FRENZEL, G. (1958) Ein neues Mineral: Idait (vorläufige Mitteilung) *Neues Jb. Mineral. Mh.* p. 142.

——— (1959) Idait und "blaubleibender Covellin." *Neues Jb. Mineral.* **93,** 87–132.

——— (1960) Nochmals über Idait (Entgegnung auf die Kritik von E. N. Eliseev). *Mitt. Mineral. Ges. UdSSR*, p. 490.

——— (1960) Über die Darstellung von Cu_5FeS_6. *Schweiz. Mineral. Petro. Mitt.* **40,** 243–251.

FRIEDRICH, O. M. (1959) Mineralogische Bemerkungen über die Kieslagerstätte Prettau im Ahrntal, Südtirol. *Veröff. Mus. Ferdinandeum*, **39,** 139–146.

KOBE, H. W. (1961) Idaita-Mineral de Cobre en Yauricocha. *Bol. Soc. Geol. Peru.* **36,** 103–114.

YUND, R. A. (1963) Crystal data for synthetic $Cu_{5.5x}Fe_xS_{6.5x}$ (Idaite). *Am. Mineral.* **48,** 672–676.

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FLUOBORITE FROM CRESTMORE, CALIFORNIA

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INTRODUCTION

The thermally metamorphosed impure limestones at Crestmore, California, are well known for the wealth of minerals found in them (Murdoch and Webb, 1948). Among specimens collected by one of us (E.R.S.) during an excursion to Crestmore quarries in 1958 was a dolomitic marble containing numerous prismatic crystals up to 5 mm by 1 mm in size. Thin sections of the rock showed the presence of two non-carbonate minerals. One was the new mineral wightmanite (Murdoch, 1962), and the other occurred as somewhat poikiloblastic crystals which were first taken to be scapolite. Some basal sections, however, appeared to be hexagonal rather than tetragonal (Fig. 1), and more detailed optical and *x*-ray examination identified the material as fluoborite. It comprised about one per cent of the rock sample.

CHEMICAL COMPOSITION

An analysis of the Crestmore material is given in Table 1. Two samples, each of approximately 0.1 gram, were separated from two apparently identical rock fragments by dissolving the carbonate mineral in 10 per cent hydrochloric acid followed by centrifuging the residue in bromoform, in which the fluoborite just sank.

The first sample was almost completely free from contaminating materials. Fluorine and boron were determined on this at the C.S.I.R.O. Micro-Analytical Laboratory, Melbourne, Australia. The second sample

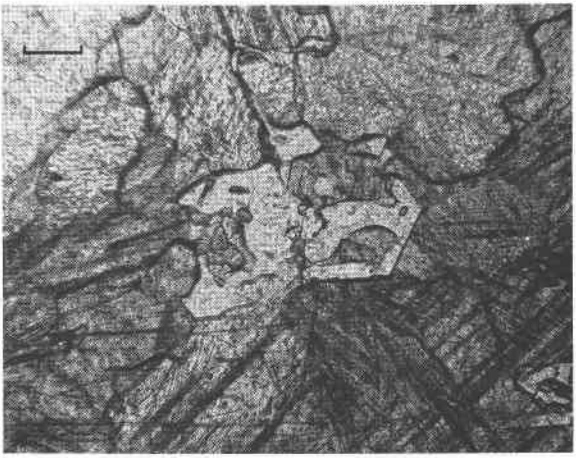

FIG. 1. Basal section of poikiloblastic crystal of fluoborite in dolomite marble from Crestmore, California. Scale line repesents 0.1 mm.

contained inclusions of prismatic crystals of higher refractive index. Extra lines in the *x*-ray powder photograph of this sample identified the contaminant as a member of the humite group. Magnesia was determined on this sample by EDTA titration on the residue after evaporation with sulfuric acid. The silica figure was obtained by hydrofluoric-sulfuric acid evaporation of a similar residue, and may thus be somewhat low. Insufficient material was available for a reliable direct water determination; the figure given in the analysis is that calculated from the fluorine content, after allowing for the silica which was calculated as humite.

Loss on ignition was 16.5 per cent. If this is assumed to be H_3BO_3, the

TABLE 1. COMPOSITION AND OPTICAL PROPERTIES OF FLUOBORITE FROM CRESTMORE, CALIFORNIA

MgO	64.0	Uniaxial negative
B_2O_3	18.5	Refractive indices:
F	14.8	$\omega = 1.570 \pm .001$
$(H_2O)^1$	6.1	$\epsilon = 1.534 \pm .001$
SiO_2	3.7	$\omega - \epsilon = .036$
	107.1	
Less O for F	6.2	
	100.9	

[1] Calculated from fluorine content.

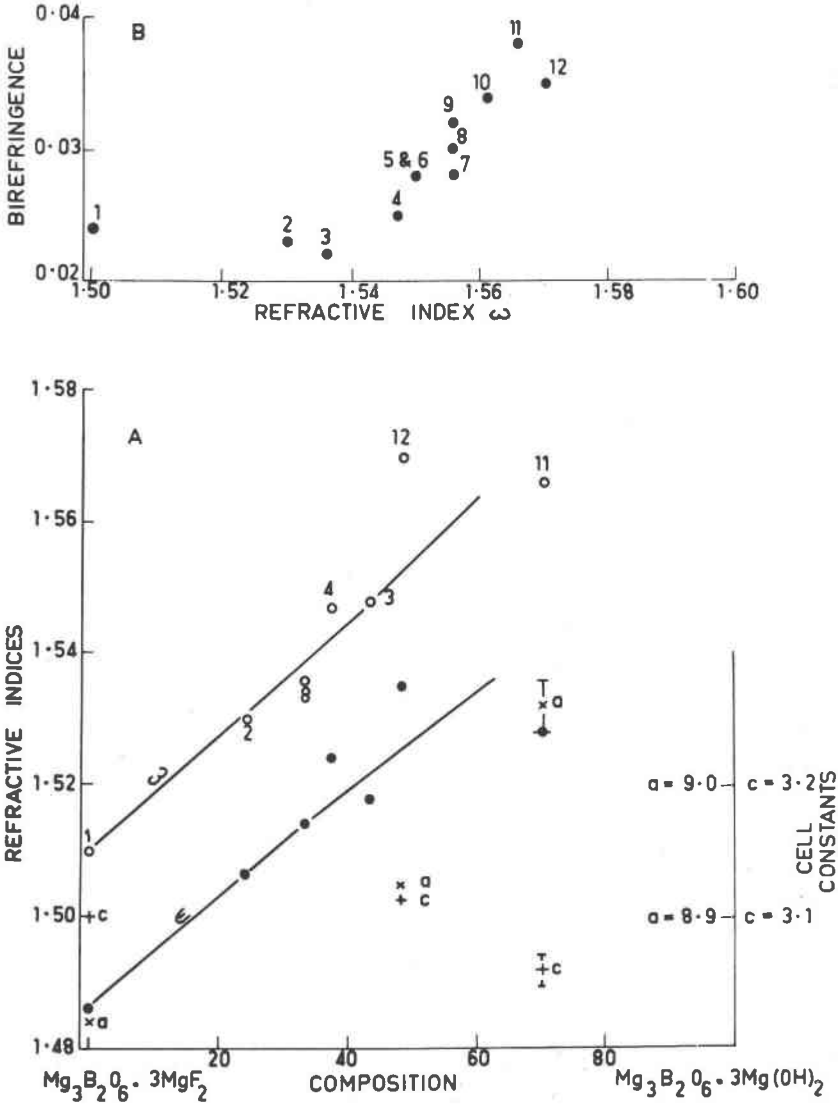

FIG. 2. A. Variation of refractive indices with composition of fluoborites.
B. Plot of refractive index of ordinary ray against birefringence.

1—Nocera, Italy. (Brisi and Eitel, 1957)
2—Seilibin, Malaya. (Johnston and Tilley, 1940)
3—Pitkäranta, Finland. (Eskola and Juurinen, 1952)
4—Sterling Hill, N. J. (Bauer and Berman, 1929)
5—Chosen, Manchuria. (Watanabe, 1939)
6, 7 } Broadford, Skye (Tilley, 1951)

Table 2. *X*-ray Powder Diffraction Data for Fluoborite from Crestmore, California

(CuK $_\alpha$ radiation, $\lambda = 1.5418$ Å, focussing transmission camera of 114.6 mm diameter)

hkl	d calc. Å	d obs. Å	I
100	7.73	7.72	m
110	4.462	4.462	ms
200	3.863		
001	3.115		
210	2.921	2.921	mw
101	2.889	2.890	mw
300	2.576	2.575	m
111	2.554	2.554	mw
201	2.425	2.424	s
220	2.231	2.229	vw
310	2.143	2.143	ms
211	2.131	2.129	ms
301	1.985	1.984	vvw
400	1.932	1.931	w
221	1.814	1.815	m
320	1.773	1.773	mw
311	1.766	1.765	mw
410	1.686	1.686	vw
401	1.642	1.641	mw
002	1.558	1.557	mw
500	1.546		
321	1.541	1.540	mw
102	1.527		
330	1.487		
411	1.483	1.483	m
112	1.471	1.471	vvw
420	1.461	1.461	vw
510	1.388	1.388	w
212	1.374	1.374	vvw
331	1.342	1.343	vw
302	1.333	1.334	w

Lattice parameters:
$a = 8.924$ Å $\pm .001$
$c = 3.115$ Å $\pm .003$

8—Sterling Hill, N. J. (Palache, 1935 quoted in Schaller, 1942)
9—Quérigut, France. (Struwe, 1957–8)
10—Lincoln County, Nev. (Gillson and Shannon, 1925)
11—Norberg, Sweden. (Geijer, 1927)
12—Crestmore, Calif. (This paper).

equivalent water content would be 7.1 per cent, which is of the same order as that calculated from the fluorine content.

The composition of the fluoborite, calculating silica as a humite mineral with 58 per cent MgO, is thus close to 48 per cent of the hydroxyl end-member.

OPTICAL PROPERTIES

Optical properties of the Crestmore sample are given in Table 1. Refractive indices were determined by the immersion method using sodium light. Indices of liquids were checked during the determinations by a Hilger refractometer.

The optical properties of fluoborites described in the literature have been plotted in Fig. 2. "A" shows the variation of refractive indices with composition. The Crestmore fluoborite appears to have rather high refractive indices but no explanation can be offered for this at present. "B" shows a plot of the refractive index of the ordinary ray against the birefringence. There is a strong non-linearity in the change of the latter property with the refractive index, the break occurring in the region of composition of 50 per cent of each end member. This may also be related to the possible discontinuity in cell dimensions near this composition.

X-RAY DATA

X-ray powder patterns were prepared with a focussing transmission camera of 114.6 mm diameter and CuK_α radiation monochromatized by a quartz focussing reflector. An average of measurements obtained from two films standardized against αAl_2O_3 is given in Table 2. The Swanson and Fuyat (1953) determination of the αAl_2O_3 cell size has been used. The hexagonal fluoborite cell of dimensions $a = 8.924$ Å and $c = 3.115$ Å gives good agreement between observed and calculated d values for a wide range of reflections.

Takeuchi (1950) determined the structure of fluoborite on material from the type locality (Tallgruvan, Norberg District, Sweden) and determined the following cell constants: $a = 9.06 \pm 0.02$ Å and $c = 3.06 \pm 0.01$ Å. These, together with the cell constants of the fluorine end-member (Brisi and Eitel, 1957) are plotted against composition in Fig. 2. An increase of the *a* dimension with replacement of F by OH is indicated, while the *c* dimension shows little change, which is in agreement with the structure proposed by Takeuchi.

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REFERENCES

BAUER, L. H. AND H. BERMAN (1929) Mooreite, a new mineral, and fluoborite from Sterling Hill, New Jersey. *Am. Mineral.* **14.** 165–172.

BRISI, C. AND W. EITEL (1957) Identity of nocerite and fluoborite. *Am. Mineral.* **42,** 288–293.

ESKOLA, P. AND A. JUURINEN (1952) Fluoborite from Pitkäranta. *Bull. Comm. Geol. Finlande,* **157,** 111–114.

GEIJER, P. (1927) Some mineral associations from the Norberg district. *Svër. Geol. Unders. Årsbok,* **20,** (for 1926) (4).

GILLSON, J. L. AND E. V. SHANNON, (1925) Szaibelyite from Lincoln County, Nevada. *Am. Mineral.* **10,** 137–139.

JOHNSTON, R. W. AND C. E. TILLEY (1940) On fluoborite from Selibin, Malaya. *Geol. Mag.* **77,** 141–144.

MURDOCH, J. (1962) Wightmanite, a new borate mineral from California. *Am. Mineral.* **47,** 718–722.

——— AND R. W. WEBB (1948) Minerals of California. *Calif. Div. Mines. Bull.* **136.**

SCHALLER, W. T. (1942) The identity of ascharite, camsellite and β-ascharite with szaibelyite; and some relations of the magnesium borate minerals. *Am. Mineral.* **27,** 467–486.

STRUWE, H. (1957–8) Data on the mineralogy and petrology of the dolomite-bearing northern contact zone of the Quérigut granite, French Pyrenees. *Leidse Geol. Mededel.* **22,** 237–349.

SWANSON, H. E. AND R. K. FUYAT (1953), Standard X-ray diffraction powder patterns. *Nat. Bur. Stand. Circ.* **539** (Vol. 2).

TAKEUCHI, Y. (1950) The structure of fluoborite. *Acta Cryst.* **3,** 208–210.

TILLEY, C. E. (1951) The zoned contact-skarns of the Broadford area, Skye: A study of boron-fluorine metasomatism in dolomites. *Mineral. Mag.* **29,** 621–666.

WATANABE, T. (1939) Kotoit, ein neues gesteinbildendes Magnesiumborat. *Min. Petr. Mitt. (Tschermak),* **50,** 441–463.

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LEONHARDITE AND LAUMONTITE IN DIABASE FROM DILLSBURG, PENNSYLVANIA[1]

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INTRODUCTION

A detailed survey of the laumontite-leonhardite relation was presented by Coombs (1952) and subsequently incorporated into the ASTM x-ray powder data file. The principal difference between the two minerals is a variation in hydration from the full hydrated laumontite to less hydrous

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