SULPHUR AND PYRITE.

SULPHUR DEPOSITS IN PARK COUNTY, WYOMING.

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Location and surroundings.—The group of sulphur deposits here described has been known locally for a number of years, but as efforts have recently been made to determine their extent, a brief examination of them was made by the writer in connection with routine field work in the region during the summer of 1912. The deposits are 12 miles south of those in Sunlight Basin, which were examined by the writer in 1911.[1] They lie at an elevation of 6,700 feet along Sweetwater Creek, about 2 miles north of its junction with the North Fork of Shoshone River, near which is situated the summer settlement of Wapiti, about 32 miles west of Cody on the road to the Yellowstone Park.

From its source near Sylvan Pass to a point about 25 miles west of Cody the North Fork of Shoshone River flows eastward, for the most part in a deep, narrow valley which only for short stretches widens into grassy or timber-covered parks. Sweetwater Creek, one of the numerous tributaries which descend from the snow fields of the main ridges of the Absaroka Range, rises among a group of prominent peaks forming a ridge that separates the waters of Sunlight Creek on the north from those of Shoshone River on the south. The valley of Sweetwater Creek is narrow and the bordering slopes are steep and rugged. In common with most of the streams of similar relations in the region, the creek only locally flows on bedrock, the greater part of its erosional work being the removal of the large quantities of débris which are liberated by frost on the neighboring slopes and are delivered as alluvial fans from tributary gulches.

The sulphur deposits are confined to a narrow strip adjoining Sweetwater Creek on the east, and the area within which sulphur has been found does not exceed 20 acres.

Geology.—The superficial rocks in the vicinity of the sulphur deposits are wholly igneous and constitute the lower portion of a great thickness of lava flows and breccias from which the Absaroka Mountains have been carved. The geology of the region has been studied and described by Hague,[2] who states that these rocks have a maximum thickness of 11,000 feet and rest upon the eroded surface

[1] Hewett, D. F., Sulphur deposits of Sunlight Basin, Wyoming: Bull. U. S. Geol. Survey No. 530, 1913, pp. 350–362.

[2] Hague, Arnold, Absaroka folio (No. 52), Geol. Atlas U. S., U. S. Geol. Survey, 1899.

of folded sedimentary rocks which range in age from Cambrian to Tertiary. In Sunlight Basin, 14 miles north, the igneous rocks lie upon Madison (Carboniferous) limestone, and on the North Fork of Shoshone River, 2 miles south, they lie upon Tertiary sandstones and shales, probably of Wasatch age. The total thickness of these sedimentary rocks on Shoshone River near Cody is 18,000 feet.

The igneous rocks along Sweetwater Creek are consolidated breccias of augite andesite porphyry. They show local variations in composition, but the most common rock type is reddish brown and contains easily visible crystals of plagioclase and augite. It is essentially similar to the red variety of andesite which was observed near the deposits in Sunlight Basin.

The sulphur deposits.[1]—The sulphur deposits are confined to a narrow belt about 1,400 feet long adjoining the east bank of Sweetwater Creek. The largest deposits occur in the strip of débris formed by the merging of alluvial fans from two dry gulches with talus material which has been washed from near-by slopes. Several smaller deposits lie along the slope of the ridge to the east of the stream.

The largest deposit, which is the southernmost, is exposed in the bank of the stream where it cuts the widest portion of an alluvial fan. No sulphur was visible on the surface here before pits were sunk, but it has since been shown to exist sporadically over an area of about 2 acres. The débris consists of angular fragments of rock which range in size from fine sand to pieces 2 inches in diameter, and, though derived from dark igneous rocks, it is practically white over an area of about 6 acres. The sulphur occurs as bands of crystalline aggregates which fill the interstices between the fragments. A pit sunk on the middle of the fan shows the following section:

	Feet.
Soil and débris free from sulphur	2
Fine débris containing traces of sulphur	1
Débris containing 5 to 10 per cent of sulphur	2
Débris containing traces of sulphur	2
Débris containing 30 to 50 per cent of sulphur	1
Bedrock not penetrated.	

Three other trenches have been dug within this deposit, of which the northernmost shows the following section:

	Feet.
Soil and brown to white débris; no sulphur	2
White débris containing 5 to 10 per cent of sulphur	2
White débris containing 15 to 30 per cent of sulphur	3
White débris containing 5 to 10 per cent of sulphur	1
Dark-green débris free from sulphur but containing a velvety efflorescence of alkali alum, crusts of melanterite (and possibly a ferric sulphate), and thin films of a yellow metallic mineral, probably marcasite	3
Bedrock not exposed.	

[1] The term "deposit" will be applied in this description to those isolated portions of the area within which the rocks are bleached and decomposed and contain appreciable amounts of sulphur, as compared with the remainder of the area in which the rocks are essentially fresh and wholly free from sulphur. The term has no economic significance.

The features shown in this trench are closely similar to those observed in deposits near the level of ground water in Sunlight Basin and, aside from their bearing on the association of the sulphur, are interesting as showing the probable origin of the marcasite. The ferrous and ferric sulphates are formed by the combination of the iron oxides of the igneous rock with sulphuric acid produced by the complete oxidation of the hydrogen sulphide in the gases. It is well known from laboratory experience that at ordinary temperatures and pressures hydrogen sulphide does not precipitate a sulphide of iron from an acid solution of ferrous sulphate, but as the marcasite is undoubtedly deposited by reaction of these substances, it must be that the solutions of ferrous sulphate are neutral, owing to their seepage downward through the igneous rocks. The transition from a zone of white rock fragments to one of green fragments indicates that the white rock has been leached of iron salts, which are slightly concentrated in the ferrous state near the level of ground water.

A comparison of the sections of the trenches shows that the sulphur-bearing material occurs as one or more lenticular beds essentially parallel to the present surface of the débris but practically covered with débris free from sulphur. The odor of hydrogen sulphide is strong in the trenches, but no accumulation of heavy gases, such as carbonic acid, was noticeable.

In a deposit about 1,200 feet north of that just described sulphur occurs in two distinct associations. It cements the débris of a small alluvial fan near the stream and forms a crust coating the walls of small crevices in bedrock, a spur of which projects from a ridge to the east and adjoins the fan on the north. There are two open crevices within 80 feet along the creek, and the rock, though bleached over the greater portion of the surface, contains sulphur near the crevices only. The greater portion of the sulphur occurs as a cement of angular fragments of rock, which are liberated by weathering from the adjacent slopes. Gases containing hydrogen sulphide and carbonic acid issue freely from the crevices. Sulphur is also found on the surface of the alluvial fan over an area about 100 feet square. There has been no prospecting at this locality.

In addition to these deposits the rock on the surface of the ridge east of Sweetwater Creek up to an elevation of 6,800 feet is locally bleached and decomposed, and in the vicinity of the areas of most intense bleaching sulphur occurs as thin crusts partly enveloping fragments of the breccias or as numerous minute crystals studding the surfaces. Four such deposits were noted, none of which covered an area greater than 50 feet square.

Siliceous sinter and travertine, such as in many places accompany sulphur deposited by hot springs, are conspicuously absent.

Oil spring.—An interesting feature of the sulphur deposits is the proximity of a petroleum spring, which lies on the west bank of Sweet-

water Creek, within 100 yards of the largest sulphur deposit. It is reported that during the summer of 1911 sufficient oil was collected to supply the lamps at a temporary camp. At the time of the writer's visit in 1912 the original site of the spring was covered with water, but in a hole that was dug to a depth of 3 feet within 2 feet of the water's edge enough oil was collected to demonstrate its presence. The oil that was previously collected is reported to have been light and clear. The sand at this point is dark brown and has an asphaltic odor, but otherwise is such as would form bars along a swiftly flowing mountain stream.

Genesis.—These sulphur deposits, though much smaller, are essentially similar to those which occur in the upper portion of Sunlight Basin. They appear to have been formed by the decomposition of hydrogen sulphide contained in gases that issue from crevices in the igneous rocks. There is good reason for believing that the gases are similar in composition to those which were collected in Sunlight Basin and which on analysis were shown to contain carbonic acid, nitrogen, and methane, as well as hydrogen sulphide.

The sulphur-bearing débris, being highly porous, offers far better conditions for the aeration and oxidation of hydrogen sulphide than the massive rocks, which are thought to contain very little, if any, sulphur beyond that in the open crevices.

The thickness of débris above water level is probably in places as much as 25 feet, and a good portion of this may locally be sulphur-bearing, but it is extremely doubtful whether any sulphur will be found below the water, which effectually prevents oxidation of the gases and deposition of sulphur.

Though it would at first seem necessary that any explanation of the origin of the sulphur should explain that of the petroleum also, this is not necessarily the case. It seems highly probable that the sulphurous gases have ultimately a deep-seated or igneous origin, the gases rising to the surface along fractures. These fractures would necessarily intersect the sedimentary rocks which underlie the lavas and breccias and which are known to contain oil and gas locally along Shoshone River, 30 miles east.

Economic importance.—The sulphur deposits are small, and under the conditions existing at present in the American sulphur industry there is little chance that they can be exploited with profit. The fact that sulphur has been found in the débris where none was exposed on the surface makes it at least possible that the alluvium contains considerably more than is at present known. Even should this prove to be true, it is still doubtful whether the deposits can be utilized unless the local demand becomes great.

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, United States 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.: Bull. 225, 1904, pp. 497–500. 35c.

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

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

——— Pyrite deposits of the eastern Adirondacks, New York: Bull. 260, 1905, pp. 587–588. Exhausted.

HESS, F. L., A sulphur deposit in the San Rafael Canyon, Utah: Bull. 530, 1913, pp. 347–349.

HEWETT, D. F., Sulphur deposits of Sunlight Basin, Wyoming: Bull. 530, 1913, pp. 350–362.

LARSEN, E. S., and HUNTER, J. F., Two sulphur deposits in Mineral County, Colorado: Bull. 530, 1913, pp. 363–369.

LEE, W. T., The Cove Creek sulphur beds, Utah: Bull. 315, 1907, pp. 485–489. 50c.

PHALEN, W. C., Sulphur, pyrite, and sulphuric acid in 1912: Mineral Resources U. S. for 1912, 1913.

RANSOME, F. L., Geology and ore deposits of Goldfield, Nev.: Prof. Paper 66, 1909, 258 pp. $1.50. [Sulphur, pp. 109–110; pyrite, pp. 113–114.]

RICHARDS, R. W., and BRIDGES, J. H., Sulphur deposits near Soda Springs, Idaho: Bull. 470, 1911, pp. 499–504.

RICHARDSON, G. B., Native sulphur in El Paso County, Tex.: Bull. 260, 1905, pp. 589–592. Exhausted.

SPURR, J. E., Alum deposits near Silver Peak, Esmeralda County, Nev.: Bull. 225, 1904, pp. 501–502. 35c.

WOODRUFF, E. G., Sulphur deposits at Cody, Wyo.: Bull. 340, 1908, pp. 451–456. 30c.

——— Sulphur deposits near Thermopolis, Wyo.: Bull. 380, 1909, pp. 373–380. 40c.