Smithsonite from the Rhodesia Broken Hill mines.

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D URING an examination of zinc ores I had occasion recently to
employ methods for the identification of smithsonite, and was
surprised to find how scanty and indefinite are the data of its physical
properties as stated in text-books. Most of the smithsonite known
occurs either compact or as very small crystals many of which are of
a composite nature. In this connexion Dr. L. J. Spencer recently
acquired for the British Museum some very fine crystals from the
Rhodesia Broken Hill mines, and he suggested that this material would
be suitable for a detailed examination. These consist of two specimens
obtained in 1921 from Mr. W. E. Harris [B.M. 1921, 769] and in 1923
from Dr. O. L. Brady [B.M. 1923, 619] respectively, and are portions of
the same mass. Smithsonite crystals were first described from this
locality by Dr. Spencer in 1908,[1] but these crystals were minute and
showed only the forms v (20$\bar{1}$) and s (22$\bar{3}$).

The crystals now described are all simple rhombohedra f (1$\bar{1}$1) with
edges up to 7 mm. in length. On damaged crystals these edges are
frequently truncated symmetrically by cleavage. Some apparent faces
proved to be merely surfaces of contact of aggregated crystals, and,
although well-defined, gave no reflected images. All the rhombohedral
faces bear striations parallel to their longer diagonal, whereas similar
crystals [B.M. 1924, 1050] obtained more recently from the same locality
have their faces distorted by parallel growth as is common in calcite.

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[1] L. J. Spencer, Min. Mag., 1908, vol. 15, p. 35.

Since the faces are not rounded, this striation may be due to a composite growth of individuals relatively oriented by a slight rotation about the trigonal axis.

This composite character is borne out by reflections from the cleavage-surfaces. Only on minute cleavage-rhombs do the surfaces give single images; ten such fragments showing good images gave a cleavage-angle varying from 72° 19′ to 72° 25′ with an average of 72° 21′, whereas larger fragments gave readings of anything between 72° and 73°. For comparison, an attempt was made to measure the cleavage-angle of the more-recently obtained composite crystals, which, moreover, differ also in having a very faint yellowish tint. Several cleavage-rhombs gave good single-image reflections, the readings for the cleavage-angle varying from 72° 21½′ to 72° 27′ with an average of 72° 24′.

The hardness varies from 4 to 4½. Owing to the cleavage, it is difficult to test how far the mineral scratches fluorite, but it was always possible to scratch a cleavage-surface with apatite. The hardness of smithsonite was first determined by Robert Jameson, who in his 'System of Mineralogy' (3rd edition, 1820, vol. 2, p. 442) says 'It is as hard as apatite'. Thereafter the hardness of smithsonite has been quoted as 5.

The crystals are in general quite colourless and transparent, though some of them appear to be yellowish through admixture of limonite, with which they occur intimately associated. A little over a gram of pure material was collected and two independent determinations of the specific gravity made on 0·6785 gram with a pyknometer gave 4·397 and 4·398 at 16·2° C. and 16·6° C. respectively.

For the chemical analysis, the powdered material was divided into two portions. Preliminary tests showed the impurities to consist of FeO, MnO, CaO, MgO, and the powder after drying at 110°C. contained no water. Consequently the carbon dioxide was determined by ignition-loss in both portions. In the former ZnO, FeO, CaO, MgO were determined in the usual way, and in the latter MnO was determined colorimetrically.

On ignition the powder becomes orange-coloured (zinc oxide), and on cooling it retains a reddish-brown ferruginous tint. When the ignited material is dissolved in hydrochloric acid, ferric oxide is left behind and only dissolves very slowly or by the addition of nitric acid. The original carbonate dissolves completely and with ease in hydrochloric acid, showing that the ferric oxide is produced during ignition. Consequently, to the value of CO_2 obtained by ignition must be added the oxygen equivalent to the oxidation of the ferrous oxide.

Results of analysis.

	I.	II.	Average.		
ZnO	63.18	... —	... 63.18	ZnCO$_3$ ...	97·34
FeO	0.58	... —	... 0·58	FeCO$_3$ ...	0·93
MnO	—	... 0·01	... 0.01	MnCO$_2$ ...	0·02
CaO	0·27	... —	... 0.27	CaCO$_3$ ...	0.48
MgO	0.45	... —	... 0.45	MgCO$_3$ ...	0.94
CO$_2$	35.34	... 35·36	... 35·35		
H$_2$O (hygroscopic)	0·03	... 0.04	... 0.04		99·71
			99.88		

The optical properties were determined on two detached crystals previous to the analysis for which waste fragments were preserved. From one a 60°-prism (prism 1) was ground with its edge parallel to the trigonal axis of the crystal and its faces roughly parallel to m (2$\bar{1}\bar{1}$); the prism-angle was measured as 61° 9'. The other crystal was cleaved into two, and two prisms (prisms 2 and 3) were prepared with the edges perpendicular and parallel to the principal axis and with prism-angles of 60° 56' and 57° 56' respectively. In prism 2 one of the faces corresponded roughly to $f(1\bar{1}1)$, and the orientation of prism 3 was similar to that of prism 1. The grinding was done with a Thomas & Smith instrument on a glass plate, putty-powder being used for the final polishing.

The refractive indices were determined with these three prisms for different wave-lengths by employing the Tutton monochromatic illuminator, for the calibration of which I am indebted to Dr. Herbert Smith, and gave the following results:

Line.	Extraordinary ray.				Ordinary ray.		
	1.	2.	3.		1.	2.	3
Li ...	1·6187	1·6187	1·6186	...	1·8427	1·8424	1·8423
C ...	1·6190	1·6190	1·6189	...	1·8436	1·8427	1·8433
Na ...	1·6214	1·6214	1·6212	...	1·8488	1·8480	1·8485
Tl ...	1·6243	1·6237	1·6239	...	1·8550	1·8545	1·8547
F ...	1·6277	1·6270	1·6274	...	1·8623	—	1·8621
G ...	1·6327	1·6320	1·6326	...	1·8737	—	1·8736

With prism 2 the violet end of the spectrum gave very faint images, and in the case of the ordinary ray the light was obstructed by a flaw. The results of prism 3 are probably nearest the truth.

Optical values for smithsonite are very few in the literature, and all those in the text-books appear to be derived from the following two sources. W. Ortloff[1] gave $\epsilon = 1\cdot61766$ on analysed pure material from

[1] W. Ortloff, Zeits. physik. Chem., 1896, vol. 19, p. 215.

Aachen. Sir Henry A. Miers in his 'Mineralogy' (1902, p. 553) gave the birefringence as 0·200, but I have been unable to trace the origin of this figure. Until recently these figures were the only ones published, when P. Gaubert[1] gave $\epsilon = 1·612$ and $\omega = 1·872$ for somewhat impure ($ZnCO_3 = 90·43 \%$) analysed material from Chessy; he also gave $\epsilon = 1·619$ for smithsonite from Laurion. The value of ω he had previously given[2] as $\omega = 1·782$, and I understand from Professor A. N. Winchell that P. Gaubert ascribes the higher value ($\omega = 1·872$) to a misprint; moreover these values for ω were determined only indirectly from the extreme values of the extraordinary refractive index given by total reflection from the cleavage-surfaces.

Attempts to determine the indices by this method gave for the Rhodesian material $\epsilon = 1·620$ and $\epsilon' = 1·740$, from which, assuming $cr = 42° 57'$, $\omega = 1·838$. The readings of the refractometer were, however, very obscure.

Summary of Data.

Crystal-form $f(1\bar{1}1)$. Cleavage-angle $rr' = 72° 21'$. H = 4–4$\frac{1}{2}$. G = 4·398. $\epsilon_{Na} = 1·6212$, $\omega_{Na} = 1·8485$. Contains 97·34 % $ZnCO_3$.

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[1] P. Gaubert, Bull. Soc. Franç. Min., 1919, vol. 42, p. 99.

[2] P. Gaubert, Compt. Rend. Acad. Sci. Paris, 1917, vol. 164, p. 47.