

XXII.—*Chemical Researches on New or Rare Cornish Minerals.*

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No. 7. RESTORMELITE.

I have obtained on various occasions, from the Restormel Iron Mine, a mineral which might easily be mistaken for one or other

of the Chinese stones, which are grouped under the vague term agalmatolite. But on comparing the physical and chemical characters of these oriental pinites and pyrophyllites with my Cornish specimens, I found such marked differences as to induce me to make a more extended study of the subject. The material being amorphous, and evidently incompletely altered, was far from promising, but the hope of throwing some light upon the chemical history and formation of similar products, induced me to make several analyses of my specimens. The constancy of their characters and composition was distinctly proved by a physical examination, and by the experimental chemical results given below. I do not, however, think that I should be in the least degree warranted in assigning specific rank to the Restormel mineral, and though I propose for it the definite name of restormelite, its proper place appears to me that of a new variety of kaolinite. If we look at the various hydrated aluminium silicates, which have been separately recognized, we shall find that restormelite is near halloysite, but differs from that species by containing 7 per cent. of alkalis, and only half as much water; that it is not to be included under the comprehensive pinite, since that species contains only 6 instead of 12 per cent. of water; and that it is separated from pyrophyllite by the same divergence. These are chemical differences; in hardness and specific gravity further points of variation are to be observed. In fact it is only when we come to those lithomarges included by Dana under kaolinite, that we find a collocation of physical and chemical characters, nearly the same as that of restormelite. The specific gravity of restormelite is 2.58, that of lithomarge nearly the same. Its hardness is about 2, in which also it agrees with lithomarge. In its percentages of silica and alumina, its chief constituents, there is little difference, but while restormelite contains 7 per cent. of soda and potash, lithomarge contains a mere trace of these alkalis. There is less water in restormelite than in lithomarge, but as we do not know how much hygroscopic water is included in the 15 per cent. found in the latter mineral, this point is of minor importance. I think on the whole we must regard restormelite as preserving in its alkalis more evident traces of its felspathic origin than we usually find in such alteration products. I give below the analyses and characters of restormelite.

The restormelite employed for analysis was taken from

several distinct specimens. It was uniform in texture, and in colour, a faint, greenish grey, streak white, fracture subconchoidal, lustre greasy to dull. Its sp. gr. was 2·58, and its hardness 2. Heated in a tube, it readily gives off neutral water, and becomes grey and opaque. With oil of vitriol it does not gelatinize. Restormelite contains a small but variable amount of hygroscopic water, about 1 per cent. This water is lost in vacuo over oil of vitriol after some time, or very rapidly at 100°. The selected specimens for analysis were dried in the water oven, and the uniformity of the results shows the fixity of the combined water.

Analyses of Restormelite.

Analysis.	Substance taken.	Loss on Ignition.	SiO ₂ .	Fe ₂ O ₃ .	Al ₂ O ₃ .	Mg ₂ P ₂ O ₇ .	PtK ₂ Cl ₆ .	Na ₂ SO ₄ .
I.	1·706	·1995	—	—	—	—	—	—
II.	1·463	—	—	—	—	·0335	·139	·148
III.	·9825	·1155	—	·012	·3445	·019	·1175	·093
IV.	·842	·098	·3845	·0118	·3002	·022	—	—
V.	·914	·1065	—	—	—	—	—	—
VI.	·960	—	—	·0105	·332	—	—	—

Percentages deduced from Analysis.

	I.	II.	III.	IV.	V.	VI.
H ₂ O.....	11·69	—	11·75	11·64	11·65	—
SiO ₂	—	—	[44·77]	45·66	—	—
FrO.....	—	—	1·11	1·25	—	·98
Al ₂ O ₃	—	—	35·05	35·66	—	34·58
MgO.....	—	·92	·69	·95	—	—
K ₂ O.....	—	2·10	2·51	—	—	—
Na ₂ O.....	—	4·66	4·12	—	—	—

These results correspond pretty well with the formula of kaolinite, Al₂O₃2SiO₂, 2aq., if we suppose several replacements, such as a partial replacement of hydrogen by sodium or potassium, and of aluminium by iron. Pure kaolinite would contain 46·3 p.c. silica, 39·8 p.c. alumina, 13·9 p.c. water. It would, perhaps, be more strictly exact were we to speak of restormelite as an *immature* kaolinite, rather than as a kaolinite in which subsequent changes had taken place.

No. 8.—CHALCOPHYLLITE.

IN some of my previous communications to the Society, I have included the results of analyses of rare as well of new materials. Chalcophyllite, the tamarite of Brooke and Miller, the mineral sometimes termed copper-mica, is not often found in well defined crystals. I do not know of any fresh localities where this species may be procured in forms so good as in the three or four Cornish mines where it was first discovered. In consequence of the few and discordant analyses which we possess of this most beautiful mineral, I have devoted much time and labour to an endeavour to clear up the mystery of its constitution. The results to be given further on were obtained with two very choice specimens, one from Wheal Gorland, and the other from an unknown Cornish locality. I need not say that every possible care was taken to exclude all visible impurities or intruding materials from the prepared samples employed in my analyses.

It will be proper to show, in the first place, that the recorded analyses of chalcophyllite are not quite satisfactory. This will be evident enough when Chenevix found in this mineral 58 per cent. of cupric oxide and 21 of water; Hermann, 44·45 per cent. of cupric oxide, and 31·19 of water; and Damour, intermediate proportions, namely, 52·61 of cupric oxide, and 23·26 of water. Smaller variations are also to be observed in the percentage of the third chief constituent of chalcophyllite, the arsenic pentoxide. Ferric oxide, phosphorus pentoxide, and alumina, have also been detected to a trifling extent in this mineral by different analysts.

It will be readily conceived that there is some difficulty in arriving at a formula for so apparently variable a substance. The expression usually adopted has been, $8\text{CuO}, \text{As}_2\text{O}_5, 12\text{aq.}$, which corresponds pretty well with the analysis by Chenevix, but in the percentage of water which it demands is quite incompatible with the results of the other analysts. All my results confirm the ratio of CuO to As_2O_5 ; but the accepted formula must nevertheless be modified in two particulars. I find the water present in perfectly pure and transparent crystals to amount to more than 31 per cent., while the above formula demands only 20, and I also find an amount of alumina, too

large in quantity to be neglected in constructing an expression for this species. In fact, by the results now to be laid before the Society the previous discrepancies are explained, and it will be seen that chalcophyllite is much more nearly allied to liroconite, another hydrated cupric aluminic arseniate, than is generally thought to be the case. I will here only state that the two minerals have been observed to occur together, that somewhat similar variations of colour are found in specimens of the two species, and that the oxygen ratio of their constituents is analogous, though not identical. I may also add that the alumina detected in liroconite was for some time considered an accidental impurity.

Before giving the analytical results, it should be stated that chalcophyllite cannot be dried, even *in vacuo*, without an entire change in its appearance. It then becomes opaque, paler, and of a more bluish-green, acquiring an almost pearly lustre, if in crystalline fragments. These changes correspond to a loss of 13·79 per cent. of water. At 100° C. the insignificant further loss of ·31 per cent. of water takes place. In the following analyses the finely powdered mineral was dried at 100°, and its loss of water, under these circumstances, was so constant, that it becomes impossible from this cause (as well as from other considerations) to regard any part of this water as hygroscopic. We now come to the analyses :—

Analyses of Chalcophyllite.

No.	Substance taken.	H ₂ O lost at 100°.	CuO.	Fe ₂ O ₃ .	Al ₂ O ₃ .	As ₂ S ₃ .	(MgNH ₄ AsO ₄) ₂ aq.
I.	·2218	·0313	—	—	—	—	—
II.	·3325	·046	·1555	·002	·019	·0555	—
III.	·296	·042	·1347	0018	·0185	—	·076

Percentages deduced from Analyses.

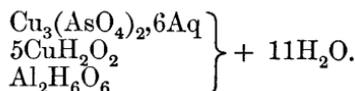
Analyses.	I.	II.	III.	Mean.
H ₂ O lost at 100° C.	14·10	13·83	14·19	14·06
CuO	—	46·76	45·51	46·14
Al ₂ O ₃	—	5·69	6·25	5·97
Fe ₂ O ₃	—	·60	·61	·60
As ₂ S ₃	—	15·49	15·58	15·54
H ₂ O (by difference)	—	31·46	32·05	31·75

Two formulæ suggest themselves as best expressing the above results: here are the percentages demanded by these theories, placed, for comparison, side by side, with the mean percentages furnished by analysis:—

	Theory.		Experiment.
	I.	II.	Mean.
	8CuO, Al ₂ O ₃ , As ₂ O ₅ , 24H ₂ O.		
CuO	45·39	44·82	46·14
Al ₃ O ₃	7·35	7·26	5·97
As ₂ O ₅	16·42	16·21	15·54
H ₂ O	30·84	31·71	31·75
	100·00	100·00	99·40

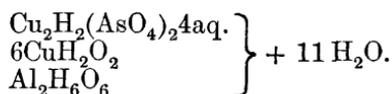
If we accept formula I, we shall find that a loss of 11H₂O out of its 24H₂O will correspond to a percentage loss of 14·13; with the formula II above, 11H₂O correspond to 13·95 per cent. Either of these numbers corresponds very closely with the actual loss of water which our mineral suffered *in vacuo*, namely, in analysis I above, 13·79 per cent., the mean result of all similar experiments being 14·06. As the residual water was determined by difference, owing to loss of arsenic on heating the mineral, I fear that the analyses will not decide between the claims of these rival formulæ, with 24 or 25 aq. As to the other constituents of chalcophyllite, the slight discrepancies between theory and experiment can be explained in a measure. The cupric oxide is a little too high, because it probably contained a trace of alumina and arsenic pentoxide, so lowering the numbers of those two compounds proportionately: part of the alumina was probably replaced by the trace of ferric oxide found. I should expect to find more ferric oxide in the grass-green specimens of the mineral than in the emerald-green ones submitted to analysis.

It now remains to be seen how the elements of chalcophyllite are arranged. The following formula corresponds to and includes most of the experimental results:—



If we take formula I, the expression will only differ by containing 5H₂O in place of the 6H₂O, united with the arseniate.

In order to compare the formulæ of liroconite and chalcophyllite we shall have to assume the basicity of 1 of the $5\text{H}_2\text{O}$ in the latter:—



The oxygen ratios of basic oxide, acid oxide, and water, will then stand thus:—

Liroconite	6	:	5	:	12
Chalcophyllite ..	12	:	5	:	24

As to the general physical characters of chalcophyllite, I have only to add that the specific gravity of my specimen was 2·44; and that the pyrognostic indications usually assigned to this species require this addition, that the olive-green scales left when the crystals are heated blacken when the temperature is further raised, and finally evolve a vapour condensing to a white or straw-coloured sublimate.
