

XVII.—*On Brochantite and its associations.*

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THE large series of combinations of copper with sulphuric acid found in mineral veins, present many features which call for attentive study.

Some of the series, as Chalcantinite and Pisanite, are easily soluble in water, while others, as Brochantite and the members of the group allied to it, are insoluble therein, and the solubility seems to run in parallel lines with the per centage of copper.

The "Basic" sulphates have of late received considerable notice, and English mineralogists must remember with pleasure that the masterly essay by Prof. Maskelyne "On the minerals of the Brochantite group," gave us for the first time a clear insight into the characters of some of its constituents. This elaborate paper shewed that the ortho-rhombic varieties were clearly entitled to be divided into distinct mineral species.

As I believe neither the Chilian nor the Peruvian varieties of Brochantite have yet been described in detail, the following notes on a few specimens obtained from some mines near Pisco may be of interest. My attention in examining them was directed partly to their physical and chemical characters and partly to their associations, and for the sake of completeness I have added some notes on the associations of the mineral when found in other localities.

No. 1, from near Pisco, consists of an aggregation of crystals of a light emerald-green colour closely compacted together. The crystals run in all directions, but as none of them protrude beyond the surface, I could not obtain any measurement of their angles. An analysis of this specimen was kindly made for me by my friend Mr. H. T. Mannington of Messrs. Muspratt and Son's chemical works, and the results obtained were

Cu O .. .. .	61.21
S O <sub>3</sub> .. .. .	18.10
C O <sub>2</sub> .. .. .	2.20
Cl .. .. .	.99
Fe O .. .. .	.33
Zn O .. .. .	1.50
Al <sub>2</sub> O <sub>3</sub> .. .. .	4.95
H <sub>2</sub> O .. .. .	8.90
Silica (chiefly) &c. .. .. .	1.82

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 100.

Specific gravity 3.32.

This variety being scratched by Calcite, the hardness may be taken as somewhat under 3 on Mohs' scale.

This aggregation of crystals was met with in a large number of specimens.

The analysis of the above shows it to be intermediate in composition between the Brochantites of which analyses are given in Dana's "System of Mineralogy," and the Cyanotrichites named in the same volume.

In some other specimens, however, a few cavities ("vughs") were met with, and here I found a few crystals. They have the curved appearance and striations generally noticed in crystals of Brochantite, and their resemblance to the crystals of Atacamite found in the same deposits is extremely striking. It is often a matter of difficulty indeed to distinguish one mineral from the other in my specimens, though perhaps the Brochantites are rather lighter in colour than the Atacamites, and are also more transparent.

No. 2 specimen had some crystals 6 m/m in length, and 1 m/m in breadth. As I did not feel sufficient confidence in my measurements of these crystals, I forwarded some to Dr. O. C. Trechmann, and his remarks thereon are appended at the end of this paper. I would here express my obligations to this gentleman for the kindness with which he voluntarily accepted this duty, and the care with which he has executed it.

No. 3 is, in the lower portion of the stone, composed of hemispherical and in some cases almost spherical masses of Malachite of a dark-green colour, the fibres of which are not very closely aggregated together. On these is a layer of an amorphous mineral which is adherent to the tongue. A chemical examination of this amorphous matter shows this to contain both carbonic acid and sulphuric acid in combination with copper. It is in fact an amorphous sulphato-carbonate of copper. This amorphous material, which is of a delicate light bluish-green colour, passes into a darker shade, and at length we meet with a mineral of an emerald-green colour which has the appearance of Malachite, but not its composition. It is sulphate and not carbonate of copper.

A close examination of the light-coloured portion enables one to detect some parts of it which have a fibrous structure, and these pass insensibly into the amorphous variety. It is evidently Malachite decomposing. Though I endeavoured with a lens to pick out pieces in which no structure was visible, I invariably found a slight effervescence with Hydrochloric acid. On its uppermost surface were distinct crystals of Brochantite with the usual well-developed cleavage.

No. 4.—A large specimen which I broke into several pieces shows the replacement of the carbonate by the sulphate still more clearly, as the outer portion of a hemispherical mass was found to be composed of sulphate while the interior is composed of carbonate of copper.

No. 5 and 6 have beautiful tufts of acicular crystals of Brochantite of a light-green colour, much resembling the tufts of Malachite found with the Ruby ore of New Quebrada Mine, but presents no other features of importance except the occurrence of these crystals in connection with dark-green transparent crystals of Atacamite, which might at first sight be taken for crystals of Brochantite.

*Pseudomorphs of Chrysocolla after Brochantite.*

No. 7 is a specimen of much importance, and deserves more than a passing notice. It is a mixture of Malachite, Atacamite, and Chrysocolla, the exterior being principally composed of nodules of the first-named mineral. These nodules are coated with a thin layer of Brochantite, and in some places distinct and well-defined crystals of this mineral are seen.—Some of the nodules have been decomposed into the amorphous sulphato-carbonate of copper before described, and the whole is then covered by a layer of Chrysocolla. My attention was first attracted by several of the Brochantite crystals being covered by a thin layer of chrysocolla, and on making a very close examination I found that in many instances the original sulphate had been entirely replaced by silicate of copper, and that in fact we had pseudomorphs of Chrysocolla after Brochantite

*Conclusions*

Looking at these specimens from a paragenetic point of view, one is struck with the association of Brochantite. In my paper on the "Chrysocolla Group" (see Min. Mag. No. 11), I noticed the occurrence of sulphate of copper in connection with silicate of copper, and further examination have shown me that this association is very common, but I find that the sulphate is met with quite as frequently in association with the carbonate of copper in the Chilian ores, and as the instances given at the close of this paper will show, the same close connection is met with in other localities.

The occurrence of Brochantite in Peru associated with the same minerals as at Arizona is important as illustrating its origin.

The ores of copper found with it, malachite, chrysocolla, and atacamite (though perhaps the last should not be used in argument), are all indicative of "change." So too are the sulphates of lime, baryta, and alumina.

Herrengrundite seems to show the combination of the two sulphates of lime and copper, and the elaborate review which appeared in a late number of the Mineralogical Magazine, points to a similar origin for this mineral, namely, the decomposition of other copper ores.

With Herrengrundite is found a group of interesting minerals, Azurite, Malachite, Peticite, Gypsum.

With the Brochantite of Laurium we find Azurite, Malachite, Cyanotrichite, Adamine, Aurichalcite and Calamine.

With the Arizona and Chilian Brochantites we meet with Malachite, Chrysocolla, Gypsum, and Barytes.

With the Brochantites of Cumberland we find Malachite and Chrysocolla.

All these "species" are the products of decomposition. The occurrence too of these carbonates, sulphates and silicates near the surface, and their general disappearance as we proceed deeper in our mines, point to their being "derived" or "secondary" products.

The important investigations of Field, which prove that chloride of copper can be formed when an alkaline hypochlorite is added to a boiling solution of sulphate, nitrate or chloride of copper, appears to me to throw much light on the frequent association of Gypsum and Barytes with the Brochantites and Atacamites of Chili and Peru. Some specimens I have present layers of Gypsum and Atacamite, much resembling the layers in a stratified rock. "Lyellite" too is shown by Tschermak to be Langite, an important member of the Brochantite group mixed with Gypsum. An analysis of some copper ore from Bolivia, by Mr. W. Terrill, F.C.S., of Morfa Works, Swansea, also bears on this subject. It seems to point to the action of sulphate of copper on a basic feldspar, and the following are the rough results:—

Cu O	..	..	..	..	..	..	..	..	14
Ca SO <sub>4</sub>	..	..	..	..	..	..	..	..	18
Al <sub>2</sub> O <sub>3</sub>	..	..	..	..	..	..	..	..	18
Ca O	..	..	..	..	..	..	..	..	11
Si O <sub>2</sub>	..	..	..	..	..	..	..	..	25
H <sub>2</sub> O	..	..	..	..	..	..	..	..	12

98 %

The changes resulting from the decomposition of ores composed of copper, sulphur and arsenic, seem almost endless. It must strike even the most superficial observer as a strange fact, that the sulphates containing copper constitute about one third of the basic sulphates of Dana.

Doubtless, were analyses made, we should obtain a large number of New Minerals, if the replacement of small quantities of copper by other elements constitute the title to a new name.

It was with feelings of regret that I saw the cargo of ore, from which my specimens were derived, consigned to immediate and complete destruction in the crushing mill. Like a botanist witnessing the trampling down of his fairest and rarest flowers, I saw these brilliant gems mangled and crushed.

Through the kindness of the owners I was, however, enabled to preserve a few specimens, and as some of them are deposited in our grand National Collection, they can be referred to by other Mineralogists; but I cannot help noticing what a vast heap of valuable specimens was here destroyed with scarce a look being bestowed upon it, or fragment preserved.

Observations on the crystals by Dr. Trechmann.

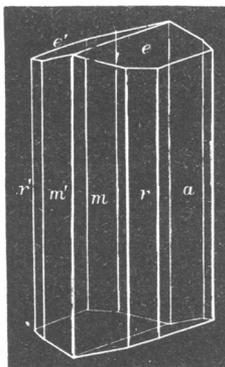


Fig. 1.

*Brochantite from Pisco.*

The small acicular emerald to dark-green crystals, are so ill-adapted for measurement, on account of the striations and curvatures of the faces, that the following angles can only be regarded as approximations to the truth, but sufficient for fixing the forms.

Retaining for comparison the prismatic system (later researches refer this mineral to the oblique or anorthic systems), I find the following combination of well-known forms, (Fig. 1):

<i>a</i>	.. .. .	100	<i>r</i>	.. .. .	210
<i>m</i>	.. .. .	110	<i>e</i>	.. .. .	101

Measured Angles.	Brooke and Miller.*	Kokscharow.†
<i>a</i> : <i>m</i> = 52° 43'	52° 5'	T : M = 52° 16'
<i>a</i> : <i>r</i> = 32° 33'	32° 42'	T : <i>l</i> = 32° 52'
<i>a</i> : <i>e</i> = 76° 10'	75° 56'	T : <i>x</i> = 76° 19'

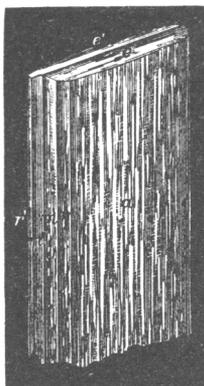


Fig. 2.

All the faces in the prismatic zone are more or less vertically striated, and consequently give to the crystal a curved appearance, which I have tried to represent in Fig. 2. The faces of *e* are slightly curved but not striated.

Similar crystals, also associated with atacamite, chrysocolla, &c., were described by F. A. Genth, (*Am. Journ. of Science*, 1868, p. 321) from Bill Williams' Fork, Arizona.

Fig. 1 is reproduced from Kokscharow, Atlas, Plate LIII.

\* Brooke and Miller, *Mineralogy* 1852, p. 553.

† Kokscharow, *Materialien z. Min. Russlands*, III, p. 260.