of the underground workings, which are reported, however, to comprise several hundred feet. The plant for the separation of the sulphur from the gangue was located on the Wood Canyon side of the divide.

The sulphur, associated with small crystals of gypsum, occurs as the cement of a fault agglomerate or breccia composed of fragments of tuff, limestone, and quartzite. The tuff is composed of angular fragments of volcanic glass and makes up the most conspicuous part of the agglomerate. It is snow white and apparently does not weather to a nourishing soil, and the barren character of its outcrop was noted by the early explorers. It is wholly probable that the gases exhausted by the rock crevices in the immediate vicinity have also the effect of stunting, retarding, or even destroying plant and animal life. Dead rabbits and birds bore ample evidence to this fact. The principal indication of the age of the tuff is gained from the age of the faulting, which is of course inferred from a broader view of the region than can be had in this particular area. The age of these particular faults is not evident more definitely than that they are post-Triassic, but by comparison with other parallel faults, of which the Cokeville fault[1] can be taken as a type, they may be and probably are late Cretaceous. The fact that the tuff forms a prominent part of the fault agglomerate is taken to indicate that it is pre-Cretaceous in age and not to be correlated in any way with the late basaltic flows of the vicinity.

The sulphur is found in small pyramidal crystals lining cavities and in crystalline and amorphous masses in the interstices of the breccia. The crystallinity is shown by the spherical radiating figure formed upon some surfaces obtained by breaking, and the smooth to conchoidal fracture on other surfaces serves to indicate the amorphous variety. A rather spectacular form of occurrence in stalactites in vertical crevices in the breccia was noted in the south wall of the quarry on the Wood Canyon side of the divide. This variety has almost a canary-yellow color on fresh fracture, but on exposure changes rapidly to a dull submetallic gray. The gray color of much of the lower grade ore is apparently due to a thin coating of similar material. The air bubbles which are included in the stalactitic sulphur may indicate that the sulphur was exuded in a fluid state rather than deposited from solution. An unsatisfactory attempt was made to

estimate the percentage of sulphur contained in the ore and the conclusion reached—that the run of the quarry face would average 10 per cent native sulphur—must be accepted with caution, for it depends entirely on observation and inference.

Alum is reported by Mr. James Call, of Soda Springs, as present in the ore, but none was found by the writers.

METHOD OF SMELTING THE ORE.

The ore from these deposits was smelted by the Western Sulphur Co., of Duluth, Minn., in a plant located near the deposits, but the company failed, although the equipment appears to have been well selected and well installed. It consisted of two coal-burning boiler units, a battery of five or six cylindrical retorts, and a crushing plant. The system of smelting consisted of introducing the hand-sorted ore in perforated iron cars of about half a ton capacity into a retort which would hold one car at a time, melting the sulphur from the gangue by the introduction of steam into the retort, and drawing off the sulphur into suitable molds. The sulphur cake was then put through a crusher and grinder and reduced to a fine powder and bagged. The condition of the gangue in the dump indicated that the recovery, though not perfect, was up to the standard usually set for the method used.

ORIGIN OF THE SULPHUR.

According to Clarke,[1] the deposition of the sulphur is due apparently to the imperfect oxidation of the hydrogen sulphide, which may be generated either by the action of acid waters on sulphides or through the reduction of sulphates, such as gypsum, by micro-organisms, or the gas may be of volcanic origin, as it is regarded in the view generally adopted for the origin of the deposits near Girgenti, in Sicily. Large deposits of gypsum are unknown in the geologic section of southeastern Idaho, and the small amount of that mineral associated with the sulphur appears rather to have had a common origin than to have served as a source. The proximity of these deposits to volcanic centers suggests that the volcanic origin for the hydrogen sulphide and the associated carbon dioxide is plausible.

OUTLOOK.

The failure of an apparently well-backed attempt to develop these deposits will render improbable any further attempts in the immediate future. It is extremely doubtful if the deposits can be profitably worked by a process giving a complete recovery of the values, even to supply the local demand, in competition with the relatively high-grade deposits of Wyoming and Utah.

[1] Clarke, F. W., Bull. U. S. Geol. Survey No. 330, 1908, pp. 465–466.

SURVEY PUBLICATIONS ON SULPHUR AND PYRITE.

The list below includes the important publications of the United States Geological Survey on sulphur and pyrite.

These publications, except those to which a price is affixed, may be obtained free by applying to the Director, U. S. Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ADAMS, G. I. The Rabbit Hole sulphur mines, near Humboldt House, Nev. In Bulletin 225, pp. 497–500. 1904. 35c.

DAVIS, H. J. Pyrites. In Mineral Resources U. S. for 1885, pp. 501–517. 1886. 40c.

ECKEL, E. C. Gold and pyrite deposits of the Dahlonega district, Georgia. In Bulletin 213, pp. 57–63. 1903. 25c.

——— Pyrite deposits of the eastern Adirondacks, New York. In Bulletin 260, pp. 587–588. 1905. 40c.

LEE, W. T. The Cove Creek sulphur beds, Utah. In Bulletin 315, pp. 485–489, 1907.

PHALEN, W. C. Sulphur and pyrite. In Mineral Resources U. S. for 1909, pt. 2, pp. 685–696. 1911.

RANSOME, F. L. Geology and ore deposits of Goldfield, Nev. Professional Paper 66, pp. 258. 1909. [Sulphur, pp. 109–110; pyrite, pp. 113–114.]

RICHARDSON, G. B. Native sulphur in El Paso County, Tex. In Bulletin 260, pp. 589–592. 1905. 40c.

SPURR, J. E. Alum deposit near Silver Peak, Esmeralda County, Nev. In Bulletin 225, pp. 501–502. 1904. 35c.

WOODRUFF, E. G. Sulphur deposits at Cody, Wyo. In Bulletin 340, pp. 451–456. 1908.

——— Sulphur deposits near Thermopolis, Wyo. In Bulletin 380, pp. 373–380. 1909.

MISCELLANEOUS NONMETALLIC PRODUCTS.

THE TYPES, MODES OF OCCURRENCE, AND IMPORTANT DEPOSITS OF ASBESTOS IN THE UNITED STATES.

By J. S. DILLER.

INTRODUCTION.

The United States has for many years led all other countries in the manufacture of asbestos goods, but in the mining of asbestos it has not until recently attained any importance, and even now it produces only about one-twentieth as much as Canada. The production of Canada forms so large a part of the world's total annual output, however, that even 5 per cent of it is well worthy of mention.

Asbestos is reported to have been mined in the United States as early as 1880. It was of the amphibole variety and the mining of this variety has continued with variable annual production ever since, but it was not until 1908, when the production of chrysotile began, that a more important phase of the industry was initiated. The annual production has been increased to over 3,000 tons and the outlook for the future is promising.

At present there are in the United States six asbestos localities of more or less interest either to the asbestos industry or to science. They are in the vicinity of Lowell, Vt.; Casper, Wyo.; Grand Canyon, Ariz.; Sall Mountain, Ga.; Kamiah, Idaho; and Bedford, Va. At the localities in Vermont, Wyoming, and Arizona the asbestos is chrysotile, and at those in Georgia, Idaho, and Virginia it is amphibole.[1] Practically all of the asbestos produced in the United States in 1909 came from Vermont and Georgia.

All these localities have been visited by the writer for the special purpose of noting production, but the stay of only a few hours or days at each locality gave no opportunity for detailed study. However, the great interest in asbestos is a sufficient justification for the

[1] The term "amphibole" is used here in its broad sense to include anthophyllite.