THE

AMERICAN

JOURNAL OF SCIENCE.

EDITORS
JAMES D. AND EDWARD S. DANA.

ASSOCIATE EDITORS
PROFESSORS JOSIAH P. COOKE, GEORGE L. GOODALE
AND JOHN TROWBRIDGE, OF CAMBRIDGE.

PROFESSORS H. A. NEWTON AND A. E. VERRILL, OF
NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA.

THIRD SERIES.

VOL. XXXVIII.—[WHOLE NUMBER, CXXXVIII.]

Nos. 223—228.

JULY TO DECEMBER, 1889.

WITH XII PLATES.

NEW HAVEN, CONN.: J. D. & E. S. DANA.
1889.

ART. XXXVI.—*Notes on some Native Iron Sulphates from Chili;** by JAMES B. MACKINTOSH.

IN March, 1887, I received from Dr. Thos. Egleston a series of the native iron sulphates from South America, which I analyzed for him, as there were some minerals among them which he was not able to identify and which he regarded as probably new. It is with his permission that I now give the results of my analyses and the conclusions to which they lead. My results confirm his opinion as to the novelty of some of the specimens analyzed.

Among the series of specimens were several of well known species, of which I also made analyses. These I will give first, with but little comment, as they do not afford much that is new, and then take up the new varieties in turn.

1. *Coquimbite.*—Of this species I had three varieties, as described below, which gave the following results:

	I (No. 1). Amethystine crystalline transparent.	II (No. 2). Amethystine massive translucent.	III (No. 10). White massive opaque.
Specific gravity	2·07	2·086	----
SO_3	43·40	42·90	42·32
Fe_2O_3	22·17	26·10	28·10
Al_2O_3	4·39	1·65	SiO_2, Al_2O_3 } 0·91
Na_2O	0·25	0·27	----
CaO, MgO	traces	traces	----
H_2O (difference)	[29·79]	[29·08]	[28·67]

All lead to the same formula, Fe_2O_3, $3SO_3$, $9H_2O$. The water expelled at 110° in the three samples was 5, 6, and 5½ molecules respectively. It is interesting to notice that the most crystallized and transparent specimen is the poorest in iron and richest in alumina, while the most opaque and non-crystallized is the richest in iron.

2. *Copiapite* (No. 6).—The specimen analyzed was massive, yellow, with specific gravity = 2·118. The analysis gave

SO_3	39·03
Fe_2O_3	29·16
FeO	1·56
Na_2O	0·31
H_2O	[29·94]

---

* Recent contributions to our knowledge of the iron sulphates of South America have been given by Frenzel, on amarantite and hohmannite, Min. petr. Mitth., ix, 397, 1887; and by G. Linck on coquimbite, copiapite, quenstedtite, stypticite, roemerite, halotrichite, Zeitschr. f. Kryst., xv, 1, 1888.

The formula corresponds to

$$91\{2Fe_2O_3, 5SO_3, 18H_2O\} + 22\{FeSO_4, H_2O\} + 5\{Na_2SO_4, H_2O\}$$

The water lost at 110° C. is 1124 out of 1663 molecules represented in the above formula or about 12 out of each molecule of $2Fe_2O_3$, $5SO_3$, $18H_2O$ or $\frac{2}{3}$ of total H_2O. Readily soluble in water before and after heating to 110°.

3. *Roemerite* (No. 8).—Brown, crystalline; specific gravity 2·15; analysis gave:

		Ratio.
SO_3	40·19	50·24
Fe_2O_3	19·40	12·125
FeO	9·52	13·22
Na_2O	0·14	0·226
H_2O	[30·85]	171·39

After subtracting SO_3 corresponding to Na_2O present, the molecular ratio is 4 : 0·97 : 1·058 : 13·7 or nearly 4 : 1 : 1. At 110° C. most of the H_2O is expelled with simultaneous oxidation of part of the ferrous iron. The net loss amounts to 11·8 molecules of H_2O, leading to the formula FeO, Fe_2O_3, $4SO_3$, $13{\cdot}7H_2O$ ($12H_2O$ Tschermak, $15H_2O$ Linck). Readily soluble in water—after heating only partially soluble.

4. *Amarantite* (No. 3).—Red, crystalline, with sp. gr. = 2·005; associated with copiapite. Analysis:

		Ratio.
SO_3	36·15	2·0
Fe_2O_3	35·69	0·987
Al_2O_3	0·21	0·009
Na_2O	0·51	0·036
H_2O	[27·44]	6·75

Hence the formula corresponds to

$$Fe_2O_3, 2SO_3, 7H_2O$$

When heated to 110° C., 3·48 molecules of water are expelled, and the residue leaves a slight insoluble basic salt on solution in water.

5. We will now consider some minerals which have not yet been described and which are of seemingly definite formula. The first of these (No. 9) occurs associated with copiapite and amarantite, but quite distinctly separated from them, in pulverulent orange flakes which are arranged in parallel tabular layers. It shows no crystalline structure, which might be expected if it was a direct alteration of amarantite, and there is a sharp line of demarcation between the minerals on the same specimen with no appearance of a transition state. Analysis gave:

		Ratio.
SO_3	41·24	2·001
Fe_2O_3	41·22	1·000
H_2O	[17·54]	3·78

Formula Fe_2O_3, $2SO_3$, $4H_2O$

Water lost at 110° C. = 0·304 molecule, leaving a residue containing 3·48 molecules. The result of heating this mineral is the same as of heating amarantite. They only differ by 3 molecules H_2O, but there is no apparent structure like amarantite to indicate that the one is a direct product of dehydration of the other.

6. *Ferronatrite* (No. 11).—The analysis of this mineral I have recently completed, having received it from Prof. Egleston only a short time since. It occurs in stellate groups of a pale, whitish green color, forming nearly spherical nodules; it is in general similar to pale wavellite in appearance. It is associated with copiapite and coquimbite. Analysis:

		Ratio.
SO_3	50·25	6·281
Fe_2O_3	17·23	1·077
Al_2O_3	0·43	0·042
Na_2O	18·34	2·958
K_2O	0·40	0·042
SiO_2, etc., insoluble	2·00	
H_2O	11·14	6·189
	99·79	

Formula $3Na_2O$, Fe_2O_3, $6SO_3$, $6H_2O$

Water lost at 110° = 5½ molecules, the residue dissolves readily in water. This mineral is somewhat similar to sidero-natrite, Na_2O, Fe_2O_3, $3SO_3$, $6H_2O$, to urusite, $2Na_2O$, Fe_2O_3, $4SO_3$, $8H_2O$ and to bartholomite, $2Na_2O$, Fe_2O_3, $4SO_3$, $2H_2O$, but differs from them in being soluble in water and being a neutral instead of a basic salt. It is quite analogous, however, to Kröhnkite,* the double sulphate of sodium and copper if we can consider that the copper may be replaced by its equivalent in ferric iron without destroying the analogy. The relationship is clearly shown by the formulæ, taking 3 parts of Kröhnkite.

Kröhnkite	$3(Na_2O, CuO, 2SO_3, 2H_2O)$
Ferronatrite (new mineral)	$3Na_2O$, Fe_2O_3, $6SO_3$, $6H_2O$

7. Associated with these minerals are several white pulverulent sulphates which are apparently alteration products, but which nevertheless possess some points of interest. Of these the first gives the following results on analysis. White, pulverulent (No. 4), sp. gr. not taken. Analysis:

---

* Cf. Darapsky, Jahrb. f. Min., i, 192, 1889.

		Ratio.
SO_3	38·00	6·25
Fe_2O_3	12·16	1·00
FeO	22·51	4·114
Na_2O	0·58	1·124
H_2O (by difference)	26·75	19·55

Formula $3FeO, Fe_2O_3, 5SO_3, 18H_2O+FeO, SO_3, H_2O$
or $4FeO, Fe_2O_3, 6SO_3, 19H_2O$

Water lost at 110° C.=9·61 molecules. This cannot be regarded as a mixture of $4FeSO_4$, Aq. and (Fe_2O_3, $2SO_3$, Aq.) because it is *perfectly white* and not red or yellow-brown, which would be the case if it was a mixture containing amarantite or No. 9. Another argument in favor of its individuality seems to be the loss of one-half its water at 110° C. It bears a certain similarity to copiapite, which suggests that it may be a product of partial reduction of, or of action of ferrous sulphate on, copiapite. This view does not seem to me to be far fetched, since the analysis of the copiapite, quoted above, shows the presence of a small quantity of ferrous sulphate. If we write copiapite $2Fe_2O_3, 5SO_3, 18H_2$ it is seen that by the substitution of $3FeO$ for $1Fe_2O_3$ in the above formula, with simultaneous addition of another molecule of $FeSO_4$ we would arrive at the formula adopted, viz:

$$3FeO, Fe_2O_3, 5SO_3, 18H_2O+FeO, SO_3, H_2O$$

8. Two other white powders associated with these minerals have given the following figures:

	A.	Ratio.	B.	Ratio.
SO_3	47·90	599	45·61	570
FeO	30·81	428	35·05	487
Fe_2O_3	5·64	35	5·14	32
Al_2O_3	0·65	6	----	---
Na_2O	4·42	71	0·33	5
H_2O (difference)	10·58	588	13·87	770

These both have as their chief constituent a ferrous sulphate with one molecule of water, as shown below:

A $428(FeSO_4, H_2O)+71Na_2SO_4+40(2Fe_2O_3, 5SO_3, 4H_2O)$
B $487(FeSO_4, H_2O)+5Na_2SO_4+16(2Fe_2O_3, 5SO_3, 18H_2O)$

In the first of these this monohydrated ferrous sulphate amounts to about 70 per cent of the material and in the second to about 78 per cent. This same compound also appears in the copiapite analysis. This form of ferrous sulphate is far more stable than melanterite, which, indeed, changes into this form very readily by loss of water when protected from oxidizing influences.