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I.—*Mineralogical Notices.*

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1. ON THE FORMATION OF BASIC CUPRIC SULPHATES.

In 1867 M. Pisani described a mineral which he supposed to be the woodwardite of Mr. Church. The substance, however, is not the latter mineral. It had previously been examined in the laboratory of the British Museum, and the results sufficiently tallied with those of M. Pisani to enable us to identify the mineral.

It occurs in very thin crusts of various shades of yellow and green, the surface exhibiting a wavy appearance. Though the outer surface is occasionally somewhat compact, the mass is loose, and some of the layers pulverulent. Below are the results of the analyses of both portions:—

The inner layer—

Copper oxide.....	24·561
Alumina.....	23·063
Calcium oxide	0·086
Magnesium oxide.....	0·749
Sulphuric acid	6·775
Silicic acid	6·689

Water—

lost at ord. temperatures.....	15·39	
„ 100°.....	10·413	
„ 120°—260°	7·333	
„ over 260°.....	5·392	
	38·528	

100·451

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The crust—

Copper oxide	10·255
Alumina	27·25
Calcium oxide	1·403
Magnesium oxide	6·183
Sodium oxide	0·643
Sulphuric acid	2·438
Silicic acid	7·53
Carbonic acid	0·528

Water—

lost at ord. temperatures	13·938
„ 100°—260°	23·864
„ over 260°	6·167
	<hr/>
	43·969
	<hr/>
	100·199

These numbers give us but little insight into the constitution of the mixed minerals. M. Pisani was right in regarding them as made up of langite and one or more hydrated aluminous silicates. The only interest they offer is in the light they seem to throw on the possible modes of the formation of native basic cupric sulphates.

The actions of solutions of magnesium- or calcium-sulphate on malachite in presence of carbonic acid may terminate in the production of langite, the alkaline earth being removed as acid carbonate, and the aluminous silicate may be looked on as an accidental ingredient, if not as a mechanical vehicle in which the langite has been retained.

An experiment in the laboratory showed that an insoluble cupric sulphate and acid magnesium carbonate were actually formed. Such experiments, however, obviously need much time for the process to be sufficiently complete to justify our assigning this as the *modus operandi* by which the minerals of the brochantite group have been formed in the mine.

2. OPAL, WADDELA PLAIN, ABYSSINIA.

Mr. Markham, geographer to the Abyssinian Expedition, presented to the British Museum some remarkable specimens of green opal from the above locality. The mineral is banded,

of a dark smoky green with occasional layers of white opal, resembling the prase opal of Faroe, its ribboned character recalling the structure of the onyx agate of that locality. Its exterior is weathered, and passes into a yellowish-white cacholong.

Most, but not all, of the water passed off at 100°, and the analysis of the mineral yielded the following numbers:—

Silicic acid (soluble).....	90·562
Silicic acid (insoluble)	2·049
Water.....	5·656
Iron peroxide.....	0·933
Manganese oxide	Trace
Calcium oxide	0·137
Magnesium oxide.....	0·311
	<hr/>
	99·648

3. FRANCOLITE, CORNWALL.

To the localities of this mineral hitherto recorded, Wheal Franco, near Tavistock, and Fowey Consols, Mr. Talling added two years since a third as yet unnamed source. The matrix as before, is quartz and chlorite, but the new specimen is not associated, like that from Fowey Consols, with chalybite, whilst small quantities of pyrites accompany it. But the interest of the mineral lies in the fact that it contains a definite proportion of calcium carbonate; it is in fact a fluor-apatite in which one equivalent in every six of the calcium phosphate is replaced by carbonate. Analyses of several specimens gave the following results:—

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Calcium oxide	54·008	—	—	—	54·168	—	—	—
Iron and manganese oxide.....	0·937	—	—	—	0·786	—	1·016	—
Sodium oxide.....	—	—	—	—	0·694	—	—	—
Phosphoric acid.....	—	37·943	—	—	38·336	—	—	—
Carbonic acid.....	—	—	2·414	2·079	—	—	—	—
Fluorine	—	—	—	—	—	—	—	3·342
Water	—	—	—	—	—	1·593	—	—

The mean of these analytical results gives the subjoined numbers as indicative of the constitution of this mineral:—

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		Equivalent ratios.
Tri-calcium phosphate.....	83.261	0.537
Calcium fluoride	7.683	0.197
Calcium carbonate	5.104	0.102
Iron and manganese oxide..	0.913	—
Sodium oxide	0.694	—
Water.....	1.593	—
	<hr/> 99.248	

The ratios point to the following formula :—

That the calcium carbonate is present as an essential constituent is shown by the fact of the mineral dissolving in acid, with an effervescence which continues as long as any portion of the substance remains visible.

It is not a little remarkable that the francolite of Wheal Franco analysed by Mr. Henry* fell short of the full percentage by precisely the amount corresponding to the CO_2 found in the above analysis. In fact, the Wheal Franco francolite, as well as that of Fowey Consols, contains this ingredient.

This mineral contains no chlorine; its solution in hydrogen nitrate, when evaporated to dryness, strikes a fine violet tint, owing to the presence of a small amount of manganese.

The crystallography of this mineral seems also to point to its not being ordinary apatite, and, indeed, to its not being the same mineral as that from Wheal Franco, originally named francolite. This variety and that from Fowey Consols, while being so far similar in their chemical composition, that both contain calcium carbonate, are also similar in the composite nature of their crystals.

The true francolite consists of small well-defined hexagonal prisms, usually terminated by the basal plane 111. The crystals of the variety under description consist of little aggregated crystals, in which the prisms intersect with each other in a confused manner, which may arise from their being twinned; but with such minute and rough or tessellated surfaces it is impossible to determine the twin plane. The prisms are terminated by a low pyramid, the faces of which form, with those of the prism $2\bar{1}\bar{1}$, an angle which an average of several measure-

* Phil. Mag., 1850 [3], xxxvi, 134.

ments by the goniometer, with its object-glass used microscopically, gave as $72^{\circ} 47'$.

The summit plane 111 seems singularly enough to be always absent, a not common feature in a true apatite.

If we assume the angle $55^{\circ} 40'$, which Miller takes for that of the planes 111,100 of apatite, the plane in question may have for its symbol 744; the angle $2\bar{1}\bar{1},744$ being by calculation $73^{\circ} 41'$, by observation $72^{\circ} 47'$.

It would be futile to modify the angle of the fundamental rhombohedron so as to bring this angle into more precise accordance with the measurements.

It is well known that the elementary angle varies in the apatites of different localities and composition; and it is quite probable that in this case also it is not quite the same as in ordinary fluor-apatite, but the measurements are not sufficiently exact to justify a modification of the elementary angle to meet them.

It is, however, clear from the above observations on the mineral from Fowey Consols and from the new locality, that it is not the same variety of apatite with that from Wheal Franco, nor indeed from any other locality.

4. EPIDOTE AND SERPENTINE, IONA.

Several green minerals occur in Iona, some of which have been miscalled Jade. One of these sent to the British Museum by the Duke of Argyll is a pebble in which the green mineral traverses bright red felspar and quartz in veins. Its specific gravity is 3.14 and hardness 6.5; it has a dull lustre and fracture and gives no indications of cleavage; its physical characters did not accord with those of epidote, nephrite, or serpentine. Its analysis gave the following numbers:—

		Oxygen ratios.
Silicic acid.....	51.565	27.50
Iron peroxide	13.519	4.05
Aluminium oxide	13.402	6.24
Calcium oxide	17.642	5.04
Magnesium oxide.....	0.642	0.25
Sodium oxide	1.400	—
Water.....	0.661	—
	<hr/>	
	98.831	

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The percentages and oxygen ratios indicate a mixture of a lime-epidote with some 23 per cent. of quartz, the former mineral having the following constitution:—

This formula requires 17·77 per cent. Al_2O_3 , and 18·65 per cent. Fe_2O_3 against 17·87 per cent. of the former and 18·03 per cent. of the latter oxide in the above analysis.

Greg and Lettsom mention Iona as a locality of epidote in association with clinkstone, and Jameson observes that epidote occurs at Icolmkill (*i.e.*, Iona) and Rona, in small veins with red felspar and quartz.

The other green stones from Iona were varieties of serpentine, some mixed with dolomite, others nearly pure and very translucent. The tint varies from greenish yellow to olive green, and a specimen of each extreme of colour was analysed. The yellow variety has a specific gravity of 2·52, a hardness nearly 4, and is given below as A. The green variety has a specific gravity of 2·574, a hardness of 3·5 to 4, and is B of the subjoined table:—

	A.	B.
Silicic acid	41·792	41·103
Iron protoxide	2·537	5·734
Calcium oxide.....	1·864	5·734
Magnesium oxide	39·262	32·882
Water,.....	14·012	14·481
	<hr/> 99·467	<hr/> 99·934

These numbers accord tolerably well with the formula

where R represents, in the first case, Mg with a little Fe and Ca; in the second Mg, nearly one-fifth of the equivalent of which is replaced by a mixture of equal equivalents of iron and calcium,

5. VIVIANITE.

For some time past specimens of vivianite, found by Mr. Talling in a new unnamed Cornish locality, have been in the hands of mineralogists. Some are beautifully crystallised, and present a very pale bluish-green tint; others are nodular in

form, deep blue in colour, and pulverulent in character, sometimes enclosing crystals or crystalline masses of incomplete form, dark brown colour, and exhibiting a reddish tint by reflected light.

The first of these varieties occurs generally in cavities with crystals of quartz and chalybite on a gangue, principally composed of blende, with a little galena, iron pyrites, copper pyrites, and some mispickel. It also occurs associated with hisingerite and limonite in cavities in massive iron pyrites, or again occasionally with bright and excellent crystals of scorodite, or with chalybite and cronstedtite on quartz. This assemblage of minerals much resembles that met with in some of the specimens from Old Wheal Kind, near St. Agnes.

The pale tinted and well crystallised variety has been examined crystallographically by Professor vom Rath.* When pounded in a mortar it rapidly changes from an almost colourless to a fine blue powder, evidencing an instability in the nature of the compound, which render precautions necessary in its analysis. When these precautions were taken, the mineral proved to be a nearly pure octahydrated ferrous orthophosphate. The following numbers were obtained in the analysis:—

	I.	II.	III.	Mean.	[3FeO,P ₂ O ₅ ,8H ₂ O.]
Iron protoxide	42·358	43·06	—	42·709	43·028
Iron peroxide.....	—	—	1·126	1·126	—
Phosphoric acid	—	28·526	—	28·526	28·286
Water.....	—	28·984	—	28·984	28·686
				<hr/> 101·345	<hr/> 100·000

The brown crystalline variety contained in the nodules of pulverulent vivianite, when analysed, proved also to be almost pure orthophosphate, and no doubt the differences in colour that distinguishes the two minerals, must be due to difference in the degree of oxidation of a minute portion of the iron. The analysis of three separate specimens gave the following results:—

		[3FeO,P ₂ O ₅ ,8H ₂ O.]
Iron protoxide	42·889	43·028
Iron peroxide	0·801	—
Phosphoric acid	28·792	28·286
Water	29·433	28·686
	<hr/> 101·915	<hr/> 100·000

* Pogg. Ann., cxxxvi, 405.

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The earthy and friable mass which formed the bulk of the nodules enclosing the brown variety, was of a dark indigo-blue colour, and on analysis presented a much less simple composition than either of the previously described varieties. The following are the results of the analysis of this substance:—

	I.	II.	III.	IV.	V.	Mean.
Iron protoxide	—	36·928	—	37·501	—	37·214
Iron peroxide	—	—	—	—	—	9·169
Phosphoric acid.....	—	—	—	—	23·897	23·897
Carbonic acid	—	—	5·162	—	—	5·162
Water.....	23·825	—	—	—	23·918	23·871
Silica	—	—	0·811	—	—	0·811
Organic matter	—	—	0·826	—	—	0·826
						<hr/> 100·950

These numbers may be interpreted as representing five equivalents of octahydrated ferrous orthophosphate with one equivalent of octahydrated diferric phosphate mixed with four equivalents of ferrous carbonate. It would seem to have been the result of the decomposition, probably under the action of alkaline carbonated water, of the ferrous orthophosphate found in its purer form in the crystalline nucleus which is met with in almost every nodule.

The mineral collection at the British Museum contains some fine crystals of vivianite from Fernando Po, presented by Sir John Barrow, Bart., Secretary to the Admiralty. They are of very dark bluish black when viewed by reflected light, while light transmitted through portions of the crystal, acquires a fine indigo colour. Thin laminæ are often nearly colourless. The chemical examination of the vivianite from this locality gave the following result:—

	I.	II.	III.	IV.	
Iron protoxide....	38·437	38·565	—	[43·076]	38·501
Iron peroxide	—	—	—	—	5·083
Phosphoric acid ..	—	—	—	27·802	27·802
Water	—	—	28·326	—	28·326
					<hr/> 99·712

Under IV the total iron is given as protoxide. It will be seen that this specimen stands intermediate between the blue and brown crystalline varieties on the one hand, and the blue

earthy mineral on the other. The oxygen-ratios of the above percentages correspond to a mixture of ten equivalents of octahydrated ferrous orthophosphate with one of the octahydrated diferric phosphate already spoken of as possibly present in the blue earthy variety of vivianite.

6. CRONSTEDTITE.

Among the minerals already alluded to as associated with vivianite, is one of singular interest, as being known only in Pzribam and in Cornwall, and in both localities in great rarity. That mineral is cronstedtite. The specimens recently found in Cornwall by Mr. Talling present themselves in radiating groups on quartz, associated with blende, chalybite, iron pyrites, copper pyrites, a little galena, and mispickel, and occasionally fluor spar. The mineral also occurs in the form of a drusy coating on the killas. And it is met with in association with hisingerite* in acicular crystals in cavities on massive iron pyrites. The usual structure of this mineral is fibrous and radiating. The vitreous lustre of the marked cleavage-plane of the crystals which is parallel to their base, gives a sort of polyhedral surface to the fibrous masses.

The first analysis of this mineral gave the following numbers:—

		Theory.
Iron protoxide	36·307	41·54
Iron peroxide	36·762	30·77
Silicic acid.....	17·468	17·31
Water.....	10·087	10·38
Calcium oxide	0·087	—
	<hr/> 100·711	<hr/> 100·000

In juxtaposition with the analytical determinations are given the percentages required by the formula $3\text{Fe}''\text{SiO}_4 + 4(\text{Fe}_2)''\text{H}_6\text{O}_6$, which von Kobell assigned to this mineral. A considerable discrepancy exists between the numbers in the two columns as far as the oxides of iron are concerned, and may perhaps be due to an admixture of some iron hydrate, goethite for example, whose percentage of water corresponds with that of cronstedtite.

* Journ. Chem. Soc., viii, 5.

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A second analysis with a fresh and more carefully selected material gave the following percentages :—

Iron protoxide	38·570
Iron peroxide.....	32·752
Silicic acid	18·546
Water	[10·132]
	<hr/>
	100·000

The above numbers, though more nearly agreeing with, still differ somewhat from, those required by theory. Ascribing this disparity to an impurity in the specimen taken, a further quantity was picked over with the greatest care, and on analysis gave the number 41·272 as its percentage of iron protoxide, theory requiring 41·54 per cent.

It is possible that the excess of iron peroxide, silicic anhydride, and water in the first and second analyses over that required by cronstedtite, may result from a mixture with this mineral of some hydrated ferric silicate like hisingerite, with which in fact cronstedtite has been shown to be associated. The oxygen ratios of the excess of these constituents, however, will not allow us to assume them to be present in this form only. It is more than probable that during the weathering of the cronstedtite a portion of the silica may have been removed. If the silica in excess be left out of consideration, or supposed to be present only as an impurity, it will be found that the oxygen ratios of the excess of iron oxide and water correspond in each analysis with great precision to those of limonite.

The crystals of cronstedtite offer a problem of considerable interest to the crystallographer, from the hemimorphous character of the mineral. Hitherto, however, the only localities that have produced cronstedtite, namely, Pzribram and Wheal Maudlin—to which, perhaps, must be added the Brazilian locality Conghona, at which the mineral sideroschisolite, described by Wernekink, and probably identical with cronstedtite, has been found—failed to yield measurable crystals.

Among the specimens furnished by Mr. Talling, there were three or four on which the diverging groups of the crystals of cronstedtite presented here and there a crystal, or more generally a small group of crystals, with more definite crystalline features than usual. In some cases the crystals were mutually interpenetrating, the brilliant cleavage-planes of the different

crystals projecting through one another, presenting re-entering angles which indicated the probability of their being twinned. In most cases, again, a careful scrutiny of the bright summit plane showed it to be tessellated, and that the crystal was in fact composite, the different individuals comprising it being generally in parallel juxtaposition (Fig. 1), but sometimes (Fig. 2) twinned round the normal to that plane (the morpho-

Fig. 1.

Fig. 2.

Fig. 3.

logical axis of the crystal); but never so as to mask the truly hemimorphous character of the crystal.

The symmetry round the axis of each crystal is trigonal; the form of the crystal being that resulting from the combination of two rhombohedra, of which only the planes on one side of the unique plane of symmetry (that parallel to the summit plane) are extant. The crystal thus presents the aspect of a combination of two trigonal pyramids, of which one is more acute than the other. (See Fig. 3.)

Unfortunately the faces of these two forms are not only deeply striated, parallel to their vertical intersections, but are also invariably more or less rounded, the triangular summit plane of the crystal usually presenting in consequence a curved outline. With such unpromising planes, from which reflections are hopeless, it was very difficult to get trustworthy measurements. By operating on several crystals, however, and taking the average of the results, the following angles were obtained for the two rhombohedra:—

	Calculated.
111 on 100 = 85° 12'	85° 12'
111 on 522 = 75° 45'	75° 51'

Besides the twinning on the plane 111, it would seem also that the cronstedtite crystals are twinned on the plane 100. One angle observed on various crystals gave an average of—

	Calculated.
111 (100) $\bar{1}\bar{1}\bar{1}$ = 9° 42'	9° 36'

Another number found to recur in the measurement of the mutual inclinations of the planes 111 and $\bar{1}\bar{1}\bar{1}$ on different groups approximated to $19^{\circ} 12'$ (in four cases). Other recurrent numbers were very near $21^{\circ} 30'$ and $10^{\circ} 15'$.

In these cases the little crystals are very numerous, and interpenetrate each other in a very complicated manner. It was hoped by numerous measurements of the inclinations of the cleavage-planes on the different crystals (the only plane that was measurable), to deduce more trustworthy angles for the rhombohedron, on the plane of which it was assumed that the crystals in the group were twinned. In many cases, however, these measurements were rendered unreliable from the fact that the crystal cleaves so readily parallel to this single reflecting plane, that whenever pseudomorphous change has begun (to which cronstedtite seems peculiarly liable), or any mechanical cause, such as pressure, has disturbed the crystal, this plane has become distorted from its true position. And where only one plane on each crystal is amenable to geometrical measurement, it is almost hopeless to seek to determine the relative orientation of the axes of the different crystals forming a group.

This symmetry of the crystals suffices to prove that in cronstedtite we have an illustration of hemimorphism of a very interesting kind.

7. PHOLERITE.

This mineral was sent to the Museum from Capt. W. A. Ross, R.A., by the Secretary of State for India, and was called by Capt. Ross, meerschalmunitite.

It is massive, of a pale flesh-white, has a dull, even fracture, and adheres to the tongue. Patches and veins of a black mineral penetrated the mass in several places.

An analysis of the flesh-white mineral gave the following results:—

Silicic acid	36.388
Aluminium oxide	34.594
Water:	
Combined	13.294
Hygroscopic	15.019
	<hr/> 28.313
	99.245

Traces of iron and manganese oxides accompany the aluminium oxide. Omitting the hygroscopic water, we have—

		Oxygen.
Silicic acid	43·144	23·009
Aluminium oxide.....	41·073	19·14
Water	15·783	14·029
	<hr/>	
	100·000	

This composition may be expressed by the formula, $2\text{Al}_2\text{O}_3$, 3SiO_2 , $4\text{H}_2\text{O} + \text{SiO}_2$, H_2O . Whether the silicic acid and water in excess of the formula for the silicate be uncombined with the alumina, or whether the minerals be a mixture of two hydrated aluminium silicates, such as pholerite with kaolinite, it was not thought necessary to investigate further. The mineral hardly needs a new name, the analysis according quite sufficiently with those of the pholerites; especially when it is considered that these uncrystallised products of the decomposition of other minerals are rarely so pure from admixture as to give a satisfactory formula. The black infiltrated substance exhibited the blowpipe reactions of manganese and cobalt, and contained, as did the pholerite, considerable traces of infiltrated nitrogenous organic matter.

By treating a portion of the mineral with an excess of solution of potassium hydrate, at 100° for several days, there were dissolved the following percentages of

		Oxygen.
Silicic acid	3·943	2·102
Aluminium oxide	7·482	3·487