

REFERENCES

- Alabaster (C.), 1975. *Proc. Bristol Nat. Soc.* **34** (for 1974), 76–104.
 Mart (J.) and Sass. (E.), 1972. *Econ. Geol.* **67**, 145–55.
 Mellor (J. W.), 1929. *Comprehensive Treatise on Inorganic and Theoretical Chemistry*. London, Longman Green & Co.
 Wray (J. L.) and Daniels (F.), 1957. *J. Am. Chem. Soc.* **79**, 2031–4.

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Chromium in dravite

THE general formula of dravite is $(\text{Na}, \text{Ca})\text{Mg}_3\text{Al}_6\text{B}_3\text{Si}_6(\text{O}, \text{OH})_{30}(\text{OH}, \text{F})$; it grades evenly, without miscibility gaps, to uvite $(\text{Ca}, \text{Na})\text{Mg}_3(\text{Al}_5\text{Mg})\text{B}_3\text{Si}_6(\text{O}, \text{OH})_{30}(\text{OH}, \text{F})$.

Chromium can enter the tourmaline structure in limited amounts in substitution for aluminium, and less commonly, magnesium. The substitution of trivalent elements in the normally divalent site of tourmalines has been well established, as in elbaite and in buergerite (Mason *et al.*, 1964).

A *chromturmalin* was reported in 1883 by Cossa and Arzruni from Sysstertox Dach, Ural Mountains, Russia. Their analysis of this material is given in Table I. The given analysis suggests that the 10.86 % Cr_2O_3 is substituting for magnesium and not aluminium, and since this reported analysis has $\text{Cr} > \text{Mg} > \text{Fe}$, it would likely qualify as a new legitimate end-member of the tourmaline group in accordance with contemporary rules of mineral nomenclature. A re-examination of the material of Cossa and Arzruni, a sample of which was deposited in the British Museum by Arzruni (BM56285), was thus in order, and a review of chromium substitution in tourmaline was undertaken.

Previous work. Relatively few tourmalines with significant ($> 1.00 \text{ Cr}_2\text{O}_3$) chromium content have been reported. Subsequent to the description of the original material by Arzruni (1883), a chromian dravite from Etchison, Maryland, U.S.A., was reported by Gill (1889). Recent investigations include the description of a chromian dravite from the Krivoy Rog area, U.S.S.R. by Shenderova (1955). Peltola *et al.* (1968) described samples from Outukumpu and Kaavi, Finland, and Mukherjee (1966) described a chromian dravite from Nausahi, Keonjhar District, Orissa, India. A compilation of these analyses is presented in Table I.

Chemistry. The analysis of additional specimens from the previously mentioned localities was performed with an ARL-SEM-Q electron microprobe using an operating voltage of 15 kV and a sample current of $0.15 \mu\text{A}$. Standards used were wet-chemically analysed elbaite, uvite, and buergerite for Si, Al, Fe, Mg, Ca, Mn, and Na and chromite for Cr. The resultant analyses are presented in Table I.

The chromian tourmaline of Cossa *et al.* was re-examined. The new analysis of this material (BM 56285) does not agree with the original analysis. The material has $\text{Mg} > \text{Cr} > \text{Fe}$ and is a chromian dravite. The major disparity between the old and new analyses is in the chromium, iron, and magnesium content. Since there is no proof that the sample is the very one analysed by Cossa *et al.*, this difference may reflect a compositional variation in the Urals

TABLE I. *Prior analyses and partial microprobe analyses of chromian dravite*

	SiO ₂	Al ₂ O ₃	FeO	Cr ₂ O ₃	MgO	MnO	CaO	K ₂ O	Na ₂ O	TiO ₂	F	B ₂ O ₃	H ₂ O	Total
1.	36.79	30.56	2.91	10.86	4.47	tr	0.72	tr	1.36	—	0.65	9.51	2.25	100.08
2.	36.51	32.58	0.79	4.32	9.47	tr	0.75	0.13	2.22	0.09	0.06	8.90	3.74	99.69
3.	36.43	31.53	5.19	1.60	9.23	tr	1.83	0.17	1.73	0.75	—	8.00	3.76	100.20
4.	36.60	27.20	0.13	9.60	10.60	—	1.00	0.05	2.00	0.22	tr	8.50	2.97	99.82
5.	35.74	28.85	0.28	8.97	9.05	tr	1.22	0.14	1.91	0.28	0.31	10.30	2.95	99.86
6.	36.4	29.0	1.2	8.5	8.2	—	0.03	0.04	2.8	0.09	—	—	—	—
7.	—	—	—	16.98	—	—	—	—	—	—	—	—	—	—
8.	34.87	17.68	0.09	22.85	8.62	—	0.18	—	2.85	—	—	—	—	87.14
9.	34.91	18.38	0.09	18.92	10.60	—	0.33	—	2.77	—	—	—	—	86.00
10.	34.60	29.19	0.00	9.04	9.67	—	1.23	—	2.21	—	—	—	—	85.94
11.	35.26	31.11	0.18	5.96	9.13	—	0.56	—	2.29	—	—	—	—	84.49
12.	35.61	30.62	1.19	5.85	10.08	—	0.89	—	2.28	—	—	—	—	86.52
13.	36.02	32.17	0.40	5.29	9.35	—	0.29	—	2.06	—	—	—	—	85.58
14.	35.54	33.54	0.59	2.61	10.10	—	0.78	—	2.43	—	—	—	—	85.59

1. Urals, U.S.S.R. — Cossa and Arzruni (1883) — contains 0.05 NiO, 0.04 P₂O₅.
2. Etchison, Maryland — Gill (1889) — total is after subtraction of 0.02 O=F.
3. Krivoy Rog, U.S.S.R. — Shenderova (1955).
4. Outukumpu, Finland — Peltola *et al.* (1968) — contains 0.34 SrO, 0.61 V₂O₅.
5. Kaavi, Finland — Peltola *et al.* (1968) — total is after subtraction of 0.14 O=F.
6. Swat, West Pakistan — Jan *et al.* (1972) — includes 0.25 V₂O₅, 0.75 NiO.
7. Orissa, India — Mukherjee (1966).
8. Orissa, India — NMNH 120534.
9. Orissa, India — NMNH 120534.
10. Kaavi, Finland — NMNH 119820.
11. Urals, U.S.S.R. — BM 56285.
12. Outukumpu, Finland — NMNH R15783.
13. Etchison, Maryland — NMNH 78452.
14. Etchison, Maryland — NMNH 78452.

NMNH — National Museum of Natural History Smithsonian Institution

BM — British Museum (Natural History)

For analyses 8-14: Accuracy of data — $\pm 2\%$ relative.

All iron calculated as FeO.

All samples have less than 0.05% K₂O or MnO.

Errata: Anal. 2, for 36.51 read 36.56. Anal. 3, for 3.76 read 3.74. Key, line 1, 'contains . . . P₂O₅' belongs to line 2. Line 2, for O=F. read O=F.

material. However, since this material is intimately associated with magnesiochromite, some of which is present as minute inclusions in this very-dark-green tourmaline, the original analysis may have been performed on impure material.

A dark-green tourmaline from Kaavi, Finland (NMNH 119820), occurring in a mica schist, was also analysed. The analysis is in good agreement with that of Y. L. Tong given by Peltola *et al.* (1968).

Zoning was common in the specimens examined. The tourmaline from Etchison, Maryland (NMNH 78452) was comprised of irregular light and dark areas with 2.61 % and 5.29 %

Cr_2O_3 respectively. The high aluminium content (> 6 atoms per formula unit) suggests that the available chromium is substituting for magnesium in this material.

The dark-green tourmaline from Outukumpu, Finland (NMNH R15783) was similarly zoned in an irregular manner with the chromium content varying from 5.85 to 11.01 % Cr_2O_3 in ill-defined irregular segregations.

The most chrome-rich sample examined is from Orissa, India (NMNH 120534). This material is also zoned and the chromium content varies from 18.92 to 22.85 % Cr_2O_3 . The two analyses indicate that the chromium is substituting for both aluminium and, to a lesser extent, magnesium. A formula for the most chromium-rich Orissa material was calculated on the basis of six silicon atoms and assuming three boron atoms: $(\text{Na}_{0.95}\text{Ca}_{0.03})(\text{Mg}_{2.21}\text{Cr}_{0.70}\text{Fe}_{0.01})(\text{Al}_{3.59}\text{Cr}_{2.41})\text{Si}_6\text{B}_3(\text{O},\text{OH})_{30}(\text{OH},\text{F})$. It should be noted that several of the analyses are deficient in silicon. This is possibly due to the substitution of boron for part of the silicon as noted by Barton (1969).

In summary, chromium can substitute for both aluminium and magnesium in dravite. All such chromian dravites have $\text{Na} > \text{Ca}$ and are not uvite. High-chromian dravite is compositionally zoned as irregular segregations of light- and dark-green material with the depth of colour corresponding to increasing chromium. No tourmaline is known which has $\text{Cr} > \text{Al}$. In cases wherein the aluminium content approximates six atoms, no tourmaline is known with $\text{Cr} > \text{Mg}$. The name chrome-tourmaline is not justified, and following the nomenclature rules of Schaller (1930), all specimens described herein should be termed chromian dravite.

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REFERENCES

- Barton (R.), 1969. *Acta Crystallogr.* **B25**, 1524-33. [M.A. 22-1750].
 Chatard (T. M.), 1890. *U.S. Geol. Surv. Bull.* **64**, 41.
 Cossa (A.) and Arzruni (A.), 1883. *Z. Krystallogr. Mineral.* **7**, 1-16.
 Dunn (P. J.), Appleman (D. E.), and Nelen (J. A.), 1977. *Mineral Record*, **8**, 100-8.
 Gill (A. C.), 1889. *Johns Hopkins Univ. Cir.* **75**, 100-1.
 Jan (Q. J.), Kempe (D. R. C.), and Symes (R. F.), 1972. *Mineral. Mag.* **38**, 756-9. [M.A. 5-5251].
 Mason (B.), Donnay (G.), and Hardie (L. A.), 1966. *Science*, **144**, 71-3. [M.A. 17-701].
 Mukherjee (S.), 1966. *Q. J. Geol. Min. Metall. Soc. India*, **38**, 59-60. [M.A. 18-275].
 Peltola (E.), Vuorelainen (Y.), and Häkli (T. A.), 1968. *Bull. Geol. Soc. Finland*, **40**, 35-8. [M.A. 20-3227].
 Schaller (W. T.), 1930. *Am. Mineral.* **15**, 566-74. [M.A. 5-525].
 Shenderova (A. G.), 1955. *Mineral. Sbornik Lvov. Geol. Obshch.* **9**, 324-6. [M.A. 13-187].

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Datolite and apophyllite from the Mendips

DURING most of 1975, working of the main faces in the northern segment of Merehead Quarry, near Cranmore, Somerset, exposed a large, complex manganese- and iron-rich vein within the Carboniferous Limestone. The vein at its maximum development of nearly 4 m wide had a constant northerly strike and dipped steeply to the east. However, for most of its exposed length (150 m) the structure was near vertical.