(1) *The crystal-habit of Topaz from New Brunswick, Canada.* (2) *A method of silvering crystal-faces for giving improved reflections on the goniometer.*

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IT is only recently that the mineral topaz has been found in any considerable quantity in Canada. Previous to the discovery of the topaz of York County, New Brunswick, in 1911, it was distinctly a rarity among Canadian minerals and had never been found crystallized in any Canadian locality. The above-mentioned district, however, has yielded both the massive and crystallized varieties in fair abundance and some fairly perfect crystals have been obtained for measurement.

The first topaz reported from Canada appears to have been of somewhat doubtful authenticity. It is stated that: 'At the London Exhibition, 1862, Mr. McDonald exhibited two topazes (?) from Cape Breton, one in the rough, and the other, which had been cut at Pictou, half an inch in length and of a yellow colour, the variety peculiar to Brazil, which leads to the inference that these stones may have been citrine or artificially decolorized smoky quartz, and not the true mineralogical topaz.'[1]

In 1896 two rolled pebbles of topaz were obtained from the gravel of a small river west of Jasper House in the Rocky Mountains of Alberta. Both were transparent. The one measured $20 \times 20 \times 13$ mm. and was of a light bluish-green colour, while the other measured $25 \times 15 \times 15$ mm. and had a faint orange-yellow tinge.[2]

In 1911 E. S. Moore found topaz quite abundant in thin-sections of hornblende-syenite from the eastern shore of the narrows of Sturgeon Lake, Ontario. It was observed as a colourless mineral filling in spaces

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[1] Report of the Geological Survey of Canada, 1887–8, vol. iii, p. 66 S.

[2] Report of the Geological Survey of Canada, 1896, vol. ix, p. 18 R.

between the felspars and in places apparently partly replacing them. Associated with it were considerable quantities of fluorite and titanite with some tourmaline and apatite and other products of pneumatolytic action.[1]

The latest and by far the most important occurrence of topaz in Canada, however, is in the district around the confluence of Burnt Hill Brook and the South-West Branch of the Miramichi River in York County, New Brunswick (Long. 66° 48′ W., lat. 66° 34′ N.). Geologically, the region is rather simple. Great batholiths of granite have intruded slate which is supposed to be of Cambro-Silurian age. Near the contact, the slate has been fissured and quartz-veins have been formed by the action of the intrusive granite. For many years it had been known that these quartz-veins carried small quantities of molybdenite, but the presence of other minerals apparently had never been reported. In 1910 Professor T. L. Walker visited the district to examine the molybdenite deposits in behalf of the Mines Branch, and discovered that many of the veins carry considerable quantities of wolframite besides the small and unimportant amounts of molybdenite.[2]

In the winter of 1910 Mr. R. A. A. Johnston noted the presence of topaz in specimens of ore from this locality. The association of the minerals wolframite, molybdenite, and topaz suggested the possibility of finding tin-stone also, and led to a further examination of the district by R. W. Brock the following summer. As a result, small quantities of cassiterite were actually found in greisen associated with the quartz-veins. The quartz-veins themselves were found to contain considerable quantities of topaz, both massive and as crystals in vugs and druses, besides wolframite and molybdenite and a little fluorite.[3]

At the suggestion of Dr. Walker, the material collected by him from this locality was examined by the writer with the object of finding crystals suitable for measurement.

The massive topaz appears in considerable quantity associated with quartz, wolframite, and a little molybdenite. In this form it is almost invariably covered by a brown coating of iron oxide, but on a fresh fracture is usually more or less milky in colour. The quartz is somewhat less stained and has a fresher appearance. Crystals are common

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[1] Twentieth Report of the Ontario Bureau of Mines, 1911, p. 155.

[2] Summary Report of the Mines Branch, Ottawa, 1910, p. 65. Also, Economic Geology, 1911, vol. vi, p. 396.

[3] Canadian Mining Journal, No. 17, Sept. 1, 1911; reprinted in Summary Report Geological Survey of Canada, 1911, p. 13.

lining vugs, and range in size from microscopic dimensions up to 2 cm. in diameter, with by far the greater number less than 5 mm. in diameter. The larger ones are comparatively rare and are imperfect and unsuitable for measurement.

The crystals are usually more or less stained also, and often contain minute fractures into which the iron oxide has penetrated. The majority are somewhat cloudy or milky, but some perfectly clear, colourless and transparent specimens of small size were obtained. The crystal-faces are often well developed, but the domes and pyramids more particularly sometimes appear to have suffered more or less corrosion and thus have become dull or rough. The edges of the smaller faces also are apt to be somewhat rough and rounded.

Twelve of the best crystals, varying in size from $1 \times 1.5 \times 1$ mm. to $3.5 \times 5 \times 5$ mm., were selected and measured on the Goldschmidt two-circle goniometer. The following sixteen forms were found definitely developed, doubtful and vicinal forms having been omitted.

Table of Forms.

Crystal No.	$M = \infty$ (110)	$l = 2\infty$ (120)	$f = 0\infty$ (011)	$u = \tfrac{1}{2}\infty$ (112)	$i = \tfrac{1}{3}\infty$ (113)	$c = 0\,0$ (001)	$m = \infty\tfrac{3}{2}$ (230)	$o = 1\infty$ (111)	$x = \tfrac{3}{2}\infty$ (123)	$y = 0\,2\infty$ (021)	$d = 10\,0\infty$ (101)	$\mu = \infty\,5$ (150)	$b = 0\,0\infty$ (010)	$\pi = \infty\tfrac{5}{2}$ (250)	$g = \infty\,3$ (180)	$z = \infty\,4$ (140)
1	+	+	+	+												
2	+	+	+	+												
3	+	+	+	+	+											
4	+	+	+	+	+											
5	+	+	+	+	+	+										
6	+	+	+	+	+	+	+									
7	+	+	+	+	+	+	+									
8	+	+	+	+	+	+	+	+								
9	+	+	+	+	+			+	+							
10	+	+	+	+	+	+	+	+	+							
11	+	+	+	+	+	+	+	+		+						
12	+	+	+	+	+	+			+	+	+	+	+	+	+	+

The forms have been arranged in the table in the order of their frequency of occurrence.

It might be mentioned that, among the doubtful forms, one very narrow but quite distinct prism-face was observed which, though it gave no signal, admitted of being read fairly accurately by maximum illumina-

tion, and was found to approximate very closely to the form $\infty \; \frac{5}{4} = (450)$.

The character of the signals, on the whole, was such as to preclude any very accurate calculation of the axial ratios. The value calculated from seven of the best faces on crystal 12 giving 'fair' signals was—

$$p_0 : q_0 : r_0 = 1{\cdot}8073 : 0{\cdot}9557 : 1$$
$$(\text{or} \quad a : b : c = 0{\cdot}5288 : 1 : 0{\cdot}9557)$$

which is high as compared with Goldschmidt's calculated value of—

$$p_0 : q_0 : r_0 = 1{\cdot}8049 : 0{\cdot}9539 : 1$$
$$(\text{or} \quad a : b : c = 0{\cdot}5285 : 1 : 0{\cdot}9539).$$

The crystals examined may be divided into two general classes according to habit.

Type I.—The simplest form of this type is represented by crystal 1 (fig. 1) in which the brachydomes $f = 01 = (011)$ are enormously developed, exceeding in size any other terminal faces which may be present, and always accompanied by the pyramid $u = \frac{1}{2} = (112)$. The unit prism $M = \infty = (110)$ and the prism $l = \infty 2 = (120)$ are also invariably present, the latter almost always exceeding the former in development and usually exhibiting vicinal striations, while the former is usually a better reflecting face and is less often striated. Other prism forms are relatively rare and when they do occur are only slightly developed. In addition to the forms mentioned, the base $c = 0 = (001)$ and the pyramid $i = \frac{1}{3} = (113)$ are of fairly common occurrence, and other pyramids as $o = 1 = (111)$ and $x = \frac{1}{3} \frac{2}{3} = (123)$ may appear but are rare. All these latter forms, however, are developed only to a comparatively small extent.

Of the twelve crystals measured, ten were of the general type represented by fig. 1, so that this may be considered the commonest and most characteristic habit for crystals from this locality.

The simpler forms of this type are replicas in habit of some very large specimens of gem topaz from Japan in the collection of the University of Toronto. They are also comparable to the topaz from Altenberg figured by Hintze (Handbuch der Mineralogie) after Groth.

Type II.—The remaining two crystals 11 and 12, and another which could not be measured accurately, were of the general habit represented by fig. 2 (crystal 12), in which all the characteristic forms of type I (M, l, f, u) are retained, but the domes are much reduced in relative size and are accompanied by a greater number of pyramids with correspondingly larger development. Several additional prism forms along with the brachypinacoid also appear.

As the characteristic forms of type I persist on crystals of type II it

would appear that habit II is merely an elaboration of habit I by the addition of more pyramids and prisms and consequent reduction in development of the forms of type I. This is borne out by the fact that forms which are intermediate between the two types occur, as may be
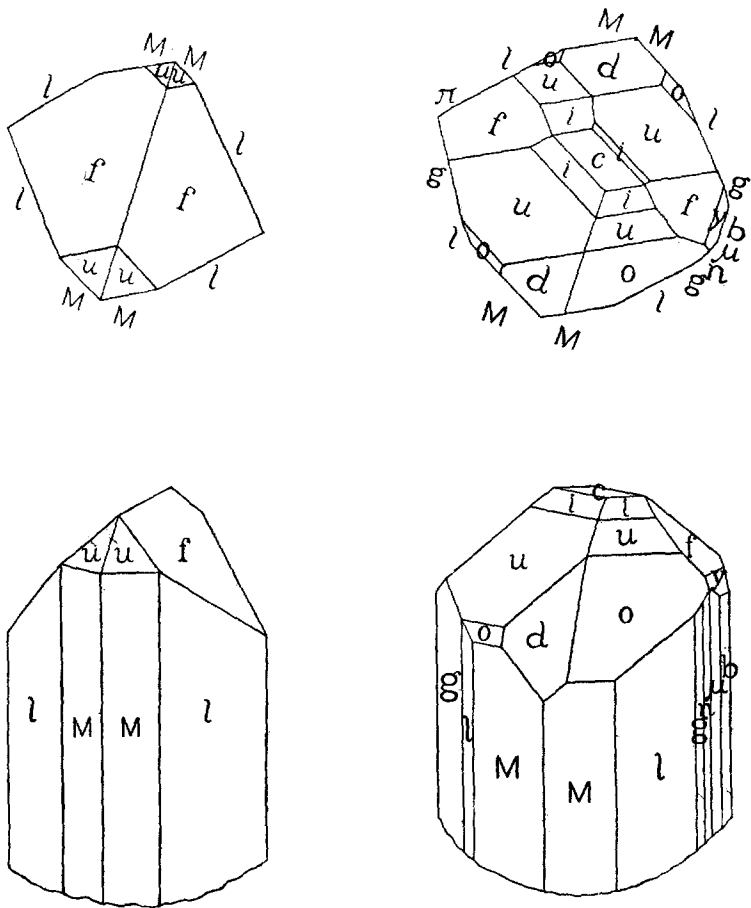

FIG. 1.   FIG. 2.

Crystals of Topaz from York County, New Brunswick.

seen from the table, e.g. crystals 9 and 10, in which the domes are somewhat reduced and additional forms appear. Thus, a sufficient number of crystals might yield a complete series, beginning with the

simple type I and with the number of forms gradually increasing until type II or a still more complex type was reached.

(2) *A method of silvering crystal-faces for giving improved reflections on the goniometer.*

In the course of measuring the crystals it was found that many of the faces, particularly the pyramids and domes, were so dull as to give very unsatisfactory reflections. In some cases, indeed, though the faces were well developed, no signal whatever could be obtained. As a possible remedy, the idea of plating the crystals with a thin, uniform film of silver by chemical means suggested itself to the writer and led to some experiments in that direction. As the external surface of the silver film would be the reflecting medium in this case, the methods used in silvering astronomical mirrors might be expected to best suit this requirement. After some experimenting with the various methods used in astronomical work, the Brashear process,[1] in which an ammoniacal solution of silver nitrate is reduced by a sugar solution, was adopted as being the quickest and most satisfactory.

The crystals were first cleared of iron oxide by treatment with acid. All traces of grease were removed with potash and alcohol, so that distilled water would wet the whole surface of the crystal uniformly. This thorough cleaning of the crystal is the point upon which the success of the whole process chiefly depends, as the slightest greasiness will prevent the deposition of silver as an adherent film. After cleaning, the crystals were mounted in the usual way, a pair of chemically clean forceps being used to avoid contamination by grease.

The mounted crystals were then suspended by a piece of pasteboard over a small evaporating dish containing the silvering solution so that the crystals were immersed just up to the mounting-wax. A sufficiently thick coating was obtained in from three to ten minutes, depending on the temperature and the amount of reducing solution used. The crystals were then removed, rinsed and dried, and were ready for measurement.

If the crystals are left in the solution too long the coating loses its brilliancy and becomes dull grey or black. They should be removed as soon as opaque and while still bright.

[1] Astrophysical Journal, 1895, vol. i, p. 252. The writer is indebted to Prof. Chant of the Department of Astro-Physics for a reference to a very comprehensive review of the various modern silvering methods, including Brashear's process, by H. D. Curtis in the 'Publications of the Astronomical Society of the Pacific,' San Francisco, 1911, vol. xxiii, No. 135.

By mounting the crystals before silvering, subsequent handling of the rather delicate silver film is avoided, and moreover, much better results are obtained than if the crystals are simply placed in the bottom of the dish and the silvering solution poured over them.

The results obtained were very satisfactory. The advantages of silvering the crystals may be summed up as follows :

1. The amount of light reflected from the crystal-faces is greatly increased. Hence very small, dull, or rough faces, which ordinarily are hard to locate and may easily be overlooked, are much more readily seen when silvered.

2. In cases where the face is not too rough, but simply dull, the signal usually appears to be improved in brightness and distinctness of outline.

3. As the crystal is rendered opaque by the silver coating, light cannot be reflected through the crystal from faces opposite the one being read. This, and the ease with which the faces are seen owing to their great luminosity, makes the reading of the crystal much less trying to the eyes of the observer.

4. Theoretically, the accuracy of the readings should not be affected, as the coating is excessively thin and very uniform. As a matter of fact, in the case of some of the crystals with dull faces and very poor signals it was found that the silvering resulted in more nearly correct readings due to the improvement in the signals.

In view of the success of these silvering experiments with topaz, it would appear that the method might be extended to other transparent mineral crystals in cases where silvering would be advantageous.

In conclusion, the author wishes to express his sincere thanks to Dr. T. L. Walker and Mr. A. L. Parsons of the University Department of Mineralogy for their interest and advice in the work.