

and  $c_0 = 15.20 \text{ \AA}$ ;  $a_0:b_0:c_0 = 0.6257:1:1.311$ . The measured specific gravity is slightly less than 3.5 (minute needles of the mineral rose very slowly to the surface of Clerici solution of sp. gr. = 3.503), and the calculated specific gravity is 3.467, assuming 8 formula units of  $\text{UO}_3 \cdot 2\text{H}_2\text{O}$  per unit cell.

This study is part of a program undertaken by the Geological Survey on behalf of the Division of Raw Materials of the Atomic Energy commission.

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ANALYSES AND INDICES OF REFRACTION OF TOURMALINE  
 FROM FAULT GOUGE NEAR BARSTOW, SAN  
 BERNARDINO COUNTY, CALIFORNIA<sup>1</sup>

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Blue cryptocrystalline tourmaline is the principal mineral in massive, pale-blue fault gouge<sup>2</sup> 3.5 miles north of Barstow, California. T. W. Dibblee, Jr., of the U. S. Geological Survey, collected samples from the north side of a low ridge in the SE $\frac{1}{4}$  sec. 18, T. 10 N., R. 1 W., San Bernardino base and meridian (lat. 34° 57' N., long. 117° 00' W.). According to Dibblee (personal communication) the blue tourmaline rock, a lenticular mass roughly 30 feet long and 10 feet wide, occurs in a local shear zone in fine-textured, poorly bedded, greenish-brown lime-silicate rock within a thick series of dark-gray biotite-hornblende-feldspar schists.<sup>3</sup>

An x-ray diffraction pattern of purified material is in close agreement with standard tourmaline patterns cited by the American Society for Testing Materials. Spacings of  $d/n(A)$  calculated from the hexagonal unit-cell dimensions  $a_0 = 15.96 \text{ \AA}$ ,  $c_0 = 7.16 \text{ \AA}$  (Buerger and Parrish, 1937) are in reasonable accord with experimental values found on Barstow tourmaline.

Microscopically, this tourmaline is gray-green and cryptocrystalline

<sup>1</sup> Publication authorized by the Director, U. S. Geological Survey.

<sup>2</sup> Pale blue 5B 6/2, Rock-Color Chart, *Geol. Soc. Am.* (1951).

<sup>3</sup> Subsequently, two other occurrences of blue tourmaline rock similar to that described above were found on the same ridge, one about 300 feet to the southeast and the other about 1200 feet to the west. In both these localities the tourmaline rock occurs at the contact between the metamorphic rocks and a small andesite body capping the hill.

with chalcedony-like fibrous to radiating structure. Associated minerals are quartz and calcite, the former included as minute doubly terminated prismatic crystals in polycrystalline tourmaline aggregates. Indices of refraction, determined with sodium light, are as follows:  $\epsilon = 1.638 \pm 0.002$ ;  $\omega = 1.645 \pm 0.002$ . To the writers' knowledge, the birefringence ( $0.007 \pm 0.004$ ) is less than any previously reported for tourmaline. The mineral is faintly pleochroic and has wavy extinction.

The chemical analysis of Barstow tourmaline is compared with two analyses quoted by Hamburger and Buerger (1948) of colorless and black tourmalines from De Kalb, New York, and Andreasberg, Harz, Germany, respectively.

	<i>Blue</i> Barstow, Calif.	<i>Colorless</i> De Kalb, N. Y.	<i>Black</i> Andreasberg, Harz
	(per cent)	(per cent)	(per cent)
SiO <sub>2</sub>	33.41	36.72	34.01
TiO <sub>2</sub>	1.08	0.05	0.61
B <sub>2</sub> O <sub>3</sub>	9.68	10.81	10.89
Al <sub>2</sub> O <sub>3</sub>	32.46	29.86	28.80
Fe <sub>2</sub> O <sub>3</sub>	3.25	—	4.37
FeO	6.39	0.22	13.57
MnO	trace	—	0.12
CaO	0.23	3.49	0.58
MgO	6.40	14.92	0.42
Na <sub>2</sub> O	2.71	1.26	2.03
K <sub>2</sub> O	0.69	0.05	0.20
Li <sub>2</sub> O	nil	—	0.10
PbO	0.09	—	—
SnO	0.10	—	—
V <sub>2</sub> O <sub>3</sub>	0.06	—	—
H <sub>2</sub> O (+)	3.33	2.98	2.92
F	nil	0.93	0.71
Total	99.88	none given	none given
Analysts:	Henry Kramer	S. L. Penfield and H. W. Foote	M. Dittrich and F. Noll

Barstow tourmaline is intermediate between the others with respect to Fe<sub>2</sub>O<sub>3</sub>, FeO, MgO, and MnO. In contrast, Barstow tourmaline is higher than the others in TiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, K<sub>2</sub>O, and H<sub>2</sub>O; it is lower in SiO<sub>2</sub>, B<sub>2</sub>O<sub>3</sub>, and CaO. Other characteristics are (1) the absence of Li<sub>2</sub>O and F, and (2) the presence of PbO, SnO, and V<sub>2</sub>O<sub>3</sub>.

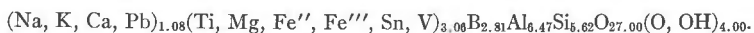
Purification of tourmaline was accomplished by (1) acid leaching to

remove calcite, and (2) bromoform separation to reduce the amount of quartz. It was not possible, however, to rid the tourmaline of included finely crystalline quartz. By means of the proportion  $B/Si = \frac{1}{2}$  (Hamburger and Buerger, 1948; Donnay and Buerger, 1950), the amount of excess  $SiO_2$  was calculated. All oxides were then recalculated to nullify the sample dilution by excess  $SiO_2$ .

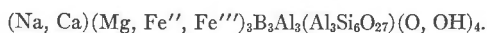
The spectrographic analysis, in per cent, is tabulated below.

Si	XX.0
Al	XX.0
Fe	X.0
Mg	X.0
Na	X.0
B	X.0
K	0.X
Ca	0.X
Ti	0.X
V	0.X
Pb	0.OX
Sn	0.OX
Ga	0.OX
Cu	0.OOX
Sr	0.OOX
Cr	0.OOX
Mn	0.OOX
Ni	0.OOX
Co	0.OOX

The formula for the blue tourmaline calculated from the above analysis is:



This formula is patterned after one proposed by Berman (1937):



In our analysis the Al/Si ratio is 1.15. Thus, boron, aluminum, and silicon fail to yield integral subscripts in the Barstow tourmaline formula. It is possible that aluminum substitutes for silicon and boron in this structure.

X-ray diffraction data were supplied by Arthur Chodos, Department of Geology, California Institute of Technology. The tourmaline was independently identified by Fred A. Hildebrand of the U. S. Geological Survey. The spectrographic analysis was made by Hal W. Johnson, Pacific Spectrochemical Laboratory, Los Angeles, California.

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## DERIVED DIFFERENTIAL THERMAL CURVES\*

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Under certain routine conditions where, for example, original grain size of particles, the presence of other mineral constituents, and certain chemical impurities are known, differential thermal techniques can be applied in a semi-quantitative manner. Greatest accuracy is obtained by measuring the area under portions of the curve representing certain kinds of reactions: loss of absorbed or other kinds of water, decomposition, inversion from one polymorphous form to another, and recrystallization. Ordinarily, the loss of water (and perhaps atomic oxygen) as well as decomposition reactions do not start at a sharply defined temperature, but are first represented by a gradual departure of the differential thermal curve from baseline. This gradual drift from baseline often grades imperceptibly into the portion of the curve representing the important part of the reaction which is used for quantitative measurement. If the operator cannot accurately select the point where the important part of the reaction started, it is impossible to accurately position a baseline from which to delimit the area under the curve. Small changes in the positioning of the baseline result in large changes in the measured area under the curve so, under these conditions, the technique degenerates to only a rough, semi-quantitative procedure.

Baseline drift can often be controlled, when carbonate minerals or rocks are being investigated, by the use of a CO<sub>2</sub>-atmosphere in the furnace (Rowland and co-workers, 1951 and 1952). This technique, however, does not help in systems where carbonate minerals are not present: when clay and other silicate systems are being investigated.

The purpose of this note is to call attention to a technique long used by the metallurgist to help resolve this difficulty. The metallurgist employs heating or cooling curves to help construct equilibrium diagrams and, in particular, to locate inversion temperatures in steels and other

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