Communications from the Oxford Mineralogical Laboratory.

1. *On a Rhombic Pyroxene from South Africa.*

2. *On a method of illustrating the variation of thermal conductivity of crystals in different directions.*

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By H. L. Bowman, M.A., Demonstrator in Mineralogy.

1. *On a Rhombic Pyroxene from South Africa.*

[Read June 20th, 1899.]

THE stones to which this paper refers were sent to Prof. Miers for determination by Mr. Francis Powell, and were stated to come "from the diamond washings." They are of a fine green colour, and quite transparent, and possess a highly perfect cleavage parallel to the faces of a prism having an angle of about 88°. This serves to distinguish the material from olivine, which it otherwise much resembles, and —coupled with the uniformly straight extinction through cleavage flakes, the specific gravity (3·199) and hardness (6—7)—suffices to identify the mineral as one of the rhombic pyroxenes.

Since unaltered rhombic pyroxenes, such as the present, are rare, and but few of the known occurrences have ever been completely examined, it seemed desirable to submit the stones to a thorough examination.

The mineral occurs in small irregular fragments up to 6 or 8 mm. in diameter, devoid of crystal faces, but partly bounded in some cases by cleavage planes, the surface being perfectly fresh. In addition to the very good prismatic cleavage of 88°0′ (mean of 15 measurements), there are two other less perfect cleavages, parallel to $a(100)$ and $b(010)$ respectively. These are visible on some fragments as numerous minute parallel surfaces, which give a good single image of the goniometer signal. They are also brought out in grinding sections perpendicular to the prism. The cleavages are not always easily obtained, and the crystals often show a conchoidal fracture. The prismatic cleavage-angle corresponds to an axial ratio—$a : b = 0{\cdot}9657 : 1$.

The surface of the fragments often has a characteristic drusy appearance due to the cleavage, and one specimen shows a platy structure, as if due to a twin-parting parallel to $b(010)$. This, together with occasional absence of extinction and a fracture recalling the "ripple fracture" of quartz, probably indicates the existence of twin-lamellation. The stones have a fine green colour, sometimes of a rather light shade and inclining to olive, and are quite clear and transparent, closely resembling in appearance some varieties of olivine. The sp. gr. is 3·199, and the hardness between 6 and 7. The lustre is vitreous, and the streak nearly colourless. Several of the cleavage prisms show a fine straight line running transversely across them, the cleavage surfaces on either side of the line not being quite in the same plane. I have measured 3 crystals, and find that the cleavages on the two parts are inclined to one another at a constant angle of about 2°10′, the numbers varying between 2°1′ and 2°16′, and the mean of 6 measurements being 2°9½′. The disposition of the salient and re-entrant angles shows that the (100) faces of both individuals would lie in the same plane, and that the (010) faces would be inclined to one another at an angle of 3°6′. If the combination is to be considered a twin, the indices of the twin-plane would be near to (0.1.21).

In polarised light cleavage flakes show straight extinction, and in convergent sodium light a cleavage prism affords traces of a wide angle — bisectrix at the edge of the field, the plane of the optic axes lying parallel to the trace of the cleavage, and the bisectrix emerging in the equatorial plane. (This bisectrix does not, however, emerge through the horizontal plane, but through the second cleavage at the side of the prism.)

The plane of the optic axes is parallel to $b(010)$, *i.e.* to the shorter diagonal of the cleavage prism, the + acute bisectrix being parallel to the vertical axis $\dot{c}$. Thus, the optical scheme is $\alpha\ \beta\ \gamma = a\ b\ c$.

The birefringence is rather weak.

For the measurement of the optic axial angle two fragments were ground down to plates parallel to $c(001)$ and $a(100)$.[1] The plates were immersed in olive oil, of refractive index 1·4707, and gave the following values for 2H:—

$$2H_a = 88°34' \qquad 2H_o = 135°24' \text{ (Na light)};$$
$$\text{whence } 2V = 74°\ 5' \quad \text{and } \beta = 1{\cdot}705.$$

[1] The perfect prismatic cleavage rendered this a process of some difficulty. I found fine carborundum, used with water on an iron or pewter lap, to be the most convenient grinding material, as flour emery is exceedingly slow in action, and a coarser emery is very apt to break the specimen along the cleavages.

The dispersion about the acute bisectrix is $\rho > v$.

In order to determine the refractive indices I employed a prism, for the preparation of which Mr. Fletcher kindly allowed me to use the Tutton cutting and grinding instrument in the British Museum. The material at my command only sufficed for the preparation of one prism, and this was ground so that its angle is approximately bisected by the plane (100), and its edge is parallel to the vertical axis. The bisecting plane deviates about 1° from the plane (100), but this error will not materially affect the value of the resulting indices. The values of β and γ obtained with this prism are:—

$$\left.\begin{array}{lcl} \beta & = & 1{\cdot}669 \\ \gamma & = & 1{\cdot}675 \end{array}\right\} \text{ (Na light)}^1.$$

The pleochroism is rather weak:—

$\breve{a}$ pale yellow $\bar{b}$ pale green $\dot{c}$ pale yellowish-green

An approximate analysis of some of the material yielded me the following numbers:—

$SiO_2 = 56{\cdot}0$, $FeO = 5{\cdot}0$, $MnO = 0{\cdot}5$, $Al_2O_3 = 2{\cdot}5$, $Cr_2O_3 = 0{\cdot}6$, $MgO = 36{\cdot}5 \ldots = 101{\cdot}1$

I learn from Mr. Powell that he has received the stones from different sources, the association being with "a darker blackish green stone and fine red garnet." Some are said to be from Griqualand West, where they are found in the diamond washings.

In the Museum of Practical Geology I have found among the exhibits from the Diamond Fields two specimens of washings, from Kimberley Mine and from Du Toit's Pan respectively, which contain green fragments closely resembling the present material in colour and drusy surface-appearance, and it seems not improbable that they may be identical with it, as in specific gravity they fall within the same limits. They are associated with red garnet (which forms the chief constituent of the washings), quartz, and a little iron pyrites.

Green transparent rhombic pyroxenes have been already described from South Africa, namely:—

By Maskelyne and Flight [*Q. J. G. S.* XXX, 406, 1874] from the "blue ground" at Du Toit's Pan, Bultfontein, and Colesberg Kopje—all in the neighbourhood of Kimberley.

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[1] The difference between the values of β as calculated from the axial angle and as measured with the prism, may perhaps be due to a variation in the optical characters of the three specimens used, corresponding to a slight observed difference in the specific gravity. The prism value is probably the most reliable.

By Maskelyne, in a rock from Lydenburg and Korn Kopje, in the Transvaal [*Phil. Mag.* (5) VII, 135, 1879].

By Friedel [*Bull. Soc. Min. d. France*, II, 198, 1879] from Kimberley.

By Knop [*Oberrh. Geol. Verhandl.* 1889, 10; 1890, 20] from Jagersfontein, in the Orange Free State, about 60 miles S.E. from Kimberley.

No optical examination was made in any of these cases, and it is therefore difficult to say if any of the minerals described are identical with the present.

Some material at the British Museum, supposed to be the mineral described in Maskelyne and Flight's paper, consists of green fragments of the size of small peas, apparently very similar to the present mineral. Their paper, however, speaks of "green grains not larger than a canary seed." The analysis by Flight agrees in the main with mine, but shows the presence of a little lime and a trace of nickel, which I have failed to detect, and does not include any manganese, which is a marked, though not very plentiful, constituent of the present mineral.

A specimen in the British Museum, labelled "Diopside from Colesberg Kopje," is probably identical with the blackish green stone mentioned as being found with the rhombic pyroxene described in the present paper.

It seems, therefore, probable that the material comes from the mines in the Kimberley district, and is associated with red garnet and blackish green diopside in the blue ground.

A similar mineral appears to be found elsewhere in association with diamond-bearing materials, as the British Museum possesses a very similar specimen among a set of minerals from Jagersfontein.

The group of rhombic pyroxenes has been variously subdivided by different observers. Excluding the altered products, bastite, diaklasite, &c., which have a different optical orientation, the unaltered minerals have been differently grouped under the names enstatite, bronzite, and hypersthene, according to the percentage of FeO. Kenngott suggested that minerals having the + acute bisectrix perpendicular to (001) (up to 10 per cent. FeO) should be classed as enstatite, and those with more FeO, having the − acute bisectrix perpendicular to (100), as hypersthene. Tschermak applied the name enstatite arbitrarily to minerals with less than 5 per cent. FeO, bronzite to those having 5-15 per cent., and hypersthene to those richer than this. Des Cloizeaux used a similar arbitrary classification with < 6, 6-10, > 10 per cent. of FeO to define the three species. Hintze proposes to restrict the term bronzite to varieties showing metallic lustre, due to "schillerization," and a parting parallel to $b(010)$, and to include varieties poor in FeO under enstatite, those rich in

FeO under hypersthene. The obvious boundary is at about 10 per cent. FeO, corresponding to the change in optical sign.

According to this arrangement the present mineral, with 5·0 per cent. FeO, will be classed as enstatite.

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2. *On a Method of illustrating the Variation of Thermal Conductivity of Crystals in different directions.*

[Read Feb. 1, 1898.]

WHILE endeavouring some time ago to produce, for demonstration purposes, a satisfactory specimen to show the "Curve of Conductivity for Heat," I hit upon a method which may be worthy of mention, as it is exceedingly simple, and gives results which are at once clearly visible and permanent.

I have as yet only tried the method on gypsum and copper sulphate, but it might, no doubt, be applied to other substances containing water of crystallisation.

The gypsum crystals on which the experiments were made were obtained from Shotover Hill, near Oxford.

A stout brass wire ($\frac{3}{16}$ inch. dia.) is filed at one end to a conical point. It is then supported in a vertical position with its point resting on the face of the crystal, and is heated by means of a Bunsen burner directed horizontally at a point 1 or 2 ins. above the end. The water of crystallisation is driven off by the heat, and an opaque white spot formed round the point. This spot has an elliptic outline, which approximates to the curve of conductivity.

If figures be produced on faces belonging to different forms, they can be seen to vary, in the directions and ratios of their axes, in accordance with the symmetry of the crystal (Fig. 1). Figures may readily be obtained with a major axis of 5-6 mm. or more, but beyond this size the outline is rather apt to become irregular, the opacity extending outwards in streaks which, on the cleavage face, run nearly parallel with the edge $b/\!/$, [010 : 111].

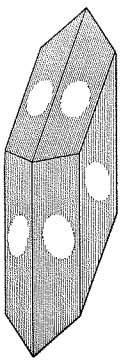

FIG. 1.

No advantage appears to be gained by screening the crystal from the direct radiation from the source of heat.

Under the microscope the white patch is seen, near the margin, to consist of dots, which (with a $\frac{1}{4}$ in. objective)

show a form like that of the "Verwitterungsflecken" figured by Sohncke (*Zeits. Kryst.* XXX, 1, 1899).[1]

The outline of the figures is usually somewhat indefinite, as the dots, which overlap in the centre, are at the edge more sparsely distributed. The shading-off is, however, fairly regular, and allows of the determination of the ratio $\left(\frac{a}{b}\right)$ of the axes of the ellipse, with some approach to accuracy. I have measured some of the smaller figures on a cleavage face under the microscope, with the following results:—

Face.	Outline.	a	b	$\frac{a}{b}$	mean $\frac{a}{b}$
(010) Cleavage	very sharp	10·0	9·2	1·09	1·129
	sharp ...	13·5	12·0	1·116	
	,, ...	13·0	11·6	1·12	
	fair ...	14·0	12·0	1·166	
	hazy ...	14·0	12·5	1·12	
	,, ...	13·0	11·5	1·13	
	very sharp	12·5	11·2	1·12	
	fair ...	15·6	13·2	1·18	
	,, ...	14·0	12·5	1·12	

Using the same method of heating, combined with Senarmont's wax coating, I obtained from 8 ellipses a mean ratio, $\frac{a}{b}=1{\cdot}151$, the limits being 1·077 and 1·25. A nearer approximation between the two methods is hardly to be expected, on account of the disorganisation of the structure of the crystal by the high temperature. The value obtained by Senarmont on gypsum from Montmartre was $\frac{a}{b}=1{\cdot}23$. The opacity extends downwards from the surface into the crystal, inside which it has an ellipsoidal shape, which, in the case of faces inclined to the plane of symmetry, is seen to be oblique to the surface.

The sharpness of the figures is improved if the irregularities of the face have been first removed by grinding with water on a sheet of ground glass.

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[1] By exposing crystals of Gypsum from Bex to a temperature of about 100° in an air bath, Pape (*Pogg. Ann.* cxxxv. 4, 1868) obtained elliptical figures pointing to the existence of an ellipsoid ("Verwitterungsellipsoïd"), similar to those calculated by him in the case of copper sulphate, &c. Later observers, *e.g.* Sohncke (*l.c.*), have produced by the same method polygonal and not elliptical spots.

The figures on the face *b* are usually traversed by 3 radiating cracks, somewhat resembling the percussion figure of mica. The principal of these runs parallel to the edge *b*/*l*, [010 : 111] ; another parallel to the edge *b*/*m*, [010 : 110]; and the third makes an angle of about 16° with the direction of fibrous fracture, lying between this and the vertical axis.

Some cleavage plates of gypsum from Montmartre, which I have tried, do not give quite such regular figures as the Shotover material, but the radiating cracks and the Sohncke figures are particularly clear.

The production of the larger figures may occupy an hour, but good small figures may be made in a few minutes.

Senarmont's first paper (*Ann. Chim. Phys.* [3], XXI, 466, 1847) on the conductivity of crystals for heat, mentions that he obtained similar dehydration figures in gypsum when the wire passing through the perforated crystal was strongly heated. It would seem, however, either that the observation has escaped notice (with the exception of an incidental mention by Jannettaz (*Ann. Chim. Phys.* [4], XXIX, 23, 1873), or that the simplicity of the method, especially in the form described above, and its adaptation to demonstration purposes, have not been recognised.

According to the few experiments I have made, copper sulphate does not readily yield such good figures as gypsum, but the deviation from a circular form is, nevertheless, quite apparent.

NOTE.—*A Modification of Senarmont's Process.*

In the case of stibnite, I have found that a thin layer of ammonium chloride, obtained by sublimation, answers well as a substitute for Senarmont's wax coating. The application of a heated point in the same manner as with gypsum, volatilises the salt, and leaves the surface of the crystal (cleavage plate) exposed. The resulting figures are clearly visible, but the specimens must of course be subsequently protected from injury in a glass tube or otherwise.

3. *A twin crystal of Sapphire.*

[Read June 20th, 1899.]

AMONG the specimens which have been recently added to the Oxford collection is a twin crystal of sapphire, of which it may be worth while to give a description in view of the rarity of well-formed twins of this mineral.

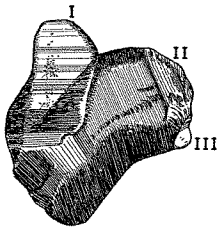

Fig. 1.

The crystal is shown about the natural size in the accompanying figure (Fig. 1); its weight is 10·23 grams. The two individuals are of somewhat unequal size, the largest (II) being 1 in. long by about ½ in. thick, the smaller (I) flattened and rather thinner. The edges are rounded and dull, as if worn by water, but portions of the faces still retain their original brilliant lustre.

The faces lie in the zones $[a, c] = [1\bar{1}0, 111]$, and are much striated. The front zone of (I) yields a series of angles which are arranged symmetrically on the two sides of a face $a(1\bar{1}0)$, (not present), and hence appear to correspond to definite faces—

$$\varepsilon\{12.1.\bar{1}0\}, \quad \mu\{10.1.\bar{8}\}, \quad \xi\{17.2.\bar{1}3\}$$
$$\pi\{45.6.\bar{3}3\}, \quad \sigma\{29.5.\bar{1}9\}, \quad \tau\{14.3.\bar{8}\}$$

The indices are high, as is often the case with corundum, and the forms are all new. The angles are as follows, the mean of the readings for the best pair of faces (ξ) being taken to fix the position of (a)—

		Edges.	Limits.	Observed.	Calculated.[1]
$c : \varepsilon$	$111 : 12.1.\bar{1}0$	2	84°14′ – 84°21′	84°17½′	84°17′
$c : \mu$	$111 : 10.1.\bar{8}$	2	83 7 – 83 8	83 7½	83 1½
$c : \xi$	$111 : 17.2.\bar{1}3$	1	—	81 48	81 39
$c : \pi$	$111 : 45.6.\bar{3}3$	1	—	80 19	80 23
$c : \sigma$	$111 : 29.5.\bar{1}9$	1	—	77 3	77 5
$c : \tau$	$111 : 14.3.\bar{8}$	1	—	73 17	73 17

At the back of (II) some small bright reentrant cleavage planes are visible, which may perhaps correspond to $n\{31\bar{1}\}$, and $\nu\{13.1.\bar{1}\bar{1}\}$, though no such cleavage or parting seems to have been recorded. The angles are :—

	Observed.	Calculated.
$c : n$ ...	61°17′ ...	61°11′
$c : \nu$ ...	84 48 ...	84 45½

The colour is pale blue, and traces of milky "ghosts," which are yellowish by transmitted light, are visible inside the crystals. There is a brilliant cleavage or parting, parallel to $r\{100\}$, and also a less perfect one, with silky lustre, parallel to the basal plane. A measure-

[1] Axial angle, $a = 85°47'$, $(a : c = 1 : 1{\cdot}363)$.

ment on the goniometer of the angle between the r-cleavage of one individual and the basal cleavage of the other gave the values:—

$100 : \underline{\bar{1}\bar{1}\bar{1}} = \left\{\begin{matrix} 56°43' \\ 57°16' \\ 58°\ 5' \end{matrix}\right\}$, 3 (good) images being given by the basal plane.

The crystal is therefore twinned about the face (100), the calculated value of the above angle being 57°34′. This is the same twin law which governs the ordinary twin-lamellation of corundum. A small portion of a third individual (III) projects from the main crystal (II), and is proved by the rhombohedral cleavage to be parallel in position to (I).

The density is 3·989. A few small pieces of a greenish-black mineral are embedded in the crystal.

Etched pits, having the asymmetric form shown in Fig. 2, are present on some of the faces, and correspond—so far as can be judged from the upper half of the crystal, on which alone the pits occur—with the assumption of the rhombohedral symmetry of the calcite class.

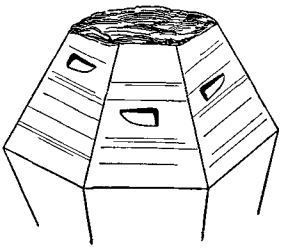

Fig. 2.

The locality of the specimen is uncertain, as it comes from an old collection, but it may probably be from Kashmir.

Twin crystals of sapphire have been previously described in a few cases:—

Jeremejeff, *Verh. k. russ. min. Ges.* (2), XIII, 426, 1877 [Abstr. *Zs. K.* II, 504].

Jeremejeff, *Verh. k. russ. min. Ges.* (2), XIV, 227, 1878 [Abstr. *Zs. K.* III, 438].

Jeremejeff, *Gornyi Journal*, III, 263, 1887 [Abstr. *Zs. K.* XV, 537].

Hidden and Washington, *Am. J. Sc.* (3), XXXIII, 507, 1887 [Abstr. *Zs. K.* XIV, 302].

Barvĭř, *Ann. d. k.k. Hofmuseums*, Wien, VII, 135, 1892 [Abstr. *Zs. K.* XXV, 431].

The last observer describes and figures two crystals, of which one somewhat resembles the present specimen. The locality is given as "probably Ceylon."

I have also examined two specimens, kindly lent me by Mr. Francis Powell, which show a second small crystal projecting from the side of the main individual, and find that they are twins obeying the same law. In one of them a third small individual is twinned on the main crystal,

forming a triplet. It seems probable that many of the crystals of sapphire which have small knobs projecting from their surface may really be twins of this nature.

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4. *On Monazite and associated minerals from Tintagel, Cornwall.*

[Read June 19th, 1900.]

IN the *Mineralogical Magazine*, Vol. VI, p. 164 (1885), Prof. Miers described a specimen in the British Museum, which carried crystals of monazite, dispersed on albite and quartz upon a silky slate, and in the absence of any label suggested that it probably came from Cornwall. Shortly after this he visited Tintagel, and in one of the large slate quarries there succeeded in finding a single crystal of monazite, very similar in appearance and association to those on the original specimen described by him.

In the Christmas Vacation of 1899, a small collecting party from Oxford visited the quarry at Tintagel, under the guidance of Prof. Miers, and our search was rewarded with four crystals of monazite and some good specimens of the associated minerals.

Of the numerous quarries in the neighbourhood in which albite and quartz are to be found, only one appears to yield monazite, namely, the large (though now but little worked) quarry about 1½ mile southwards along the coast from Tintagel Castle, which is marked on the 6 in. Ordnance map as "Lanterdan Quarry," but is locally known as part of "West Quarry."

The rock is a Devonian slate, which, just at this point, possesses a peculiar silky lustre. It is traversed by numerous straight joints running roughly in a N.E. and S.W. direction, which dip at a steep angle, and are lined with crystals of albite and quartz, and (in some places) calcite.

The monazite usually lies upon the albite in the joints, but one of the crystals found lies in a small secondary crack directly on the slate.

This Cornish occurrence of monazite offers no exception to the generalisation that this mineral is always accompanied by some form of TiO_2, for rutile is found along with it on the albite, and anatase occurs in the neighbouring "Lambshouse Quarry," a few hundred yards to the north.

Monazite.

Most of the crystals are of the common habit, forming rather thick tables parallel to *a*(100), and of a reddish-brown colour. The finest of those we obtained is about 2½ mm. long (*b*-axis), and shows the forms:—

$a\{100\}$; $w\{101\}$; $e\{011\}$; $i\{\bar{2}11\}$; $z\{\bar{3}11\}$; $r\{111\}$; $m\{110\}$; $q\{701\}$.

It is a twin upon the face $a(100)$, and appears to be more or less interpenetrant. The specimen on which it occurs consists of albite, with quartz and calcite and rutile needles. The form $q\{701\}$ was originally discovered by Miers on the specimen in the British Museum, and as it does not seem to have been again observed, its occurrence on the present crystal confirms his suggestion with regard to the locality of that specimen.

The crystal mentioned above as lying directly on the slate, differs from the others both in its colour (a darker brown) and its habit, which is quite exceptional. It is tabular parallel to $b(010)$, and lies on a face of this form. I have measured the angles of the exposed portion without detaching the crystal from the matrix, and find the following forms:—

$b\{010\}$; $u\{021\}$; $e\{011\}$; $v\{\bar{1}11\}$; $o\{\bar{1}21\}$; $m\{110\}$; $n\{120\}$; $\mu\{130\}$; $w\{101\}$; $r\{111\}$; $\eta\{\bar{1}32\}$; $\theta\{\bar{1}22\}$.

Of these, μ, η, θ are new, and are established by the following angles:—

			Edges.	Limits.	Observed.	Calculated.[1]
In the zone $[bnm]$	$b\,\mu$	010:130	2	19°56′—20°26′	20°11′	19°29½′
	$n\,\mu$	120:130	1	..	9° 0′	8°28½′
,, $[uv]$	$u\,\eta$	$02\bar{1}:13\bar{2}$	1	..	[17°][2]	16°34′
	$v\,\eta$	$11\bar{1}:13\bar{2}$	1	..	[22°15′][2]	22°56′
,, ,, $[ev]$	$e\,\theta$	$011:\bar{1}22$	1	..	20°58′	20°26½′
	$v\,\theta$	$\bar{1}11:\bar{1}22$	1	..	18°29′	18° 9½′
	$u\,\theta$	$021:\bar{1}22$	1	..	25°33′	25°16′

The new faces are all distinct, though small, and μ is particularly bright. This crystal is shown in the accompanying figure (Fig. 1).

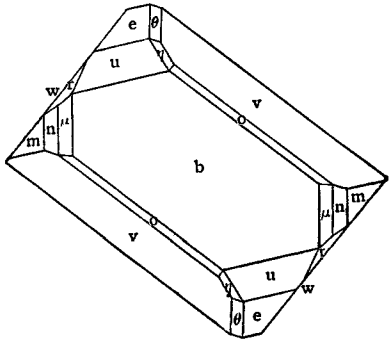

FIG. 1. Monazite.

[1] $a:b:c=0{\cdot}9693:1:0{\cdot}9256$ $\beta=76°20'$ (E. S. Dana.)

[2] Angles obtained by method of maximum illumination

Rutile.

The rutile found associated with the monazite is peculiar, as it forms very fine hair-like needles of a golden colour, lying quite loose upon the albite, and often matted together. Similar needles are also occasionally found enclosed in the quartz crystals.

Thin layers of rutile, of the same colour, and showing the "sagenite" structure, are also found in cracks in massive quartz in the same quarry along with chlorite.

Albite.

The albite occurs in good crystals, sometimes attaining a length (parallel to $x(\bar{1}01)$) of 2 cm., and often covers considerable areas of the faces of the joints. It is usually white, though sometimes stained with ochre, and the smaller crystals are often perfectly transparent.

The following forms are present:—

$b\{010\}$; $m\{110\}$; $M\{1\bar{1}0\}$; $z\{1\bar{3}0\}$; $c\{001\}$; $n\{0\bar{2}1\}$; $o\{\bar{1}\,\bar{1}1\}$; $\delta\{\bar{1}\,\bar{1}2\}$; $p\{\bar{1}11\}$; $x\{\bar{1}01\}$; $y\{\bar{2}01\}$.

Besides these, a small striated face (ξ) occurs on some crystals on the edge c/δ, making an angle of 3°—4° with the face c. The measurements are too uncertain to admit of the definite assignment of indices, but the form is not far from $\{\bar{1}.\bar{1}.16\}$, for which $c\xi = 3°22'$.

In sodium light, the extinction angles are—

On $c\{001\}$, somewhat variable, but usually about $+3°$ to 4°.

On $b\{010\}$, $+20°$.

These values would correspond to a nearly pure soda-felspar, as would also the emergence of a bisectrix through b, at a slight inclination to the normal.

Quartz.

The perfectly clear crystals of quartz, which mostly have a diameter of about 1 cm., but are also found considerably larger, occur with albite and calcite in nests along the joints. They are interesting on account of their commonly rhombohedral termination (the faces of $\{r\}$ being usually much larger than those of $\{z\}$), and from the frequency of twins.

Faces of $s\{41\bar{2}\}$ are very common, but $x\{4\bar{1}\bar{2}\}$ appears to be absent.

Twins according to two laws occur, viz.:—

(1) Rotation twins—twin axis $\perp$ $c\{111\}$—(the common form).

(2) Reflection twins—of the kind described by Prof. Lewis as "laevo dextro-gyral, β"—which may be explained in a simple manner as inter-

penetration twins, of which the two individuals are related to one another by reflection over the equatorial plane.

Only two examples of the second law were obtained. They are represented in Fig. 2, and are characterised by the right- and left handed striation on the two halves of an *s*-face.

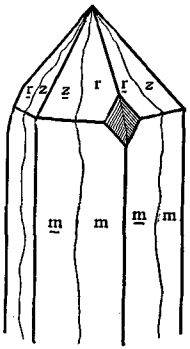

FIG. 2. Quartz twin.

Some of the crystals of quartz contain fine golden needles of rutile.

Pyrite.

On some of the specimens minute brown grains are to be seen on and among the needles of rutile, on which they are often strung like beads. These appear under the microscope to be very perfect model-like crystals of pyrite, showing a combination of a pyritohedron with the octahedron and narrow faces of the cube.

Striated cubic crystals of pyrite of larger size also occur embedded in the slate.

Calcite.

The calcite is always dull on the surface, and forms crystals from 1 to 4 cm. in diameter, the smaller being sharp, but the larger very coarse and rough. Owing to the dullness of the faces, it was necessary to cement small fragments of microscope cover-glass to them in order to obtain measurements. The latter are only approximate, owing to the difficulty of getting the covers to lie flat on the smaller faces. Hence it is impossible to be certain of the indices, which in calcite are often not simple, and in assigning probable indices I have assumed that the faces belong to the nearest form given in Irby's tables.

The smaller crystals are usually surrounded by an equatorial belt of flat plates resembling "schiefer spar," of very peculiar appearance, in parallel position. The basal planes of the schiefer spar, though much pitted and lying at different levels, are very brilliant, and yield a single perfect image of the goniometer signal.

Three habits may be distinguished :—

(1) Large, coarse, rounded crystals, apparently combinations of scalenohedra and rhombohedra.

(2) Rather flat scalenohedra (up to 2 cm. dia., but usually smaller), the points of which project from a bed of the schiefer spar, and are sometimes truncated by a small bright face of $c\{111\}$. The scalenohedron approximates to $\{310\}=\{21\bar{3}4\}$.

(3) Small scalenohedra, either near $v\{20\bar{1}\} = \{21\bar{3}1\}$, or differing somewhat from it—perhaps $\{46.\bar{5}.\bar{3}2\} = \{17.9.\bar{2}6.3\}$—, combined with an inverse rhombohedron, near $\epsilon\{22\bar{1}\} = \{01\bar{1}1\}$, and small faces of a very flat scalenohedron, perhaps $\{10.4.1\} = \{21\bar{3}5\}$, and possibly also $\{310\} = \{21\bar{3}4\}$.

Crystals of types (2) and (3) are very symmetrically developed. Some of those of (2) are twinned about $e\{011\} = \{\bar{1}012\}$, as is shown by the mutual inclination of the basal planes of the schiefer spar.

The calcite appears to be always associated with the quartz crystals and collected in definite nests, with or without albite, which latter is more abundant than either of the other two minerals. Rutile in fine needles occurs in these nests as well as on the albite alone.

Anatase (from Lambshouse Quarry).

This mineral occurs with small opaque white albite crystals, in small steel-blue octahedra (not exceeding 1 mm.), bounded by $p\{111\}$ and $k\{112\}$, striated and alternating with each other, with minute planes of $o\{107\}$ and $e\{101\}$.

This may probably be the locality mentioned by Greg and Lettsom for anatase, under the name "Tintagel Cliffs," though we did not find any of the "adularia" said by them to be associated with it.