

*Magnesian Tourmaline from Renfrew, Ontario.*

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THE specimens of the mineral examined were obtained from a limestone quarry near the town of Renfrew. The tourmaline occurs near the contact of grey granite-gneiss and crystalline limestone of the Grenville series. The gneiss is intrusive into the limestone, and contact effects are observable both in the intrusive and in the intruded rock. The gneiss consists of quartz, plagioclase, microcline, and a green pyroxene. The limestone is composed (almost entirely) of calcite, but contains some graphite. The secondary minerals occurring in both limestone and gneiss are, besides the tourmaline, pyrrhotite, titanite, and muscovite.

The tourmaline is reddish-brown in colour, with a resinous lustre, and in the hand-specimens had previously been mistaken for garnet. It occurs as grains and as small button-shaped crystals, one of which was measured. This shows in the prismatic zone the trigonal prism  $m$  (1010) and the hexagonal prism  $a$  (1120). At the antilogous pole are the basal plane  $c$  (0001), the ditrigonal pyramid  $u$  (3251), and three trigonal pyramids—the unit pyramid  $r$  (1011), a steeper pyramid  $d$  (5052) truncating the edge between  $r$  and  $m$ , and  $o$  (0221) replacing the corner of the unit form. At the analogous pole only the complementary unit-pyramid  $r_1$  (1011) appears.

Graphite occurs in the tourmaline very plentifully, and so makes chemical analysis and physical examination somewhat uncertain. However, a small piece was obtained for specific gravity determination which seemed to be free from foreign material. Owing to the small size of the fragment, the heavy solution method (with mercuric potassium iodide) was used. The mean of the determinations gave a result of 3.07.

In polarized light the tourmaline is distinctly dichroic, changing from colourless to light-brown, but owing to lack of well-crystallized specimens the relation of the dichroism to the orientation of the crystals could not be determined. Basal sections give a good uniaxial interference-figure,

and the optical sign is negative. An attempt to determine the refractive indices by means of a prism of the mineral was unsuccessful, owing to its lack of transparency.

To obtain material for a chemical analysis, the rock was coarsely crushed and the tourmaline separated under a lens. Pieces showing graphite were rejected, and most of the calcite was also separated in this way. After this fairly pure substance was obtained it was crushed more finely and leached for some time with hot, dilute acid, thoroughly washed, and dried. It was then crushed still more finely and dried at 110° C. The analyses were made in duplicate. No trace of manganese was found, and the spectroscope failed to show any lithium line. The value obtained for ferrous iron is probably too low, due to the difficulty of decomposing the mineral; and thus the ferric iron, if, indeed, any is present, acquires a correspondingly high value.<sup>1</sup> The water content was determined by the direct method; it is rather low as compared with published analyses.

The results of the analyses are given below in column I; in II are the corresponding molecular ratios, and in III the hydrogen equivalents of the bases. Column IV gives for comparison an analysis of magnesian tourmaline from Hamburg, Sussex Co., New Jersey, made by R. B. Riggs in 1888, as quoted in Dana's 'System of Mineralogy' (Analysis 55, p. 555):

	I.	II.	III.	IV.
SiO <sub>2</sub> ...	35.29 ...	0.588 ...	— ...	35.25
B <sub>2</sub> O <sub>3</sub> ...	10.56 ...	0.151 ...	— ...	10.45
Al <sub>2</sub> O <sub>3</sub> ...	28.93 ...	0.283 ...	1.698 ...	28.49
Fe <sub>2</sub> O <sub>3</sub> ...	2.35 ...	0.015 ...	0.090 ...	—
FeO ...	0.70 ...	0.010 ...	0.020 ...	0.86
TiO <sub>2</sub> ...	0.025 ...	0.0003 ...	— ...	0.65
CaO ...	5.49 ...	0.098 ...	0.196 ...	5.09
MgO ...	14.53 ...	0.360 ...	0.720 ...	14.58
K <sub>2</sub> O ...	0.22 ...	0.003 ...	0.006 ...	0.18
Na <sub>2</sub> O ...	1.72 ...	0.030 ...	0.060 ...	0.94
F ...	0.84 ...	0.040 ...	— ...	0.78
H <sub>2</sub> O ...	0.70 ...	0.040 ...	0.080 ...	3.10
	<u>101.355</u>		<u>2.870</u> ...	<u>100.37</u>
O = F ...	<u>0.355</u> ...	... ..	... ..	<u>0.38</u>
	<u>101.00</u> ...	... ..	... ..	<u>100.04</u>
Sp. gr. ...	3.07			

<sup>1</sup> The total iron reckoned as ferrous oxide corresponds with FeO 2.81 per cent.

The molecular proportions of the acid from which tourmaline is derived would thus be:

	H	SiO <sub>2</sub>	B <sub>2</sub> O <sub>3</sub>	Total Oxygen.
	2.870	0.588	0.151	3.086
or	19.524	4	1.027	20.993
or nearly	20	4	1	21

This agrees with the general formula for tourmaline deduced by Penfield and Foote,<sup>1</sup> namely H<sub>20</sub>B<sub>2</sub>Si<sub>4</sub>O<sub>21</sub> or H<sub>10</sub>(BOH)<sub>2</sub>Si<sub>4</sub>O<sub>19</sub>, in which the hydrogen is for the most part substituted by monovalent, divalent, and trivalent basic elements. It is probable, as argued by Penfield and Foote from the limits between which the content of aluminum varies, that part of the aluminum acts as an acid-forming element and the acid of tourmaline is an aluminoborosilicic acid rather than a borosilicic acid.

<sup>1</sup> S. L. Penfield and H. W. Foote, 'On the chemical composition of tourmaline', Amer. Journ. Sci., 1899, ser. 4, vol. vii, pp. 97-125.

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