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On an Occurrence of Minerals at Haddam Neck, Connecticut, U.S.A.

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(With Plate IV.)

[Read March 19, 1901.]

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IN the summer of 1896 the Oxford Museum was enriched by a fine series of about eighty mineral specimens from a newly opened quarry at Haddam Neck in Connecticut, which were kindly presented by Mr. Ernest Schernikow of New York.

The species included in the series are green and pink tourmaline, albite, microcline, green and pink apatite, brown fluor, beryl, quartz,

cookeite, lilac lepidolite, greenish-white muscovite, and a peculiar pink fibrous variety of the same mineral. To these must also be added, as occurring at the same place, green fluor, microlite, and columbite.

The locality is described as Haddam Neck, a village opposite to Haddam, on the other (eastern) bank of the Connecticut River, which is here about half a mile wide.

Mr. Schernikow gives the following account of the occurrence:—'The deposit is what I would call a vein of very coarse granite—that is, the quartz, felspar, and mica are in very large pieces. Quartz and felspar predominate, mica being also quite abundant, and sometimes in plates 2 ft. across. The tourmalines and associated minerals, like lepidolite, beryl, cookeite, etc., occur usually in pockets, all of which are lined with crystallized quartz and felspar, and sometimes beryl. *All* the minerals occur in these pockets. The deposit is well defined between walls of country rock—possibly gneiss, but I am not positive.'

In the following description of the species, the position of the crystals and the lettering of the faces are throughout those used in Dana's 'System of Mineralogy' (1892); as are also the axes, except in the case of tourmaline, where the faces are referred to the rhombohedral axes of Miller. In the case of apatite and beryl, the letters and indices used by Miller (in his edition of Phillips's 'Mineralogy') are added.

THE MICAS.

Intergrowth of Muscovite and Lepidolite.

Perhaps the most interesting minerals of the occurrence are the micas. Stout hexagonal or rhombic prisms terminated at right angles by the basal plane are found associated with smoky quartz, albite, microcline, cookeite, and sometimes tourmaline. They have ordinarily a diameter of 1·5 to 3 or 4 cm., but to judge from one tabular (cleavage) specimen, they appear to attain a diameter of 8 cm. They are usually terminated by cleavages, but some specimens attain a length of 4 cm. When broken across, they are found to consist either of transparent lilac lepidolite throughout, or (more usually) of an outer zone of this mineral surrounding an inner nucleus of yellowish- or greenish-white muscovite, the cleavage being parallel in both border and centre.

Pink Fibrous Muscovite.

The outer surface of the prisms has a fibrous appearance due to a thin layer of longitudinal fibres of a pink mineral, and at the ends the lepidolite is covered (in unbroken specimens) by a layer of the

same material, often 1 cm. or more in thickness, the fibres being always parallel to the axis of the prism. The fibrous mineral has a perfect cleavage perpendicular to its fibres, and thin plates can be split off from it parallel to the cleavage of the lepidolite nucleus. Such plates form beautiful objects under the microscope, when they are seen to be built up of minute rhombic units, with angles of 60° and 120°, fitted together in three positions, forming tesselated areas which extinguish in three positions, 120° apart—each rhomb extinguishing parallel to its diagonals (fig. 1, plate IV). In convergent light the rhombs show a nearly normally-emergent negative bisectrix of rather wide angle, the plane of the optic axes lying along the longer diagonal.

These characters indicated a mineral belonging to the group of micas, and an analysis became necessary in order to determine the species.

The material analysed was of a uniform light rose-pink, and quite clean and free from any brown crust. Its specific gravity (before crushing) was 2·791.

A small amount of water is given off on heating the dried powder in the closed tube, and a qualitative examination showed the presence of SiO_2, Al_2O_3, Fe_2O_3 (or FeO), MnO, K_2O, Na_2O, Li_2O, F, P_2O_5. The MnO is sufficient to give the fused carbonates a pale bluish-green tinge, and is probably the cause of the pink colour of the mineral, but it does not appear to be present in weighable amount.

The finely powdered mineral was found to show practically no loss of weight after being exposed for forty-eight hours over calcium chloride, and a very trifling loss after being heated for two hours to about 96° in a water-oven. For the quantitative determinations, therefore, the material was dried in this manner.

The water was estimated by Penfield's direct method[1], the mineral, mixed with previously well dried litharge to retain fluorine, being heated by a Bunsen burner in a closed hard-glass tube with a bulb on its neck kept cool by wet filter-paper. The neck containing the water was cut off and weighed, the water then tested and found neutral, and the neck dried and again weighed. Further heating of the residual material in the blowpipe produced no more water. In two experiments, 0·0975 and 0·0759 grams of the dried mineral gave 0·0043 and 0·0033 grams of water, corresponding to 4·41 and 4·35 per cent. respectively of water [mean 4·38 per cent.].

The fluorine was determined according to the method of Berzelius; two experiments with 0·1186 and 0·2531 grams of the dried mineral

[1] Amer. Journ. Sci., 1894, ser. 3, vol. xlviii, p. 31.

yielding (after removal of one-tenth of the solution to test for P_2O_5) 0·0008 and 0·0018 grams of calcium fluoride, corresponding to a total percentage of fluorine of 0·37 and 0·385 [mean 0·377].

The determinations of the silica by the Berzelian method were not concordant, and this constituent was therefore estimated in the usual way by evaporation of the carbonate-fusion with acid, the amount of fluorine being so small that any loss of silica which it might cause (the maximum possible being just over three-quarters of its weight) must be insignificant. Seven experiments yielded the numbers given below. The acid solution was in each case evaporated twice on the water-bath and extracted through separate filters, and in nos. 3, 4, 5, 6 the residue after the second evaporation was heated to 110° in an air-bath, till it no longer gave off acid fumes. In the case of nos. 3, 4, 7, nitric acid was used instead of hydrochloric acid.

The weighed silica was exposed in the open platinum crucible to the fumes of hydrofluoric acid (produced from a mixture of NH_4HF and strong sulphuric acid) for 12–15 hours in a closed leaden box[1] over a small flame placed some distance below, and the silica determined by the loss of weight.

	1	2	3	4	5	6	7	
Weight of mineral .	0·3827	0·2423	0·3023	0·3208	0·3069	0·3045	0·3004	
Weight of SiO_2 . .	0·1792	0·1112	0·1399	0·1475	0·1419	0·1409	0·1396	
Percentage of SiO_2 .	46·83	45·89	46·28	45·98	46·24	46·27	46·47	mean 46·28

The filtrates from the silica in nos. 1, 2, 6 were precipitated hot with ammonia, the precipitate washed, dissolved in nitric acid, and reprecipitated; the precipitate of Al_2O_3, Fe_2O_3, P_2O_5, after weighing, was tested for manganese by fusion with carbonates, but gave hardly any perceptible green colouration. The weights of the precipitates were 0·1456, 0·0917, 0·1153 grams, corresponding to 38·05, 37·85, 37·87 per cent. of $(Al_2O_3+Fe_2O_3+P_2O_5)$ respectively. [Mean 37·92 per cent.]

The filtrates from the silica in no. 5 and in another experiment with 0·3077 gram of the dried mineral, were precipitated with ammonia, the precipitate washed and redissolved in dilute sulphuric acid, the iron

[1] Such a box may conveniently be made of a piece of 4 in. lead pipe, about 4 in. long, with the ends filed true and closed by flat plates of sheet lead. The crucible is covered with a loose roof of platinum foil to protect the silica from any particles falling from the lid of the box.

reduced with zinc and titrated with permanganate. The results showed 1·07 and 0·87 per cent. of ferric oxide, respectively. Ferrous iron was not separately determined. [Mean Fe_2O_3=0·97 per cent.]

In the filtrate from no. 7, the phosphoric acid was separated with ammonium molybdate and estimated as $Mg_2P_2O_7$. The result showed the presence of 0·09 per cent. P_2O_5.

Taking the means of the determinations and calculating the alumina by difference gives 36·86 per cent. Al_2O_3.

For the estimation of the alkalies the mineral was decomposed by the Lawrence Smith method and the separation of the lithium effected by means of amyl alcohol as recommended by Gooch[1]. The lithium was weighed as lithium sulphate. The potassium was separated from the sodium in the residue as K_2PtCl_6, the latter ignited, and the resulting platinum washed and weighed. The weight of sodium was obtained by difference.

The results of three experiments with 0·3096, 0·3049, and 0·3986 grams of the dried mineral, after correction for the solubility of the various alkaline salts in the amyl alcohol, gave the following percentages:—

	1	2	3	mean
Li_2O	0·31	0·25	0·21	0·26
K_2O	10·90	10·53	10·46	10·63
Na_2O	1·37	1·52	1·33	1·41

The composition of the mineral may then be taken as:—

	I. Haddam Neck.		Goshen. II. Rbg.	Goshen. III. Mallet.
SiO_2	46·28		47·02	
Al_2O_3	36·86		36·83	
Fe_2O_3	0·97 (incl. FeO)		0·51	
MnO	trace		1·05	
K_2O	10·63		9·80	9·08
Na_2O	1·41	}	0·30	0·99
Li_2O	0·26	}		0·64
P_2O_5	0·09		—	
F	0·377		0·52	1·89
H_2O	4·38		3·90	
	101·257		99·93	
less O	0·158			
	101·099			

[1] Proc. Amer. Acad. Arts and Sci., 1886, new ser., vol. xiv, p. 177; Bull. U. S. Geol. Survey, 1887, no. 42, p. 73; Chem. News, 1887, vol. lv, p. 18, et seq.

The mineral is therefore a variety of muscovite, and may be compared with the pink variety of muscovite from Goshen (Massachusetts), the analysis of which, by Rammelsberg[1], is quoted in column II. A determination of the alkalies of the same by Mallet[2] is also given in column III.

A small fragment of a fibre detached from the side of a specimen admitted of measurement on the goniometer, and proved to be a very steep pyramid (fig. 2, plate IV[3]), the vertical faces not lying in a zone. The angles are:—

	Measured.	Calculated.
SS	$= 59° 52'$	$59° 58'$
$\pi\pi$	$= 59\ 43$	$59\ 52$
cS	$= 88\ 21\frac{1}{2}$, $88° 21'$	$88\ 36\frac{1}{2}$
$c\pi$	$= 86\ 38$, $86° 33'$	$86\ 28$

The plane of symmetry is thus parallel to the shorter diagonal of the rhomb. The measured angles lead to the indices S $\{\bar{5}51\}$ and π $\{552\}$. Both forms are new for muscovite, but S $\{\bar{5}51\}$ is given by Dana for biotite. The corresponding calculated angles given above are based on Tschermak's axes $a : b : c = 0{\cdot}57735\ \ 1 : 3{\cdot}3128$; $\beta = 89° 54'$, as adopted by Dana for muscovite.

The axial angle measured in air is:—

$$2E = 75\tfrac{1}{2}° \text{ (Na light).}$$

Dispersion, $\rho > v$ (slight).

The acute bisectrix is perhaps not quite normal to the plate, and in some instances seems to deviate a few degrees *in* the plane of the optic axes (i. e. across the plane of symmetry), but owing to the small size of the rhombs and the difficulty of isolating them, the position of the plate-normal has not been ascertained with certainty.

Some of the cleavage flakes show a bright line, which does not extinguish, along the boundary between the areas with different orientation, due to overlapping of the contiguous elements, and corresponding with the obliquity of the prism faces with respect to the cleavage.

The tesselated structure gives the mineral an opaque appearance to the naked eye, though the separate elements are transparent. The size of the small rhombs is on the whole very uniform, being about 0·18 mm. for the longer diagonal, but a few isolated fibres reach 0·65 mm.

I was for a long while unable to find any specimens from other

[1] Min.-Chem., 1875, p. 514.

[2] Amer. Journ. Sci., 1857, ser. 2, vol. xxiii, p. 180.

[3] The convergence of the faces is somewhat exaggerated in the figure.

localities at all resembling the present mineral, but among the lepidolites in the Vienna Museum I came upon a single large tabular crystal of muscovite bordered by a zone of lilac lepidolite, outside which was a small quantity of rhombic, tesselated material. The specimen is from Auburn, Maine, and proves on examination to be very similar to those of the Haddam Neck occurrence. The rhombs are fitted together in twin-position, extinguishing 120° apart. The axial plane is parallel to the longer diagonal. The axial angle is rather wide ($2E=75°\,20'$), and the figure shows distinct axial dispersion, $\rho > v$. The lilac lepidolite has its axial plane parallel to one of the rays of the percussion figure, and is therefore brachydiagonal. It is much twinned. The muscovite centre is macrodiagonal, with rather wide axial angle, and very distinct dispersion, $\rho > v$. The whole specimen very closely resembles the large tabular crystal from Haddam Neck mentioned above.

Lepidolite.

The solid prisms of lepidolite and the borders surrounding muscovite form extremely fine examples of this mineral. The material is of a beautiful lilac colour and perfectly transparent. To the eye it appears quite uniform and homogeneous, but application of the percussion test combined with the microscope, shows that the crystals fall really into two groups, in one of which the axial plane is brachydiagonal, while in the other it is macrodiagonal. It may be mentioned that the lepidolite yields a percussion figure much less readily than the muscovite, being more flexible and less elastic than it.

Lepidolite is usually stated to belong to the macrodiagonal group of micas, but brachydiagonal lepidolite has been described by Scharizer[1] from Schüttenhofen in Bohemia, where the zonal growth of the lepidolite and muscovite and the tourmalines appear to show a general resemblance to those of the present occurrence. Cleavage plates of the Haddam Neck lepidolite do not as a rule extinguish at all unless very thin, owing to the superposition of layers of material in twin-position. Thin plates show an irregular patchwork of areas extinguishing 120° apart. The axial angle is variable on account of the twinning, but appears to be generally smaller than that of the muscovite.

Both the brachy- and macrodiagonal varieties show a slight dispersion of the optic axes, in the sense $\rho > v$. The brachydiagonal flakes show a deviation of the bisectrix from the plate-normal in the plane of the optic axes. The macrodiagonal flakes also show a deviation of the

[1] Zeits. Kryst. Min., 1886, vol. xii, p. 1.

bisectrix of from $5\frac{1}{4}°$–$7\frac{1}{2}°$ from the centre of the microscope field, which is again in the plane of the optic axes, and therefore in this case in the plane perpendicular to (010). A deviation of this sort would contradict the assumption of monoclinic symmetry for the crystals, and it was therefore of importance to determine if the effect was real or due to instrumental errors (such as want of perpendicularity between the stage and the axis of the microscope), or to the somewhat uneven cleavage flake not lying flat upon the stage.

A small and exceptionally plane flake having been chosen, it was cemented on to a thin cover-glass in such a position that when mounted on the goniometer the best image of the signal reflected from the mica was not more than a few minutes distant from that reflected from the glass. The parts of the flake yielding other images were covered with a mask of paper. The mounted flake was then placed on a disc of glass laid flat on the stage of the microscope (Dick pattern), and capable of rotating in its own plane within a cardboard ring. The positions of the optic axes O_1O_2 in the field were read off on an eyepiece-micrometer, first in one position (A), and then after rotating the plate on the stage through 180° (B). The mean of O_{1_A} and O_{1_B} (or O_{2_A} and O_{2_B}) gives the reading for the plate-normal, while those of O_{1_A} and O_{2_A} and of O_{1_B} and O_{2_B} give readings for the bisectrix in the two positions.

A flake, which was subsequently proved by percussion to be macro-diagonal, showed a deviation of the bisectrix from the plate-normal of $6\frac{1}{2}°$ in the plane of the optic axes, the inclination of the mica to the cover-glass being only 16′. The true deviation of the bisectrix from the normal to the flake in the plane of the optic axes cannot therefore be less than $6\frac{1}{4}°$.

Hence it must be concluded that, unless a ray of the percussion star is perpendicular to (010) [1], this mica belongs to the anorthic system.

With the nicols in the extinction position, the lateral shift of the axial brush produced by a rotation of the plate through 180° falls within the errors of observation. The axial plane is thus sensibly normal to the plane of cleavage.

Another flake, examined as above, which turned out to be brachy-diagonal, showed a deviation of $4\frac{3}{4}°$ in the plane of the optic axes, the

[1] There seems no reason to doubt that the star belongs to a percussion- and not to a pressure-figure, as its form agrees exactly with the type figured by Max Bauer (Zeits. Deutsch. geol. Gesells., 1874, vol. xxvi, pl. II, fig. 2, and copied in Hintze's Mineralogy, vol. ii, p. 518, fig. 236).

mica being nowhere inclined more than 7′ to the plate on which it was mounted.

Greenish-white Central Muscovite.

The central core of many of the mica crystals consists of greenish- or yellowish-white muscovite, and a similar material also occurs in irregular flakes dispersed in parallel positions through massive quartz.

The centre of the large tabular crystal mentioned above (p. 98) has an axial angle in air[1]:—

$$2E = 75° 38'.$$

That of a smaller rhombic-shaped prism has:—

$$2E = 74° 35'.$$

The material is a perfectly normal muscovite—the axial plane is macrodiagonal, and there is a well-marked axial dispersion, $\rho > v$.

Zonal Growth and Twinning of the Micas.

(1) *Lepidolite on Muscovite.*—The line of junction between the central muscovite and the lepidolite border is occasionally irregular, but more usually straight and sharp. The outline is generally either rhombic or hexagonal, corresponding to faces in the zone $[c, (110)]$ and the clinopinakoid $\{010\}$ of the muscovite. The obtuse angles of the rhomb are often truncated by small faces of a $\{100\}$, and the angles between $\{010\}$ and $\{110\}$ are frequently replaced by short edges apparently representing several different forms. The indices of these can scarcely be determined owing to the shortness of the edges and the rounding of the angles, but Q $\{130\}$ is probably present, and two faces at angles, respectively, of 23° and 24° from $\{110\}$, may belong to a form $\{370\}$, for which the calculated angle (taking $(110) : (1\bar{1}0) = 60°$) is 23° 25′. Seven measurements (varying from 59° to 60½°) of the plane angle of the rhomb on the microscope-stage yielded 59½° as the mean value of that angle.

The relation of the lepidolite border to the central muscovite is somewhat difficult to determine, owing to the twinned structure of the former; the untwinned areas being so small as to admit only exceptionally of the production of a recognizable percussion figure.

Immediately outside the junction is generally (but not always; see fig. 4, pl. IV) a narrow band of lepidolite (L_m) which extinguishes in the same position as the muscovite, the axial planes being also parallel (fig. 3, pl. IV). The percussion star, which I have succeeded in obtaining on

[1] For the muscovite-centre of the zoned mica from Schüttenhofen, the axial angle (as given by Scharizer) is $2E = 70°$–$74°$.

two specimens, shows this zone to consist of the macrodiagonal variety grown in parallel position on the muscovite.

Outside this inner zone of lepidolite, and occasionally also in direct contact with the muscovite, are irregular patches (L_b) having their axial planes parallel to one side or the other of the rhombic outline of the muscovite, i.e. at 30° in one direction or the other from that of the muscovite. Those of these patches which have yielded me a percussion figure are found to be brachydiagonal, and all are probably to be explained as brachydiagonal mica in twin-position according to the ordinary 'mica-law' (twin plane {110}).

The extinction of the lepidolite and also of the muscovite in the neighbourhood of the junction, is somewhat wavy, and cannot therefore be determined with sufficient accuracy to afford an answer to the questions, whether the lepidolite in contact with muscovite is twinned on that mineral or on the zone of lepidolite parallel to it (in cases like fig. 4), and whether the latter is absolutely parallel with the muscovite or grown upon it with the prism faces in common. The wavy extinction may probably itself be an indication of the strain set up by want of complete coincidence between the molecular structures of the two minerals.

In the larger crystals, the lepidolite border is composed of intimately twinned material and scarcely extinguishes anywhere. Here and there, however, in thin flakes, small patches may be found, on which the extinction directions may be determined. Those adjoining the junction have their axial plane parallel to that of the muscovite and are probably macrodiagonal; others, in the body of the lepidolite, have the axial plane inclined at 30° to that of the muscovite, and are shown by the percussion figure to consist of the brachydiagonal variety in twin-position.

The outer boundary of the lepidolite is consistently parallel to its junction with the muscovite, though in the larger crystals it is somewhat rough and irregular. This parallelism is maintained irrespective of the face which is in contact with the muscovite; thus, along the prism edge of a muscovite rhomb, in the case of lepidolite in either parallel position or twin-position about that prism face, the outer edge corresponds to {110}, while both the line of contact and the outer edge of an area of lepidolite twinned about the other prism face, represent {010} (see fig. 4).

(2) *Pink fibrous Muscovite on Lepidolite.*—The junction of the lepidolite with the border of pink fibrous muscovite is usually quite sharp and straight. The small rhombs are either in parallel position on the lepidolite or twinned upon it according to the ordinary mica-law. The general structure of the border is shown in fig. 5, pl. IV, which represents

a flake from a hexagonal lepidolite prism without any central core of muscovite. The flake consists of three macrodiagonal lepidolite crystals, irregularly twinned together, and the sides of the hexagon are formed principally by {010}; {110} is also present on one individual, and the corners of the hexagon are truncated by short edges corresponding to {130}.

The arrangement of the rhombs round brachydiagonal lepidolite is quite similar, the crystals being sometimes attached in parallel and sometimes in twin-position, and the axial planes being at 90° and 30° respectively to that of the lepidolite.

The chief points of interest shown by this occurrence of micas may be thus summarized:—

A new variety of muscovite, which appears to be scarcely met with elsewhere, is here very abundant. It consists of masses of pink fibres of rhombic section attached together in parallel or twin-position, so that the whole mass can be cleaved across like a single crystal. The fibres generally occur surrounding, or at the ends of, lepidolite crystals, and at first sight resemble an alteration-product of the latter.

The lilac-coloured lepidolite occurs either in solid prismatic crystals or as a border surrounding greenish-white muscovite, and comprises two varieties, differing only in the position of the optic axial plane, which is parallel respectively to the brachydiagonal or macrodiagonal axis. In the latter case, a deviation of the acute bisectrix from the plane (010) indicates that this mica is to be referred to the anorthic system. The lepidolite is usually much twinned on the ordinary 'mica-law.' The muscovite is generally surrounded by a narrow zone of macrodiagonal lepidolite (fig. 3, pl. IV) in parallel position, while outside this are patches of brachydiagonal lepidolite twinned on each other and on the zone of macrodiagonal material. Among them are sometimes found patches of the macrodiagonal variety. I have found no instance of brachydiagonal lepidolite attached to the muscovite in parallel position, nor of macrodiagonal in twin-position, but brachydiagonal lepidolite is sometimes in direct contact with the muscovite in twin-position (fig. 4, pl. IV).

The lepidolite is often surrounded by a layer of the rhombic fibres of pink muscovite in either parallel or twin-position, the arrangement being similar round both brachy- and macrodiagonal varieties.

The intimate association of the two varieties of lepidolite does not seem to have been observed before, and being thus unsuspected it caused

at first some little difficulty in explaining the relations of the border to the muscovite.

No case was observed in which any other than the ordinary twin-law need be invoked in order to explain the relative positions of the various areas.

Colourless Muscovite.

Besides the greenish-white muscovite described above in association with the lepidolite, there also occur large sheets (sometimes two feet across, as Mr. Schernikow reports) of ordinary clear colourless muscovite, such as is used commercially, which is brownish in thick sheets. This mica contains thin included films of a dark material appearing bronze-coloured by reflected light, and opaque or of a very dark grey by transmitted light under the microscope. The inclusions are hexagonal in outline, the sides of the hexagons being perpendicular to the percussion-rays, and are traversed by cracks perpendicular to the sides of the hexagons; they reach a breadth of 2–3 mm., but are mostly smaller. I have not been able to isolate, or determine the nature of these inclusions owing to their extreme thinness. They do not appear to affect the magnetic needle.

Flattened tabular and elongated crystals of black, brown, and green tourmaline are also enclosed in this mica. The axial plane of the mica is macrodiagonal and the axial angle in air, $2E = 71° 0'$.

Tourmaline.

The tourmaline occurs in the form of beautiful, transparent, striated prisms, of curved triangular outline or flattened, and varying much in colour—the most usual colours being shades of light and dark green and pink[1]. A few crystals are almost perfectly colourless. Crystals frequently exhibit transverse bands of different colours, which are usually separated from each other by perfectly sharp planes perpendicular to the prism, or the junctions may be slightly hazy though still parallel to (111). In one case, the junction between a pale green and a pink band shows the form of the trigonal pyramid $\{11\bar{1}\}$ (fig. 6), and sometimes the pyramidal termination $\{11\bar{1}\}$ shows a thin parallel layer covering the faces of an earlier termination of the same form but of a different colour. The frequency of the occurrence of the basal plane alone among these colour divisions is somewhat remarkable, as this form is usually but poorly developed in the present terminations of the crystals. Occasionally the later growth has extended from the terminal

[1] Mr. Spencer informs me (January, 1902) that the pink specimens in the British Museum have faded very markedly during four years' exposure in a glass case.

band backwards along the prism, forming an outer zone of differently coloured material.

The crystals bear no resemblance to the well-known tourmalines 'from Haddam,' which are black.

The crystals are frequently doubly-terminated: they vary in habit from short and stout (30 mm. long and 20 mm. diam.) to long and slender (80 × 4 mm.)[1], and small, almost acicular crystals are found scattered over the surface of larger ones or embedded in other minerals.

The following forms are present:—

Antilogous pole . . o {11$\bar{1}$}
Analogous pole . . e {0$\bar{1}\bar{1}$}, r {$\bar{1}$00}, c {$\bar{1}\bar{1}\bar{1}$}.

There does not appear to be any connexion between the colours of the ends and the polarity of the crystals.

G. Rose stated[2] that, as a general rule, that end at which the faces of the principal rhombohedron [trigonal pyramid] (RR=46° 54′) lie over the edges of the trigonal prism, is the antilogous pole, and vice versa, but found that crystals from Penig in Saxony formed an exception to this rule, having the faces of R over the *faces* of the trigonal prism at the antilogous pole.

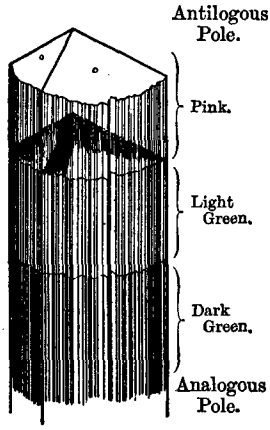

FIG. 6.—Banded crystal of tourmaline showing an internal 'ghost.' (Length 30 mm., diam. 5 mm.)

This rule may be taken as equivalent to the statement that (the antilogous pole being placed uppermost) +R {100} {$\bar{1}$00} and the prism {$\bar{2}$11} are the more commonly occurring forms as compared with the corresponding inverse forms — R {22$\bar{1}$} {$\bar{2}\bar{2}$1} and {2$\bar{1}\bar{1}$}. An exception to the rule may be due to the presence of either (*a*) the rarer inverse pyramids −R {22$\bar{1}$} {$\bar{2}\bar{2}$1} (combined with {$\bar{2}$11}), or (*b*) the rarer complementary trigonal prism {2$\bar{1}\bar{1}$} (combined with +R). The occasional occurrence of the latter prism on tourmaline is proved by the simultaneous existence, on crystals from Bovey Tracey, Sonnenberg in the Harz, and Gouverneur, of both trigonal prisms, of which {2$\bar{1}\bar{1}$}

[1] Some specimens in the British Museum attain a length of 5 inches, and Kunz mentions and figures (18th Ann. Rep. U. S. Geol. Survey, 1896–7 (1897), part v, pp. 1183, 1204; 20th Rep., 1898–9 (1899), part vi (2), plate I, fig. E) a perfect crystal 10 in. long × 1 in. diam. in Mr. Bement's Collection.

[2] Ann. Phys. Chem. (Poggendorff), 1836, vol. xxxix, p. 285; 1843, vol. lix, p. 357.

in the first two cases sometimes, and in the latter case habitually predominates[1].

The exception in the case of the Penig crystals is perhaps to be explained (as Rose at first suggested) on the first assumption, as the R-faces are very rough and the faces of the flatter rhombohedron truncating the edges of R, very smooth and shining, while normally the reverse of this is found to hold. (According to von Worobieff, however, this explanation is not likely to be correct.)

An examination of a number of the Haddam Neck crystals by Kundt's method showed them to conform to the above rule; they also confirm Rose's further statement that the basal plane only occurs on the analogous pole.

The faces of r $\{\bar{1}00\}$ are always bright, while those of e $\{0\bar{1}\bar{1}\}$ are usually so, but occasionally dull and drusy; o $\{11\bar{1}\}$ is bright but generally somewhat pitted.

The mean pyramid-angle of $\{11\bar{1}\}$, as determined from four measurements on pink crystals, is 76° 37′ (76° 18′—76° 45′), giving 114° 4′ for the axial angle. Two measurements on green crystals gave 76° 45′ as the pyramid-angle, corresponding to 114° 0′ as the angle between the axes.

The lighter coloured crystals are usually but slightly pleochroic, while in some of the darker green varieties the ordinary ray is almost completely absorbed. The pleochroism corresponding to the various colours is indicated in the following table:—

Colour.	Vibrations	
	∥ axis (extraordinary ray).	⊥ axis (ordinary ray).
Rose-pink	Dark pink	Ruby.
,, ,,	Pink	Pink.
,, ,,	Very pale lilac	Brown-pink.
Nearly colourless	Pale blue	Pale brown-pink.
Bluish green	Pale blue	Light olive.
,, ,, (darker)	Leek-green	[Nearly dark.]
Greyish green	Greyish green	Olive.
Light green	Pale greenish blue	Olive-green.
Dark green	Grass-green	[Dark.]
Violet	Pale mauve	[Nearly dark.]

[1] V. von Worobieff has recently found in the course of his exhaustive study of tourmaline (Zeits. Kryst. Min., 1900, vol. xxxiii, p. 419) a large number of exceptions to Rose's rule, so that the latter can no longer be said to be of general application. The number of forms on the crystals from Haddam Neck is too small to permit the determination of the polarity by the rules proposed by v. Worobieff, but the occurrence of o $\{11\bar{1}\}$ at the antilogous pole is in accordance with his observations.

Some of the 'uniform, rather pale green crystals' have been analysed by Penfield and Foote[1], who give the following composition:—

$SiO_2 = 36{\cdot}96$, $TiO_2 = 0{\cdot}03$, $B_2O_3 = 11{\cdot}00$, $Al_2O_3 = 39{\cdot}56$,
$FeO = 2{\cdot}14$, $MnO = 2{\cdot}00$, $MgO = 0{\cdot}15$, $CaO = 1{\cdot}28$,
$Na_2O = 2{\cdot}10$, $Li_2O = 1{\cdot}64$, $H_2O = 3{\cdot}10$, $F = 1{\cdot}13$.

Total =	101·09
less O =	0·48
	100·61

Flattened tabular crystals of black tourmaline are found (as are also thin prisms of the green variety) between the laminae of large sheets of the ordinary white muscovite; but no black crystals appear to occur in association with the other minerals, though a few green crystals are so dark as to appear almost black.

Kunz states[2] that a number of crystals have been found showing marked internal striations, arranged in such a way as to show in gems cut across the crystal a line of light, similar to the 'cat's-eye' variety of chrysoberyl from Ceylon.

Apatite.

Two varieties of this mineral are found, viz. thick hexagonal tables or short prisms (up to 2 cm. diam.) of a pale greyish green, and rose-coloured crystals having the form of short, stout prisms terminated by the basal plane. The prism- and basal-edges of both varieties are modified by narrow faces.

The greenish crystals occur embedded in albite and quartz: the pink crystals in the Oxford Collection do not show any matrix.

The following are the forms found on the pink crystals:—

Bowman.	Dana.		Miller.	
	m	{10$\bar{1}$0} . . .	*a* {10$\bar{1}$}	
	a	{2$\bar{1}\bar{1}$0} . . .	*b* {2$\bar{1}\bar{1}$}	
	h	{32$\bar{1}$0} [or *h'* {3$\bar{1}\bar{2}$0}].	*h* {32$\bar{1}$}	narrow faces replacing
**W*	–	{7$\bar{5}\bar{2}$0} [or *W'* {72$\bar{5}$0}]	– {7$\bar{5}\bar{2}$}	the edges of *m* and *a*.
	c	{0001} . . .	*o* {111}	
	r	{10$\bar{1}$2} . . .	*i* {321}	
	x	{10$\bar{1}$1} . . .	*x* {210}	
	y	{20$\bar{2}$1} . . .	*z* {31$\bar{1}$}	
	s	{2$\bar{1}\bar{1}$1} . . .	*r* {100, 22$\bar{1}$}	

[1] Amer. Journ. Sci., 1899, ser. 4, vol. vii, p. 107; and Zeits. Kryst. Min., 1899, vol. xxxi, p. 333.

[2] 19th Ann. Rep. U. S. Geol. Survey, 1897–8 (1898), part vi, p. 505.

The green crystals are richer in forms, and exhibit the distribution of faces shown in the projection, fig. 7:—

Bowman.	Dana.		Miller.	
	m	$\{10\bar{1}0\}$	a	$\{10\bar{1}\}$	
	a	$\{2\bar{1}\bar{1}0\}$	b	$\{2\bar{1}\bar{1}\}$	
	h	$\{3\bar{2}\bar{1}0\}$	h	$\{3\bar{2}\bar{1}\}$	
k'	h_1	$\{3\bar{1}\bar{2}0\}$	h	$\{3\bar{1}\bar{2}\}$	
k'	–	$\{5\bar{1}\bar{4}0\}$	k	$\{5\bar{1}\bar{4}\}$	narrow faces replacing the
$*l$	–	$\{7\bar{4}\bar{3}0\}$	–	$\{7\bar{4}\bar{3}\}$	edges of m and a.
$*W$	–	$\{7\bar{5}\bar{2}0\}$	–	$\{7\bar{5}\bar{2}\}$	
$*W'$	–	$\{7\bar{2}\bar{5}0\}$	–	$\{7\bar{2}\bar{5}\}$	
	c	$\{0001\}$	o	$\{111\}$	
	r	$\{10\bar{1}2\}$	i	$\{321\}$	
	x	$\{10\bar{1}1\}$	x	$\{210\}$	
	y	$\{20\bar{2}1\}$	z	$\{13\bar{1}\}$	
	s	$\{2\bar{1}\bar{1}1\}$	r	$\{100, 22\bar{1}\}$	
	v	$\{2\bar{1}\bar{1}2\}$	e	$\{411, 110\}$	small uneven faces, each
	μ	$\{3\bar{2}\bar{1}1\}$	u	$\{4\bar{1}0, 23\bar{2}\}$	observed once only.

Of these, l, W, W' are new forms.

The form l occurs five times, on four crystals, as a narrow face on the edge a/m. One of these crystals also bears μ on the same side of a as l, and hence, assuming μ to be $\{21\bar{3}1\}$ (this being commoner than μ_1 $\{12\bar{3}1\}$), l must be $\{43\bar{7}0\}$. No evidence was found of the complementary form $\{34\bar{7}0\}$.

The form k' occurs once as a narrow face, in combination with l but on the opposite side of a, the faces present being [*mhamlak'm*]; its symbol must therefore be $\{14\bar{5}0\}$. Haidinger[1] mentions a form 'f' found on a crystal from St. Gothard, which from his figure and description must correspond to this form. It was, however, afterwards omitted by him from the (otherwise similar) figure (fig. 148, pl. xxvii.) in his edition of Mohs' 'Mineralogy' (Edinburgh, 8 5), though it remains ($f(P+\infty)^3$) in the list of forms (vol. ii, p. 74). Apparently on this ground its existence was doubted by Schrauf[2]. Des Cloizeaux figures[3] a corresponding form 'h^4,' on the same side of a as μ, on crystals 'from Cornwall,' and

[1] Edinb. Phil. Journal, 1824, vol. x, p. 148, and pl. v, fig. 16; Isis, 1824, p. 852.

[2] Ber. Akad. Wien, 1870, vol. lxii (2), p. 754. Dana (System, 1892, p. 768, Ref. [4]) mentions k $\{41\bar{5}0\}$ as having been questioned by Schrauf. The latter was however only referring to Haidinger's form ($k'\{14\bar{5}0\}$), though his symbols cover both k and k'.

[3] Manuel de Min., vol. ii, p. 434, and pl. lxxiii, figs. 442, 443.

on both sides of a on crystals 'from Jumilla.' I have, however, been unable to discover the source of these figures. The complementary form k {4150} has been found by E. S. Dana on a crystal from Paris, Maine[1]. It does not, however, appear to occur on the present crystals.

The form h {2130} is holohedrally developed, as noted by Kenngott[2] and confirmed by Klein[3], on crystals from Poncione della Fibia in the St. Gothard. So also is the new form W {5270}. The evidence for this

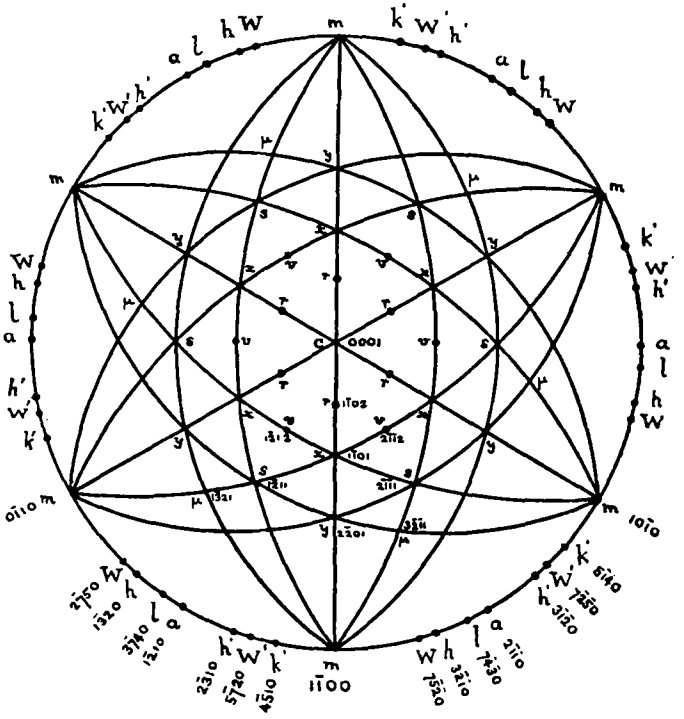

FIG. 7.—Stereographic projection of apatite showing all the forms observed at Haddam Neck.

is derived from two of the greenish crystals showing the following faces in the prism zone:—

(1) [*mlamhamhamlah'mah'm*]. (This is the crystal showing μ, mentioned above.)

[1] Amer. Journ. Sci., 1884, ser. 3, vol. xxvii, p. 480.
[2] Min. d. Schweiz, 1866, p. 353.
[3] Neues Jahrb. Min., 1871, p. 485.

(2) [*maW'mWhah'mWlam*].

W (or *W'*) also occurs on one of the pinkish crystals, combined only with *m* and *a*. Here the two forms cannot be distinguished, as also happens in the case of *h* (or *h'*) occurring with only *m* and *a* upon another pink crystal.

The evidence for the new and doubtful forms is based upon the following measured angles:—

	Edges.	Limits.	Observed mean.	Calculated. $c' = .734603$ (Koksharov).
$al = 1\bar{2}10 : 3740$	5	4° 8′ – 5° 50′	4° 44′	4° 43′
$mh = 1\bar{1}00 : 32\bar{1}0$	5	18 22 – 19 9	19 5	19 6
$mh' = 1\bar{1}00 : 2310$	3	18 55 – 19 47		
$m\{h \text{ or } h'\} = 1\bar{1}00 : \{32\bar{1}0 \text{ or } 2310\}$	4	18 45 – 19 27		
$mk' = 1\bar{1}00 : 4510$	1	—	11 13	10 54
$mW = 1\bar{1}00 : 7520$	2	14 34 – 16 45	15 38½	16 6
$mW' = 1\bar{1}00 : 5720$	1	15° 28′		
$m\{W \text{ or } W'\} = 1\bar{1}00 : \{7520 \text{ or } 5720\}$	1	15 49		

The basal plane is bright and gives very perfect reflections, but it appears uneven to the naked eye, owing to its surface being broken by shallow hexagonal pits (2 mm. diam.), which have their edges parallel to the edges *c*/*m*, and are bounded by somewhat curved vicinal faces, *P*, approximating to $\{2\bar{2}\cdot\bar{2}\cdot0\cdot19\}$. These faces also occur occasionally upon the edges of the basal plane, as do faces of a form *Q*, near to $\{22\bar{0}7\}$.

The angles are:—

	Edges.	Limits.	Observed mean.	Calculated.
$cP = 0001 : 2\bar{2}\cdot0\cdot19$	5	4° 46′ – 5° 27′	5° 4′	5° 6½′
$cQ = 0001 : 22\bar{0}7$	2	13 9 – 14 8	13 38½	13 37

The faces of *m* are bright and yield excellent reflections; those of *a* are slightly striated parallel to the edge *a*/*m*.

Microcline.

This occurs in stout, greenish-white, opaque crystals (up to 5 cm. high and 4 cm. thick) of the usual habit, which are often very drusy and cavernous, especially on the faces *c* $\{001\}$, *x* $\{10\bar{1}\}$. Minute brilliant

crystals of albite and crusts of cookeite are sometimes found on the surface.

The following forms are present:—

c {001}, b {010}, m {110}, M {1$\bar{1}$0}, f {130}, z {1$\bar{3}$0}, x {10$\bar{1}$}, y {20$\bar{1}$}, p {$\bar{1}$11}, o {$\bar{1}\bar{1}$1}.

Cleavage flakes parallel to c {001} sometimes show the microcline structure; some are free from twinning and have an extinction angle of about 14°. The extinction angle through a b-cleavage is about $+7°$; these flakes show an obliquely emergent positive bisectrix.

Some crystals exhibit a cross-hatching, visible to the naked eye, upon the faces c and x.

The specimen carrying colourless beryl, and also a beryl specimen in the British Museum, show a pegmatitic intergrowth of quartz with white microcline.

Albite.

The crystals of this mineral are large and well formed: they are either flattened parallel to b {010} or elongated parallel to x {$\bar{1}$01}, and aggregated in parallel or twin-position to form a group which presents the aspect of a large crystal elongated in the direction of the axis b.

Stout, single crystals are occasionally found (up to a centimetre or more in diameter). (Fig. 8.)

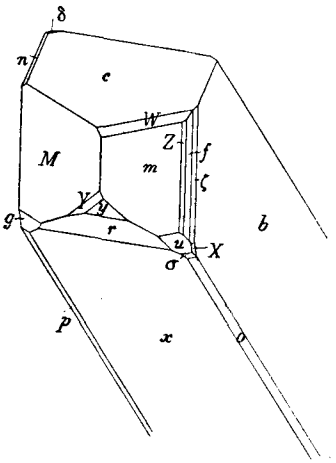

Fig. 8.—Albite from Haddam Neck.

Twinning upon the albite-law is very frequent, but no other kinds of twinning have been observed.

The cleavage-angle bc, obtained from the measurement of a twin-crystal, is 86° 26½′.

The following forms are present:—

b {010}, c {001}.
m {110}, *Z {120}, f {130}, ζ {150}, M {1$\bar{1}$0}.
x {$\bar{1}$01}, r {$\bar{4}$03}, y {$\bar{2}$01}.
n {0$\bar{2}$1}.
u {22$\bar{1}$}, σ {44$\bar{3}$}, o {11$\bar{1}$}, δ {11$\bar{2}$}, *X {24$\bar{1}$}.
g {2$\bar{2}$1}, p {1$\bar{1}$1}, *Y {3$\bar{1}$1}, *W {111}.

Of these, *W*, *X*, *Y*, *Z*, do not seem to have been previously recorded; their existence is inferred from the following measurements :—

	Limits.	Edges.	Mean.	Calculated (Dana).	
mW 110 : 111	32° 29′ to 33 51′ rounded	1	33° 10′	32° 28′	Rounded face on edge c/m (on 1 crystal).
yX 201 : 241	52° 57′–53° 40′	2	53 18½	52 56	Narrow face on edge b'/u (on 3 crystals).
uX 221 : 241	—	1	19 51	20 7½	
cX 001 : 241	—	1	87 58	87 52	
bX 010 : 24$\bar{1}$	—	1	39 8	39 24	
yY 201 : 31$\bar{1}$	—	1	16 12	16 18	Small bright face on edge y/M' (on 1 crystal).
bZ 010 : 120	—	1	[40 46]	41 21	Very narrow face in zone [b m] (on 1 crystal) [reading by max. illumination].

The mean extinction angles for Na light are :—

$$\text{on } c\,(001) = 3\tfrac{1}{2}^\circ$$
$$\text{on } b\,(010) = 19\tfrac{1}{2}^\circ.$$

Good specimens, consisting of aggregations of thin tabular crystals thickly covered with spherules of cookeite, are also found.

Beryl.

The Oxford collection contains four specimens of beryl, which belong to two types. The first of these is represented by three incomplete, and mostly semi-opaque, crystals consisting of a pale rose-pink outer layer (which is occasionally transparent), and a greenish-white core. They have the form of hexagonal prisms, m {10$\bar{1}$0}, terminated by the basal plane, and bearing faces of a pyramid, s {11$\bar{2}$1} on the corners. They range up to 8 cm. in diameter, and are remarkable for the possession of fairly perfect cleavages, parallel to m {10$\bar{1}$0} and c {0001}, and sometimes enclose crystals of albite and tourmaline. To the second type belongs a nearly colourless crystal, about 2 cm. in diameter, embedded among grey quartz crystals. It is almost devoid of smooth faces and difficult to decipher, but an acquaintance with the British Museum specimen described below, leads to the recognition

of its two bright faces as belonging to m {10$\bar{1}$0}, while the dull, rough faces probably belong to s {11$\bar{2}$1}, n {31$\bar{4}$1}, p {10$\bar{1}$1}. The basal plane c {0001} is probably also present, but is almost hidden by the surrounding quartz crystals. The habit differs somewhat from the crystal figured, being flat-pyramidal owing to the reduction of the prism faces to small rhombs bounded by n {31$\bar{4}$1}.

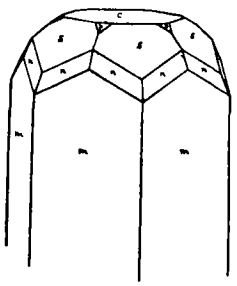

FIG. 9.—Beryl from Haddam Neck.

In the British Museum are two specimens of beryl from Haddam Neck, which are both labelled as containing caesium[1]. One of these is a large, stout prism of very pale pink colour, corresponding to the first type, and enclosing small prisms of the usual tourmaline and a small fragment of a brown mineral, probably garnet. The other, which represents the second type, is a nearly colourless hexagonal prism (fig. 9), 1·5 cm. in diameter and 2·5 cm. long, with pyramid faces, associated with grey quartz, white microcline, pink and green tourmaline and albite, on 'graphic' microcline-pegmatite. The faces belong to the following forms:—

Dana.		Miller.
m {10$\bar{1}$0}	. . .	a {10$\bar{1}$}
c {0001}	. . .	o {111}
s {11$\bar{2}$1}	. . .	r {100, $\bar{1}$22}
n {31$\bar{4}$1}	. . .	– {203, 423}
p {10$\bar{1}$1}	. . .	p {120}

The basal plane is very uneven, with ridges and pits, but bright; the prism is smooth and brilliant; of the pyramids, s is somewhat pitted, while n is usually dull but with some bright areas. The faces of the latter form generally show a rounding-off in the direction of s. The form p only occurs as minute triangular faces on the corners *scs*. The crystal resembles the colourless beryl known as 'goshenite' from Goshen, Massachusetts.

QUARTZ.

Quartz occurs both in nearly colourless and in somewhat smoky crystals: those of the former variety are curiously flattened parallel to a pair of

[1] Mr. Lazard Cahn, through whom the specimens were obtained, informs me that they were tested by Prof. Penfield and found to contain caesium.

prism faces. Only one side of such tabular crystals has the faces regularly developed, the faces at the back being interrupted, uneven, and drusy, with the result that the specimens (though frequently doubly terminated and bounded on all sides by faces) present the appearance of flakes split off from the side of a large normally developed crystal.

The smoky crystals are regular prisms with pyramidal termination, the faces of which are sometimes rhombohedrally developed. The surface of the crystals is often encrusted with cookeite.

Cookeite.

Small globular masses (up to 5 mm. diam., but usually not above 1 mm.) occur, having the following characters. They are of a yellowish-white colour and are composed of silvery radial plates with hexagonal outline. These are seen under the microscope to be divided radially into biaxial sectors, each striated perpendicular to the edge of the hexagon, and showing a normally emergent bisectrix of wide axial angle, with axial plane perpendicular to the striations and positive birefringence. The axial angle diminishes towards the centre, and the central part is uniaxial, with the optic axis normal and weak positive double refraction. These characters agree with those of cookeite as given by Penfield[1].

The cookeite occurs chiefly on the surface of albite and quartz crystals and on the prisms of lepidolite. It does not seem to occur much on the tourmaline, and where it does so the surface of the latter underneath is quite fresh and smooth, so that the cookeite would not here appear to have been derived from the decomposition of rubellite, as has been suggested by Brush[2] in regard to cookeite from Hebron and Paris, Maine.

The minerals are so intimately mixed that it is hard to say of what the cookeite is a decomposition product, but it may be perhaps derived from the micas.

The blowpipe characters agree with those given for cookeite.

Fluor.

The fluor is dark reddish-brown, and sometimes shows faces of the octahedron. None of the fragments show any of the matrix.

[1] Amer. Journ. Sci., 1893, ser. 3, vol. xlv, p. 393.
[2] Ibid. 1866, ser. 2, vol. xli, p. 247.

Besides this brown variety, I have recently seen a specimen consisting of small pale-green, opaque, somewhat drusy octahedra (4 mm. diam.) showing a purplish tinge in parts, associated with spherules of cookeite and a few fibres of the pink muscovite.

Microlite.

I have had no opportunity of seeing specimens of the microlite, as there is none in the Oxford collection and it is also wanting in the British Museum. Mr. Schernikow, however, says that it was found 'sparingly, associated with the other minerals. A few good crystals, perhaps $\frac{1}{4}$ inch in diameter, were obtained, but most of them were broken.'

Mr. Cahn tells me that the mineral was identified as microlite by Professor Penfield, and that the specimens occur in the pink beryl or in albite.

Columbite.

Columbite is stated to occur in the Haddam Neck quarries in association with beryl. The crystals are small but well defined, with brilliant faces, and differ thus from the columbite from Haddam, where the crystals are usually large and coarse.

Mode of Occurrence and Paragenesis.

In their mode of occurrence and characters some of the minerals from Haddam Neck show a remarkable resemblance to those from the well-known occurrences in the pegmatite veins of Maine and other parts of New England. The large crystals of muscovite surrounded by a border of lepidolite, for example, correspond exactly with similar specimens from Auburn, and some of the latter show, outside the lepidolite, a small amount of a rhombic tesselated mica similar to the pink fibrous muscovite which forms such a marked feature of the Haddam Neck specimens.

The regular intergrowth of greenish-white muscovite with massive quartz, which is visible on more than one of the specimens from Haddam Neck, finds its exact equivalent in a specimen in the British Museum, showing beryl from Goshen, Massachusetts. The beryl on the same specimen (the colourless 'goshenite') also strongly resembles the same mineral from Haddam Neck, the presence of caesium in which indicates an affinity with the beryls of Norway and Hebron in Maine, in which from 1·66–3·6 per cent. of Cs_2O have been found by Penfield and Harper and by Wells, respectively.

Judging from the relative positions of Haddam and Haddam Neck and from the information I have been able to obtain, it seems probable that the pegmatite veins traversing gneiss, which are the source of the minerals in both places, form part of the same system, though the minerals from the recently opened felspar quarries on Haddam Neck differ somewhat from those of the old occurrences described as Haddam. Thus the tourmaline from the latter occurs as stout black prisms, and the well-known chrysoberyl of Haddam does not seem to have been so far discovered at the new quarries, although it is mentioned as having been found on both banks of the river[1].

In regard to the order of formation of the minerals but little can be said, as the different species are intimately mixed together in a way which suggests that they were all formed more or less contemporaneously. The quartz was probably one of the last-formed minerals, as it frequently encloses complete crystals of tourmaline and masses of the pink fibrous mica. It forms in some cases a pegmatitic intergrowth with microcline, and sometimes also encloses flakes of greenish muscovite in parallel position, forming a somewhat analogous structure. The micas perhaps represent an early stage in the crystallization. Among themselves they never show any deviation from the order, greenish-white muscovite—lepidolite—fibrous muscovite. Minute scales of lepidolite, dispersed through the apatite crystals, are found after solution of the latter in acid. Microcline is probably a late formation, contemporaneous with the quartz, and sometimes encloses tourmaline and lepidolite.

In conclusion, I wish to express my thanks to Mr. Schernikow for his kindness in supplying me with information as to the locality and occurrence of the specimens, to Professor Berwerth for allowing me to examine the collection of micas in the Museum at Vienna, and to Mr. Fletcher for similar permission in respect of the specimens in the British Museum. I also wish to thank Professor Penfield for kind hints in connexion with the analysis, and Professor Miers for his kind advice throughout the work.

[1] Amer. Journ. Sci., 1822, ser. 1, vol. iv, p. 53; 1823, ser. 1, vol. vi, p. 220.

DESCRIPTION OF FIGURES 1-5 (PLATE IV).

Fig. 1.—Cleavage flake of the pink tesselated muscovite, showing the arrangement of the rhombs in twin position (×14).

Fig. 2.—A fibre of the pink muscovite. (The convergence of the faces is exaggerated.) $\pi = \{552\}$, $S = \{551\}$.

Figs. 3 and 4.—Flakes from crystals of muscovite with border of lepidolite (*M*, muscovite; L_m, macrodiagonal-; and L_b, brachydiagonal-lepidolite). The areas are shaded parallel to their axial planes. Unshaded areas of the border do not extinguish, owing to overlapping.

Fig. 3 shows a narrow band of L_m in parallel position on *M*, with areas of L_b outside it (×8).

Fig. 4 shows L_m in parallel position, and L_b in twin-positions, on *M* (×10). $m = \{110\}$, $b = \{010\}$.

Fig. 5.—Flake from a crystal of macrodiagonal-lepidolite showing the arrangement of the fibrous border. $m = \{110\}$, $b = \{010,\}$ $Q = \{130\}$. The areas II are in the extinction-position (×5).

(Figs. 6-9 in the text.)