THE
AMERICAN
JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEORGE L. GOODALE, JOHN TROWBRIDGE,
W. G. FARLOW AND WM. M. DAVIS, OF CAMBRIDGE,

PROFESSORS ADDISON E. VERRILL, HORACE L. WELLS,
L. V. PIRSSON AND H. E. GREGORY, OF NEW HAVEN,

PROFESSOR HENRY S. WILLIAMS, OF ITHACA,
PROFESSOR JOSEPH S. AMES, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES

VOL. XXXII—[WHOLE NUMBER, CLXXXII.]

NEW HAVEN, CONNECTICUT.

1911.

ART. XLIV.—*Some Minerals from Beaver County, Utah;*[*]

by B. S. BUTLER and W. T. SCHALLER.

Introduction.

WHILE making an examination of some of the mines in Beaver County, Utah, in the summers of 1909 and 1910, one of the writers, B. S. Butler, collected several minerals that on examination proved to be of unusual interest. One of these is a species not hitherto known, a second has never before been reported from this continent, and a third, although previously reported from but two localities, was found to be relatively abundant in this district.

Beaverite, a New Mineral.

From the Horn Silver mine near the town of Frisco was collected a mineral that on examination in the laboratories of the United States Geological Survey proved to be a new species. For this mineral, which is a hydrous sulphate of copper, lead and ferric iron, the name *beaverite* is proposed, after the name of the county from which it was first described.

Occurrence.—The mineralization in the Horn Silver mine occurs along a fault plane that has thrown Tertiary lavas down against Cambro-Ordovician limestone, the ore deposits being mainly a replacement of the volcanic rocks.

The principal primary minerals of the deposit are: Galena, sphalerite, wurtzite, pyrite, chalcopyrite, a sulph-antimonite of lead possibly jamesonite, pyrargyrite, argentite, quartz, barite, muscovite, and small amounts of other minerals.

The mine has been developed to a depth of 1600 feet. For about 600 feet the primary minerals have been almost entirely altered by descending solutions, and this alteration has taken place in a lesser degree to a much greater depth. The characteristic alteration in the deposit is to sulphates with some carbonates, chlorides and sulphides.

The following secondary minerals have been recognized: Anglesite, cerussite, plumbojarosite, jarosite, beaverite, linarite, bindheimite?, smithsonite, calamine, goslarite, covellite, chalcocite, brochantite, malachite, azurite, chrysocolla, chalcanthite, cerargyrite, sulphur, chalcedony, kaolinite, gypsum, alunite, and hydrous oxides of iron and manganese.

The beaverite occurs with other secondary minerals in the upper part of the deposit. Only a small portion of the upper levels was accessible at the time of the visit and the mineral

---

[*] Published by permission of the Director of the U. S. Geological Survey.

was not seen in place, but the frequency with which it was met in the old dump leads to the belief that it must have been a rather common mineral in some parts of the deposit.

Physical Properties.—The mineral is a canary-yellow earthy looking material commonly mixed with other secondary lead and copper minerals, but occasionally in small masses that appear to be composed of a single mineral. Such masses are easily crushed in the fingers. Under the high power of the microscope the material is seen to be crystallized in distinct hexagonal plates. These are too small for accurate measurement of the crystal angles or determination of the optical character. The refractive index of the light ray vibrating perpendicular to the plates is considerably higher than that of solutions available in the laboratory for the immersion method of determining indices, namely 1·74.

Almost every crystal contains a minute inclusion whose character has not been determined. The material analyzed appeared under the microscope to be very pure except for these inclusions, and it is possible that the silica that appears in the analysis is due to them.

Chemical Composition.—The mineral is soluble in boiling hydrochloric acid, leaving the insoluble matter, chiefly silica, behind. On cooling, lead chloride separates out in considerable amount. The lead reaction can also readily be obtained with sodium carbonate on charcoal. On adding ammonia in excess to the hydrochloric acid solution, the ferric iron is thrown down as a voluminous brown precipitate, and the solution has the deep blue color indicative of copper. By the quantitative determination, the presence of a small amount of alumina was established. The insoluble matter consists mostly of silica, only a slight residue remaining after treatment with hydrofluoric acid.

The average of the results of the chemical analyses is shown in the table below. The ratios obtained therefrom are also given.

Analysis and ratios of beaverite (*W. T. S.*).

Insol.	10·05			
CuO	9·70	·121		·92 or 1
PbO	29·44	·132		1·00 " 1
Fe_2O_3	17·28	·108	·144	1·07 " 1
Al_2O_3	3·64	·036		
SO_3	21·32	·266		2·01 " 2
H_2O	9·02	·501		3·80 " 4 (=4×·95).
	100·45			

The ratios agree well with the formula $CuO.PbO.Fe_2O_3.2SO_3.4H_2O$, in which the copper and lead are assumed to be present in equal molecular amounts, and in which a little ferric iron is replaced by alumina. As the ratio of Fe_2O_3 to Al_2O_3 is as 3:1, the formula can be written more exactly as $4CuO.4PbO.3Fe_2O_3.Al_2O_3.8SO_3.16H_2O$. A comparison of the analysis with the insoluble matter deducted and reduced to 100 per cent, with the values calculated for the formula last given, is shown below.

Comparison of analysis with calculated values.

	Analysis	Calculated
CuO	10·74	11·70
PbO	32·50	32·80
Fe_2O_3	19·13	17·61
Al_2O_3	4·03	3·75
SO_3	23·60	23·54
H_2O	10·00	10·60
	100·00	100·00

The water is all constitutional, as none was driven off below 250°. The actual results obtained are as follows:

Loss of weight of beaverite on heating.

Tempt.	Total loss
110°	0·04%
170°	0·10
250°	0·14
390°*	3·72
590°*	10·45

* Heated in an electric furnace.

The loss at 590°, as given, is higher than the true value, as a little of the material was lost by the thermal couple accidentally reaching into the crucible when some of the powder adhered to the wires.

No known mineral could be found with which beaverite seems related, so that at present it must stand as an isolated member of the sulphate group.

Wurtzite.

The hexagonal zinc sulphide, wurtzite, is present in considerable abundance in the primary ores of the Horn Silver mine. The principal primary minerals of this deposit have been noted above. The richer zinc ore in the hand specimen has the general appearance of light honey-yellow sphalerite, but under the microscope a portion is seen to be rather strongly birefringent and some of this has the outline of pyramidal crystals.

A closer examination of the specimen revealed pyramidal crystals that could be separated from the surrounding material. Several of these crystals were removed from the matrix and measured. They showed a steep hexagonal pyramid, which was strongly striated horizontally. Accurate measurements were not possible, as the striations caused the crystals to become rounded with consequent absence of plane faces. The crystals were measured on the two-circle goniometer and ρ angle determined for the pyramid faces. This angle corresponds to that between the basal plane (absent on these crystals) and the pyramidal faces. The values obtained are shown below, the pyramid being the form $o\{20\bar{2}1\}$

FIG. 1.

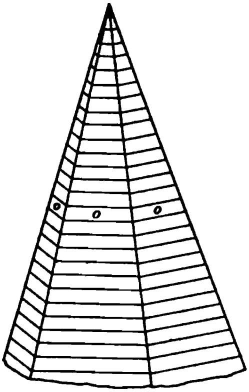

FIG. 1. Wurtzite, $o\{20\bar{2}1\}$.

Measurement of $o\{20\bar{2}1\}$ *wurtzite.*

Crystal No.	1	2	3	4	
Average measurement	61°	62°	60°	61°	Calc. 62° 06′

The general habit of these crystals is shown in figure 1, where the marked horizontal striæ are also shown.

The crystals of wurtzite dissolve readily in HCl, evolving H_2S. The solution contained abundant zinc and no other metal was present in appreciable quantity.

It may be noted that the zinc sulphides in this mine have the property of tribo-luminescence or of giving off light when scratched. This is so marked that sulphides of zinc can be readily detected in the mine by drawing the point of the pick or mine candlestick across the ore. If zinc sulphides are present the point of the metal is followed by a line of sparks.

Plumbojarosite.

Plumbojarosite has previously been described from two localities, first from Cook's Peak, N. M.* and second from American Fork, Utah.†

Since this mineral has been so rarely noted, it was a matter of some surprise to find it in no less than six mines and prospects in Beaver County, in some cases in such abundance that a considerable quantity could be picked from the ore bins and dumps. The writer was told by one superintendent that several tons of the mineral had been thrown on the dump and later on being found to contain metal values had been shipped to the smelter.

Plumbojarosite has been determined from the following mines and propects in Beaver County: Horn Silver, Hub, Moscow, Red Warrior, Harrington-Hickory, and an unnamed prospect pit, and probably is present in still others.

Occurrence.—The mineral is secondary, resulting from the alteration of ore composed mainly of sulphides of iron, lead, copper, and zinc. The secondary minerals for the most part are the oxides, sulphates, carbonates and silicates of these metals, and with these are plumbojarosite, frequently jarosite, and other minerals in varying amounts. It is of interest to note that from the Horn Silver mine three members of the jarosite group were determined, namely, jarosite, plumbojarosite, and alunite.

Physical properties.—As seen in the hand specimen, the material is dark brown in color and distinctly micaceous in appearance with a silky luster. Where the crystals are very fine the micaceous character is less pronounced and the mineral, if not examined with some care, might be mistaken for limonite or some iron-stained material. Although the mineral is frequently in rather large pieces as it comes from the mine, it is readily crushed in the fingers and has an oily look and feel, similar to fine graphite. Under the microscope the crystals are seen to be thin hexagonal plates of a light golden-yellow color. The crystals vary greatly in size but rarely exceed $0{\cdot}25^{mm}$ in width. Measurement of the crystals has not been made but they are undoubtedly hexagonal and so far as their properties have been determined they correspond to the material examined by Wright from the American Fork locality. The

---

* Hillebrand, W. F., and Penfield, S. L., this Journal, vol. xiv, p. 213, 1902.

† Hillebrand, W. F., and Wright, Fred E., this Journal, vol. xxx, p. 191, 1910.

crystals are uniaxial, optically negative with strong birefringence. It may be noted that jarosite from the same mines is so similar to the plumbojarosite in physical properties that a distinction can be made only by chemical tests.

Chemical composition.—The analysis (by W. T. S.) of the plumbojarosite is shown in the table below, where, for comparison, are also given the two analyses, by Hillebrand, of the mineral from New Mexico and American Fork, Utah. The values calculated from the formula $PbO.3Fe_2O_3.4SO_3.6H_2O$ are also given in the last column for comparison.

Analyses of plumbojarosite.

	Beaver Co., Utah	Cook's Peak, N. M.	American Fork, Utah	Calculated
Fe_2O_3	42·11	42·37	42·87	42·38
PbO	18·32	19·84	18·46	19·74
K_2O	0·13	0·17	0·15	----
Na_2O		0·21	0·52	----
SO_3	27·59	27·06	27·67	28·33
H_2O	9·16	9·56	10·14	9·55
CuO	----	0·27	0·10	----
CaO	0·00	0·05	0·06	----
Insol.	2·64	0·51	0·40	----
ZnO	0·30	----	----	----
	100·25	100·15	100·37	100·00
Density	3·60	3·665		

The three analyses show a close agreement among themselves as well as with the calculated values.

Corkite.

A light yellowish-green mineral that has the properties of corkite, a hydrous phosphate and sulphate of lead and iron, was collected from the Harrington-Hickory and the Wild Bull mines. So far as is known to the writers, these are the only localities on this continent from which this mineral has been reported.

In both of the mines mentioned the original ores were a replacement of limestone near the intrusive rock and there was considerable apatite and contact silicates formed with the metallic sulphides, mainly pyrite, galena, sphalerite, and chalcopyrite. The corkite is a secondary mineral resulting from the alteration of these ores, the phosphate doubtless being derived from the apatite and the metallic content from the sulphides.

In physical properties the mineral corresponds with that previously described. In the hand specimen it is a light green earthy looking material which when crushed in the fingers has a gritty feel like fine sand. Under the microscope it is seen to be well crystallized, the larger crystals being 0·15$^{\mathrm{mm}}$ in diameter. The crystals are golden yellow in color and have the general appearance of being a combination of the cube and octahedron. They are rather strongly birefringent, however, and are probably hexagonal rhombohedral. The index of refraction is higher than 1·74.

Corkite is readily soluble in boiling hydrochloric acid from which solution lead chloride separates out in quantity on cooling. The solution contains, besides lead, abundant ferric iron and the sulphate and phosphate radicals. Qualitative tests failed to show the presence of any arsenic, and only a mere trace of copper is present in the American corkite. Heated in a closed tube, the mineral darkens and gives off water.