BERYL AT MOUNT MICA, MAINE*

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ABSTRACT

In 1949 a new pocket was opened at Mount Mica which appears to be on the projected strike and dip of the zone of the old pockets which contained gem tourmaline. In the new pocket, beryl crystals of unusual habit were found with milky cores and colorless exterior. It is believed that cores were derived by the shattering of large crystals on the wall of the pocket and that the later colorless beryl was deposited in such a way as to preserve as nearly as possible the shape of the fracture fragments. Chemical analyses of both types of beryl are given.

EARLY WORKINGS AT MOUNT MICA

Gem tourmaline was discovered in the pegmatite on Mount Mica in 1820. From that time until 1864 there were only desultory attempts at mining, although the locality was visited by many geologists and mineralogists. In 1864 active work was commenced which continued intermittently until 1913. For a short time in 1873 mining was carried on for muscovite and between 3,000 and 4,000 pounds of mica were removed. Aside from the mica mining, the activity was entirely a search for pockets containing gem tourmaline. The operations were of doubtful financial success, but they did produce a large number of beautiful gem tourmalines which make Mount Mica a world-renowned mineral locality.

An interesting account of the work up to 1895 and a description of some of the finest gems are given by Hamlin in his book, *The History of Mount Mica*. Bastin† discusses the mineralogy of the pegmatite and describes the later work up until 1910. He also gives a brief account of the geology; a portion of which is as follows:

" . . . the Mount Mica pegmatite mass dips gently 20° to 30° SE., being intruded in general parallel to the trend of quartz-mica schists, which at the quarry strike N. 50° to 60° E. and dip 20° to 30° SE. . . .

"The whole pegmatite mass is not productive, the gem and pocket bearing portion constituting a zone ranging from a few inches to 6 or 7 feet in thickness lying immediately below the schist capping. The productive layer originally outcropped at the surface, a relation to which was due its discovery and the ease with which it was worked in the early days. At present the southeastern wall of the quarry is capped by about 10 to 15 feet of schist which must be stripped off before the pocket-bearing zone is reached."

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† Geology of Pegmatites of Maine: *U. S. Geol. Survey, Bull.* **445** (1911).

Subsequent to the operations reported by Bastin, workings were extended only slightly to the northwest and in 1913 the last pocket containing tourmaline was opened. Mining came to an end when it became too costly to remove the overlying schist for further exploration down the dip. The workings, essentially the same to-day as they were then, are shown diagrammatically in Fig. 1.

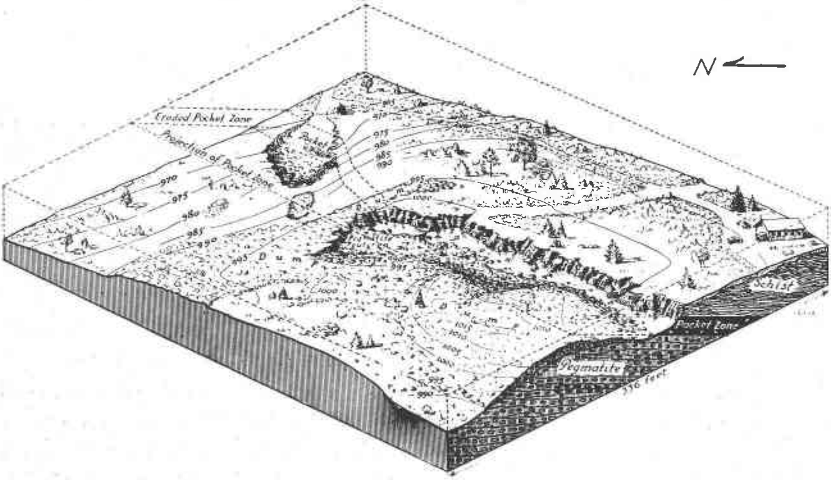


FIG. 1. Block diagram of Mount Mica. Topography by Robert Miller and Lawrence Wing. Maine Geological Survey, Maine Development Commission, 1943.

THE NEW POCKET

To the northeast of the old workings quarrying operations for feldspar have been undertaken in recent years where the slope of the hill exposes the pegmatite at the surface. No pockets were encountered until June 1949 when the operations of the United Feldspar Company broke into a cavity—the second largest to be found at Mount Mica.

Neglecting minor irregularities and assuming that the pocket zone of the pegmatite is a sheet 7 feet thick striking N. 55° E. and dipping 25° SE., this new pocket lies within the same horizon (Fig. 1). Its presence may well indicate an extensive continuation of the pocket zone under the southeast slope of Mount Mica.

Although the new pocket lies along the projected strike and dip of the zone containing the old workings, its relation to the schist is quite different. Fifteen feet of pegmatite, composed mostly of microcline and quartz, overlie the pocket and extend to the surface with no schist above. It may well be that this overlying pegmatite is a separate injection intruded between the pocket zone and the schist and it is in this upper pegmatite that the recent feldspar operations have been carried out.

The new pocket was about 20 feet long, 5 feet wide and 4 feet high with the longest dimension essentially horizontal with a NW-SE strike. The largest pocket in the old workings measured $20' \times 12' \times 7'$. The day before the pocket was actually broken open, drilling indicated its presence. After penetrating about two feet below the quarry surface, a drill dropped several feet into the cavity. When, in another hole six feet away, the drill reached the same depth, it likewise dropped and water

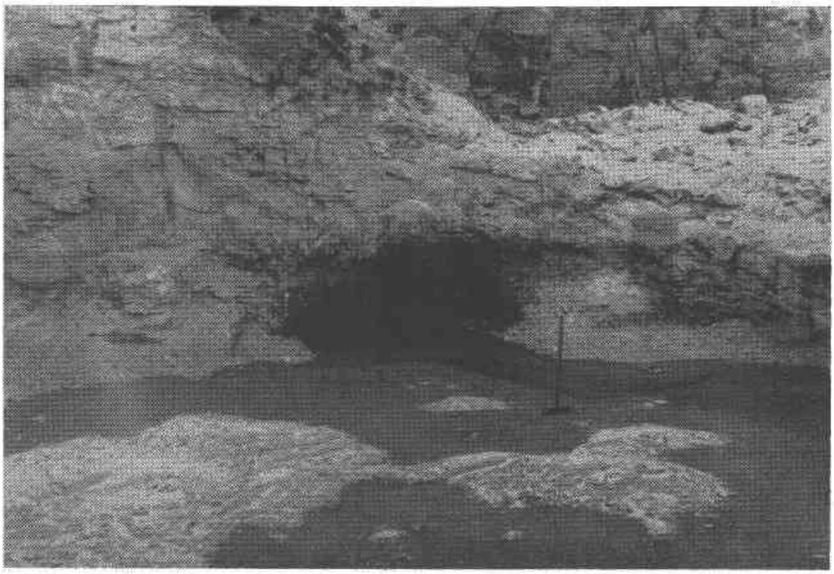


FIG. 2. Southeast end of the pocket exposed by deepening of the quarry floor. The main portion of the pocket extended into the foreground.

spouted several feet in the air from the first hole. Because of this advanced notice, the writers were able to be present on the following day when a blast made a small opening into the northwest end of the water-filled pocket.

Initial exploration carried out by reaching arm's length into the hole yielded nothing of unusual interest. The roof was covered with subparallel books of muscovite 4 to 5 inches in diameter with the platy edges projecting downward. On the sloping floor were fragments of feldspar and a few imperfect quartz crystals. Just within reach was a large loose crystal which proved to be a deeply etched Baveno twin of microcline $10 \times 8 \times 8$ inches. No lepidolite nor cleavelandite was noted either inside the pocket nor in the rock surrounding it. In the old workings these minerals were usually encountered in the vicinity of gem-bearing pockets.

When the pocket was eventually opened for complete inspection, the writers could not be present but most of the contents gathered from the floor were made available to them through the courtesy of the owner, Mr. Howard Irish of Buckfield, Maine. In addition to the books of muscovite on the walls and roof of the pocket, there were large areas covered by a subparallel aggregate of albite crystals. No tourmaline was found and thus this pocket would have been declared barren by the early workers at Mount Mica.

Beryl Crystals

The contents of the pocket gathered from the floor amounted to about two bushels of small crystals (four inches and under) mostly quartz. In addition there were several larger smoky quartz crystals; the largest, 18 inches long and 10 inches wide, was well formed. On the floor at the southeast end of the pocket were many colorless to milky white beryl crystals of such unusual habit that their identity was not immediately apparent. They ranged from $\frac{1}{2}$ inch to 8 inches in length and the majority were covered with crystal faces. Their most remarkable feature was the complete individuality of each crystal. No two were alike in shape nor in development of forms and none showed the prismatic habit characteristic of most beryl.

Morphology. In spite of the large size of many of the crystals, most of the faces were sharp and gave usable signals on the reflecting goniometer. Only in determining the angular measurements of the largest crystal was recourse made to the contact goniometer. This crystal measured $8\times3\times2$ inches and weighed three pounds (Fig. 6). Because of the high quality of the faces, one felt justified in having faith in the angular measurements even though the resultant indices are unusual. On many crystals a form with high indices is represented by only one face, but it, as $(\bar{7}\cdot14\cdot\bar{7}\cdot8)$ in Fig. 5 is a major face. Table 1 lists the forms and compares measured with calculated angles. The frequency of occurrence and distribution of forms on the fourteen crystals measured is also indicated. Of the thirty forms included in the table, seventeen (marked with an asterisk) are not listed by Goldschmidt* or Whitlock.†

From Table 1 it can be seen that certain forms such as $\{0001\}$, $\{10\bar{1}0\}$, $\{11\bar{2}1\}$ and $\{21\bar{3}1\}$ are usually present. However, the size of the faces of

* Goldschmidt, V., Atlas der Krystallformen, Heidelberg (1913).

† Whitlock, H. P., A List of New Crystal Forms of Minerals: *Bull. Am. Mus. Natl. Hist.*, XLVI (1922).

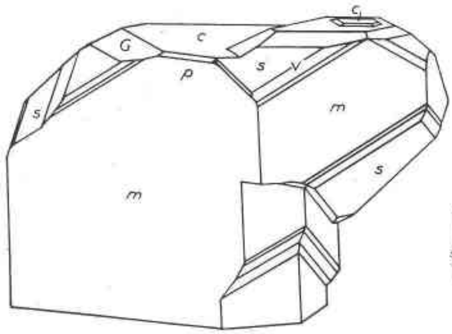


Fig. 3

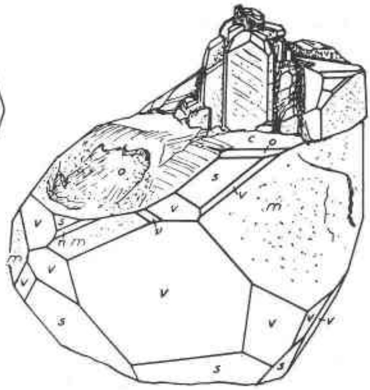
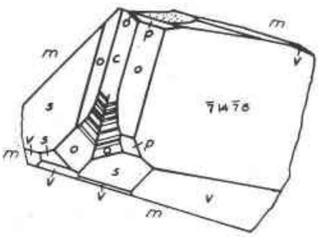
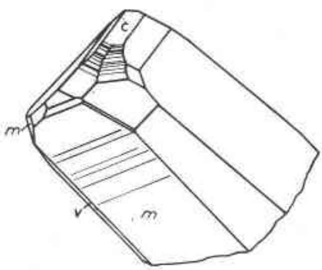


Fig. 4



(a)



(b)
Fig. 5

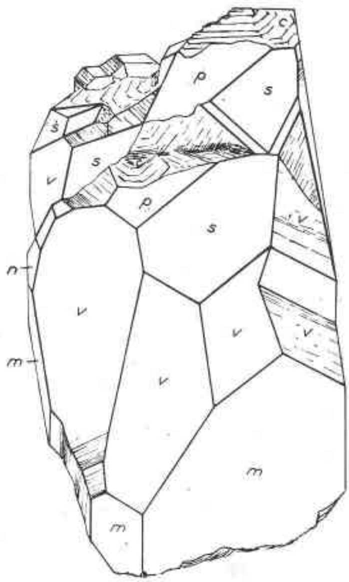


Fig. 6

FIGS. 3, 4, 5, 6. Beryl crystals, Mount Mica. Fig. 5(*a*) Orthographic projection of the same crystal shown in clinographic projection in Fig. 5(*b*).

TABLE 1. MOUNT MICA BERYL: TWO-CIRCLE MEASUREMENTS

Form	Measured		Calculated (P_0=0.5762)		Number of Faces	Number of Crystals
	ϕ	ρ	ϕ	ρ		
0001	—	0°00′	—	0°00′	14	12
$10\bar{1}0$	29°50′–30°04′	89°50′–90°04′	30°00′	90°00′	81	14
$10\bar{1}1$	29°53′–30°02′	29°54′–29°58′	30°00′	29°57′	8	3
*$70\bar{7}4$	29°57′–30°00′	47°20′–47°23′	30°00′	47°23′	3	2
*$80\bar{8}3$	29°58′–30°01′	49°00′–49°04′	30°00′	49°03′	3	2
*$16\cdot 0\cdot \overline{16}\cdot 3$	29°59′	71°57′	30°00′	71°58½′	1	1
$11\bar{2}6$	359°54′– 0°05′	9°20′– 9°30′	0°00′	9°27′	4	2
*$11\bar{2}4$	359°47′– 0°04′	13°50′–14°02′	0°00′	14°00′	15	3
$11\bar{2}3$	359°55′– 0°03′	18°10′–18°31′	0°00′	18°24′	17	5
*$22\bar{4}5$	0°01′– 0°13′	21°45′	0°00′	21°46′	3	1
$11\bar{2}2$	357°56′– 0°05′	26°14′–26°46′	0°00′	26°31′	19	4
*$7\cdot 7\cdot \overline{14}\cdot 8$	0°04′	41°06′	0°00′	41°08′	1	1
$11\bar{2}1$	359°50′– 0°07′	44°18′–45°20′	0°00′	44°56′	50	11
*$43\bar{7}6$	4°40′– 4°44′	30°15′–30°18′	4°43′	30°17½′	2	2
*$32\bar{5}6$	6°34′– 6°38′	22°33′–22°49′	6°35′	22°43′	8	2
$21\bar{3}3$	10°52′	26°54′	10°53½′	26°56′	2	1
$21\bar{3}1$	10°28′–10°59′	56°30′–57°11′	10°53½′	56°44′	88	12
*$7\cdot 3\cdot \overline{10}\cdot 3$	12°59′–13°04′	59°30′–59°43′	13°00′	59°38′	8	1
$52\bar{7}2$	13°50′–13°53′	60°50′–60°56′	13°54′	60°56′	6	3
*$33\cdot 11\cdot \overline{44}\cdot 6$	16°00′–16°05′	75°15′–75°18′	16°06′	75°17′	7	1
*$41\bar{5}1$	19°10′–19°24′	69°03′–69°20′	19°06½′	69°15½′	4	2
*$9\cdot 2\cdot \overline{11}\cdot 2$	20°10′–20°19′	71°00′–71°09′	20°10½′	71°07′	10	2
*$19\cdot 4\cdot \overline{23}\cdot 4$	20°29′–20°35′	71°54′–72°01′	20°38′	71°56′	19	4
$51\bar{6}1$	21°01′–21°09′	72°39′–72°44′	21°03′	72°41′	9	1
$61\bar{7}1$	22°24′–22°28′	75°01′–75°14′	22°24½′	75°11′	6	2
*$13\cdot 2\cdot \overline{15}\cdot 2$	22°53′	76°09′	22°57′	76°11′	1	1
*$81\bar{9}1$	24°12′–24°16′	78°34′	24°11′	78°31′	2	1
$13\cdot 1\cdot \overline{14}\cdot 1$	26°20′–26°22′	82°39′–82°45′	26°20′	82°41′	4	1
*$14\cdot 1\cdot \overline{15}\cdot 1$	26°37′	83°05′–83°11′	26°35′	83°34′	4	1
*$60\cdot 3\cdot \overline{63}\cdot 4$	27°38′–27°42′	83°30′–83°41′	27°41′	83°34′	8	1

* New forms.

these forms on the different crystals varies widely; on some they may be major faces, whereas on others they are extremely minor. All crystals on which $\{11\bar{2}2\}$ was found showed curved surfaces between the faces of this form and $\{0001\}$. Some of the forms, particularly those with high indices, seemed open to question after the first measurement. All, however, have been checked by remeasurement. Four additional forms were considered uncertain and are not included in Table 1.

Zoning. All of the beryl crystals are zoned with a core of milky material and a colorless, glassy exterior. By looking through the colorless portion one can observe well the contact between the two zones. In most crystals this contact is not parallel to crystal faces as is commonly seen in ghost crystals, but is a rough fracture surface without crystallographic orientation. On one crystal which was sawed in two, a small cavity was present between the two zones exposing the original fracture surface (see Fig. 7). The evidence indicates, therefore, that the cores are rough fragments broken from earlier formed beryl and that the glassy exterior was added later.

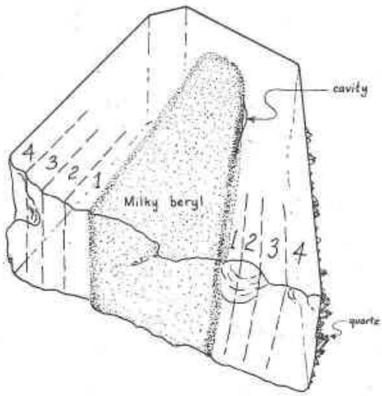


FIG. 7. Section sawed from crystal illustrated in Fig. 5. Numbers indicate the locations of samples taken for spectrographic analysis.

Covering a portion of the wall of the pocket in the vicinity of the crystals, beryl in coarse columns about three feet long was found sloping toward the center of the pocket at an angle of 45°. This coarse beryl corresponds exactly to the material of the cores of the smaller crystals; it is milky white and has the same specific gravity and refractive indices. It appears likely that the columnar beryl was shattered and fragments of it fell to the floor of the pocket where they acted as nuclei for the deposition of the later transparent beryl. Moreover, the columnar beryl on the surfaces exposed in the pocket is covered with clear material exhibiting many crystal faces, and cracks within it have been healed with the same colorless beryl.

The unusual habit of the smaller crystals appears to be due to the irregular shape of the fragments which acted as cores. The late transparent beryl was deposited on the cores with a tendency to form crystal faces as nearly parallel to the fracture surfaces as possible. This accounts for the extraordinary habits and the fact that one face of a form may be large and the other faces poorly developed or absent. On a few of the crystals one or two prism faces have little or none of the later material deposited upon them, and represent the original prism faces of the columnar beryl.

The cores of milky beryl are very uniform in composition as indicated by constant indices of refraction and specific gravity. The milky beryl owes its cloudy appearance to many microscopic cavities and their presence undoubtedly accounts in part for the very low specific gravity. (G = 2.650)

The transparent beryl of the exterior, on the other hand, shows a wide variation in its properties. Attempts to determine the indices of refraction by the method of minimum deviation on cut prisms yielded erratic and variable values which were not in agreement with earlier values obtained by the double variation method. Although the clear beryl coatings were apparently homogeneous and displayed no obvious

TABLE 2. ALKALI CONTENT, REFRACTIVE INDICES AND SPECIFIC GRAVITIES OF MOUNT MICA BERYL

Sample	Total* Alkalis	Spectrographic Analysis**				(Na) Refractive Index		Sp. Gr.
		Cs	Li	Rb	K	O	E	
Milky	0.84	0.15	0.6–0.8	0.04	tr	1.580	1.574	2.650
1	1.07 (samples 1–4)	0.1	0.1	0.05	tr	1.573	1.568	2.675
2		0.15	0.1	0.05	tr	1.580 (samples 2–3)	1.574	2.692
3		1.0	0.5	0.05	tr			
4		2 to 6	1.0	0.1	tr	1.598	1.591	2.780

* F. A. Gonyer, analyst.

** H. C. Harrison, analyst.

evidence of zoning, compositional variation was suspected. Small fragments were broken from the clear zone of a sawed slab and the indices determined by immersion. The specific gravities of similar fragments, ten to fifteen milligrams in weight, broken from the inner, outer and middle portions of the clear beryl layer, were obtained on the Berman balance. An increase in refractive indices and specific gravity from the milky core outward is clearly shown (Table 2). Because of the continuous nature of the change and the relatively thin coating of clear beryl (5 mm. maximum), it is impossible to obtain even a small fragment of uniform composition. Consequently, it is probable that neither the high nor the low extreme in specific gravity is represented by the values given below. Moreover, the refractive indices as given should be considered merely as the mean of the zone they represent.

By the use of a small diamond drill, four separate channel samples of the clear beryl were obtained for spectrographic analysis from the crystal shown in Fig. 5. The locations from which these samples were removed are shown in Fig. 7. Semiquantitative spectrographic analysis shows a progressive increase in cesium and lithium from the innermost zone outward. There is a concomitant, but much less clearly marked, increase in rubidium, while potassium is present only as a trace in all samples.

Chemical Analysis. Analyses of both the clear and milky beryl were made by F. A. Gonyer. Analysis 1 represents merely the average composition of the clear beryl, for no attempt was made to separate the zones. The chief differences in the two beryls are shown in the higher percentage of alkalis and the lower percentage of BeO in the clear beryl.

TABLE 3. CHEMICAL ANALYSES OF BERYL FROM MOUNT MICA

	Clear Beryl 1	Milky Beryl 2
SiO_2	64.54	64.80
Al_2O_3	18.51	18.38
BeO	13.20	14.68
Li_2O	0.86	0.68
Na_2O	1.12	0.76
K_2O, Rb_2O, Cs_2O	0.21	0.16
H_2O	1.24	0.78
Total	99.68	100.24

Cell Dimensions. X-ray powder photographs were made on the same samples of clear beryl used for spectrographic analysis. Back reflection lines in the region $2\theta = 145°$ to $170°$ were compared in a search for a systematic variation in cell dimensions with changes in alkali content. The variations found lie within the estimated limits of experimental error and it is concluded that no systematic change in cell dimensions has accompanied the wide variation in alkali content indicated in the table above. For example, the spacing for a line in the region $2\theta = 145°$ was determined as $d = 0.8081$ Å $\pm .0001$ for the inner zone, $d = 0.8081$ Å $\pm .0001$ for the intermediate zone, $d = 0.8082$ Å $\pm .0001$ for the outer zone (samples 3 and 4 combined). The d values above represent the mean of calculated values based on measurement of both $CuK\alpha_1$ and $CuK\alpha_2$ lines.

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