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Substituting, we have $\varphi-\frac{4\alpha_2 t}{\lambda^3 \cos r}=0$ or $n_0 \cos i=n \cos r=\frac{2\alpha_2}{\lambda^2 \cos r}$

$$=\frac{\frac{2\alpha_2}{\lambda^2}+n\cos^2 r}{\cos i \cos r}, \text{ or finally,}$$

$$n_0=\frac{2(n-\alpha_1)+n\cos^2 r}{\cos i \cos r}. \qquad (8)$$

If the angle i is small, the value of n_0 will vary very little with i, consequently there will be a large number of circles all nearly achromatised. Under favorable circumstances as many as one hundred rings have been counted, using an ordinary lamp, as source of light. The difference of path of the two pencils which produce these rings in white light may exceed a thousand wave lengths.

ART. XLVII. — *On two New Minerals, Monetite and Monite, with a notice of Pyroclasite;* by CHARLES UPHAM SHEPARD; *with analyses*, by C. U. SHEPARD, Jr.

THE specimens here described were sent to us by Mr. John G. Miller of Ottawa, to whom Canadian mineralogy owes so many mineralogical discoveries. They came from the Twin islands, Mona and Moneta, which are situated forty miles from the port of Mayaguez, Porto Rico, W. I.

1. *Monetite.*—The Moneta mineral, which we call monetite from its locality, is accompanied by two other species; all of them, however, have originated together in a guano-formation. The prevailing rock of the island is probably a Tertiary marine limestone, which at the top of the ground has been coated with bird-guano. The soluble ingredients of this investment, in percolating the highly porous strata, have been thrown down in their transit in the metamorphosed combinations now met with, lining the walls of cavities in the formation.

The material supplied came from one of these caverns. The specimens present a remarkable feature, as compared with the stone-guanos of the West Indies. The latter are usually uncrystalline, more or less compact, heterogeneous in their composition; and contain considerable traces of organic matter. They very rarely present dissociated simple minerals; but rather constitute what are called rock-aggregates. The examples from Mona, on the contrary, are almost wholly made up of distinctly separate mineral species, for the most part are crystallized, and as free from organic impregnation as if derived from trap or granite. The most abundant species in the specimens received, is the monetite which sometimes forms isolated patches, half the size of one's hand. The second constituent of the masses is a snow-white gypsite, either crystallized, fibrous or pulverulent; while the remaining one is calcite, in well-formed, semi-transparent crystals. No alumina or oxide of iron is present in the aggregate.

The monetite, besides occurring in thick isolated masses as above mentioned, also forms irregular seams through the gypsite; and shows itself likewise in thick crusts, lining irregular shaped cavities. More rarely, it presents itself in botryoidal shapes, with rough crystalline surfaces. But under all circumstances, it is an highly crystalline mineral.

Mineralogical description.—Primary form,* right oblique angled prism. M on T about 143° as determined approximately by the common goniometer. Secondary forms, terminal and acute lateral edges replaced by single planes, the former generally very narrow. Height of prisms less than one-third their longest breadth; sometimes much less. Greatest length of crystals between $\frac{1}{12}$th and $\frac{1}{20}$th of an inch. They exhibit numerous irregular surface indentations, but are without striæ or curvatures. They cross and interpenetrate each other in several directions, some of the groups suggesting a regular composition of individuals. Though exhibiting frequent rifts, the cleavage is indeterminate. Fracture, uneven. Luster, vitreous. Semi-transparent. Color, pale yellowish white. Hardness =3·5. Gravity =2·75, which is a little below the actual, from the impossibility of wholly clearing the crystals of the mealy white monite and gypsite by which they are more or less coated.

Before the blowpipe, heated in a glass tube, turns white and evolves moisture, but unattended by odor. In the platinum forceps, turns white and melts into a globule with crystalline facets.

Analysis.

	I.	II.	Mean.
Lime	39·92	40·59	40·255
Phosphoric acid	44·41	49·79	47·100
Sulphuric acid	7·20	1·90	4·550
Water	8·47†	7·88	8·175
	100·00	100·16	100·080

4·55 per cent sulphuric acid calls for 3·185 per cent lime and 2·047 per cent water; thus constituting 9·782 per cent of gypsite. The mineral lost 0·2 per cent of moisture on drying it several hours at nearly 100° C. Subtracting the above constituents we have:

* See also the note on the crystalline form by E. S. Dana, on p. 405.

† The water in the first analysis was estimated by difference.

Phosphoric acid	47·100
Lime	37·070
Water	5·928
	90·098

And raising the above figures to 100, we have as the composition of the *monetite*,

Phosphoric acid	52·28
Lime	41·14
Water	6·58
	100·00

Dividing the above percentages by the respective molecular weights, we have:

Phosphoric acid	$52·28 \div 142 = 0·368$
Lime	$41·14 \div 56 = 0·735$
Water	$6·58 \div 18 = 0·366$

or very nearly, as 1 phosphoric acid: 2 lime: 1 water. This would require the formula $2CaO, H_2O, P_2O_5$ (or $CaHPO_4$), as a comparison of the calculated and obtained results will show.

	Calculated.	Found.
Phosphoric acid	52·20	52·28
Lime	41·18	41·14
Water	6·62	6·58
	100·00	100·00

Monetite is a crystalline dicalcic-hydric-phosphate, or dicalcic-ortho-phosphate, differing from that artificially prepared (by the action of calcic chloride on disodic-hydric-phosphate), in not possessing water of crystallization as does the latter—$(PO_4H)_2 Ca_2 + 2H_2O$.

2. *Monite.*—Intimately associated with the monetite, above described, is a hydrated tricalcic phosphate, resembling in color and density the more friable varieties of kaolinite, and which we propose to designate *monite*, after one of the islands where it is found. It has the following characters:

Massive, slightly coherent, impalpable and wholly uncrystalline; snow-white, fracture earthy, dull; hardness, below 2, gravity 2·1 (approximately). B.B. melts with difficulty to an opaque, white enamel of feeble luster. In closed tube emits much moisture.

Analyses.

				Mean.
P_2O_5	40·39	39·44	39·75	39·86
CaO	50·04	50·89	49·51	50·15
SO_3		2·57	1·75	2·16
H_2O			7·56	7·56
				99·73
Deducting $2·16\ SO_3 = 1·51\ CaO = 0·97\ H_2O$ = gypsite,				4·64
				95·09

	Remaining.	Raised to 100.	Molecular weights.	Approximate ratios.
P_2O_5	39·86	41·92 ÷	142 = 0·295	1
CaO	48·64	51·15 ÷	56 = 0·913	3
H_2O	6·59	6·93 ÷	18 = 0·385	1¼
	95·09	100·00		

Or corresponding to $Ca_3P_2O_8 + H_2O$ with some slight excess of moisture, probably hygrometric.

The two minerals, monite and monetite, are much intermingled, constituting together three-quarters of the variously sized masses, whose remaining quarter consists of gypsite and calcite, the latter however in isolated patches and in much the least proportion. The remarkable feature of the aggregate as coming from a stone-guano formation, consists in the entire absence (in masses, half a foot in thickness), of all traces of organic matter. The monetite is the most abundant species, sometimes occupying areas several inches long by one or two broad; and inasmuch as its crystals are confusedly aggregated and rather sharp, the specimens are exceedingly rough to the touch. The interspaces between the crystals occupy as much room as the crystals themselves; and are more or less filled with the monite. When the intervals are completely occupied with the latter, the aggregate is often arranged in imperfect layers, separated by intervals of about one-sixth of an inch, filled by the monite. A cross-fracture of such masses displays an obscurely banded appearance. Rarely the monetite presents globular concretions, with a sub-fibrous structure. It is also sometimes granular, but when pure it is rarely impalpable.

The associated gypsite is white, in small shining crystals, in coarse fibrous individuals, small globules, fine granular and pulverulent. The calcite is in distinct, semi-transparent crystals, having the form of acute rhomboids, analogous to those resulting from the slow evaporation of brine-waters. The presence of silica, or some insoluble silicate is detected in the analyses of the aggregate only, where it varies from 0·5 to 2· per cent.

Pyroclasite.—As the series of specimens sent were said to have been from caves, which abound at these islands, it would appear that their contents originated in percolations across the Tertiary strata. Indeed, examples of the lime-rock are among the collection, evincing the progress of metamorphosis from the unaltered calcic carbonate, to entire calcic phosphate. Wherever the solutions in their descent encountered caves or open joints in the strata, stalagmite and incrustations would result. Several specimens of these were among the collection sent. They strongly resemble the impure stalagmites of our limestone caves. Portions of the guano-stalagmite are singularly in the shape of mushrooms; and must have occupied the surface of the floor-crust. When broken, their structure is seen to be concentrically laminated, and not fibrous. In color they are brown, intermingled in spots with ash-gray, suggestive of a composite constitution. Other masses appear to have come from the floor stratum itself; and are hard and compact, with a subconchoidal fracture, like the monetite and like some varieties of opal. Its color is brown, though much darker and occasionally almost black. It is moreover variegated with ash-gray. The specific gravity is 2·62–2·65; hardness, 3·5–4·0. B.B. it decrepitates, emits a decidedly organic odor, turns white and fuses, but less easily than monetite, to a white, shining enamel. Heated in a glass tube, it decrepitates, with liberation of much water and strong empyreumatic odor. The subjoined analyses give its chemical composition.

	Robertson.		Shepard.	Mean results.
P_2O_5 ....(total)	40·81		38·80	39·080
CaO	40·27		39·98	40·125
SO_3	6·85		6·80	6·825
Phosphate iron and alumina			2·90	2·900
Insoluble	0·58		1·13	0·855
Water and loss on ignition..	9·76		10·91	10·335
	98·27		100·52	100·120
Deduct gypsite		14·670		
" insoluble		0·855		
" phosphates iron and alumina		2·900		
" ¼ of loss by ignition, as organic		2·422		
				20·847
				79·273

This raised to 100 gives

			Calculation requires
P_2O_5	38·08	49·30 ÷ 142 = 0·347	49·05
CaO	35·35	44·59 ÷ 56 = 0·796	44·06
H_2O	4·84	6·11 ÷ 18 = 0·339	6·29
	79·27	100·00	100·00

Admitting the following formula:

$$3(Ca_2H_2P_2O_8)+Ca_3P_2O_8+H_2O.$$

The substance above analysed is undoubtedly identical with that from Monk's Island (Caribbean Sea) described in 1856, in this Journal, vol. xxii. p. 97, and named pyroclasite, from its very striking property of decrepitation when heated.* Whether it forms a true mineral species must depend upon more extended examinations. The analyses given favor the idea of its being an uniform compound of monetite and monite. It may, however, prove only a mechanical mixture of the two. Whether chemical or mechanical, it is eminently prone to admixture with gypsite, aluminum and iron phosphates, silica and organic matter, constituting the important phosphatic rock of the West Indies and South Carolina.

It may be added in conclusion that the collection embraced several specimens of antillite, which is identical with the trappean rock mentioned in connection with the pyroclasite of Monk's Island.

* An associated mineral which I then examined and called glaubapatite is essentially the same thing; the soda found therein having without doubt been owing to the damaged state of the cargo from which it was taken. The vessel that brought it to this place was bound for Baltimore; but was compelled, from damage at sea, to put into this port. The sulphuric acid found in the mineral was erroneously dosed with soda instead of lime. With the correction of these errors of analysis I desire to withdraw the name glaubapatite. The mineral to which it was given comes under pyroclasite.

Note on Crystals of Monetite.—The crystals of monetite placed in my hands may with tolerable certainty be referred to the triclinic system. The general form is that of a rather thin rhomboid. The longer lateral edge is replaced by the plane 100 (*a*), and the shorter by the hemi-prism $1\bar{1}0$ (*I*); there are also present in this zone the brachypinacoid 010 (*b*), and two other hemi-prisms $h\bar{k}o$ (*m* and *n*) between 100 and $1\bar{1}0$, and a third *hko* (*l*) on the other side of 100. The top of the tabular crystals is formed by the basal plane 001 (*c*) which is rough and uneven, and the edge behind, between *a* and *c*, is replaced by a dome $\bar{1}01$ (*e*). The angles measured with a reflecting goniometer are only roughly approximate, and would not justify an attempt to calculate the axial ratios and inclinations. The supplement angles are: *aI* ($100 \wedge 1\bar{1}0$)=42°, *ab* ($100 \wedge 0\bar{1}0$)=81°, *am*=17°, *an*=28°, *al*=18°, *ac*=76°, *ae* ($100 \wedge \bar{1}01$)=138°. There appears to be a distinct cleavage parallel to *a*. The crystals often interpenetrate each other, forming complex groups, but there is no uniform law of composition.—E. S. Dana.

Charleston, Feb. 18, 1882.