ART. LVIII.—*Mineralogical Notes;* by ALFRED J. MOSES.

1. *Pyrite Crystals from Kings Bridge, N. Y.*

THE crystals described in this paper were obtained on November 19, 1892, by G. F. Sherman and E. H. Messiter, students of the Columbia College School of Mines, from material recently quarried within 300 feet of the eastern end of the cut known as "the Harlem River Improvement" at Kings Bridge, New York City. The pyrite crystals were in a narrow cavity, in a block of limestone, associated with small crystals of dolomite, very pretty crystals of pale green transparent mica and curiously modified crystals of quartz. In a few instances minute crystals of rutile were also noticed.

The pyrite crystals are rarely more than $\frac{1}{4}$ inch in their longest dimension but a few were found almost $\frac{1}{2}$ inch in length. In most of the crystals the prevailing form is the octahedron always however modified by three or more other forms. The curious fact was noticed that in all the specimens showing quartz the general shape of the pyrite crystals was cubic and the crystals were relatively small. No large crystals of the cubic type were observed.

The angles were measured with a Mallard-Wollaston goniometer reading to half minutes. The angles obtained were:

	Measured.	Calculated.
$1 \wedge i\text{–}2$	39° 13½′	39° 16′
$1 \wedge 3\text{–}\frac{3}{2}$	22° 14½′	22° 15′
$1 \wedge 2\text{–}2$	19° 25½′	19° 28′
$\mathrm{H} \wedge 2\text{–}2$	35° 19′	35° 16′
$i\text{–}2 \wedge 3\text{–}\frac{3}{2}$	16° 59′	17° 1½′

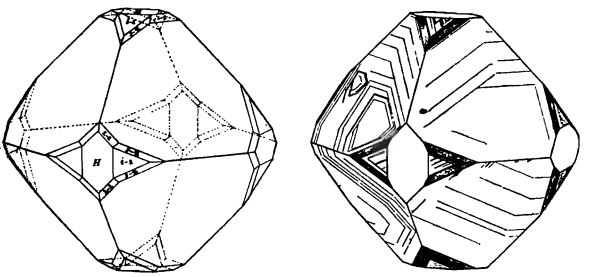
Closer results might have been obtained by readjustment but these were sufficiently exact to determine the symbols beyond question.

The occurring faces (see fig. 1) are therefore the common faces of pyrite: cube (100, $i\text{–}i$); octahedron (111, 1); and pentagonal dodecahedron (120, $i\text{–}2$); and the rarer forms: diploid (321, $3\text{–}\frac{3}{2}$) and tetragonal trisoctahedron (211, 2–2).

In pyrite crystals striations are frequently found upon the faces of the cube and pyritohedron ($i\text{–}2$) parallel to the intersections of the faces of these forms and this is attributed to oscillations between the two forms. In the crystals from Kings Bridge all faces *except* those of the cube are more or less striated sometimes with only one or two very prominent lines, at other times in several directions and with many lines.

The accompanying figure (2) copies striations observed upon two crystals; the upper left hand octahedral face in particular is a fairly accurate reproduction. The striations on octahedral faces rarely if ever cross and in each face are parallel always

1. 2.



either to its intersections with the cube or with the pyritohedron *i*–2. The striations on the diploid and the pyritohedron were not parallel to intersections with the cube but to intersections with each other (or with the octahedron). No striations were observed on any cube face.

2. *Ettringite from Tombstone, Arizona, and a formula for Ettringite.*

The first specimen of this mineral I received over a year ago and proved it to be a hydrated sulphate of alumina and lime, but was prevented from making a complete examination by the small amount of material available. Since that time I have received and examined several other specimens.

The mineral was found by Mr. W. F. Staunton in an ore shoot in the white crystalline limestone of the Lucky-Cuss Mine, Tombstone, Arizona; just at the water level. It occurs incrusting a massive silicate of lime and alumina from which it has apparently been produced by the action of sulphuric acid, as it frequently fills little veins and hollows in the silicate and the latter is usually in these portions loosely coherent as if corroded.

In appearance the sulphate resembles a fibrous pectolite as it is made up of white somewhat translucent radiating fibers of a length up to one inch, or sometimes in little bunches of silky parallel fibers. No crystals have been found but the fibers are doubly refracting and appear to extinguish parallel to their length; cross fractures (or cleavage) approximately at right angles to the length are frequent. The hardness is a little over 2 and the specific gravity determined on 200^{mg} was 1·55.*

* If the silicate in the sample is assumed to be of the specific gravity of the silicate gangue (2 66) the gravity of the sulphate is reduced to 1·27, but the silicate near the sulphate is very much altered and probably nearer the gravity of the sulphate.

Before the blowpipe the mineral fuses readily coloring the flame red and forming a white enamel. On grinding it is damp and adhesive. Dissolves partially in water to an alkaline solution and is rapidly and completely decomposed by hydrochloric or even acetic acid.

It differs from the ettringite of Prof. Lehmann in that the latter occurs in needle-like hexagonal crystals, has a recorded specific gravity of 1·75 and is said to be infusible.

From the tendency of the portions of the silicate nearest the sulphate to crumble the material for analysis had to be picked almost fiber by fiber. Upon the purest sample thus obtained a complete analysis yielded:

	No. I. On ·2235 grms.
CaO	25·615
Al_2O_3	10·157
SO_3	17·675
H_2O (at 115°)	33·109
Loss (at red heat)	10·872
SiO_2	1·901
	99·329

The SiO_2 is present as a silicate more or less impregnated with metallic ores but which two analyses show to contain proportionately SiO_2 100 pts., CaO 27·89 pts., Al_2O_3 47·02 pts., H_2O (at 115°) 9·70 pts., H_2O (at red heat) 25·97 pts. Deducting in this proportion and recalculating to 100 we have:

	No. I (recalculated).
CaO	26·31
Al_2O_3	9·72
SO_3	18·54
H_2O (115°)	34·53
H_2O (red heat)	10·88

To prove that there had been no volatilization of SO_3 or reduction to sulphide during ignition ·2088 gms. of the mineral was dissolved in acid without ignition and the SO_3 and SiO_2 determined.

SO_3	15·066
SiO_2	9·909

Recalculated as in previous analysis this corresponded to SO_3 19·03.

An attempt was made to obtain another complete analysis on a sample of material not quite so pure as the first but in the ignition there was a loss of SO_3 due partly to reduction to

sulphide as evidenced by effervescence and odor in the subsequent solution, and also made evident by the very low result for SO_3. The comparison therefore fails for SO_3 and ignition. The other results were:

CaO	24·174
Al_2O_3	8·298
H_2O (110°)	30·613
H_2O (ignit.)	15·514
SiO_2	3·497

Recalculated as in No. 1 these correspond to

CaO	25·04
Al_2O_3	7·18
H_2O (115°)	32·68
H_2O (red heat)	15·76

Another determination yielded CaO 23·445, SiO_2 3·920. Recalculating as before we find CaO 25·55.

The comparison therefore is

	Arizona mineral				Ettringite of Ettringen.
	No. I.	No. II.	No. III.	No. IV.	
CaO	26·31	25·04		25·55	27·27
Al_2O_3	9·72	7·18			7·76
SO_3	18·54		19·03		16·64
H_2O (115°)	34·53	32 68			} 45·82
H_2O (red heat)	10·88	15·76			
				Loss	2·51

If the loss in Prof. Lehmann's analysis is taken as SO_3 the comparison is still more striking and my own results in No. II proved the probability of such a loss.

Analysis No. I of the Arizona mineral was very satisfactory in all respects, needed very slight deductions and recalculations and I prefer to regard the other determinations as confirmatory but not worthy to be averaged with this of No. I. The formula suggested for ettringite was $6CaO, Al_2O_3, 3SO_3, 33H_2O$; but the analysis of No. I suggests a more simple formula very closely fitting the analysis.

	No. I.		Approximate ratio.
CaO	26·31 ÷ 56	·470	10
Al_2O_3	9·72 ÷ 102	·095	2
SO_3	18·54 ÷ 80	·232	5
H_2O (115°)	34·53 ÷ 18	1·918	40
H_2O (red heat)	10·88 ÷ 18	·605	14

This means a mineral of closely the type of felsöbányite ($2Al_2O_3 . SO_3 + 10H_2O$), for the ratio yields $(H_{28}Ca_{10}Al_4)O_{30}(SO_3)_5 + 40H_2O$ or $2R_2O_3 . SO_3 + 8H_2O$. This formula not only suits the analysis of the Arizona mineral almost exactly but that of the Ettringen variety at least as well as the formula assumed as may be seen.

	Ettringite of Ettringen.	Ettringite of Arizona.	Percentages required by $(H_{28}Ca_{10}Al_4)O_{30}(SO_3)_5 + 40H_2O$.	Percentages required by $6CaO, Al_2O_3, 3SO_3 32H_2O$.
CaO	27·27	26·31	26·21	26·4
Al_2O_3	7·76	9·72	9·55	8·0
SO_3	19·15	18·54	18·72	18·9
H_2O	45·82	45·41	45·50	46·7

We may therefore conclude that this mineral is to be placed in a group of hydrous basic sulphates of the general formula $2R_2O_3 . SO_3 + nH_2O$ and that the definite and close division between the loss at 115° and at red heat in my analysis supports the supposition that 14 pts. of H_2O may be considered as basic in the Arizona variety while the almost perfect agreement in total H_2O in the Arizona and Ettringen analyses makes a similar assertion for the latter not improbable.

The calculated ratio would yield the formula for the Arizona variety

$$H_{28}Ca_{10}Al_4O_{30} . 5SO_3 + 40H_2O$$

While the assumed formula for the Ettringen variety might be written

$$H_{18}Ca_6Al_2O_{18} . 3SO_3 + 24H_2O$$

Both of these are of the type $2R_2O_3 . SO_3 + nH_2O$ and closely agree when reduced

Arizona variety .... $2[H_{\frac{14}{5}}CaAl_{\frac{2}{5}}O_3] . SO_3 + 8H_2O$

Ettringen variety - $2[H_3CaAl_{\frac{1}{3}}O_3] . SO_3 + 8H_2O$

The group therefore of hydrous basic sulphates of the general formula $2R_2O_3 . SO_3 + nH_2O$ is composed of

Glockerite		$2Fe_2O_3 . SO_3 + 6H_2O$	Earthy or massive.
Felsöbányite		$2Al_2O_3 . SO_3 + 10H_2O$	Orthorhombic six sided scales.
Paraluminite		$2Al_2O_3 . SO_3 + 15H_2O$	Massive.
Ettringite	Arizona -	$2[H_{\frac{14}{5}}CaAl_{\frac{2}{5}}O_3] . SO_3 + 8H_2O$	Silky double refracting fibers.
	Ettringen	$2[H_3CaAl_{\frac{1}{3}}O_3] . SO_3 + 8H_2O$	Hexagonal needle crystals.

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