

SHORT COMMUNICATIONS

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Tourmaline from amphibolized gabbro at Hanter Hill, Radnorshire

A GENERAL description of the igneous rocks of the Stanner-Hanter district of Radnorshire (Powis) referred to various modes of alteration affecting the gabbro of the complex (Holgate and Hallows, 1941, pp. 252-3). The occurrence in these rocks of a blue-black tourmaline was also reported and the present contribution offers a fuller description of this paragenesis, the pertinence of which is underlined by the continued scarcity of data relating to tourmalines from comparable parageneses (cf. Deer *et al.*, 1962, pp. 300-19). The tourmaline-bearing rocks are sparingly exposed over a limited area some 300 m to S 30°W from the summit of Hanter Hill (SO/252571). Here, sporadic tourmaline clots may be observed within the altered gabbro, which has plagioclase in poikilitic relation with a green amphibole that replaces the original pyroxene met with elsewhere in the gabbro. The plagioclase (An₆) is usually crowded with finely granular epidote and comparison with the less altered gabbro suggests that the original feldspar was An₆₆. The areas of amphibole consist of either individual grains or decussate felts; a pale green actinolite with $\gamma:[001] = 16\frac{1}{2}^\circ$, $2V_\alpha = 80^\circ$ and $\beta = 1.627 \pm 0.002$ is typically associated with the tourmaline. Other secondary amphiboles are represented in minor amounts (Holgate and Hallows, 1941, p. 252). The tourmaline clots are up to 15 mm across and consist of a single crystal or group of crystals in nearly parallel orientation with faces of a prism zone occasionally recognizable. Well-defined colour zones become darker outwards and are parallel to a prism form. Pleochroism is moderate to strong with ϵ pale slate-grey to olive-grey and ω slate blue-grey to deep slate-green; refractive indices are ϵ 1.638 and ω 1.665 (both ± 0.002). A pale green clinocllore of platy and often radiating habit is commonly developed within plagioclase adjacent to tourmaline, and may be enclosed within the latter. The clinocllore is often accompanied by groups of stoutly prismatic epidote; epidote also forms granules and anhedral patches in plagioclase and in numerous veinlets cutting the major constituents. Since the tourmaline is freely intersected by these veinlets, the tourmaline-clinocllore-euhedral-epidote-actinolite-albite assemblage must be older than the veining epidote, which is probably a local manifestation of the widespread epidotization characteristic of the Stanner-Hanter area (Holgate and Hallows, 1941, pp. 250, 252). The source of the boron for the tourmaline has been provisionally identified with ramifying veins of aplogranite that intrude the gabbro in this neighbourhood. These veins have occasional slender prisms (associated with apatite of similar habit) that exhibit slight pleochroism (with maximum absorption for the transverse vibration) and birefringence suggestive of tourmaline.

A hand-picked concentrate of the tourmaline was crushed to pass the 100-mesh sieve; washed to remove dust and purified by the use of heavy liquids in the centrifuge: final purification was by contact with cold strong hydrofluoric acid over a 24-hour period after which the mineral was carefully washed and dried. The specific gravity of the mineral at this stage had a mean value of 3.14. SiO₂, TiO₂, Al₂O₃, total Fe oxides, and MnO were then determined colorimetrically and MgO and CaO titrimetrically (E.D.T.A.). Na₂O, K₂O, and Li₂O were

TABLE I. *Chemical analyses of tourmalines and a tourmaline-bearing altered gabbro*

	I	A	II		Ia	Aa	
SiO ₂	34.01	35.20	47.29	Si	5.621	6.070	I. Bluish-black tourmaline from altered gabbro, Hanter Hill, Radnorshire (Powis). Anal. W. Neilson, W. Robb, and D. L. Skinner; B ₂ O ₃ by N. Holgate.
TiO ₂	0.34	0.51	0.18	B	2.870	2.616	
B ₂ O ₃	10.06	8.82	(1.18)	Al	5.829	5.774	A. Black tourmaline from contact-altered dolerite, Carrick Dhu, St. Ives, Cornwall. Anal. R. A. Howie, quoted Deer <i>et al.</i> , 1962, Table 51, col. 7, p. 307.
Al ₂ O ₃	29.93	28.49	22.65	ΣZ	14.320	14.460	
Fe ₂ O ₃	1.65	0.79	1.27	Fe ³⁺	0.209	0.105	II. Tourmaline-bearing amphibolized gabbro, 300 m S. 30°W. of summit, Hanter Hill. 'Rapid' analysis by W. Neilson; B ₂ O ₃ by N. Holgate.
FeO	5.26	11.55	3.76	Mg	2.443	1.441	
MnO	0.02	0.07	0.07	Ti	0.040	0.062	Ia. Ionic ratios of tourmaline I, calculated to 31 (O, OH, F).
MgO	9.92	5.63	6.55	Li	—	0.062	
CaO	3.05	2.75	10.58	Fe ²⁺	0.725	1.660	Aa. Ionic ratios of tourmaline A, calculated to 31 (O, OH, F).
Na ₂ O	1.68	2.12	1.92	Mn	0.003	0.010	
K ₂ O	0.03	0.13	1.16	Na	0.536	0.704	n.d. not determined * Li ₂ O less than 20 p.p.m.
Li ₂ O	tr.*	0.08	n.d.	Ca	0.536	0.507	
H ₂ O ⁺	4.25	3.52	3.27	K	0.006	0.029	
H ₂ O ⁻	n.d.	0.07	n.d.	ΣR	4.498	4.580	
P ₂ O ₅	—	—	0.02	OH	4.687	4.040	
F	n.d.	0.08	n.d.	F	—	0.020	
CO ₂	—	—	0.17				
		99.81					
O ≡ F	—	0.03	—				
Sum	100.20	99.78	100.07				
Sp. gr.	3.14	3.14	—				

TABLE II. *X-ray powder data for tourmaline from altered gabbro, Hanter Hill, Radnorshire: Cu-Kα radiation*

<i>d</i>	<i>I</i>	<i>hkil</i>	<i>d</i>	<i>I</i>	<i>hkil</i>	<i>d</i>	<i>I</i>	<i>hkil</i>
7.063 Å	6	—	2.382 Å	14	2352	1.6452 Å	10	2791
6.390	37	1011	2.347	14	5161	1.5963	12	5.5.10.0
4.984	22	0221	2.303	4	6060	1.5870	4	4592
4.683	6	—	2.265	8	—	1.5359	8	9090
4.599	18	3031	2.196	9	5052	1.5297	6	7292
4.417	9	—	2.170	12	4371	1.5112	15	8.2.10.0
4.230	59	2131	2.132	24	3033	1.4852	3	2464
3.990	55	2220	2.1175	8	4262	1.4588	18	5164
3.862	14	—	2.0615	16	2243	1.4349	7	0115
3.488	81	0112	2.0415	40	1562	1.4206	4	6.5.11.1
3.381	12	1341	2.0223	8	1671	1.4135	10	2025
3.286	18	—	1.9938	6	4480	1.3720	3	3.8.11.1
3.118	3	4041	1.9227	28	3472	1.3589	3	10.0.10.1
3.016	14	4150	1.8811	7	4153	1.3309	10	0445
2.969	100	1232	1.8496	6	6281	1.3287	6	6.6.12.0
2.905	13	3251	1.8198	4	6172			5.5.10.3
2.856	15	—	1.7858	7	1014	1.3087	5	10.1.11.0
2.661	4	3360	1.7668	4	3363	1.2923	3	9093
2.627	7	3142	1.7467	3	0224	1.2782	9	5055
2.579	95	0551	1.7347	3	5382	1.2613	4	4265
2.493	4	0442	1.7202	2	5491	1.2452	2	1565
2.455	3	2461	1.6914	4	2682	1.2372	3	0.11.11.1
2.406	14	0003	1.6631	15	6063	1.2284	4	4.8.12.2

determined spectrographically. B₂O₃ was determined by Chapin's method (Hillebrand *et al.* 1953, pp. 733–59), while for FeO the metavanadate method of Wilson (1955) was employed. The Penfield tube method was used for H₂O⁺. The resulting analysis appears under I, Table I, along with an analysis of the tourmaline-bearing rock. Owing to the coarse texture of the rock

and the sparse development of tourmaline within it, sampling is only broadly representative and no meaningful mode can be offered. The X-ray diffraction pattern for the Hanter tourmaline was determined with the Phillips PW 1011 vertical scanning goniometer using $\text{Cu-K}\alpha$ radiation and d spacings and intensities corresponding to reflections with $I > 1$ are listed in

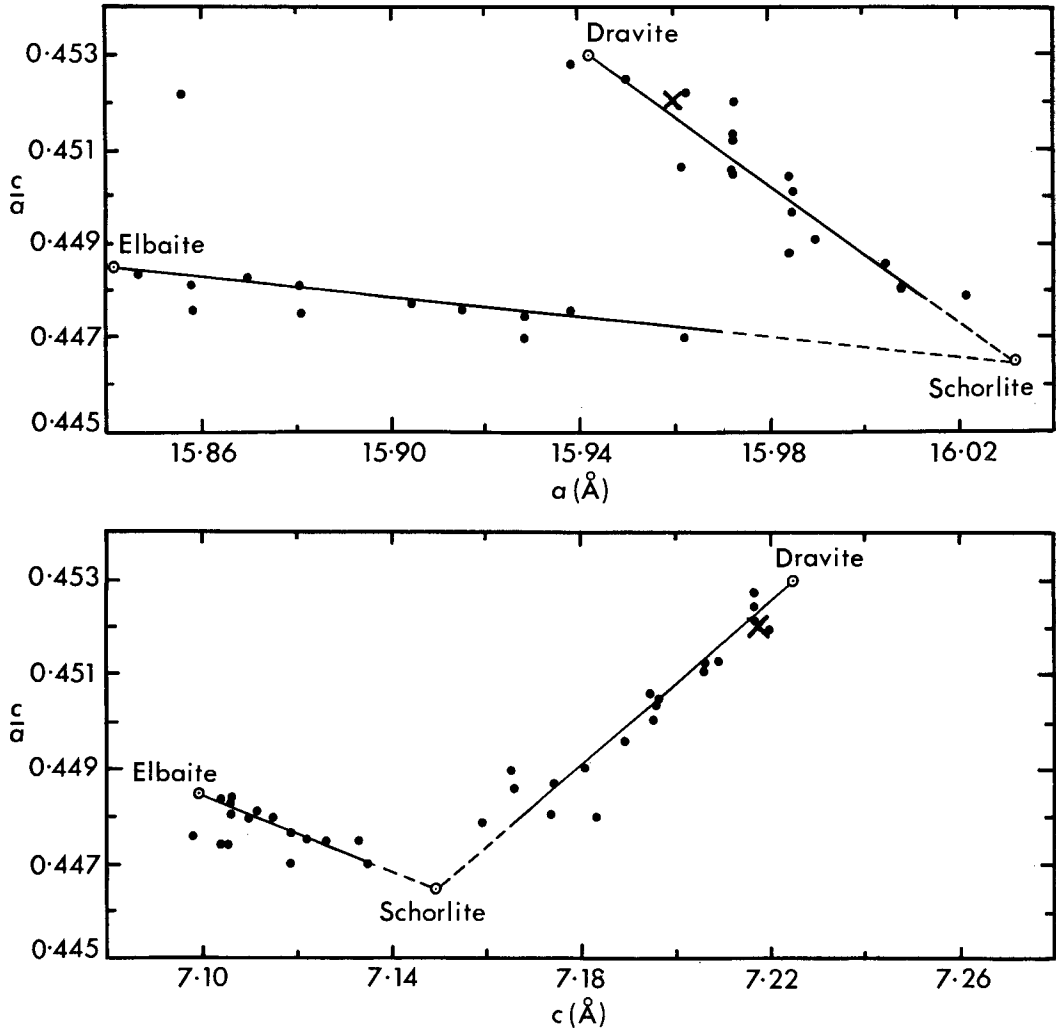


FIG. 1, a (top) and b (bottom): tourmaline unit cell dimensions a and c respectively, plotted against axial ratios c/a (adapted from Deer *et al.*, 1962, p. 303, fig. 85, after Epprecht). Points marked by spots represent Epprecht's data (1953, p. 487) with dimensions converted to \AA units. The position of the Hanter tourmaline with respect to the schorlite-dravite series is indicated by the crosses (X).

Table II. Comparison of this pattern with that reported for dravite from Dubrova, Carinthia (Nat. Bur. Standards (U.S.) 1963, pp. 47, 48) is sufficiently close to permit the indexing of the reflections of the Hanter tourmaline as shown (under $hkil$) in Table II. From these data the unit cell for the Hanter mineral has dimensions $a = 15.96 \text{ \AA}$, $c = 7.218 \text{ \AA}$ and $c/a = 0.452$.

The chemistry of the present tourmaline shows that it is essentially a member of the schorlite-dravite series, although its CaO content is unusually high (cf. Deer *et al.*, 1962, pp. 304-7,

tables 50 and 51). The abnormally high H_2O^+ is so far unexplained, although this order of magnitude has been confirmed. Fluorine has not been determined, but in view of the absence of lithium at more than trace level it is unlikely that fluorine is present in significant quantity (cf. Němec, 1969, pp. 237–8). The closest parallel with the Hanter tourmaline is afforded by Howie's analysis of black tourmaline from Carrick Dhu, Cornwall (A, Table I), which is quoted from Deer *et al.* (1963, p. 307). The Hanter mineral shows a considerably higher ratio of Mg/Fe (2.62) than the Carrick Dhu tourmaline (0.82), indicating that it is closer to the dravite end of the series. This conclusion is supported by the unit cell dimensions which, plotted on graphs of c/a against a and c/a against c (fig. 1), lie close to the dravite end-member of the series. The unusually high Ca content of the Hanter mineral constitutes a divergence from the schorlite–dravite series but cannot be regarded as supporting Kunitz's (1929) proposal of a 'uvite' molecule $\text{CaMg}_4\text{Al}_5\text{B}_3\text{Si}_6\text{O}_{27}(\text{OH})_4$ as a component of some tourmalines.

Conclusions. Tourmaline developed in altered gabbro at Hanter Hill lies close to dravite in the dravite–schorlite series, as is shown by its high Mg/Fe ratio, unit cell dimensions, and despite an unusually high Ca content. The tourmalinization appears to have resulted from the localized transformation of a normal olivine-free gabbro under the influence of veining aplogranite, and was succeeded by a general epidotization affecting the rocks of the Stanner–Hanter complex.

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An occurrence of antimony-ochre (stibiconite) as an alteration product of antimonite in Dashkasan, West Iran

AN antimony deposit in Western Iran was worked between 1941 and 1955 in a number of small mines. The mining area is between Dashkasan and Baharlu, 70 km north of Hamadan ($34^{\circ}45'N$, $48^{\circ}45'E$). The surrounding area has been geologically mapped on a scale of 1 : 1 000 000