3.—MINYULITE, A NEW PHOSPHATE MINERAL FROM DANDARAGAN, W.A.

By

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In July of this year one of the authors (E.S.S.) examined the phosphate deposits of the Dandaragan district with a view to determining their distribution and economic importance, and particularly their relation to stock breeding in the area. The district is occupied by almost horizontal beds of glauconitic and non-glauconitic sands and clay-shales, with chalk of Upper Cretaceous Age. Only one bed of chalk has been clearly defined, and at the base of this, on top of a highly glauconitic sand or clay, is a thin bed of nodular apatite, whose outcrop has been found at about a dozen points in the form of ledges projecting from gentle slopes well covered with soil.

A considerable amount of secondary chemical action has gone on in the outcrops. Decomposition of the glauconite, and possibly other associated iron compounds, has resulted in the formation of much limonite, so that the nodules are found at the surface embedded in iron-stained sand, ferruginous sandstone or hard siliceous ironstone. Some of the iron has taken the place of lime in combination with the phosphoric oxide, the common product being bright green dufrenite, which is found more or less plentifully in every outcrop. It is most strongly developed in an outcrop on Crown Grant 1110, adjacent to the Minyulo Estate and not far from Minyulo Well.*

In examining the Minyulo outcrop there was to be seen a fibrous mineral, closely resembling wavellite, which occurred in small quantities in a hard phosphatic ironstone carrying partly altered apatite nodules. Under the impression that the mineral was the comparatively common species wavellite, only a few small specimens were collected. This was unfortunate, as the mineral has been proved in the laboratory to be a well defined new species for which the authors suggest the name *Minyulite.* It is a hydrous basic phosphate of potassium and aluminium.

Occurrence.—Minyulite occurs as the complete or sometimes partial filling of minute veins and cavities in a highly phosphatic ironstone bed, which is about three or four feet thick, and whose horizontal outcrop forms the summit of a low cliff of ferruginous sandstone. The phosphatic rock is composed of a mixture of limonite, quartz grains, dufrenite, nodular apatite and glauconite grains. It represents the outcrop of a coprolite-bearing greensand-chalk contact. Immediately above it is a gentle grassy slope representing the surface of the chalk, which in turn is capped by a second bed of limonitised greensand without coprolite.

* Such wells sunk on the site of permanent springs, known to and named by the aborigines, have been important *points d'appui* for pioneers in this semi-arid country, and their positions are always shown on local maps and plans.

The matrix of the best specimens of minyulite has not been analysed, but analyses of somewhat similar material showing either none, or else only small quantities, of the new mineral, collected from other parts of the same outcrop, yielded the following results:—

Mark.	D 14.	D 18.	D 19.
P_2O_5 sol. in $2\frac{1}{2}$ E. HNO_3 ...	15·84	5·22	7·18
P_2O_5 insol. in $2\frac{1}{2}$ E. HNO_3 ...	2·67	10·92	6·29
P_2O_5 total	18·51	16·14	13·47
K_2O sol. in 10 E. HCl	3·38	·50	2·33
Na_2O sol. in 10 E. HCl	·36	1·14	·78
Fe_2O_3 sol. in 10 E. HCl	26·21	41·66	27·82
CaO sol. in 10 E. HCl	0·83	0·80	?
Siliceous insoluble	29·67	19·76	33·90

As apatite is readily soluble in warm $2\frac{1}{2}$ E.HNO_3, and minyulite slowly soluble, whilst dufrenite is practically unaffected by it, the proportions of P_2O_5 under the two headings in the table give (in reverse order) an indication of the relative proportions of P_2O_5 present in combination with iron, and not so combined.

Physical Properties.—Minyulite is distinctly crystalline, forming dense radiating groups of fine fibres, often with a silky lustre. These groups either dovetail into one another, completely filling the original cavity, or form mammillated crusts round it. In one specimen of the latter kind, the individual fibres are coarser and less coherent than in the type, and they are associated with two other colourless minerals. One of these has nearly the same Nm but is monoclinic, and more broadly prismatic. The other is only imperfectly prismatic and has a much lower Nm. On the faces of very narrow cleavages in the rock, minyulite appears as flat rosettes of radiating fibres resembling wavellite. In each case the fibres are 2 to 4 or 5 mm. long, but only a small fraction of a millimetre in diameter, usually 0.02 to 0.05 mm. No terminal planes were observed and the prism boundaries did not appear to be measurable. A prismatic cleavage is suggested.

The mineral is fragile, with a hardness of 3.5, and specific gravity 2.45, determinations on two specimens giving 2.447 and 2.453. It is colourless to milky white in colour, and is translucent in thicknesses up to 3 mm. Under the microscope, the powder (0.1 mm. or less) is colourless and transparent.

The crystallisation is proved by optical tests to be orthorhombic, the extinction being parallel to the elongation of the fibres in all positions, and a difference in the value of N being observed across the fibres as they are rolled. The elongation was proved to be negative by use of the gypsum plate, *i.e.*, $X = \frac{1}{c}$. The refractive indices determined on the type by immersion were—

Ng 1.538. Nm 1.534. Np 1.531.

On the other more coarsely fibrous specimen mentioned above, determinations gave Ng 1.538, Np 1.532, and on a third specimen Ng 1.538, Np 1.5315, in all cases with negative elongation.

Composition.—Minyulite is a hydrous basic phosphate of potassium and aluminium having the formula—

$$KAl_2(OH,F)(PO_4)_2\cdot 3\tfrac{1}{2}H_2O$$

which may also be written—

$$2K(OH,F)\cdot 2Al_2O_3\cdot 2P_2O_5 + 7H_2O.$$

An analysis was made by one of us (C.R. LeM.) on a small fraction of a gramme with the following results:—

	Per cent.	Mols.	Mol. ratios.
H_2O above 200° ...	2·79	155	1
K_2O	12·30	131 }	1
Na_2O	·45	7 }	
Al_2O_3	29·98	294	2
Fe_2O_3	trace	...	...
CaO, MgO	nil	...	...
P_2O_5	35·58	250	2
F	traces	...	...
H_2O below 200° ...	17·84	979	7
	98·94		

Chemical Properties.—The mineral is readily soluble in warm dilute NaOH and in hot concentrated HCl, and slowly soluble in warm dilute HNO_3. It dissolves in hot concentrated H_2SO_4 etching slightly a glass surface in contact with it.

On heating in a closed tube it decrepitates and yields much acid water, which etches the glass. It finally melts into opaque white globules at a dull red heat.

Specific Characters.—Minyulite possesses both chemical and physical characters which indicate specific differences between it and other related aluminium or potassium-aluminium phosphates. These are best shown in the form of a table in which the distinctive characters of minyulite are given under the headings of "Chemical Differences" and "Physical Differences."

Properties of Minyulite which distinguish it from other similar minerals.

Mineral.	Formula.	Chemical Differences.	Physical Differences.
Minyulite ...	$KAl_2(OH,F)(PO_4)_2\cdot3\frac{1}{2}H_2O$ ...	...	...
Wavellite ...	$Al_3(OH,F)_3(PO_4)_2\cdot5H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Negative elongation, higher G, lower N. Low fusibility.
Spherite ...	$Al_6(OH)_9(PO_4)_2\cdot3H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Lower G, lower N, and biref. Low fusibility.
Vashegyite ...	$Al_4(OH)_3(PO_4)_3\cdot13H_2O$ ...	Presence of K, higher ratio of PO_4 to Al, less H_2O	Higher G, higher N, negative elongation. Low fusibility.
Minervite ...	$H_2KAl_2(PO_4)_3\cdot7H_2O$ ...	Basic not acid salt, lower ratio of PO_4 to Al, less H_2O	Higher G (no optical data).
Palmerite ...	$K_4Al_9(OH)(PO_4)_{10}\cdot31H_2O$ ...	Lower ratio of PO_4 to K, less H_2O	Crystalline not amorphous. (No optical data).
Leucophosphite	$K_2(Fe,Al)_7(OH)_{11}(PO_4)_4\cdot6H_2O$	No iron, higher ratio of PO_4 to R'''	(Insufficient data for comparison.)
Taranakite ...	$KAl_5(OH)(PO_4)_5\cdot18H_2O$? ...	Higher ratio of K to Al and PO_4, less H_2O	Crystalline not amorphous (No optical data.)
Englishite ...	$KCa_2Al_4(OH)_5(PO_4)_4\cdot5H_2O$ ...	No Ca, higher ratio of K to Al and PO_4	Lower G, lower N, fibrous habit.
Millisite ...	$(Na,K)CaAl_6(OH)_9(PO_4)_4\cdot4H_2O$	No Na or Ca, higher ratio of PO_4 to Al and of K to Al and PO_4	Straight extinction, lower N, lower G.
Lehiite	$(Na,K)_2Ca_5Al_8(OH)_{12}(PO_4)_8\cdot6H_2O$	No Na or Ca, higher ratio of K to Al and PO_4, more H_2O	Straight extinction, lower N, lower G.
Wardite ...	$Na_4CaAl_{12}(OH)_{18}(PO_4)_8\cdot8H_2O$	No Na or Ca, higher ratio of PO_4 to Al, higher ratio R' to R'''	Or. cryst., lower N, lower G.

The type specimen is being presented to the Western Australian Museum and a paratype to the British Museum.

SUMMARY.

A complete chemical and physical description is given of a new orthorhombic phosphate of potassium and aluminium, which was found in the altered outcrops of glauconitic coprolite beds of Cretaceous age near Minyulo well at Dandaragan. The name Minyulite is proposed for it.

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