ON KOBELLITE FROM OURAY, COL., AND THE
CHEMICAL COMPOSITION OF THIS SPECIES.

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The sulphobismutites and sulfostibnites of the southwestern part of Colorado, have repeatedly formed the subject of mineralogical and chemical research. Genth, Koenig, Hillebrand, and others have proved the occurrence there of a number of species already known from other localities, and have also described several new compounds of this class under the names of schirmerite, alaskaite and beegerite.

In the following pages, I desire to give the description of a mineral, possessing the composition $2(\text{Pb}, \text{Ag}_2, \text{Cu}_1)\text{S}(\text{Bi}, \text{Sb})_2\text{S}_3$ and to show further that it is in all probability identical with the kobellite of Setterberg.

The material for this investigation was kindly supplied by my brother, Mr. Hermann A. Keller, of Pueblo, Col. It consisted of several beautiful specimens of an ore that had been taken from the Silver Bell mine at Ouray, Col., by Mr. Philip Decker.

I have not been able to obtain any further information concerning the occurrence of the mineral, but consider it highly probable that it is closely analogous to that of alaskaite described by Koenig.* Like this it is found associated with barite and chalcopyrite. *Physical properties*.—Massive; structure, finely granular, inclining to fibrous; lustre, silky metallic; color, bluish lead-gray; fracture, uneven; streak, iron-black. Apparent hardness, 2.5—3; sp. gr., 6.334.

Chemical deportment.—Upon heating, the mineral first decrepitates violently and then fuses. In the open tube, it gives off sulphurous acid and a sublimate of antimonious acid. Upon charcoal it yields a yellow incrustation, with a white non-volatile fringe and a metallic globule, which for

* *Amer. Philos. Soc.*, June, 1881.

the greater part is volatilized upon continued blowing. The residue gives the reactions of iron and copper in the salt of phosphorus bead, and a button of metallic silver on cupellation. A crimson coating is obtained with potassium iodide and sulphur on charcoal.

Hydrochloric acid decomposes the compound with evolution of hydrogen sulphide, especially upon heating; the gangue material and chalcopryrite are left undissolved, while the silver passes into solution, from which it can be precipitated as chloride by diluting with water.

Chlorine, as well as nitric acid, exerts a powerful action upon it.

As the quantitative separation and estimation of the constituents present some difficulties, I will briefly indicate the course of an analysis which was found to be best adapted to this end. A portion of the mineral was treated with nitric acid. When proper care is taken, the oxidation is completed in an hour's time. The excess of the acid was then removed upon the water bath and the residue boiled with a solution of pure carbonate of soda. This treatment was continued until all the sulphuric acid, excepting the small quantity in the barite of the gangue, had passed in solution. The undissolved oxides and carbonates of the metals were then filtered off. The filtrate showed a bluish color, and was found to contain small quantities of copper, antimony and bismuth. These were precipitated, by hydrogen sulphide, after acidifying with hydrochloric acid, and the sulphur then determined in the filtrate as barium sulphate. This was purified after ignition, by heating with hydrochloric acid, then dissolving it in concentrated sulphuric acid and reprecipitating it finally with water.

The separation of the metals was effected as follows: The mixture of the oxides, carbonates, etc., was treated with nitric and tartaric acids, whereby only the gangue material (BaSO_4) remained undissolved. After the small quantity of sulphides before mentioned had likewise been taken up in the solution, the silver was precipitated as chloride in the cold; potassium hydrate was then added to the filtrate in excess and hydrogen sulphide passed into it. The

precipitate, consisting of the sulphides of all the metals except antimony, was filtered off, and the antimony determined in the liquid according to Bunsen's method as pentasulphide. The conversion of the pentasulphide into tetroxide served as a check, but gave invariably a slightly lower percentage.

The metallic sulphides were again oxidized with nitric acid, the latter removed by evaporation with sulphuric acid and the remaining sulphates treated with dilute sulphuric acid (1 : 8) in the cold. In this manner the lead is separated from the other metals, but not completely, as the insoluble sulphate always retains small quantities of bismuth. It is therefore dissolved in warm potash solution, which leaves the oxide of bismuth with some lead, and these can then be separated readily by a renewed treatment with nitric and sulphuric acids.

In the solution containing the sulphates of copper, bismuth, iron and zinc, the two first mentioned were precipitated as sulphides with hydrogen sulphide, filtered off, converted into the nitrates and separated from each other with ammonia and ammonium carbonate. Zinc and iron were finally separated and determined by the usual methods.

In order to ascertain which of the metals enter into the composition of the mineral, one portion of the substance (Analysis II) was dissolved in hydrochloric acid and the residue remaining analyzed separately.

Although chlorine acts strongly upon the finely divided powder, I did not succeed in effecting a complete decomposition by its means. All the samples analyzed were taken from different pieces of the ore.

ANALYSES.						
	I.	II.	III.	IV.	V.	Mean.
S	18.37	—	18.46	18.33	18.39	18.39
Bi	27.97	28.51	28.68	28.46	—	28.40
Sb	7.19	7.25	7.91	7.84	—	7.55
Pb	36.11	36.08	36.25	36.20	—	36.16
Ag	3.22	3.39	3.30	3.32	—	3.31
Cu	2.43	2.26	2.91	2.76	—	2.59
Fe	1.31	1.35	1.69	1.65	—	1.50
Zn	.50	.37	.41	.31	—	.39
BaSO ₄ , etc., .	.43	.65	.21	.49	—	.45
	97.53	—	99.82	99.36	—	98.74

In No. II the portion insoluble in hydrochloric acid was found to contain (after the chloride of silver had been removed by ammonia):

Fe, 1.09.

Cu, 1.12.

Zn, .24.

It seems therefore safe to assume* that the iron and an equivalent quantity of copper are present as chalcopyrite, and the zinc as sphalerite.

Now deducting these, plus the gangue and the loss, the percentage composition calculated from the mean results is as follows:

	Atomic ratio.	
S = 17.76	.5550	= 2.600
Bi = 30.61	.1457	} .2134 = 1.000
Sb = 8.13	.0677	
Pb = 38.95	.1881	} .2124 = .995
Ag = 3.58	.0166	
Cu = .97	.0077	
<u>100.00</u>		

and the formula is therefore: $2(\text{Pb}, \text{Ag}_2, \text{Cu}_2)\text{S}(\text{BiSb})_2\text{S}_3$. Since the atomic ratio of antimony† to bismuth is 1 : 2 the mineral may be considered as composed of one mol. of jamesonite with two mols. of cosalite.

The recent text-books of mineralogy do not assign this formula to any mineral, nevertheless such a one has been known for a long time.

As kobellite, Setterberg‡ in 1839 first described a mineral from the cobalt mines of Hvena, in Sweden, the composition§ of which he found to be:

S =	(18.61)
Bi =	28.37
Sb =	9.38
Pb =	40.74
Fe =	2.02
Cu =	.88
	<u>100.00</u>

* Chalcopyrite, when finely divided, is slightly acted upon by HCl.

† I have reason to believe that the antimony determinations I and II are a little too low.

‡ *Pogg. Ann.*, **55**, 536.

§ Recalculated with present atomic weights (Rammelsberg, *Minerauch.*, p. 100).

Deducting from this the copper with the equivalent quantities of iron and sulphur, the atomic ratios are as follows:

$$\begin{array}{rcl}
 \text{S} & = & \cdot 5506 \qquad = 2\cdot 581 \\
 \text{Bi} & = & \cdot 1351 \\
 \text{Sb} & = & \cdot 0782 \quad \left. \vphantom{\begin{array}{l} \text{Bi} \\ \text{Sb} \end{array}} \right\} \cdot 2133 = 1\cdot 000 \\
 \text{Pb} & = & \cdot 1966 \\
 \text{Fe} & = & \cdot 0221 \quad \left. \vphantom{\begin{array}{l} \text{Pb} \\ \text{Fe} \end{array}} \right\} \cdot 2187 = 1\cdot 025
 \end{array}$$

that is, they are identical with those calculated from my analyses.

Setterberg states distinctly that the iron of his mineral was dissolved in hydrochloric acid, and must therefore be considered as belonging to it; another slight difference in the composition of the minerals from the two localities is the replacement of about one-twelfth of the lead by silver in that from Ouray.

In 1862, Rammelsberg published an analysis of some material from the Hvena mine; he found:

$$\begin{array}{rcl}
 \text{S} & = & 18\cdot 22 \\
 \text{Bi} & = & 18\cdot 60 \\
 \text{Sb} & = & 9\cdot 46 \\
 \text{As} & = & 2\cdot 56 \\
 \text{Pb} & = & 44\cdot 25 \\
 \text{Fe} & = & 3\cdot 81 \\
 \text{Cu} & = & 1\cdot 27 \\
 \text{Co} & = & \cdot 68 \\
 & & \hline
 & & 98\cdot 85
 \end{array}$$

After deducting 5·61 per cent. of (FeCo)AsS and 3·67 per cent. of CuFeS₂, he arrives at the formula

In his *Mineralchemie* (p. 100), he gives an analysis of so-called kobellite from another locality (the name of which is not mentioned), and from this deduces the same formula.

He does not prove, however, that the analysis by Setterberg is incorrect, and it is more than likely that the material examined by him consisted of a mineral different from Setterberg's.

There are numerous instances of the occurrence of two different sulpho-salts of similar appearance in the same vein, and even upon the same piece.

The re-investigation of alaskaite by Koenig* was caused by it having been mistaken for cosalite from the same mine.

The specific gravity determinations also show a slight discrepancy; Setterberg found 6.29 — 6.32, while Rammelsberg's determination gave 6.145. That of the Ouray occurrence is 6.334.

In view of all these facts, I feel myself justified in retaining the name of kobellite for the mineral of the formula:

and would suggest that another name be given to that to which this name has hitherto been applied, namely,

In concluding, I desire to propose the name of lillianite for a mineral from the Lillian mine in Leadville, Col., described several years ago jointly by my brother and myself as a variety of kobellite. It possesses the composition $3(\text{PbAg}_2)\text{S} \cdot \text{Bi}_2\text{S}_3$, and represents the bismuth mineral corresponding to boulangerite.

II.—ANALYSIS OF MEGABASITE FROM BONITA MOUNTAIN, NEAR SILVERTON, COL.

More than three years ago I received from Colorado, among other specimens, one which was labelled "göethite." Some qualitative tests that were then performed upon it proved that it consists essentially of tungstic acid and manganoous oxide. The occurrence has become quite well known since, but, as far as I am aware, no quantitative analysis of the material has been published. I may therefore be permitted to put the following on record:

Sp. Gr. = 6.780

WO ₃	=	74.24
MnO	=	21.09
FeO	=	2.06
CuO	=	.11
MgO	=	trace
SiO ₂	=	2.13
		—
		99.63

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* *Proc. Amer. Philos. Soc.*, 1885, 211.