

# THE MAGNETIC PROPERTIES OF TOURMALINE AND EPIDOTE

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## 1. Introduction

As is well known, tourmaline is a complex silicate of aluminium and boron crystallising in the rhombohedral system. Its dichroism, and the piezo- and the pyro-electric properties exhibited by it make it a crystal of great interest to the physicist. A few observations of its magnetic behaviour are on record, the most recent being those by Wilson (1920) and by Grenet (1930). Numerous specimens of tourmaline of various shades of colour and transparency were available in the crystallographic collection of Sir C. V. Raman, and it appeared to be of interest to make a systematic investigation of their magnetic susceptibility and anisotropy. The specimens had their natural prismatic form, with a rounded triangular section, the sides being lustrous and marked with strong striations parallel to the axis, except No. 4 which was a plate cut perpendicular to the axis. The specimens were of different colours, black, brown, green, rose and white. Most of the specimens were transparent, No. 4 was transparent only at the edges which were thin, and No. 1 was completely opaque.

Epidote is an ortho-silicate of calcium, aluminium and iron, crystallising in the monoclinic system. The analysis of a number of specimens reported (Tempel, 1938) shows that iron is the chief paramagnetic element in it; the ferric oxide varies from 4% to 17%, and the ferrous oxide is usually much smaller, being less than 1% in the majority of the specimens. Two crystals of epidote were obtained from the crystallographic collection of Sir C. V. Raman, and their magnetic properties were studied. They were brownish-green in colour, and were bounded by well-developed crystallographic faces on all the sides, the crystals being in the form of short prisms, extending along the *b*-axis.

## 2. Experimental Results

For all the tourmalines, the susceptibility along the axis was less than that perpendicular to it, agreeing with Wilson's observation, and all the specimens were isotropic in the symmetry plane.

The magnetic susceptibility of the tourmalines perpendicular to the axis was measured by Rabi's null method. They were all paramagnetic, and a solution of manganous chloride was used for the bath. The displacement of the crystals in the bath was measured very sensitively by suspending it from the beam of a Curie-balance of low torsional constant, and observing the deflection of the beam with a lamp and scale, so that any field-dependence of the susceptibility of the specimens could be easily detected. For specimens Nos. 1 to 6, a small unbalanced deflection of the crystal in the bath was observed at low fields, showing that the susceptibility decreased very slightly with increase of field strength, presumably due to traces of ferromagnetic impurities. Since their deflection was negligibly small compared with the deflection produced in air, no correction was necessary for the effect of the ferromagnetic impurities. The fine rose-coloured specimens 7 to 11 were completely free from such impurities.

The anisotropy of the tourmalines was measured by Krishnan's torsional method. Since the crystals were appreciably asymmetric in shape, they were surrounded by the solutions of their own volume susceptibility while measuring the critical torsion. The difference between the susceptibilities perpendicular and parallel to the axis ( $\chi_{\perp} - \chi_{\parallel}$ ) was measured.

The results for the susceptibility and anisotropy, together with a description of the colour and density of the tourmalines are given in Table I.

TABLE I. *Tourmaline*

No.	Mass gm.	Specific Gravity	Colour	Mass Susceptibility $\chi \times 10^6$	Specific Anisotropy $(\chi_{\perp} - \chi_{\parallel}) \times 10^6$
1	3.010	3.12	Black	13.4	2.01
2	0.554	3.15	Dark brown with a clear zone at one end	11.0	0.295
3	2.052	3.13	Uniform dark green	10.8	1.65
4	4.042	3.11	Black	10.1	0.577
5	3.514	3.10	Light green with a clear zone at one end	9.7 <sub>8</sub>	0.226
6	1.402	3.08	Colourless with a small red spot	4.96	0.0584
7	3.102	3.03	Uniform rose	1.18	0.0379
8	3.305	3.04	Rose, one end denser in colour	0.96 <sub>8</sub>	0.0121
9	5.787	3.05	Rose, half the length denser in colour	0.95 <sub>8</sub>	0.0138
10	4.553	3.04	Uniform rose	0.73 <sub>8</sub>	0.0168
11	1.953	3.03	Uniform light rose	0.583	0.0375