On stichtite from Cunningsburgh, Shetland Islands.

By H. H. READ, D.Sc.

Professor of Geology, University of Liverpool,

and B. E. DIXON, M.Sc., A.I.C.

H.M. Geological Survey Laboratory.

THE rare mineral stichtite, a complex hydroxy-carbonate of magnesium, chromium, and iron, was defined in 1910 by W. F. Petterd[1] on material from the Adelaide silver-lead mine, Dundas, Tasmania. Petterd's description, together with detailed optical and chemical studies by A. S. Wesley, L. K. Ward, L. Hezner,[2] and A. Himmelbauer,[3] were collected by W. H. Twelvetrees[4] and issued by the Tasmanian Department of Mines in 1914. A new analysis of the Tasmanian material is included by W. F. Foshag[5] in his investigation of the hydrotalcite group.

The mineral was next recorded by E. Poitevin and R. P. D. Graham[6] from the Megantic mine, Black Lake area, Quebec; no chemical data of this occurrence are available.

The third occurrence of stichtite, in the Barberton district, Transvaal, was first mentioned by E. J. Dunn[7] in 1918, and described in detail by A. L. Hall[8] in 1922. The latter gave chemical analyses of the stichtite and of the rock in which it is found.

---

[1] W. F. Petterd, Catalogue of the minerals of Tasmania, 1910, pp. 167–169.

[2] L. Hezner, Centr. Min., 1912, p. 569.

[3] A. Himmelbauer, Min. Petr. Mitt. (Tschermak), 1913, vol. 32, p. 135.

[4] W. H. Twelvetrees, Tasmania Dept. Mines, Geol. Surv. Record, 1914, no. 2.

[5] W. F. Foshag, Proc. U.S. Nat. Museum, 1920, vol. 58, p. 147. [Min. Abstr., vol. 1, p. 175.]

[6] E. Poitevin and R. P. D. Graham, Canada Dept. Mines, Geol. Surv., Mus. Bull., 1918, no. 27, pp. 27–30. [M.A. 1–9.]

[7] E. J. Dunn, Industrial Australian and Mining Standard, 1918, vol. 60, p. 775. [M.A. 1–47.] The mineral had been found by Dunn in 1883, long before the discovery of the Tasmanian stichtite, and in 1885 he presented a specimen to the British Museum collection of minerals, which at the time was doubtfully referred to kämmererite.

[8] A. L. Hall, Trans. Geol. Soc. S. Africa, 1922, vol. 24 (for 1921), p. 182. [M.A. 1–339.]

At the three localities of stichtite hitherto described, the mode of occurrence of the mineral is the same, the stichtite forming small patches, veinlets, or coatings to slip-planes, in chromite-bearing serpentine.

The Shetland stichtite that forms the subject of this note was found by H. H. Read whilst a member of H.M. Geological Survey. He desires to express his thanks to Sir John Flett, F.R.S., Director of the Survey, for permission to investigate the material after he had left that service, and especially for the facilities afforded of chemical co-operation with B. E. Dixon.

The locality of the Shetland occurrence is 665 yards E. 14° S. of the 800-foot triangulation point on the top of Hoo Field, Cunningsburgh, Mainland. The surrounding country has been mapped by J. Knox for the Geological Survey.[1] The sedimentary metamorphic rocks of the district consist of a varied series of dominantly argillaceous rocks, including chloritoid-schists, together with limestones, calc-silicate-rocks, black amphibole-rocks and graphitic schists. In this series occur large masses of serpentine and talc-schist, bounded by planes of shear. The stichtite is found in one of these serpentine masses.

The serpentine typical of the mass is a compact greenish rock, in thin slice seen to be composed almost entirely of small blades of colourless antigorite, similar in optical properties to the antigorite associated with the stichtite and described below. The blades are often arranged in two sets, producing a lattice effect, but in some slices no arrangement is discernible. In addition to the antigorite, there are present a few grains of brown chromite, and still fewer tiny specks of black iron oxide.

In such a greenish serpentine the stichtite is conspicuous as rose-pink patches, usually rather rounded in form, at times somewhat elongated and rarely stripe-like. The maximum size of the mineral aggregates is half a centimetre. Slices show that the associates of the stichtite are antigorite, chromite, iron oxide, and dolomite.

The stichtite occurs as fibres or matted masses of fibres, variable in thickness, and often curved or with noded ends. These fibres are perpendicular to irregular kernels of residual chromite (fig. 1). There can be no doubt that the stichtite aggregates have the shapes of original chromite grains. The specific gravity of the stichtite is 2·19 at 17° C.

[1] Summ. Prog. Geol. Surv. Great Britain for 1930, 1931, part 1, p. 73.

Under the microscope the stichtite fibres are delicate rose-pink in colour and show no pleochroism. They have straight extinction and positive elongation; no interference-figures were obtained. The determination of the refractive indices of these fine and often bent fibres is not altogether satisfactory. The immersion method was employed. The maximum refractive index is for light vibrating
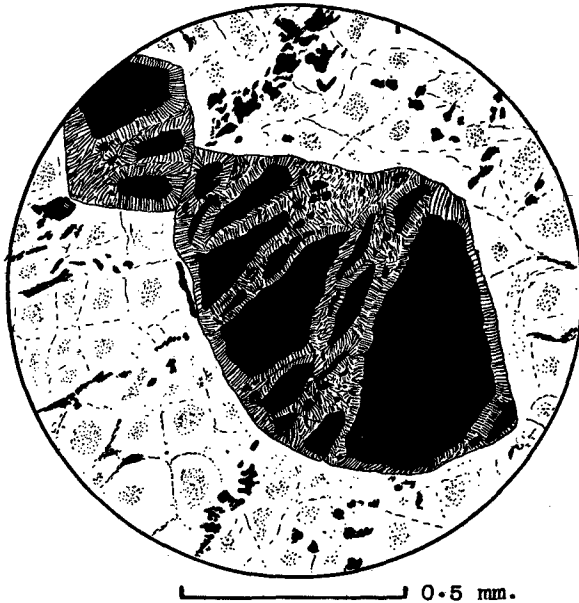

0·5 mm.

FIG. 1. Stichtite replacing chromite in antigorite-serpentine from Cunningsburgh, Shetland. ×60.

parallel with the fibres. Concordant and quite satisfactory observations gave 1·559 for sodium-light at 17° C. Determination of the values for light vibrating across the fibres is not so good; the difficulty of working with bunches of fine curving fibres in this position vitiates the results. The best observations gave 1·543 for sodium-light at 17° C.; probably the lowest refractive index is slightly lower than this. It seems possible that the refractive index for rays vibrating across the fibres is not constant, i.e. the mineral is not uniaxial.

Of the associates of the stichtite, the antigorite occurs as criss-crossing blades, with positive elongation; α across the blades is

1·564 (not a good reading), γ along the blades is 1·572, both for sodium-light at 18° C. The mineral is negative, with an optic axial angle of moderate size; the optic axial plane lies parallel to the elongation and perpendicular to the plane of the blades. Chromite is brown in very thin sections; it forms irregular fragments surrounded by radiating fibres of stichtite. Black iron oxide occurs as small grains, often in strings, or occasionally as thin irregular veinlets. Dolomite, determined by the refractive index of cleavage rhombs, builds small patches or thin veinlets. It is, of course, possible that other carbonates, e.g. magnesite, are present in this association. In view of the procedure adopted in the chemical analysis of the partly purified stichtite, mounts in oils of the material analysed, aggregating in all perhaps half a gram, were searched for carbonate; no more than half a dozen grains were found, so that even if carbonates other than dolomite are present, they can affect the interpretation of the chemical analysis only to a negligible degree. The veinlets of iron oxide or of dolomite never penetrate the stichtite-chromite areas, though they may run along their margins.

The material, mechanically purified as far as possible, was subjected to a complete analysis. It was fused with sodium carbonate and potassium nitrate in a platinum crucible until the melt had completely dissolved. A considerable amount of platinum was dissolved in this way, and also during the subsequent separation of the silica, but in view of the importance of a complete solution of the chromite and of an accurate determination of the silica, this was unavoidable. The platinum, which would have proved troublesome later, was separated from the solution by means of hydrogen sulphide after the removal of silica by evaporation to dryness and filtration.[1] The iron, aluminium, and chromium were separated by a double precipitation with ammonia and determined titrimetrically and gravimetrically. In the filtrate manganese, calcium, and magnesium were estimated by usual methods. No titanium, phosphate, nickel, cobalt, or non-chromitic ferrous iron were detected. The ferric iron, chromium, and magnesium of the stichtite were determined in a solution obtained by extracting the sample with cold $N\text{-}H_2SO_4$. The total water was estimated by Penfield's method, and carbon dioxide by absorption in caustic potash; these results were corroborated by the loss on ignition (20·95 %). The complete analysis is shown under 1.

[1] B. E. Dixon, Journ. Chem. Soc., 1931, p. 2311.

	1.	2.	3.	4.	5.	6.	7.
SiO_2	8·51	—	—	—	3·87	2·09	4·50
Al_2O_3	1·10	—	—	—	—	2·24	0·90
Cr_2O_3	27·10	17·75	17·75	11·5	20·44	14·08	8·90
Fe_2O_3	6·52	3·50	3·73	9·0	—	4·04	10·60
FeO	8·95	—	—	—	1·10	0·28	0·85
MnO	0·05	—	—	—	—	—	—
MgO	26·72	39·49	39·55	36·0	37·12	36·59	36·70
CaO	0·10	—	—	—	—	trace	—
CO_2	3·14	6·83	6·17	7·2	10·45	6·94	6·90
H_2O+	17·46 ⎫	32·43	32·80	36·1	26·31 ⎫	33·01	26·80
H_2O-	0·24 ⎭				0·95 ⎭		3·65
	99·89	100·00	100·00	99·8	100·24	99·27	99·80

1. Impure stichtite from Cunningsburgh, Shetland. Analyst, B. E. Dixon. $H_2O \pm 105°$ C.
2. Analysis 1 recalculated after deducting impurities.
3. Calculated percentage composition corresponding to the formula
   $(Cr, Fe)_2O_3.7MgO.CO_2.13H_2O$, with $Cr_2O_3 : Fe_2O_3 = 5 : 1$.
4. Stichtite from Dundas, Tasmania. W. F. Petterd, 1910. Analyst, A. S. Wesley.
5. Ditto. L. Hezner, 1912. $H_2O \pm 120°$ C.
6. Ditto. W. F. Foshag, 1920.
7. Stichtite from Barberton, Transvaal. A. L. Hall, 1922. Analysts, J. McCrae and H. G. Weall. Also NiO 0·10, Na_2O 0·05, K_2O trace. $H_2O \pm 100°$ C.

For the determination of the mineral composition of the sample analysed, the acid-soluble Fe_2O_3, Cr_2O_3, and MgO (1·61, 8·16, and 18·05 %, respectively) were calculated to stichtite, and the SiO_2 to serpentine. The value obtained by deducting the acid-soluble MgO from the total MgO agreed with that required by the serpentine. The water not required by the serpentine was calculated to stichtite, and the remaining Cr_2O_3 to chromite. After deducting the iron of the stichtite and chromite from the total iron, 4·91 % Fe_2O_3 remained. This leads to the following mineral composition of the sample analysed : stichtite 45·97, serpentine 19·63, chromite 27·89, iron oxides 4·91 %.

In view of the large amount of associated minerals present in the sample, tests were carried out as a check on the mineral composition. In a series of extractions of the original powder, the strength of acid used was gradually increased, but the amount of iron dissolved remained practically constant, e.g. hot 1 : 1 H_2SO_4 dissolved only 1·90 % Fe_2O_3. This wide gap between complete solution of the stichtite iron and commencement of solution of the remainder of the

iron justifies the identification of the 4·91 % Fe_2O_3 with the iron oxides detected in the optical examination. No alumina was found in the acid extract.

There remained the rather remote possibility of the extraction of some finely divided serpentine by the cold acid. When the acid used was so weak as to exclude the possibility of attack of the serpentine, the ratios of $MgO : Fe_2O_3 : Cr_2O_3$ extracted (16·57 : 1·60 : 7·49 %), remained unaltered, although in this case solution of the stichtite was not quite complete. Moreover, no silica was detected in the N-acid extract.

The calculation of the percentage composition of the stichtite component leads to the formula $(Cr,Fe)_2O_3.7MgO.CO_2.13H_2O$, in which $Cr_2O_3 : Fe_2O_3$ is very nearly 5 : 1 (columns 2 and 3, p. 313).

There has been considerable divergence of opinion as to the composition of stichtite. This seems to be mainly due to the great difficulty of procuring pure material for analysis, to confusion as to the function of the ferric and chromium oxides, and as to the ratio of the magnesia to the sesquioxides. Petterd (analysis 4) proposed the formula $(Cr,Fe)_2O_3.6MgO.CO_2.13H_2O$, although the actual molecular ratio $MgO : R_2O_3$ calculated from his figures is 6·77 : 1. Hezner considered the SiO_2 and FeO in analysis 5 to be due to serpentine and chromite respectively, which were shown to be present by optical examination. On recalculating the figures on this basis, she found they agreed well with the formula $Cr_2O_3.7MgO.2CO_2.12H_2O$. Another analysis (6) of stichtite was carried out by Foshag, who assigned the mineral to the hydrotalcite group, including Al_2O_3 with the sesquioxides, and proposing the formula $R_2O_3.6MgO.CO_2.12H_2O$. His analysis, however, shows an appreciable quantity of unallotted SiO_2, although the Tasmanian material he used is described as containing serpentine. Finally, Hall (analysis 7) concluded that it was doubtful whether stichtite had a constant chemical composition.

All accounts of the mineral agree that stichtite occurs intimately admixed with serpentine and chromite ; siliceous minerals other than serpentine have apparently not been reported. It is reasonable to assume, therefore, that the bulk of the silica and the small quantities of ferrous iron reported in these analyses are present in the form of these minerals. When the analytical figures are recalculated on this basis (p. 315) it is seen that :

(1) The ferric and chromium oxides are mutually replaceable over a wide range (0–60 % Fe_2O_3).

(2) The molecular ratio $MgO : R_2O_3$ approximates very closely to seven in all cases.

(3) There are two equivalents of CO_2 in the molecule when Cr_2O_3 is the only sesquioxide present; when Cr_2O_3 is partially replaced by Fe_2O_3, the amount of CO_2 approximates to one equivalent, but is somewhat in excess of this amount in all cases.

(4) In three cases the sum of equivalents of CO_2 and H_2O is very nearly fourteen, suggesting that these components are to some extent interchangeable. Unfortunately, in the cases of Analyses 4 and 6 the temperature of expulsion of the water is not stated, and the figures given may include uncombined water.

Analyses of stichtite after deducting serpentine and chromite.

		Percentages.	Molecular Proportions.		Percentage Ratio $Cr_2O_3 : Fe_2O_3$.
Analysis 1.	Cr_2O_3 ...	8·16	0·054 } 0·064	0·99	84 : 16
	Fe_2O_3 ...	1·61	0·010 }		
	MgO ...	18·15	0·450	7·00	
	CO_2 ...	3·14	0·071	1·11 } 13·96	
	H_2O ...	14·91	0·826	12·85 }	
Analysis 4.	Cr_2O_3 ...	11·5	0·076 } 0·132	1·03	57 : 43
	Fe_2O_3 ...	9·0	0·056 }		
	MgO ...	36·0	0·893	7·00	
	CO_2 ...	7·2	0·164	1·28	
	H_2O ...	36·1	2·005	15·70 *	
Analysis 5.	Cr_2O_3 ...	18·11	0·119 0·119	1·01	100 : 0
	Fe_2O_3 ...	—	—	—	
	MgO ...	33·22	0·824	7·00	
	CO_2 ...	10·45	0·238	2·02 } 13·88	
	H_2O ...	25·15	1·396	11·86 }	
Analysis 6.	Cr_2O_3 ...	13·49	0·089 } 0·114	0·93	78 : 22
	Fe_2O_3 ...	4·04	0·025 }		
	MgO ...	34·49	0·855	7·00	
	CO_2 ...	6·94	0·158	1·29	
	H_2O ...	32·38	1·798	14·72 *	
Analysis 7.	Cr_2O_3 ...	7·10	0·047 } 0·113	0·99	41 : 59
	Fe_2O_3 ...	10·60	0·066 }		
	MgO ...	32·17	0·798	7·00	
	CO_2 ...	6·90	0·157	1·37 } 13·77	
	H_2O ...	25·45	1·413	12·40 }	

* Temperature at which H_2O is expelled not stated.

On this interpretation, all five analyses agree well with the following general formula for stichtite :

$$2(Cr,Fe)(OH)_3.5Mg(OH)_2.MgCO_3.Mg[CO_3,(OH)_2].4H_2O.$$

The chromium may be regarded as completely replaceable by iron, although in the analyses examined this replacement scarcely

exceeds 50 % in extent.   There may be structural difficulties in the way of admitting complete replaceability of the carbonate radical by hydroxide over an indefinite range, and an examination of the analytical results does not exclude the possibility of replacement limited to definite stoicheiometric stages.

All descriptions show agreement as to the mode of occurrence of the mineral, small fragments of chromite serving as nuclei to masses of stichtite in the serpentine.   In all but one of the reported occurrences, chromium occupies the larger part of the sesquioxide component ; in Hezner's sample, which represents the end-member of the stichtite series, the total absence of iron is accompanied by the entry of a second molecule of carbon dioxide in place of the equivalent of hydroxide.   It is noteworthy that the associated serpentine in this case is free from ferric iron, whilst the serpentines accompanying the iron-bearing stichtites from Shetland and South Africa are distinctly ferruginous.