XIII.—*Chemical Researches on New and Rare Cornish Minerals.*

By A. H. Church, M.A., Professor of Chemistry, R.A. College, Cirencester.

(Continued from vol. III., new series, p. 259.)

IV.—*A New Hydrated Cupric-aluminum Sulphate.*

I have been engaged for some time in analysing certain chrysocollas containing aluminium, similar to the Tuscan specimens

described by Delesse. But no definite composition was presented by these bodies; indeed they were evidently mixtures in most instances. In some of the specimens, I found, as Berthier had previously stated, much sulphuric acid, and at last I have obtained from Mr. Talling some specimens of a mineral almost free from silica and containing over 13 per cent. of sulphuric acid. I noticed it in Mr. Talling's collection, was struck by its appearance, and at once secured a few fragments. The analyses proved satisfactory and accordant, and showed the mineral to be a new and undescribed species. I purpose naming the mineral *Woodwardite* after my valued friend, the late Dr. S. P. Woodward. I shall be glad if this slight act of homage to the memory of an eminent man of science, serve to recall the labours of a palæontologist who was well versed likewise in chemical geology.

Woodwardite occurs in stalactitic forms consisting of minute botryoïdal aggregations. It often constitutes a crust about $\frac{1}{5}$th of an inch in thickness, and possessing the peculiar rippled appearance well seen in some specimens of langite. Woodwardite presents a most striking appearance when viewed with an $1\frac{1}{2}$ inch objective in the microscope, the mammillary or botryoïdal aggregations being arranged in irregular columnar masses. No trace of crystalline structure has yet been detected. The mineral is perfectly uniform in appearance, and evidently free, except where in contact with its matrix, from all admixture.

To the unassisted eye, Woodwardite appears nearly opaque, but under the microscope the globules of which it consists are seen to be translucent.

The lustre is between waxy and dull.

The colour of the mineral is a rather greenish turquoise-blue.

The streak and powder are pale blue.

The mineral, though it readily falls to a coarse powder, presents a peculiar toughness and tendency to cohere under the pestle, resembling camphor and sal-ammoniac in this respect.

The hardness is about 2.

The specific gravity is about 2·38. This determination is approximative only; it was made with a specimen freed from interstitial air, but containing a large quantity of hygroscopic or accidental moisture, about 13 per cent. in all probability.

Woodwardite is tasteless and without odour. It dissolves readily in dilute acids, a minute residue, about 1 per cent., of gelatinous silica remaining unaffected.

Heated in a bulb-tube before the blow-pipe, it gives off a large amount of water with a slightly acid reaction, the residue becoming olive-brown, and, finally, black. Heated to 100° the blue tint of the mineral thereby becomes richer.

In vacuo over oil of vitriol woodwardite loses a somewhat variable amount of water. Like many other uncrystallized minerals, it is hygroscopic, and if dried merely between pieces of filtering paper would be found to give a different formula on a dry and on a damp day. One determination of this accidental water gave 13·33 per cent., another a considerably smaller proportion. But the vacuum-dried mineral loses a constant amount of water at 100°; while the mineral dried at 100° suffers a considerable and perfectly definite further loss at a temperature below redness.

Woodwardite contains traces of phosphoric acid, lime, and magnesia; the percentage of phosphoric acid has been determined, the lime and magnesia do not exist in sufficient quantity to be estimated. The analysis of the mineral offers no difficulty: in one instance (Anal. III) the sample for analysis was thoroughly washed before being employed. The wash waters contained a minute trace of copper.

Analyses I and II were made by my assistant Mr. R. Warington, Junior.

I. 5·47 grains of the mineral dried in vacuo gave:—

·06 grain of SiO_2.
·21 grain of H_2O at 100°.
2·56 grains of CuO.
1·00 grain of Al_2O_3.
2·00 grain of $BaSO_4$.

II. 10·19 grains dried in vacuo lost at a red heat:—

2·41 grains of H_2O; and gave
3·67 grains of $BaSO_4$.

III. ·4 gramme, dried at 100°, gave:—

·005 gramme of SiO_2.
·073 gramme of H_2O, at a low red heat.
·191 gramme of CuO.
·071 gramme of Al_2O_3.
·1605 gramme of $BaSO_4$.

IV. ·5725 gramme dried in vacuo gave:—

·0035 gramme of SiO_2.
·0300 gramme of H_2O at 100°.
·0955 gramme of H_2O at a low red heat.
·267 gramme of CuO.
·099 gramme of Al_2O_3.
·209 gramme of $BaSO_4$.

V. ·246 gramme dried in vacuo gave:—

·014 gramme of H_2O at 100°.

VI. ·271 gramme dried in vacuo gave:—

·015 gramme of H_2O at 100°.

The preceding analytical results point without doubt to a definite formula for the mineral, not only after it has become of constant weight in vacuo, but after drying at 100° C. To analyse the mineral, indeed, exactly in its natural condition of moisture would be useless, for as the atmospheric water increases or diminishes so does that of the mineral. But in vacuo over oil of vitriol, Woodwardite acquires in the course of an hour or two a perfect constancy of weight and composition. The formula which suggests itself for the mineral in this state is—

$$2Cu''SO_4.5Cu''H_2O_2.4Al'''H_3O_3.4H_2O.$$

This formula demands the percentages given below:—

		Theory.	Experiment. (mean.)
7 $Cu''O$	557·5	46·67	46·87
2 $Al_2'''O_3$	206·0	17·27	17·66
2 SO_3	160·0	13·42	12·50
15 H_2O	270·0	22·64	22·86
	1193·5	100·00	99·89

The numbers required by theory agree well with those furnished by experiment, except in the case of the SO_3 in which there is a deficiency of nearly one per cent. in the amount found. This may be accounted for by the occurrence of a small quantity of silicic acid in the mineral.

The formula of the mineral, after it has been dried at 100° C., is—

$$2Cu''SO_4.5Cu''H_2O_2.4Al'''H_3O_3.$$

This formula demands these percentages—

		Theory.	Experiment. (mean.)
7 CuO	557·5	49·65	48·85
2 Al_2O_3	206·0	18·39	18·33
2 SO_3	160·0	14·28	13·43
11 H_2O	198·0	17·68	18·10
	1121·5	100·00	98·71

This new mineral, though physically and chemically distinct from Lettsomite, is near that species. Woodwardite is more basic than Lettsomite, both in regard to the cupric and aluminic oxides. The difference is most strikingly seen in the percentage of alumina; in Lettsomite this amounts to 11·06 per cent. only, according to Dr. Percy's analysis: in Woodwardite it is nearly 18 per cent. It is possible to regard the new mineral as a compound of brochantite and gibbsite.

A trace of copper is removed from Woodwardite by digestion in cold water. Analysis IV. was made with a specimen so purified.

The following percentages are those deduced from analyses I., II., IV., V., and VI. Before calculating the results, the small amount of silica found, about 1 per cent., has been subtracted in all the analyses but II. In analysis I. the phosphoric acid, which was found in the alumina, has also been deducted: ·03 of a grain of $Mg_2''P_2O_7$ was obtained, corresponding to ·0192 of P_2O_5:—

Analysis of Woodwardite dried *in vacuo*:—

	I.	II.	IV.	V.	VI.
H_2O lost at 100°	3·80	23·65	5·28	5·69	5·53
H_2O lost on ignition ..	—		16·79	—	—
CuO	46·80	—	46·95	—	—
Al_2O_3	17·93	—	17·40	—	—
SO_3	12·54	12·37	12·60	—	—

The following percentages are based on analyses I., III., and IV., the weights taken being those of the mineral dried till constant at 100° C.

Analyses of Woodwardite dried at 100° C:—

	I.	III.	IV.
H_2O lost on ignition....	(19·65)	18·48	17·72
CuO	48·67	48·34	49·54
Al_2O_3.....	18·64	17·97	18·37
SO_3	13·04	13·95	13·30
	100·00	98·74	98·93

I have already described to the Society several mineral species new to science as occurring in Cornwall. During my experiments I have obtained numerous results relating to species already described, some of which, however, have not hitherto been recognized as Cornish, or are of rare occurrence.

Melaconite.—This mineral was described by me in March last as occurring in a definite crystallized form. I had then observed forms quite incompatible with the cubical system, and had communicated the fact to Professor Miller of Cambridge: in my notice in the Chemical News I stated that it was my intention to measure the crystals, but Professor Maskelyne soon after read a paper on the crystalline form of the mineral before the British Association last summer, and exhausted the subject, although the paper has not yet been published in full. I cannot regret that the crystallographic work has fallen into hands so much more competent to deal with it than my own.

Marmatite.—This black variety of blende occurs in Cornwall. The composition is similar to the Marmato specimen analysed by Boussingault, and is represented by the expression 4ZnS.FeS.

Erinite and Cornwallite.—The only reported locality of erinite is Limerick. But I have a few grains, which I have identified with this species, from Cornwall. I have met more frequently with Cornwallite, a perfectly distinct species. But there exists an impure chrysocolla containing phosphate which has occasionally been mistaken for the latter species.

Autunite.—I have examined a Cornish specimen of autunite incrusting chalcolite, and found it as free from copper as the St. Symphorien specimens.