

# BOULANGERITE, BISMUTOPLAGIONITE, NAUMANNITE AND A SILVER-BEARING VARIETY OF JAMESONITE.

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## NOTES ON THE COMPOSITION AND OCCURRENCE OF BOULANGERITE

### INTRODUCTION.

The mineral boulangerite, a lead sulphantimonite, has long had assigned to it the formula  $3\text{PbS.Sb}_2\text{S}_3$ . This is one of the simplest and most probable of the lead sulphantimonites and compounds showing the same ratio of base to acid are among the most numerous, abundant, and widespread in occurrence of the large class of sulpho-salt minerals.

In 1875 Rammelsberg<sup>1</sup> collected the then available analyses of boulangerite and, in a discussion of the composition of the mineral, showed that the analyses differed somewhat from each other, some approximating the formula  $3\text{PbS.Sb}_2\text{S}_3$ , others yielding ratios closer to  $5\text{PbS.2Sb}_2\text{S}_3$ , and still others approaching the composition expressed by the formula  $10\text{PbS.3Sb}_2\text{S}_3$ . Quite erroneously he states that the majority of the analyses given agree most nearly with the formula  $3\text{PbS.Sb}_2\text{S}_3$ .

In 1899 Sjögren<sup>2</sup> found a mineral at Sala, Sweden, in well-developed crystals similar in form to diaphorite, which he referred to boulangerite. Upon analysis these crystals were found to have the composition expressed by the formula  $5\text{PbS.2Sb}_2\text{S}_3$ . He further showed that many of the earlier analyses of boulangerite agreed most nearly with this formula.

In 1917 the present writer analyzed specimens of a steel-gray fibrous sulphantimonite from Superior, Montana, and Mullan, Idaho, both of which gave the formula  $5\text{PbS.2Sb}_2\text{S}_3$ . In rather inexcusable oversight of Sjögren's work, especially since it had been made read-

<sup>1</sup> Rammelsberg, C. F., *Handbuch der Mineralchemie*, p. 99, 1875.

<sup>2</sup> Sjögren, H. S., *Geol. Föreningens Föreläsningar*, vol. 19, p. 153, 1897.

ily available by Hintze,<sup>1</sup> this compound was described as a distinct species and given the name mullanite.<sup>2</sup> Some imperfect crystals gave angles which seemed unlike those of diaphorite, but they were too poor in quality to serve alone as a basis for considering the material distinct from that of Sjögren. Since mullanite evidently had no reasonable claim to distinction and should be eliminated from the literature, it was planned to immediately publish a retraction. Before doing so, however, several new analyses of boulangerites from various localities were made, and the early literature relating to this species was examined critically. Below is given a summary of the literature and descriptions and analyses of boulangerites from several new localities.

## EARLY DESCRIPTIONS OF BOULANGERITE.

Boulanger<sup>3</sup> in 1835 published an analysis of a "double sulphide of antimony and lead" from Molieres, Department du Gard, France. The material was in crystalline-fibrous bluish-gray metallic masses, having a specific gravity of 5.97. The mineral was associated with pyrite in quartz and was in part altered to antimony and lead oxides and limonite. Boulanger's original analysis is given in the following table, column 1. In column 2 is given the analysis recalculated after deducting impurities, and in column 3 are given the ratios derived from the figures of column 2.

*Analysis and ratios of boulangerite from Molieres, France.*

	1. Original.	2. Recalculated.	3. Ratios.		
Lead.....	49.00	53.90	0.2603	} 29.59	5.57×1.00
Iron.....	1.10	1.20	.0215		
Copper.....	.80	.90	.0141		
Antimony.....	23.20	25.50	.2122	21.22	4.00×1.00
Sulphur.....	16.90	18.50	.5769	57.69	10.90×1.00
Pyrite.....	5.60	.....	.....	.....	.....
Quartz.....	.60	.....	.....	.....	.....
Total.....	97.20	100.00	.....	.....	.....

The ratios thus give  $5.57\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$ , or midway between the two formulas,  $3\text{PbS} \cdot \text{Sb}_2\text{S}_3$  and  $5\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$ . Critical examination of the analysis, however, shows defects which tend to make the ratios unreliable. In the first place, the analysis as given shows a deficiency of 2.8 per cent, a part of which is evidently sulphur. Copper and iron are not commonly constitutional constituents of boulangerite, particularly copper. If we assume these two bases to be extraneous

<sup>1</sup> Hintze, Carl, *Handbuch der Mineralogie*, vol. 1, p. 1040, 1904.

<sup>2</sup> Shannon, E. V., *Amer. Journ. Sci.*, vol. 44, p. 66, 1918.

<sup>3</sup> Boulanger, C., *Annales des Mines*, vol. 7, p. 575, 1835.

and derived perhaps from chalcopyrite associated with the pyrite, the lead and antimony yield ratios as follows:

Pb.....	.2603	26.03	4.91	5×0.98
Sb.....	.2122	21.22	4.00	4×1.00

It thus seems very probable that the material worked upon by Boulanger, and hence the mineral which should correctly bear the name boulangerite, was of the composition expressed by the formula  $5\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$ .

The name boulangerite was first actually applied by Thaulow<sup>1</sup> to a metallic mineral occurring in straight parallel fibrous masses resembling jamesonite, from Nasafjeld, Lapland. In column 1 of the following table are given the original figures of Thaulow's analysis; in column 2 the same analysis with the value for antimony reduced to conform with the value at present used for the atomic weight of that element; in column 3 are given the ratios derived from column 2:

*Analysis and ratios of boulangerite from Nasafjeld, Lapland.*

	1. Original.	2. Recalculated.	3. Ratios.			
Lead .....	55.57	55.57	0.2683	26.83	5.36	5×1.07
Antimony .....	24.60	24.07	0.2003	20.03	4.00	4×1.00
Sulphur.....	18.86	18.86	0.5881	58.81	11.74	11×1.07
Total .....	99.03	98.50	.....	.....	.....	.....

These ratios yield almost exactly the  $5\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$  formula, though showing that the result obtained for antimony is doubtless too low.

Hausmann<sup>2</sup> in 1839 described boulangerite from Nertschinsk, Siberia, having the following properties: Massive, with an indistinctly fibrous structure like some manganites; luster, metallic with a silky appearance; color, blackish lead-gray, streak darker; scratches galena but not sphalerite, hence the hardness around 3. Determinations of the specific gravity gave 5.688, 5.726, and 5.941, the variation being ascribed to impurities. The specific gravity of the pure mineral is stated to be not less than 6. The boulangerite was mixed with arsenopyrite, pyrite, and stibnite being often intimately intergrown with the latter. The specimens were crusted with oxidation products, mainly limonite, and waxy to earthy bindheimite. In the following table the analysis made by Bromeis is given in the original form and with the antimony value corrected, together with the ratios as in the preceding tables.

<sup>1</sup> Annalen Physik Chemie (Poggendorff's), vol. 41, p. 216, 1837.

<sup>2</sup> Hausmann, J. F. L., Ann. Phys. Chem. (Poggendorff's), vol. 46, p. 281, 1839.

*Analysis and ratios of boulangerite from Nertschinsk, Siberia.*

	1. Original.	2. Recalculated.	3. Ratios.		
Lead.....	56.29	56.29	0.2718	27.18	5×1.12
Antimony.....	25.04	23.29	0.1938	19.38	4×1.00
Sulphur.....	18.22	18.22	0.5681	56.81	11×1.07
Total.....	99.55	97.80	.....	.....	.....

These ratios show that, assuming the deficiency shown by the analysis to be in part due to antimony lost, the mineral like those preceding had the composition expressed by the formula  $5\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$ .

The foregoing three original descriptions offer strong evidence in support of the conclusion advanced by Sjögren—namely, that the true formula for boulangerite is  $5\text{PbS} \cdot 2\text{Sb}_2\text{S}_3$ . Later analyses of this mineral from a large number of localities agree almost exactly with this formula. It is not improbable that the compounds  $3\text{PbS} \cdot \text{Sb}_2\text{S}_3$  and  $10\text{PbS} \cdot 3\text{Sb}_2\text{S}_3$  also occur as natural mineral species, but in the absence of distinctive physical and crystallographic data they have been confused with boulangerite, owing to the close similarity in chemical composition existing between the three compounds. The formula  $10\text{PbS} \cdot 3\text{Sb}_2\text{S}_3$  has been assigned by Frenzel<sup>1</sup> to the substances plumbostib and embrithite, but the analyses are far from satisfactory. An arsenic analogue of this compound has been found in the mineral guitermanite. Specimens of boulangerite from Prizibram, Bohemia, analyzed by Boricky and Helmhacker,<sup>2</sup> in part agree fairly well with the formula  $3\text{PbS} \cdot \text{Sb}_2\text{S}_3$ , as shown in the following table. An equal number of the same series of analyses, however, yields more nearly the 5:2 formula.

*Analyses of boulangerite from Prizibram, Bohemia.*

	Theory $3\text{PbS} \cdot \text{Sb}_2\text{S}_3$	1	2	3	4
Pb.....	58.75	57.69	58.13	57.28	57.42
Sb.....	23.09	21.87	22.81	22.91	25.11
S.....	18.16	18.89	17.60	17.95	17.74
Fe.....		.84	.57	1.35	.....
Ag.....		.25		.06	.....
Zn.....		.47		.34	.....
Total.....	100.00	100.01	99.11	99.89	100.27

<sup>1</sup>Journ. Pract. Chem., vol. 2, p. 360, 1870.<sup>2</sup>Ber. Akad. Wien., vol. 56, 1867.

A paper by Guillemain<sup>1</sup> gives analyses of material from Ober-Lahr, St. Antonio, and Betzdorf agreeing almost exactly with the formula  $3\text{PbS}\cdot\text{Sb}_2\text{S}_3$ . These results differ so sharply from those of other analysts on materials from the same localities that they have not been further considered here. The paper contains no reference to the results of Sjögren, published the preceding year.

IDENTITY OF MULLANITE WITH BOULANGERITE.

From the preceding discussion it is clear that the true formula for boulangerite is the same as that originally assigned to mullanite, which, therefore, is chemically identical with boulangerite. The angles measured on the imperfect crystals did not agree with those of diaphorite, as stated in the original paper, but it is not impossible that by adopting a different orientation the observed forms could be referred to the axial values given for boulangerite by Sjögren. Unfortunately the original measurements were not published and the notes are not now available. There exists no sufficient ground for separating the materials called mullanite from typical boulangerite. The first two boulangerites described below are the original occurrences of "mullanite."

BOULANGERITE FROM THE GOLD HUNTER MINE, MULLAN, IDAHO.

In the lead silver ore of the Gold Hunter mine at Mullan, in the Coeur d'Alene district, Idaho, boulangerite is a constant constituent of the more quartzose portions of the ore occurring commonly as small fibrous masses in quartz or as thin acicular needles in small cavities in quartz which are lined with crystals of quartz or siderite. In color the mineral is steel-gray, with a brownish gray to brown streak. The specific gravity of the needles was determined to be 6.407. Excellent specimens are frequently obtained at the mine. Some typical specimens showing abundant needles lining cavities in quartz have recently been received at the United States National Museum from Mr. C. L. Herrick, manager of the mine (Cat. 93760). Upon analysis the needles of boulangerite from this locality yielded the results given below, the iron being due to siderite present as impurity in the sample:

*Analysis of boulangerite from Mullan, Idaho.*

Lead .....	53.33
Antimony .....	24.67
Sulphur .....	18.11
Arsenic .....	.64
Iron .....	1.47
Total .....	98.22

<sup>1</sup> Guillemain, C., *Zeitschrift Kryst. Min.*, vol. 33, p. 74, 1900.

## BOULANGERITE FROM SUPERIOR, MONTANA.

Boulangerite was a constant constituent of the zinc ore in a vein mined at the Iron Mountain Mine, Superior, Montana, occurring in all of the ore as small disseminated grains and fibers in fine granular sphalerite, and as bunches of coarse fibers with coarse granular dark-brown sphalerite in white quartz. A specimen of typical material in the United States National Museum shows coarse-fibrous steel-gray boulangerite, with sphalerite in pure white vitreous vein quartz. Upon analysis the material of this occurrence, having a brownish streak and a specific gravity of 6.274, gave the following results:

*Analyses of boulangerite from Superior, Montana.*

	1	2	Average.
Lead.....	55.13	54.93	55.05
Antimony.....	25.73	25.69	25.71
Sulphur.....	18.67	18.97	18.82
Arsenic.....	.25	.25	.25
Iron.....	Trace.	Trace.	Trace.
Total.....	99.78	99.84	99.83

## BOULANGERITE FROM THE NORTH STAR MINE, IDAHO.

The United States National Museum has recently acquired several specimens of the typical mixed ore of the North Star Mine, Wood River district, Blaine County, Idaho. This mine at one time made a considerable production of lead-silver ore from workings within the oxidized zone. When the primary mineralization of the vein was encountered it was found to consist of such refractory mixtures of diverse minerals that the ore could not be mined at a profit, and the mine remained closed for a number of years. Within the past few years new operators have opened the property and have been attempting, by modern metallurgical methods, to separate the valuable minerals of the ore, but with indifferent success.

The ores are reported to consist of intimate mixtures of galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, arsenical pyrite, and "antimony" in a gangue of quartz. The specimens in the United States National Museum collections show galena, pyrite, dark brown sphalerite, arsenopyrite, and a gray antimonial mineral in a gangue of quartz, or, in one case, crystalline dolomite. The gray mineral which heretofore has evidently been mistaken for stibnite is, so far as tested, all boulangerite. This boulangerite is a constant constituent of the ore, not only of the Star mine, but also of a number of adjoining mines, and the total amount of ore in which it forms a prominent constituent must amount to many thousands of tons. The arsenopyrite which is abundant in the ore has a peculiarly brassy yellow color, like pyrite, which disappears when it is immersed in

dilute hydrochloric acid. It forms slender prismatic crystals, averaging 1 centimeter long by 1 millimeter in diameter, showing usually only the unit prism, terminations being very rare.

The boulangerite has the usual steel-gray color and metallic luster and exhibits the characteristic brownish streak. It occurs as compact parallel-fibrous masses, as slender needles lining cavities, and as compact and slightly schistose massive forms with other sulphides, the massive variety evidently having been subjected to pressure. The boulangerite is commonly the youngest mineral of the vein, and it often lines cavities or occupies the spaces between the crystals making up quartz combs. Upon analysis a sample of the boulangerite gave the results in column 1 below. In column 2 the analysis is recalculated to 100 per cent after deducting gangue.

*Analysis of boulangerite from the North Star mine, Idaho.*

	1. Original.	2. Recalculated.
Lead.....	49.44	55.52
Silver.....	Trace.	Trace.
Iron.....	.38	.43
Antimony.....	21.03	23.63
Arsenic.....	.94	1.06
Sulphur.....	17.24	19.36
Insoluble.....	10.86	.....
Total.....	99.89	100.00

**BOULANGERITE FROM THE INDEPENDENCE MINE, IDAHO.**

A specimen from the Independence Mine, Wood River mining district, Idaho, consists of coarse granular white vein quartz containing abundant small pyritohedral crystals of pyrite and fibrous masses of boulangerite. One side of the specimen bears a felted or curved fibrous mass of steel gray boulangerite, and a joint surface which bounds the specimen on one side bears small rosettes of radiating, deeply striated, short prismatic crystals of boulangerite showing well-defined cleavage parallel to the elongation. In color the boulangerite is rather light silver-gray and its streak is brownish-gray on paper and distinctly brown on porcelain. A selected sample of the compact, curved, fibrous material gave upon analysis the results tabulated below:

*Analysis of boulangerite, Independence Mine, Idaho.*

Insoluble.....	3.58
Lead.....	53.79
Silver.....	Trace.
Iron.....	.41
Antimony.....	23.83
Arsenic.....	.12
Sulphur.....	18.11
Total.....	99.84

## BOULANGERITE FROM PERU.

An exceptionally fine specimen of typical "mineral wool," recently received by the United States National Museum, has been examined and found to be boulangerite. The specimen came to the department of geology indirectly through the Division of Mineral Technology, and little is known regarding its history other than that it probably came from the Panama-Pacific exposition. It was with a lot of ores labeled Peru. A small label on one end of the specimen bears the words "Atlante No. 10," and a fragment of a label found with the specimen, so far as it could be deciphered, read: "S. S. Fluke-----veta nueva-----distanca 7----ds de Huanca----Seca, Se llama San Antonio."

*Occurrence.*—The boulangerite coats the upper surface of the specimen with a soft mat of interlaced fibers, covering an area 12 by 16 centimeters. The specimen, which is 12 by 16 by 9 centimeters in maximum dimensions, evidently represents the crust from one wall of a partly filled fissure. The specimen illustrates very beautifully the paragenesis and association of the minerals of the vein. The first deposit on the walls of the fissure was resinous dark-brown sphalerite, which, mixed with a very little pyrite and galena, forms a layer averaging 3 millimeters in thickness. Next came bluish white to white greasy quartz, which forms a massive layer up to 5 centimeters in thickness, upon the surface of which was deposited a crust or comb of long needlelike transparent quartz crystals, averaging 1.5 centimeters in length, with a thickness of from 1 to 2 millimeters. Upon the comb of quartz crystals was next formed a thin layer of arsenopyrite in crystals up to 3 millimeters in diameter, followed by pearly buff manganiferous siderite, which makes a crust composed of large and somewhat curved rhombohedral crystals 2 centimeters or more on an edge. The boulangerite forms a wool-like mass of matted fibers, 1 to 2 centimeters thick, covering the siderite. It was the last mineral in the vein to be deposited.

*Physical properties.*—The boulangerite is in the form of exceedingly thin dark steel gray fibers, matted together in a loosely coherent felt. The individual fibers are very flexible. Owing to the minuteness of the crystals and their manner of aggregation, the specific gravity and hardness of the mineral could not be determined. The streak is distinctly brownish gray to brown.

*Chemical composition.*—A sample of the wool-like material picked from the felted mass was analyzed, yielding the composition given in the following table:



*Analysis of boulangerite from Peru.*

	Per cent.
Insoluble.....	0.36
Iron .....	0.47
Lead.....	54.34
Silver .....	Trace.
Antimony .....	25.33
Sulphur.....	18.51
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Total.....	99.01

A slight evolution of carbon dioxide took place upon solution of the mineral in hydrochloric acid, indicating that a small amount of siderite was included in the sample as impurity. The iron may all be in this form, and the 1 per cent loss is probably  $\text{CO}_2$  and  $\text{MnO}$ .

## BOULANGERITE FROM OBER-LAHR, GERMANY.

A specimen of boulangerite in the United States National Museum collections, labeled Ober-Lahr, Germany, was received in exchange from Mr. B. Sturtz in 1886 (Cat. 47,005). The specimen is almost entirely composed of the boulangerite, the only impurities being rare grains of buff manganiferous siderite and quartz. The boulangerite is wholly devoid of any trace of fibrous structure, being completely massive, with a schistose structure, somewhat rounded and contorted and apparently due to pressure. The color is somewhat darker than that of the fibrous boulangerites previously described, being comparable with that of some massive tetrahedrite. The mineral assumes a bluish tarnish. The streak is the characteristic brownish color typical of boulangerite. Upon analysis the material of this specimen yielded the following results:

*Analysis of boulangerite from Ober-Lahr, Germany.*

	Per cent.
Lead .....	54.44
Silver .....	Trace.
Antimony .....	24.55
Sulphur.....	18.98
Insoluble.....	1.50
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Total.....	99.47

## BOULANGERITE FROM PRZIBRAM, BOHEMIA.

A specimen in the United States National Museum collections (Cat. 83,983) from Przibram looks precisely like the specimen from Ober-Lahr. The color, structure and streak are the same. The curved schistose structure is more pronounced, the platy layers curving completely around one end of the specimen. The boulangerite contains considerable quartz and buff manganiferous siderite and

a little fine-grained galena. A sample selected carefully, in order to avoid galena, upon analysis afforded the following results:

*Analysis of boulangerite from Przibram, Bohemia.*

	Per cent.
Lead -----	55.08
Antimony -----	24.38
Iron -----	Trace.
Sulphur -----	18.65
Insoluble -----	1.10
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Total -----	99.21

BISMUTOPLAGIONITE FROM WICKES, MONTANA.

The name bismutoplacionite was recently given by the present writer to a new lead sulphobismuthite received by the United States National Museum from Mr. Tim McCarthy, of Wickes, Montana.<sup>1</sup> The specimens of ore in which the new mineral occurs came in through the routine channels, with the request that the minerals be identified and that the material be tested for platinum. Blowpipe tests made by Mr. W. F. Foshag, of the Division of Mineralogy, indicated that the gray constituent which was present in small amount in a few of the pieces consisted essentially of a sulphide of bismuth and lead. Further correspondence with the sender resulted in the obtaining of a few additional small pieces of the ore, some of which contained the gray bismuth-bearing mineral.

OCURRENCE.

Nothing was learned about the locality from which the specimens were obtained, but it is presumed that they came from some undeveloped prospect in the vicinity of Wickes, which is a small mining town in Jefferson County, north of Boulder. The specimens as received consist of chunks an inch or two in diameter, consisting mainly of coarsely crystalline pyrite, showing cubic crystals with the corners truncated by octahedral planes. These masses of pyrite contain, in addition to the bismuth mineral, nests of yellowish scaly sericite, masses and prismatic crystals of quartz, and small aggregates of chalcopyrite, tetrahedrite, and galena. The minerals other than the bismutoplacionite occur in connection with the masses of quartz. The bismuth mineral occurs rarely with the galena and tetrahedrite, but for the most part it occurs interstitially with regard to the pyrite crystals and in masses of the latter mineral which are free from the other metallic minerals. Such pieces, when polished and examined microscopically, show no lack of homogeneity in the gray mineral. Only specimens which were unquestionably free from

<sup>1</sup> Shannon, E. V., Amer. Journ. Sci., vol. 49, pp. 166-188, 1920.

galena and tetrahedrite were used in the analysis. The bismutoplacionite is molded around both pyrite and quartz crystals. In one small cavity between pyrite crystals the bismutoplacionite was found to form small prismatic needles.

#### PHYSICAL PROPERTIES.

In appearance the new mineral is not distinctly different from cosalite, galenobismutite, or many other sulphosalts of lead. The color is slightly bluish lead-gray and the luster is rather dull metallic. The aggregates are indistinctly fibrous, the fibers curving about idiomorphic crystals of pyrite or quartz, which, when removed, leave lustrous molds in the gray mineral. There are one or more ill-defined cleavages parallel to the elongation of the fibers. In one instance the bismuth mineral formed very minute free acicular crystals, extending across a minute cavity between pyrite crystals. These needles were too minute for measurement, were not terminated, and were deeply striated parallel to the elongation. The fibrous habit of the massive material, the elongate striated needles, and the cleavages parallel to the elongation unite to suggest that bismutoplacionite is probably orthorhombic in crystallization. The streak of the mineral is dull brownish-gray; the hardness 2.8 and the specific gravity 5.35.

#### PYROGNOSTICS.

Before the blowpipe alone on charcoal bismutoplacionite fuses to a brittle globule and yields a coating which is yellow nearest the assay (lead) and white in its outer portion (bismuth). With sodium carbonate it is reduced to a metallic button, yielding similar coatings on the coal. In the closed tube it yields sublimates of yellow sulphur and black antimony sulphide. In the open tube abundant sulphur dioxide is given off, and at a high temperature there is formed a heavy sublimate, which is yellow when hot and yellowish white when cold. With potassium iodide-sulphur mixture a strong bismuth reaction is obtained.

#### CHEMICAL COMPOSITION AND PROPERTIES.

It was quite impossible to obtain a sample for analysis which did not contain pyrite, as the two minerals were found to be very intimately mixed. Several lumps of the pyrite-bismutoplacionite aggregate which, upon examination of polished surfaces, seemed to contain no additional minerals, were crushed to an average grain of 2 to 3 millimeters. From this granular sample the purest grains of the gray mineral were selected and each grain was examined with a high-power lens without detecting any galena or other impurity. This selected material was then ground and screened and used for analysis. The sample contained abundant pyrite, but this occasioned slight concern since preliminary tests had shown that the lead-bis-

muth mineral was completely soluble in hot concentrated hydrochloric acid while the fresh clean pyrite was not appreciably attacked. The portion taken for analysis was dissolved on the steam bath with concentrated hydrochloric acid and the insoluble material was caught and washed thoroughly on a Gooch crucible, dried at 105 degrees and weighed. It consisted mainly of pyrite which was later proven free from any trace of lead or bismuth. The solution was then analyzed by standard methods, yielding the results given below:

*Analysis of bismutoplagonite.*

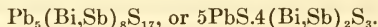
Insoluble.....	18.88
Lead (Pb).....	26.15
Iron (Fe).....	.58
Antimony (Sb).....	2.41
Bismuth (Bi).....	37.14
Sulphur (S) (calculated).....	14.17
Total.....	99.33

Because of the complications introduced by the large amount of pyrite present, sulphur was not directly determined—an omission not serious in view of the fact that the constituent bases, when calculated to their respective sulphides, bring the total reasonably close to 100 per cent. On the assumption that the pyrite was attacked to a slight extent by the acid, the iron found in solution is deducted as pyrite ( $\text{FeS}_2$ ). The composition derived for the gangue free bismuth mineral, in terms of 100 per cent, is given below, together with the ratios derived from the percentage figures:

*Recalculated analysis and ratios of bismutoplagonite.*

	Per cent.	Ratios.			
Lead.....	33.02	0.1594	15.94	5.31	$5 \times 1.01$
Bismuth.....	46.90	.2255	} 25.08	8.36	$8 \times 1.00$
Antimony.....	3.04	.0253			
Sulphur.....	17.04	.5313	53.13	17.71	$17 \times 1.00$

These ratios indicate exactly the formula:



or the compound is  $5\text{PbS}_4\text{Bi}_2\text{S}_3$ , with the Bi in small measure replaced by Sb, the molecular ratios of bismuth to antimony being approximately as 9:1. This formula brings the mineral in line, chemically, with plagonite and liveingite, the formulas for the three minerals being:

Plagonite.....	$5\text{PbS}_4\text{Sb}_2\text{S}_3$
Bismutoplagonite.....	$5\text{PbS}_4\text{Bi}_2\text{S}_3$
Liveingite.....	$5\text{PbS}_4\text{As}_2\text{S}_3$

That bismutoplacionite is strictly isomorphous with placionite and liveingite does not necessarily follow. The latter minerals are of the monoclinic division of these sulphosalts, while bismutoplacionite is probably orthorhombic. Dimorphism is very common in the sulpho minerals, and it is not improbable that orthorhombic forms having the compositions of placionite and liveingite occur or that a monoclinic modification of the compound  $5\text{PbS}\cdot 4\text{Bi}_2\text{S}_3$  may be found.

#### SILVER JAMESONITE FROM IDAHO.

A specimen of silver ore from the Poorman Mine, Silver City district, Owyhee County, Idaho, preserved in the study series of ores in the United States National Museum, was found to consist in large part of a light-gray metallic mineral which was not immediately identifiable. Subsequent analysis indicates that this is a lead sulphantimonite similar in composition to jamesonite, but unusual in containing an appreciable amount of silver.

#### OCCURRENCE.

The mineral occurs in rather large amount in a typical rather coarsely crystalline white vein quartz, which is loose textured as from combs of crystals grown together from opposite sides of a narrow vein. Where cavities occur in the specimen they are bounded by plane faces of quartz crystals. The deposition of the sulphantimonite began before the quartz crystals had ceased to grow, as shown by the quartz crystals in some cases including variously oriented needles of the metallic mineral. The deposition of the latter mineral continued after the cessation of growth by the quartz crystals, until nearly all of the intercrystal spaces were solidly filled with the jamesonite. When the quartz is broken up, prismatic crystals are loosened, leaving lustrous molds in the gray mineral. The only other minerals in the specimen are rare stains of pyrargyrite, resinous yellow grains of sphalerite, and small nests of sericite.

#### PHYSICAL PROPERTIES.

The sulphantimonite is somewhat unusual in appearance, being quite unlike ordinary jamesonite. In color it is very light gray on fresh fracture, almost silver white, and the luster is metallic splendid. The masses are fine grained and show only a faint suggestion of fibrous structure. At its contact with some of the clearer quartz crystals, however, the mineral is in distinct needles penetrating the quartz. Polished sections examined with vertical illumination show every gradation from wholly massive material to material made up of interlaced prismatic needles. Careful examination of polished surfaces failed to demonstrate the presence of more than one mineral in the gray masses. In very rare and small cavities in the quartz

the sulphantimonite occurs in free needles of very minute size, which are entirely too small for goniometric measurement. Upon examination these needles were found to be exceedingly brittle, breaking across the elongation at the slightest touch, in a manner indicating a rather perfect cleavage in this direction. Upon exposure the mineral assumes a faintly yellow color. The hardness is about 2.5. When rubbed upon paper the mineral gives a gray mark like that made by hard graphite, but its streak upon unglazed porcelain is reddish brown.

## PYROGNOSTICS.

The blowpipe characteristics of the mineral are the usual ones for sulphantimonites of lead. In the open tube it yields sulphur dioxide and a heavy sublimate of white antimony oxide. In the closed tube fragments melt and yield a faint upper ring of antimony oxide, succeeded downward by a yellow ring of sulphur, a red band of antimony oxysulphide, and a black coating of antimony sulphide.

## CHEMICAL PROPERTIES.

The mineral is completely soluble in hot concentrated hydrochloric acid. Selected fragments of the mineral when separated from quartz were analyzed with the results given in the following column:

*Analysis of silver jamesonite.*

Lead (Pb).....	40.77
Copper (Cu).....	.75
Iron (Fe).....	.46
Sliver (Ag).....	7.40
Antimony (Sb).....	30.61
Sulphur (S).....	20.81
Total.....	100.80

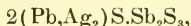
This analysis yields the ratios given in the following table:

*Ratios of silver jamesonite.*

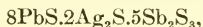
PbS.....	1,969	1,969	8.00	} 9.97	2×1.00
Ag <sub>2</sub> S.....	343	} 484	1.97		
Cu <sub>2</sub> S.....	59				
FeS.....	82	} 1,274	5.18	} 5.18	1×1.04
Sb <sub>2</sub> S <sub>3</sub> .....	1,274				

The amount of sulphur given in the analysis is somewhat higher than required by the bases present, a fact possibly traceable to an error in the analysis. From the above ratios it is evident that the

mineral agrees very closely with the simple formula given in most textbooks for jamesonite, namely,  $2\text{PbS.Sb}_2\text{S}_3$ . Taking the silver into account we have for the present mineral the formula:



with lead and silver present in definite ratios as  $\text{Pb:Ag}_2=4:1$ . Expanding the above formula gives—



with silver ( $\text{Ag}_2$ ) in small measure replaced by copper ( $\text{Cu}_2$ ) and iron ( $\text{Fe}$ ).

In a recent paper Spencer<sup>1</sup> writes that jamesonite showing the brittleness of the needles, which indicates transverse cleavage, does not agree with the formula commonly given, but has the composition expressed by the formula  $7(\text{Pb}_{4/5}\text{Fe}_{1/5})\text{S.4Sb}_2\text{S}_3$ , and shows that the more generally accepted formula  $2\text{PbS.Sb}_2\text{S}_3$  belongs rightly to plumosite, the needles of which are flexible and not brittle. Schaller,<sup>2</sup> more recently still, proposes a different formula for jamesonite—namely,  $4\text{PbS.FeS.3Sb}_2\text{S}_3$ . The present mineral may be compared with these two proposed formulas as follows:

$4\text{PbS. FeS. 3Sb}_2\text{S}_3$ .....	Jamesonite (Schaller).
$4\text{PbS. Ag}_2\text{S. 2}\frac{1}{2}\text{Sb}_2\text{S}_3$ .....	Idaho silver jamesonite.
$7(\text{Pb}_{4/5}\text{Fe}_{1/5})\text{S.4Sb}_2\text{S}_3$ .....	Jamesonite (Spencer).
$7(\text{Pb}_{4/5}(\text{Ag}_2)_{1/5})\text{S. 3.48Sb}_2\text{S}_3$ .....	Silver jamesonite.

Taking into account the perfect cleavage manifested by the brittleness of the needles, and the fact that silver almost completely replaces the iron which has been regarded as an essential constituent of jamesonite, the present mineral is designated silver jamesonite rather than simply argentiferous jamesonite. Were it not for the stress laid by recent writers on the value of the cleavage as a diagnostic characteristic of jamesonite it might perhaps have been better to call the Silver City mineral simply argentiferous plumosite.

The mineral above described does not differ greatly in composition from the argentiferous jamesonite from the Sheba mine, Star City, Nevada, described by Burton.<sup>3</sup> This mineral is described as silver-white to bluish-white in color, massive to coarsely fibrous or columnar in structure with a hardness of 2.5 and a specific gravity of 6.03. It was associated in quartz with sphalerite and tetrahedrite. Selected samples gave, upon analysis, the results in the following table.

<sup>1</sup> Spencer, L. J., *Mineralogical Magazine*, vol. 14, p. 207, 1907.

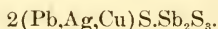
<sup>2</sup> Schaller, W. T., U. S. Geological Survey Bull. 490, p. 26, 1911.

<sup>3</sup> Burton, B. S., *Amer. Journ. Sci.*, vol. 45, p. 36, 1868.

*Analyses of argentiferous jamcsonite from Nevada.*

	1	2	Average.
Lead (Pb).....	44. 25	43. 68	43. 86
Silver (Ag).....	6. 15	6. 13	6. 14
Copper (Cu).....	1. 72	1. 39	1. 55
Iron (Fe).....	. 05	. 05	. 05
Antimony (Sb).....	29. 08	29. 45	29. 26
Sulphur (S).....		19. 06	19. 06
Total.....		99. 76	99. 92

The formula derived by Burton from this analysis is:



## NAUMANNITE FROM IDAHO.

In the course of a general mineralogical investigation of the Economic Geology Collections of the United States National Museum, the writer recently examined a specimen, supposed to be argentite, from the De Lamar mine, Silver City district, Owyhee County, Idaho. This specimen has been proven by analysis to consist of naumannite, the rare selenide of silver, which has not heretofore been reported from any locality in the United States.

## OCCURRENCE.

The specimen in question, which is labeled "Argentite nugget coated with clay, De Lamar Mine," was collected by Eldridge in 1893, and is catalogued as number 201 of the set of ores illustrating his report on a Geologic reconnaissance across Idaho.<sup>1</sup>

The De Lamar mine has been in the past an exceedingly rich and profitable gold-silver mine, having produced precious metals to the value of \$6,000,000 within as many years after the discovery of the main ore body. Several veins of the same system have been worked. The inclosing rock is rhyolite, and the veins are filled fissures, the gangue being mainly a peculiarly platy quartz, which is pseudomorphous, probably after calcite or barite. All of the veins terminate abruptly at a great transverse fissure filled with soft kaolinitic clay, derived by crushing and alteration of the material of the walls. This great clay gouge, which is locally designated the "iron dike," has had the effect of damming the mineralizing solutions and greatly localizing the deposition of the ores. Near the under side of the clay vein were the "silver stopes," where the veins upon approaching the "iron dike" were unusually rich, and bunches of rich ore also occurred in the separating country rock. In the crevices immediately adjacent to

<sup>1</sup> Eldridge, George H., U. S. Geol. Survey, Ann. 16, pt. 2, 1895.



the "iron dike" argentite and ruby silver were found in nuggets embedded in clay, and small streaks of whitish kaolin, strongly impregnated with argentite, were also rich in gold. Some clayey streaks in the hanging walls of veins elsewhere in the mine are also rich in argentite, although as a whole the mine is predominantly a gold mine. The minerals of the vein include native gold, argentite, and ruby silver, and, near the surface, some cerargyrite.<sup>1</sup> The ruby silver of this mine is largely miargyrite. The specimen of naumannite described below was supposed to be typical of the larger nodules of argentite occurring in the clay seams. To what extent the so-called argentite consisted of naumannite is not known, but it is far from impossible that nearly all of the abundant nuggets and streaks of so-called silver sulphide which occurred in kaolin in this mine may have been naumannite. It is to be hoped that other specimens of these ores can be secured for examination.

#### PHYSICAL PROPERTIES.

The specimen is an irregular flat rectangular nodule about 10 by 7 by 3 centimeters in maximum dimensions and weighing about 475 grams. Little of the metallic mineral was visible on the exterior of the nodule, which was completely coated with a tenacious layer of grayish clay. The interior of the nodule consists of the heavy metallic mineral which is so tenacious and malleable that projecting corners are broken from it with difficulty. On broken surfaces it is seen to have a hackly fracture and dark blue-gray color. The luster is metallic, and the surface, upon exposure, does not become appreciably dulled, nor does it assume the furred appearance characteristic of argentite. When polished sections are examined under the microscope with vertical illumination the mineral is seen to be pure except for the clayey matter which is scattered in grains and small patches throughout the mass, and marcasite, which forms small disseminated points in the silver mineral. The hardness is about 2.5. The streak on paper is dark brownish gray; on porcelain, gray, faintly shining. A specific gravity determination on fragments containing 5 or 6 per cent of clay gave the value 6.527.

#### PYROGNOSTICS.

Heated before the blowpipe on charcoal the mineral yields selenium immediately, and colors the flame blue with the production of the characteristic selenium odor, leaving a large mass of malleable silver. In the closed tube it gives odors of sulphur and selenium, and yields a series of sublimes in rings which grade from yellow (sulphur) at the top, through red (selensulphur), to deep red and black (selenium). In the open tube there are obtained odors of sulphur, and

<sup>1</sup> Lindgren, W., U. S. Geol. Survey, Ann. 20, pt. 3, p. 127, 1900.

especially selenium, and a white ring of volatile crystals of selenous oxide, which is faintly red in its lower portion from the presence of unoxidized selenium. The silver remaining behind is quite pure and hence is difficultly fusible.

## CHEMICAL PROPERTIES.

The mineral is insoluble in hot concentrated or dilute hydrochloric or sulphuric acids, but dissolves readily in hot concentrated nitric acid. Samples free from the clay gangue could not be obtained, as the mineral is too malleable to admit of pulverization. It was thus necessary to estimate the amount of clayey impurity in the sample analyzed from the amount of insoluble residue (ignited) obtained from the mineral. A preliminary examination of the purest and whitest clay which could be scraped from the crust gave the following results:

Insoluble matter (ignited) .....	87.70
Silver .....	1.14
Selenium and sulphur (calculated) .....	.34
Water plus loss (by difference) .....	10.82
	100.00

In the analyses the amount of insoluble material found, after ignition, was multiplied by the factor 1.1234 and deducted from the weight of the sample taken. After this deduction the analysis gave the results given in column 1 below. Since the sample contained some marcasite, the amount of iron found is deducted, together with sulphur to form  $\text{FeS}_2$ , leaving the results given in column 3 of the following table. In column 3 the figures are recalculated to show the composition of the naumannite, free from marcasite, in terms of 100 per cent.

*Analysis of naumannite from Idaho.*

	1. Original analysis.	2. Marcasite deducted.	3. Recalcu- lated.
Silver.....	74.13	74.13	75.98
Iron.....	.90		
Selenium.....	22.37	22.37	22.92
Sulphur.....	2.10	1.07	1.10
Total.....	99.50	97.57	100.00

Column two of the above table yields the following ratios:

*Ratios of naumannite.*

Silver ( $\text{Ag}_2$ ).....	0. 3436	10. 32	10. 32	$1 \times 1. 04$
Selenium (Se).....	0. 2824	8. 48	} 9. 48	$1 \times . 96$
Sulphur (S).....	0. 0333	1. 00		

The mineral thus agrees reasonably well with the formula usually assigned to naumannite,  $\text{Ag}_2\text{Se}$ , the selenium (Se) being replaced to a slight extent by sulphur (S). Aside from this replacement and from the mechanical impurities mentioned, the material is remarkably pure silver selenide, careful determinations having proven that lead, copper, gold, zinc, arsenic, antimony, bismuth, and tellurium were either absent or present in minute traces.

The ratio of selenium to sulphur is so great (17:2) that the mineral must be designated naumannite,  $\text{Ag}_2\text{Se}$ , rather than agularite,  $\text{Ag}_2\text{S}.\text{Ag}_2\text{Se}$ , in which sulphur and selenium are present in molecularly equal amounts.