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must be proportionate to the amount of heat received from the sun. In proof of the erroneous nature of this assumption, I refer to the fact that on the lofty summits of the Himalayas and Andes, for example, the quantity of heat received from the sun would be sufficient to melt at least fifty feet of ice per annum, and that is no doubt more than ten times the quantity actually required to be melted; yet notwithstanding the snow remains permanent. The cause of this non-melting I showed is due to the fact that at these elevations, owing to the dryness of the air (want of aqueous vapor), the loss of heat from radiation into stellar space is so excessive that the rays of the sun, intense as they undoubtedly are, are unable to raise the temperature of the snow to the melting-point; consequently, no matter what may be the amount of heat received, the snow can never melt. It may evaporate, but it cannot melt. I further pointed out that, were the aqueous vapor possessed by the atmosphere sufficiently diminished, the snow-line would descend to the sea-level even at the equator, and perpetual snow would cover our globe down to the sea-shore.

I was much pleased to find that Professor Newcomb has not only adopted these views regarding the effects of an absence of aqueous vapor, but suggested that they may yet afford an explanation of the cause of the Glacial epoch. Every one familiar with the subject, however, knows that that epoch was not due to a dryness of the air, but the reverse.

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ART. XLI.—*Communications from the U. S. Geological Survey, Rocky Mountain Division. VI. On an interesting variety of Löllingite and other Minerals; by W. F. HILLEBRAND.*

[Read before the Colorado Scientific Society, April and Dec., 1883.]

AROUND the base of Teocalli Mountain, on Brush Creek, Gunnison County, Colorado, there occurs, in several mines, a cobaltiferous and nickeliferous variety of löllingite of such peculiar appearance as to arrest my attention at a glance. Close scrutiny so strongly confirmed the interest at first excited, that a series of observations was undertaken, of which the results are embodied in the following.

The precise locality of occurrence of the specimens examined was unknown to Mr. William McCree, who presented them to the Colorado Scientific Society, but Mr. J. G. Ridgley has observed the mineral at various places on Brush Creek, and has investigated its occurrence, particularly at the Luona mine on the northwest slope of Teocalli Mountain. It is here found, according to Mr. Ridgley, associated with native silver, prous-

tite, argentite, pyrrargyrite, chalcopyrite, galena, siderite, barite and calcite, the last three composing the gangue. Much of it is decomposed, forming secondary oxidized products, most conspicuous among which is erythrite.

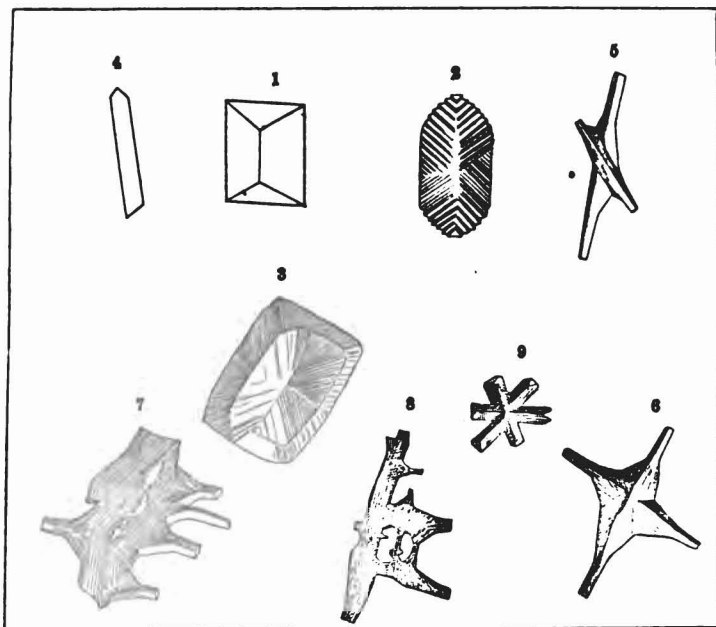
The mineral seems to occur in some quantity, and one of the specimens examined was of several pounds weight. The striking appearance already alluded to becomes visible only on fractured surfaces. There are seen, embedded in the siderite and barite gangue, steely-white forms, one-eighth of an inch, more or less, in diameter, of pronounced radiate structure, the longer radii protruding from the mass, and giving the whole a beautiful stellate appearance. The star forms occur sometimes singly, but more frequently joined together in greater or less number, without losing in any marked degree the peculiar character of the individual. In some specimens the appearance approaches that of a dense homogeneous mass several inches in diameter, but even in the densest portions the radiate structure is generally distinctly discernible.

In order to discover, if possible, a clew to the crystallographic structure, and also to obtain material for analysis, specimens were treated with hydrochloric acid without previous crushing, whereby the siderite and the arseniates of iron, cobalt and nickel were entirely dissolved. The löllingite remained quite black on all parts where the gangue had been eaten away, but surfaces of previous fracture retained their white color. The star-like forms were then seen to be composed of a considerable number of long flattened ellipsoids, interpenetrating at a common center in every direction. When one of these clusters was broken through the star form appeared on the surface of fracture. The aggregates were joined together loosely, now that the cementing material had been removed, though frequently in large clusters of many hundreds of all sizes, from those visible only with the aid of a microscope, to others an eighth of an inch or more in diameter.

A microscopic study of the finer part of the material liberated from its imprisonment in the gangue, and broken off from the larger pieces during the treatment with acid and subsequent washing, furnished the solution to the question as to what was the crystallographic form of the flattened ellipsoids composing the aggregates and the law of the twinning. The fundamental form is that of löllingite, showing only the prism and macrodome, as in fig. 1.\* Frequently these two forms are equally developed, producing a resemblance to a low pyramid of the tetragonal system. Very few even of the most minute crystals are

\* All the accompanying figures, with the exception of fig. 1, were drawn by the aid of a camera lucida, and therefore make no pretensions to crystallographic accuracy. Fig. 4 is magnified about 15 diameters, the others from 40 to 150 diameters.

perfect in form, and possessed of sufficiently smooth surfaces to allow of even approximate measurement under the microscope. Repeated attempts were made to get these in proper position under the instrument, but in only one case with comparative success, owing to their microscopic size. The angle of the prism was then found to be very nearly  $122^\circ$ , that given for löllingite being  $122^\circ 26'$ .



Parallel to the combination edge of the prism and macrodome there is almost always on the prism a striation (more coarsely marked the larger the crystal), caused by the alternate reproduction of the prismatic and domatic faces. Approaching the combination edge the reproduced dome face becomes relatively larger than that of the prism, the consequence of which is a gradual rounding of the corners and a contraction and eventual disappearance of a distinct terminal dome, the result being as represented in fig. 2, an ellipsoidal form with a slight ridge through the center representing a prism edge. Frequently the corners of a crystal, occupying the position of fig. 1, appear as if modified by a brachydome, but no such form has been observed, the replacement being a straight serrated edge, caused by the same alternation of faces as in the case of rounded corners. Even where the macrodome is well developed it generally

shows a continuation in some degree of the prismatic striation parallel to the same combination edge.

The first step toward the complex twin structure is the formation of a simple twin, or rather trilling, by interpenetration of three single crystals having the basal section in common, and a face of the prism as the composition face (fig. 3). A basal section shows a six-rayed star, with angles of very nearly  $60^\circ$ , by microscopic measurement, between the axes of the rays. In the microscopic twins one individual frequently predominates greatly in size over the other two, these appearing often as thin leaves, projecting but a short way out of the larger crystal. These trillings are finally found again interpenetrating, not according to any recognizable law, but seemingly in every direction, and in indefinite numbers, forming thus the complex aggregates first spoken of. All these stages of change in form may be observed with great ease under the microscope, the very smallest crystals alone showing crystallographic faces well defined. As the crystals, single or twin, increase in size, the faces gradually grow more and more indistinct, and finally disappear entirely in consequence of increasing striation.

Notwithstanding repeated attempts, the basal cleavage mentioned in text-books as characteristic of löllingite could rarely be produced, and never a cleavage in any other direction, except in the case of the trillings. Here an individual frequently broke off at the line of union of the three, that is, in a plane parallel to the brachypinacoid.

Aside from the forms distinctly recognizable as löllingite are, however, others belonging, apparently, to two different minerals. The first of these became visible on dissolving the gangue, when there came to the surface of the acid and the water used for washing out the latter a great number of minute but brilliant metallic particles which resolved themselves under the loupe, and still better under the microscope, into thin leaves or blades, of which fig. 4 represents one of the more perfect examples. Its forms appear to consist of two pinacoids of the rhombic system, one very broad, the other very narrow, and a terminal dome having an angle of almost exactly  $90^\circ$  by microscopic measurement. The faces are most brilliantly reflecting. Distinct cleavage was not observable. The second mineral, which is almost always microscopic in size, is represented in figs. 5, 6, 7 and 8. The prominent form is that of a lengthened prism with an angle of very nearly, if not quite,  $90^\circ$ . Repeated measurements gave values fluctuating between  $88^\circ$  and  $92^\circ$  as the extremes. It is terminated at right angles by a basal plane, the four corners of which are frequently replaced by faces which may be those of a pyramid or two domes, according as the habit is pinacoidal or prismatic. The cleavage

is parallel to the base. Single crystals are rare, two or more being generally seen interpenetrating as in figs. 5 and 6, generally at an angle of 90°, or united as in figs. 7 and 8. In the latter figure only the outlines, not the faces of the different horizontal individuals, are shown, nor do the numerous vertical attachments present appear either in this figure or in fig. 7. Occasional instances of three prisms, crossing at right angles like the axes of a rectangular system, were observed, and also a single instance of the form represented in fig. 9 where each of the arms showed a domatic face. The most striking feature of all but the last of these different forms is the invariable widening at the point of union or intersection, as shown in the figures.

Even an approximate separation of these two minerals from each other and from the smallest löllingite crystals was impossible, hence no conclusion could be reached as to their quantitative composition. Qualitative tests proved them both to be arseniates of cobalt, the square prismatic forms containing also iron and nickel. An incomplete quantitative test upon a mixture of these three minerals showed a much higher percentage of cobalt and nickel than the analysis of the pure löllingite.

Before the blowpipe the löllingite furnished the reactions mentioned in the text-books, the residue, after treatment on charcoal, being infusible, strongly magnetic, and furthermore, giving the characteristic reaction for cobalt with fluxes. Soluble in nitric acid, giving a pink solution.

Of the analyses given below, I was made upon clusters of löllingite trillings, free, so far as could be determined by the loupe, from attached or penetrating blades or prisms of the other two minerals described. As a check, a small quantity of the single crystals and trillings was picked out with the utmost care under the microscope and subjected to partial analysis (II), no trace of foreign adherent matter being visible. The specific gravity of the material used for the first analysis was 7.335 at 14½° C. Correcting for one-half per cent of siliceous gangue of assumed specific gravity, 2.65, the true specific gravity of the mineral becomes 7.400:

	I.	II.
As .....	71.18	----
S .....	0.56	----
Bi .....	0.08	----
Cu .....	0.39	----
Fe .....	22.96	22.69
Co .....	4.37	4.20
Ni .....	0.21	0.19

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99.75

The first of these analyses leads closely to the formula  $\text{Fe}(\text{CoNi})\text{As}(\text{S})_2$ , while II shows beyond a doubt that both cobalt and nickel are constituents of the löllingite and not derived from attached crystals of either of the other minerals. The presence of cobalt recalls the glaucopyrite of Sandberger, though the antimony found in that mineral is here wanting. The peculiar comb-like excrescences described by him, indicating rhombic twinning by interpenetration, may be analogous in some degree to the twinned structure of the present mineral.

Some varieties of rhombic  $\text{CoAs}_2$ , all of which, according to Leroy W. McCay,\* should be united under the name safflorite, present features remarkably like some of those herein described, notably as regards the tendency to form twins of interpenetration; and from the presence of cobalt it might be suspected that this mineral was rather to be considered as safflorite than löllingite. Its exceedingly high percentage of iron and high specific gravity, as well as the occurrence of a macrodome instead of the brachydome mentioned by Sandberger as peculiar to the rhombic  $\text{CoAs}_2$ , render necessary, however, its classification with löllingite.

#### COSALITE.

In the collection of the Colorado Scientific Society, are a few specimens of a mineral from the Comstock mine, near Parrott City, La Plata County, Colorado, presented by Mr. R. C. Hills, according to whom it occurs in a quartz vein associated with pyrite, sphalerite, a telluride of unknown composition, though probably sylvanite, and native gold. In the specimens examined it appears in irregular masses of small size, rarely an inch in length, never equally thick, and generally much smaller, without cleavage or recognizable crystalline structure, except for an occasional faint indication of fibrous texture on fractured surface. The fracture is irregular, color grayish-white, but pale yellow on exposed surfaces; hardness about 3.5; specific gravity undetermined.

The outer zone of the small bodies spoken of is found on close examination to be a mixture of two or more minerals, among which minute grains of pyrite were alone recognizable. Sufficient material was however obtained for analysis, free from all impurity, except a little pyrite and 1.29 per cent of insoluble gangue. This afforded the following reactions: in closed tube, sublimate of sulphur; in open tube, formation of sulphur dioxide; on charcoal fusible, giving reactions for lead, bismuth, silver and copper; soluble in chlorhydric and nitric acids, in the former with precipitation of silver chloride. The analysis, after deduction of the gangue, gave these results:

\* Inaugural Dissertation, Freiberg, 1883.

Bi .....	42.97
Ag .....	8.43
Cu .....	7.50
Pb .....	22.49
Fe .....	0.70
Zn .....	trace
S .....	17.11
	<hr/>
	99.20

Allowing for the iron and a proportionate amount of sulphur as pyrite, the atomic ratio deduced from the above is :

R	:	Bi <sub>2</sub>	:	S
2.02	:	1.00	:	4.98

showing the general formula for the mineral to be  $2RS + Bi_2S_3$ , wherein R represents Pb and the double atoms Ag<sub>2</sub> and Cu<sub>2</sub>. The ratio of Ag<sub>2</sub>+Cu<sub>2</sub> : Pb is 1 : 1.11.

Although copper was absent and but 2.65 per cent of silver present in the mineral originally described by Genth as cosalite, it does not appear advisable in the absence of any data as to the crystallographic form to consider this a distinct species, but to class it, as has been done with bjelkite, under cosalite.

#### A PROBABLY NEW MINERAL.

A portion of the ore from the Missouri mine, Hall's Valley, Park County, Colorado, is composed largely of a sulpho-bismuthite of copper and silver. It occurs in a quartz gangue associated with chalcopyrite and wolframite, and although the latter is only visible on close examination, it comprises from one to two per cent of the whole, as found by special tests.

A considerable quantity was extracted by chemical and mechanical means, free from all foreign matter, except a little attached quartz, and was proven to be wolframite by qualitative chemical tests and by a determination of the specific gravity.

The mass of the sulpho-bismuthite appears throughout the quartz as a dark bluish gray substance without distinct forms of crystallization. In numerous cavities appear small slender crystals, generally bronzed by oxidation and so deeply striated as sometimes to present the appearance under the loupe of bunches of needles. Occasionally they seem to be joined together laterally, forming thin corrugated plates. Owing to this deep striation no crystal faces can be detected either on the sides or the free terminations. The habit is strikingly like that of bismuthinite, for which the crystals were, indeed, at first taken.

After several days' labor, enough material was removed from the cavities for the determination of the metals. It could not,

however, be freed altogether from quartz and chalcopyrite. The specific gravity at 17° C. was 5.75. Making correction for 4.43 per cent of quartz and 6.98 per cent of chalcopyrite of assumed specific gravities 2.65 and 4.2, this becomes 6.31. The analysis appears under I below.

The more compact material, excluding as far as possible, the needles, gave, after deducting 59.75 per cent of gangue, the results under II.

III is the analysis of a mineral presented by Mr. William McCree as coming probably from the Missouri mine. In appearance it differs in no respect from the compact material already described, except that no chalcopyrite is distinctly visible in the small specimens at my disposal and the quartz grains are less firmly cemented together. It contains, however, some lead which is entirely wanting in the other specimens analyzed, although the general formula is the same, hence I am led to believe that it came from some other portion of the workings or from an adjacent mine where ore like that from the Missouri mine is reported to occur. The specific gravity was 3.869 at 15° C., which becomes 6.680 on making correction for 47.57 per cent of gangue of ascertained specific gravity, 2.643.

The most marked blowpipe reactions for I, II and III were entirely similar, a sublimate of sulphur appearing in the closed tube, sulphur dioxide escaping in the open tube and the fused fragment or powder on charcoal affording the bismuth reactions with great intensity. All were soluble in nitric and chlorhydric acids, in the latter with precipitation of silver chloride.

	I.	I.	III.
Bi	60.80	63.42	62.51
Ag	0.89	4.09	9.89
Cu	15.96	12.65	6.68
Pb			2.74
Fe	2.13	0.59	0.10
Zn	0.10	0.07	0.07
S	19.94*	18.83*	17.90
	<hr/> 99.82	<hr/> 99.65	<hr/> 99.89

After subtracting from I, 6.97 per cent; from II, 1.91 per cent, and from III, 0.33 per cent of chalcopyrite with the proportions of sphalerite represented by the zinc, the atomic ratios become:

	R	:	Bi <sub>2</sub>	:	S
I	3.00	:	3.91	:	14.75
II	3.00	:	3.99	:	14.98
III	3.00	:	4.06	:	15.15

\* Calculated.

where R represents Pb and the double atoms Ag<sub>2</sub> and Cu<sub>2</sub>. In each case the ratio is nearly 3 : 4 : 15, which leads to the general formula 3RS+4Bi<sub>2</sub>S<sub>3</sub>.

It seems probable that the needle-like crystals are a pure sulpho-bismuthite of copper and that, in the more compact portions, silver replaces a portion of the copper and in some cases a further replacement of copper by lead takes place.

This ore from the Missouri mine is auriferous. The material used for analysis II, gangue and sulphide together, assayed 1.85 ozs. gold to the ton. Mr. Richard Pearce, of the Boston and Colorado Smelting Works assures me that it is frequently much richer, running as high as 40 ozs. to the ton.

Before conferring a name upon this mineral or even definitely claiming it is a new species, I purpose investigating more fully the similar ores which are said to occur in other mines in the neighborhood of the Missouri mine. As this further investigation will, of necessity, be postponed for some time, the results already arrived at are now put on record.

#### HÜBNERITE.

In the collection of the Colorado Scientific Society are specimens of hübnerite from the Royal Albert vein, Uncompahgre District, Ouray County, Colorado, presented by Mr. R. C. Hills,

The mineral occurs in long flattened crystals vertically striated, imbedded in quartz, but none sufficiently well formed for measurement could be extracted, in fact, definite faces are rarely visible, though two prisms and the orthopinacoid have been observed. The luster is subvitreous to resinous and the color brownish-black to pale yellow in very thin crystals. In transmitted light the color is ruby-red to yellow slightly tinged with green when the thickness is not too great. Extinction takes place parallel to the vertical axis in a plate parallel to the orthopinacoid and at an angle of 19° to 20° to the same axis in a cleavage section parallel to the clinopinacoid, as observed by DesCloizeaux for wolframite. In the plates parallel to the orthopinacoid a tendency to cleave at right angles to the clinopinacoid and also at angles approximating 61° and 68° to the same face was observed. The specific gravity at 24° C. is 7.177 and the composition as follows :

SiO <sub>2</sub> .....	0.62
Nb <sub>2</sub> O <sub>5</sub> ? .....	0.05
WO <sub>3</sub> .....	75.58
MnO.....	23.40
FeO.....	0.24
CaO.....	0.13

100.02

which agrees very closely with that required by theory for the formula  $MnWO_3$ .

This mineral is also found in a mine near Phillipsburg, Montana Territory, according to Mr. Richard Pearce. The specimens in the collection of the Colorado Scientific Society show large flattened crystals of imperfect form in quartz. Mr. A. H. Low, Chemist at the Boston and Colorado Smelting Works, has analyzed the mineral approximately and found—

WO <sub>3</sub> .....	74·82
MnO .....	25·00
FeO .....	0·06
	99·88

ART. XLII. — *Notes on American Earthquakes: No. 13; by Professor C. G. Rockwood, Jr., Ph.D., Princeton, N. J.*

THIS article, the thirteenth in the series, embodies such notices as have come to the knowledge of the writer in regard to the earthquakes which occurred in North and South America and the adjacent islands, during the year 1883. The information has been derived from the current newspapers; from the Monthly Review of the U. S. Signal Service; and from Professor F. E. Nipher, Director of the Missouri Weather Service; Charles Carpmael, Superintendent of the Canadian Meteorological Service; and J. M. Batchelder of Cambridge, Mass.

Items which are regarded as doubtful are, as heretofore, printed in smaller type; and in many cases the source of the information is indicated. Also, to avoid the danger of confounding *a. m.* and *p. m.* dates, the system of numbering the hours of the civil day from one to twenty-four has been adopted.

1883.

Jan. 1.—At 2<sup>h</sup> 58<sup>m</sup> and 8<sup>h</sup> 28<sup>m</sup> two earthquake shocks at Addison, Me.—*U. S. Weath. Rev.*

A shock in other parts of Maine and Nova Scotia about 22<sup>h</sup> on the previous day was noticed in the last report (this Journal, xxv, p. 360).

Jan. 6.—Between 2<sup>h</sup> and 3<sup>h</sup> a shock was reported to have been felt in northern Ohio.—*N. Y. Times.*

Jan. 9.—At 3<sup>h</sup> a shock from east to west at Huntingdon, Ont.—*Canadian Meteorol. Serv.*

Jan. 11.—Between 1<sup>h</sup> and 2<sup>h</sup> a decided shock was felt along the Mississippi River, from St. Louis, Mo., to Memphis, Tenn.