XX.—*On the Influence of the Doubly Refracting Force of Calcareous Spar on the Polarisation, the Intensity, and the Colour of the Light which it Reflects.*

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(Read 15th February 1864.)

It was the opinion of MALUS, and adopted by ARAGO, BIOT, and other philosophers, that the surfaces of regularly crystallised bodies acted upon light in the very same manner as the surfaces of ordinary bodies, whether solid or fluid; or, in other words, that the reflecting forces extended beyond the limits of the forces that produced double refraction and polarisation. Having been led to question this opinion, I undertook an extensive series of experiments on crystalline reflexion, as exhibited in calcareous spar, a crystal peculiarly fitted for this purpose, from its perfect transparency and great double refraction; and I published the results of these experiments in the Philosophical Transactions for 1819.

In these experiments, the peculiar action of crystalline surfaces which I had expected was placed beyond a doubt. The angle of complete polarisation on the surface of the primitive rhomb was found to vary with the inclination of the plane of reflexion to the principal section of the crystal; and with different surfaces the variation of that angle depended on the inclination of the surface to the axis of the rhomb.

As the doubly refracting force thus modified the polarising angle produced by superficial reflexion, it became probable that the polarised ray might suffer some change from the same cause; but, after the most careful observation, I could not discover the slightest indication of such an effect. Conceiving, however, that the change which I expected might be masked by the powerful action of the ordinary reflecting force, I thought of reducing it till it was overpowered by the doubly refracting force. With this view, I introduced a film of oil of cassia between the larger surface of a rectangular prism of plate glass and the surface of the spar, and by inclining the prism at a small angle, as in the LITHOSCOPE, I was able to separate the image of the sun, or any other light formed by the common surface of the prism and the oil, from the image formed by the common surface of the spar and the oil, and to examine the properties of the last of these images.

In this way I found that the ordinary reflecting force of the spar was nearly reduced to nothing, and was almost entirely under the dominion of the force which emanated from the crystal. Light incident on the crystalline surface was no longer polarised in the plane of reflexion, but in planes inclined to the principal section of the crystal, the rotation or deviation of the plane increasing with the angle which the plane of reflexion formed with the principal section, and was so related to the angle which the incident ray formed with the axis of the crystal, that the Sine of half the rotation, or deviation, was equal to the square root of the Sine of the incident ray to the axis.

The bearing of these results, as published in the memoir already referred to, upon the theory of Light, directed the attention of mathematicians to this subject, and I was thus induced to resume the inquiry, by investigating the action of surfaces variously inclined to the axis of calcareous spar,—to study the effect of fluids of different refractive powers, in reducing the action of the reflecting force, and to ascertain the influence of the surfaces thus modified upon light polarised in planes differently inclined to the principal section of the crystal.

Some of the results thus obtained were communicated at different times to the British Association, and were found by the late Professor MACCULLAGH of Trinity College, Dublin, to be deducible from the Undulatory Theory; but other results, in which the phenomena were asymmetrical with respect to the principal section of the crystal were less accordant with theory. Professor MACCULLAGH was therefore desirous to observe the phenomena himself; and having resolved to have an apparatus constructed more complex and perfect than the one I used, I willingly left the subject in the hands of my distinguished friend. What experiments he made, or whether he made any, before the sad and sudden close of his life in 1847, I have not learned. The subject has therefore again come into my hands; and having been encouraged by Professor STOKES of Cambridge to publish my experiments, as having an important bearing on the theory of light, I now submit them, incomplete and imperfect as they are, to the consideration of the Society.

The experiments which I published in 1819 were made on the cleavage planes of the primitive rhomb of calcareous spar, but those which I am about to describe were made on artificial faces, carefully prepared for me by the late Mr WILLIAM NICOL, the ingenious inventor of the polarising prism which bears his name.

I could have wished to repeat some of these experiments with a better apparatus, and with freshly polished surfaces of calcareous spar, but the sharp vision and the sensitive retina of early or middle life are necessary for the observation of delicate and almost evanescent phenomena.

In the following Table I have given the observed polarising angles of the surfaces employed, and of their inclination to the axis of the rhomb:—

	Inclination to Axis.			Observed Polarising Angle.*	
A	.	.	0°	...	54° 3'
A1	.	.	4 40'	...	54 16
D	.	.	22 30	...	55 22
B	.	.	45 23	...	57 12
B1	.	.	50 51	...	...
B2	.	.	57 31	...	...
E	.	.	67 30	...	59 16
E1	.	.	84 30	...	59 38
C	.	.	90 0	...	59 59

B. SURFACE OF RHOMB, INCLINATION TO AXIS 45° 23'.

1. With Oil of Cassia, on an Artificial Face.

AZIMUTH 90°. Obtuse angle to the right.

Light polarised 0° and 90°. E' and O'† vanish simultaneously 42½° to the left of the plane of incidence, E' being *reddish* and O' *yellowish*.

Light polarised + 45° and — 45°. E' is polarised 45½° to the left. O' vanishes, but a little *blue* light is left, which disappears along with E and O. O' vanished more completely by turning the rhomb that gave the images E, O, 9° or 10° farther, from 45° to 55°.

AZIMUTH 270°. Obtuse angle to left.

Light polarised 0° and 90°. E' and O' vanish simultaneously 33½° to the right of the plane of incidence. A little *blue* light remains in E' and O' at the point of evanescence.

Light polarised + 45° — 45° O' is polarised 35° to the right. E' vanished completely.

2. With Oil of Cassia, on a Natural Face of Cleavage.

AZIMUTH 90°. Light polarised 0° and 90°. E' and O' vanish simultaneously 47½° to the left.

Light polarised + 45° — 45°. E' is polarised 46° to the left. O' is scarcely visible.

AZIMUTH 270°. Light polarised 0° and 90°. E' and O' vanish simultaneously 42½° to the right.

Light polarised + 45° — 45°. O' is polarised 44½° to the right. E' is nearly invisible.

Common light is polarised 44° to the right.

N.B.—The evanescence is not complete either on the glass or on the spar surface; but more complete on the natural than on the artificial face of the spar.

AZIMUTH 38°. Obtuse angle to right. In common sun's light, E' and O' vanish simultaneously at 45° of incidence, and in a plane 82½° to the right of the plane

* In the plane of the principal section. See Phil. Trans., 1819, p. 158.

† E' and O' are the extraordinary and ordinary images from the spar, and E and O the same from the prism surface.

of incidence. The vanishing image is at its *minimum* when crossed half with *blue* and half with *red* light.

Light polarised $+45^\circ-45^\circ$. E' and O' polarised simultaneously $82\frac{1}{2}^\circ$ to the plane of incidence. Both have the same intensity, and are crossed at their minimum with *red* and *blue* light.

Light polarised 0° and 90° . Although E does not suffer reflexion from the glass surface, yet E' is visible, and vanishes, along with O' , $82\frac{1}{2}^\circ$ to the right of the plane of incidence.

AZIMUTH 218° , Obtuse angle to the Left. Common sun's light is completely polarised 8° to the right of the plane of incidence. The evanescence is complete at the polarising angle of O , but not at greater angles.

Light polarised 0° and 90° . E' and O' are both polarised 8° to the right. E' is bright *yellow* and O' bright *pink*.

Light polarised $+46^\circ-45^\circ$. E' and O' are polarised 8° to the right, E' being *yellow* and O' *blue*.

AZIMUTH 15° to the left. Light polarised 0° and 90° . E' and O' vanish together, and O' is polarised about 40° to the right.

Light polarised $+45^\circ-45^\circ$. Obtuse angle from the eye E' and O' are polarised 55° to the right.

AZIMUTH 45° . Light polarised $+45^\circ-45^\circ$. E' and O' vanish completely at polarising angle 92° to the right. The deviation is increased by increasing the incidence.

On the Intensity of the Reflected Pencil.

COMMON LIGHT, AZIMUTH 0° and 180° . The spar and oil image S is equal to about $\frac{1}{3}$ of the prism image P .

AZIMUTH 45° and 215° . $S = \frac{2}{3} P$.

AZIMUTH 90° and 270° . $S = P$, P a little brighter.

Light polarised $+45^\circ-45^\circ$.

AZIMUTH 0° and 180° . O' gradually diminishes and vanishes at 90° , while E' increases and is a maximum at 9° .

AZIMUTH 90° and 270° . E' is a maximum and nearly equal to O' , which almost vanishes.

Beyond 90° and 270° , O' gradually increases while E' diminishes, and they become equal at 180° .

Light polarised 0° and 90° . AZIMUTH 0° and 180° . O' almost vanishes, but E'' is bright, though only equal to $\frac{1}{3} P$. O' increases gradually to azimuth 90° , where it is equal to O .

AZIMUTH 90° and 270° . $E' = O'$, both pretty bright, but less so than P .

AZIMUTH 123° . E' vanishes. O' a little less than P .

AZIMUTH 180° . O' vanishes. $E' = \frac{1}{3} P$.

B *With Oil of Anise Seeds.*

AZIMUTH 0° and 180° . E' and O' vanish together, E' at all angles less than 45° . O and a great part of E , viz. the *blue* light and more is polarised at angles above 45° , a small portion of *red* light remaining. $O = E$, O *bluish* and E *yellowish*.

AZIMUTH 90° and 270° . Change of polarisation 94° to left. Maximum polarising angle for E' at angles much less than 45° , polarisation nearly complete. No appearance of polarisation at great incidences. $O' = E'$.

AZIMUTH 39° and 321° . Change of polarisation 50° to left. The maximum polarising angles commence at the angle of polarisation for O , and the polarisation is complete at angles both above and below 45° .

AZIMUTH 219° . Change of polarisation 0° , O' and E' vanishing at the same time at about 45° . Above 45° , E' is nearly wholly polarised 15° to the right, while below 45° , it is polarised 0° , 5° , 10° , &c. to the left as the incidence diminishes.

With sunlight complete polarisation took place much lower than 45° , and *blue* light was less in this light.

B. *With Oil of Sassafras.*

AZIMUTH 0° and 180° . No change in the plane of polarisation. O' is bluish and $= 4$ to $5 E'$.

AZIMUTH 39° . Change of polarisation about 30° .

AZIMUTH 219° . Change of polarisation 0° .

AZIMUTH about 60° . Change of polarisation 45° , the polarisation increasing at great incidences.

AZIMUTH about 70° . Change of polarisation about 50° . Maximum polarisation about 48° of incidence.

AZIMUTH 90° . No light seems to be polarised at or above 45° .

AZIMUTH about 240° . Change of polarisation from 15° at great incidences to about 25° at small incidences. Light polarised in plane of reflexion is treated nearly as common light, but light polarised 90° out of that plane has a change of polarisation a few degrees greater, owing to its being incident at a less angle; the one image from the polarising rhomb being higher than the other.

B. *With Castor Oil.*

AZIMUTH 0° and 180° . O' and E' completely polarised without any change of plane.

AZIMUTH 39° . Change of polarisation about 10° to left.

AZIMUTH 90° . Change about 20° to left at moderate incidences.

AZIMUTH 141° . Change 0° . Polarisation complete.

AZIMUTH 219° . Change 0° . Polarisation complete.

AZIMUTH 270°. Change about 10° to right at considerable incidences.

AZIMUTH 321°. Change 10° to right, and polarisation complete.

B. Oil of Cajeput.

AZIMUTH 39°. Change about 5° to left, and polarisation complete.

AZIMUTH 90°. Change 7° to left at moderate incidences.

AZIMUTH 141°. Change 0°. Polarisation complete.

AZIMUTH 219°. Change 0°. Polarisation complete.

AZIMUTH 270°. Change 5° to right at considerable incidences.

AZIMUTH 321°. Change 5° to right. Polarisation complete.

B. With Olive Oil.

AZIMUTH 39°. Change about 5° to left.

AZIMUTH 90°. Change about 100° to left.

AZIMUTH 141°. Change 0°. Polarisation complete.

AZIMUTH 219°. Change 0°. Polarisation complete.

AZIMUTH 270°, Change 8° to right.

AZIMUTH 321°. Change 5° to right. Polarisation complete.

B. With Alcohol highly rectified.

AZIMUTH 39°. Change about 1° or 2° to left. The two images vanish at different incidences, S at greater than P.

AZIMUTH 90°. Change about 1° or 2° to left, spar pencil at angle greater than prism pencil.

AZIMUTH 141°. Change 0°.

AZIMUTH 270°. Change about 1° or 2° to left.

AZIMUTH 280°. Change 0°. Polarisation complete.

AZIMUTH 321°. Change at 1° or 2° to right.

A. THE FACE PARALLEL TO THE AXIS.

With Oil of Cassia.

The following observations were made with a plate of glass placed on the surface of the spar, the plate being inclined about 5° in the Azimuth 0° parallel to the axis.

Azimuths.	Change of Polarisation.	Azimuths.	Change of Polarisation.
0°	93° *	50°	47°
10	85	60	37
20	80	67½	33
22½	74	70	32
30	55	80	20
40	59	90	0
45	55		

* The change was 90° at the polarising angle of the spar and oil surface.

These observations were made at angles of incidence considerably greater than 45° , the polarising angle.

The following experiments were made with polarised light.

Inclination of Plane of Polarisation to Plane of Incidence.	Inclination of New Plane to Plane of Incidence.
0°	0°
$22\frac{1}{2}$	30
45	$67\frac{1}{2}$
$67\frac{1}{2}$	79
90	90

When E' was polarised 90° and O' 0° , O' was nearly thrice as faint as E' , and much *redder*.

When the spar and oil image vanishes, *red* light is seen on one side, and *blue* on the other side of the vanishing point, as in elliptical polarisation, the rotation being different for different colours.

The following experiments were made with an equilateral prism of glass.

In AZIMUTH 0° and 180° . Light polarised $+45^\circ - 45^\circ$ is polarised $+67^\circ - 67^\circ$, the change of polarisation being 22° .

AZIMUTH about 9° . Light polarised 0° and 90° . E' is polarised 87° to the left, and O' and O vanish together. Common light is polarised 87° to left.

Light $+45^\circ - 45^\circ$. E' is polarised $59\frac{1}{2}^\circ$ to left, and O' $71\frac{1}{2}^\circ$ to right. E' and O' are equally bright.

AZIMUTH about 17° . Light $+45^\circ - 45^\circ$. E' is polarised $27\frac{1}{2}^\circ$ to left, and O' $80\frac{1}{2}^\circ$ to right. E' is very faint and *red*.

AZIMUTH about 40° . Light $+45^\circ - 45^\circ$. Both O' and E' polarised 25° to left. O' is brighter than E' , which is faint and *bluish*.

AZIMUTH ABOUT 60° . Light $+45^\circ - 45^\circ$. O' and E' vanish together a few degrees to the left.

AZIMUTH 90° . Light $+45^\circ - 45^\circ$, and light 0° and 90° , are treated exactly as by common surfaces; the prism and spar images undergoing the same changes.

As the plane of light polarised $+45^\circ - 45^\circ$, becomes light $+0^\circ - 0^\circ$, or is all polarised in the plane of reflexion, as the azimuths change from 0° to 90° , the inclination of their planes must diminish from 90° to 0° , or from 135° to 0° ; that is, from $+67\frac{1}{2}^\circ - 67\frac{1}{2}^\circ$, to $+0^\circ - 0^\circ$.

From the observations with common light, it appears that at angles of incidence considerably above 45° , it is polarised a few degrees beyond the azimuth of 90° , and we have no doubt, that at 45° , it is polarised in that azimuth. Hence, it follows, that the change of polarisation is equal to the complement of the azimuth, or $90 - A$.

A. *With Oil of Anise Seeds.*

AZIMUTH 0° and 180° . Scarcely any effect is produced upon common light at any incidence! The spar pencil is brighter than the prism pencil, and *yellow*.

AZIMUTH between 0° and 90° , and 0° and 270° , the pencil is almost wholly polarised at great incidences, and about 90° to the left.

AZIMUTH 0° and 180° . Light $+45^\circ - 45^\circ$. E' was polarised $30\frac{1}{2}^\circ$ to left, and 36° to right. Instead of widening the planes of E' and O' into $+67\frac{1}{2} - 67\frac{1}{2}$, the anise seeds oil has brought them nearer into $+30\frac{1}{2} - 36^\circ$. Conceiving, therefore, that an oil of intermediate refractive power might produce little or no change upon the light $+45^\circ - 45^\circ$, I mixed 2 drops of oil of cassia with 1 drop of oil of anise, and obtained the following results.

A. *Oil of Cassia and Oil of Anise Seeds.*

AZIMUTH 0° and 180° . Light $+45^\circ - 45^\circ$. E' is polarised 44° to the *left*, and $0^\circ 44'$ to the right; that is, almost no change is produced.

With common light there is not a trace of polarisation, and yet reflexion from a transparent surface!

Light 0° and 90° . O' vanishes with prism image, and A' polarised about 90° .

AZIMUTH 90° and 270° . With common light, the spar and prism image vanish together.

Between AZIMUTH 0° and 90° . With common light, the polarisation increases to about 45° of azimuth, when it is complete, and then gradually returns into common light at 90° .

C. *Face perpendicular to Axis.*

On the natural surface of the *Chaux Carbonatè Basé*.

Oil of Cassia.

With common light. the spar image E is polarised 90° out of the plane of reflexion, and is then *orange*, showing that the light polarised 90° is *blue*. It becomes whiter at great incidences, and redder at small ones. The prism image O is $=2E$ at 45° . At greater incidences E increases faster than O, and becomes nearly equal to it. At small incidences, E decreases much faster than O, so that it follows a different law of reflexion.

At the greatest incidences which the prism allows, the spar pencil is completely polarised.

Light polarised $+45^\circ - 45^\circ$. E' is polarised 67° to right, and O' 67° to left.

Light polarised 0° and 90° . O' vanishes with O, and E is polarised 90° to left.

Oil of Anise Seeds.

In all azimuths about $\frac{1}{2}$ or $\frac{2}{3}$ of E is polarised 90° out of the plane of reflexion

at great incidences. At the polarising angle, the light polarised 90° is scarcely perceptible. The residual light is *reddish*, and it is obviously *blue* light that is polarised 90° .

Light polarised $+45-45^\circ$, becomes polarised $+36-36$.

With Alcohol.

The prism image O is completely polarised, and the spar image E equally so in the same plane, but at an incidence 3° or 4° greater.

With oil of sassafras, cassada balsam and water, there is no change in the plane of polarisation.

D. *Face inclined $22\frac{1}{2}^\circ$ to Axis.*

AZIMUTH 0° and 180° . In common light, the change of polarisation is 90° to the left. It decreases to 20° in azimuth 90° , becomes 0° in azimuth 113° , and in AZIMUTH 180° , it again becomes 90° , decreasing to 0° in azimuth 247° , becoming 20 in azimuth in 270° , and increasing to 90 in azimuth 360° .

AZIMUTH 0° and 180° . Light $+45-43^\circ$. E' is polarised $45\frac{1}{3}$ to left and O' $62\frac{2}{3}^\circ$ to right.

AZIMUTH ABOUT 15° . Light $+45^\circ-45^\circ$. O' is polarised $85\frac{1}{2}^\circ$ to left, E vanishing with O and E the prism images. When O' vanishes E' has reappeared, and is *red*.

AZIMUTH 38° . Light $+55^\circ-45^\circ$. E is polarised 50° to the right, and O' $77\frac{1}{2}^\circ$ to the left.

AZIMUTH 20° . E' is polarised 17° to left, and O' 83° to right.

AZIMUTH 113 . Light $+45^\circ-45'$. No change, E' and O' being both polarised in the plane of reflexion. E' nearly vanishes when O' vanishes; but by increasing the incidence it vanishes completely, showing the usual red and blue at the point of evanescence.

AZIMUTH 135° . Light $+45^\circ-45^\circ$. E' is polarised 22° to right, O'=O and vanishing with O.

AZIMUTH 142° . Light $+45^\circ-45^\circ$. E is polarised $31'$ to the right, O' vanishing with O.

AZIMUTH 160° . Light $+45^\circ-45^\circ$. E' is polarised 66° to right, and O' 22° to right.

AZIMUTH 218° . Light $+45^\circ-45^\circ$. E' is polarised 11° to left, and O' 77° to left.

AZIMUTH 90° . Light $+45^\circ-45^\circ$. E' and O' are both polarised 28° to the left.

AZIMUTH 270° . Light $+45^\circ=45^\circ$. E' and O' polarised $18'$ to right.

AZIMUTH 315° . Light $+45^\circ - 45^\circ$. E' is polarised 59° to right, and O' 69° to the left.

AZIMUTH 322° . Light $+45^\circ - 45^\circ$. E' polarised 61° to right, and O' 83° to right.

AZIMUTH 180° . Light $+45^\circ - 45^\circ$. E' is polarised $50\frac{1}{2}^\circ$ to left, and O' 58° to right.

AZIMUTH 0° . Light 0° and 90° . E' is polarised 90° out of the plane of reflexion, O' vanishing with O.

AZIMUTH 180° . Light 0° and 90° . E' is polarised to the left, about 86° , O' vanishing with O.

AZIMUTH 270° . Light 0° and 90° . E' and O' polarised 21° to the right.

AZIMUTH less than 270° . Light 0° and 90° . E' and O' polarised 8° to the right.

With Oil of Anise Seeds.

AZIMUTH 0° and 180° . When the prism pencil with common light vanishes, the spar pencil is very bright, and a great deal of light, namely, reddish light is polarised in the plane of reflexion.

AZIMUTH 90° and 270° . The spar pencil is completely polarised about 7° to the left.

In the azimuth, between 90° and 180° perpendicular to the edge beside the obtuse angle, change of polarisation varies from 45° of incidence where it is 0° , up to great incidences, where it is about 45° or 50° to the left, the pencil being there completely polarised. Between azimuths 270° and 360° , the change varies from 125° to 100° at great incidences, but the pencil is nowhere completely polarised.

With Alcohol.

At AZIMUTHS 0° and 180° , there is no change of polarisation, but the spar image is polarised at a much less angle of incidence than the prism image, whereas at azimuth 90° , they are polarised at the same incidence.

E. *Face inclined $67^\circ 30'$ to the Axis.*

In AZIMUTH 0° and 180° , the change of polarisation is 90° , the polarisation being more complete, by considerably increasing the incidence.

The change of polarisation increases from azimuth 0° to azimuth 90° , diminishes from 90° to 270° , and increases from 270° to 369° .

In AZIMUTH 0° and 180° . At the polarising angle only half the pencil is polarised 90° out of the plane of reflexion, the other half appearing to be polarised in another plane.

AZIMUTH 0° . Light $+45^\circ - 45^\circ$. E' is polarised 45° to the right, and O' 61° to the left.

AZIMUTH 9° . Light $+ 45^\circ = 45^\circ$. E' is polarised 67° to the right, and O' 55° to the left.

AZIMUTH about 16° . Light $+ 45^\circ - 45^\circ$. E is polarised 71° to right, and 51° to left.

AZIMUTH 45° . Light $+ 45^\circ - 45^\circ$. E' is polarised 90° out of the plane of reflexion, and O' a few degrees to the left of O and E.

AZIMUTH about 60° . E' is polarised 76° to left. O' vanishing with O and E.

AZIMUTH 90° . Light $+ 45^\circ - 45^\circ$. E' is polarised 70° to left, and O' 53° . O' is very faint when the prism images vanish.

AZIMUTH 180° . Light $+ 45^\circ - 45^\circ$. E' is polarised 68° to the left, and O' 63° to the right.

AZIMUTH 0° . Light polarised 0° and 90° . E' is polarised 90° to the left. O' which is reddish, vanishes with O.

AZIMUTH 180° . Light polarised 0° and 90° . E' is polarised 85° to the right. O' vanishes with O.

With Oil of Anise Seeds.

AZIMUTH 0° and 180° . There is no polarisation at great incidences. One-half the spar pencil seems polarised 90° to the left, red light being polarised in the plane of reflexion.

AZIMUTH 90° . Light is almost wholly polarised about 100° to the left at the greatest incidences. At less incidences it is half polarised, red light being left.

With Alcohol.

In AZIMUTH 0° , 90° , and 180° , there is no change of polarisation. The spar image is polarised at a less angle of incidence than the prism image.

In order to observe the changes of polarisation in passing from one plane to another, I had three artificial faces made, slightly inclined to the three principal planes C, B, and E.

E1. *Face inclined $5^\circ \frac{1}{2}$ to C.*

This face was used a few minutes after it was polished.

Polarising angle in principal section, $59^\circ 38'$.

Polarising angle perpendicular to it $58^\circ 25'$, much unpolarised light being left.

With Oil of Cassia.

AZIMUTH 0° . Light $+ 45^\circ - 45^\circ$. E' is polarised 61° to right, and O' 73° to left.

AZIMUTH 180° . Light $+ 45^\circ - 45^\circ$. E' is polarised 67° to right, and O' 76° to left.

In both these azimuths E is $\frac{1}{2}^\circ$ O with common light, and is yellowish red.

AZIMUTH 0° . Light polarised 0° and 90° . E' is polarised 84° to the right. O' vanishes with O', and is fainter and redder than E'.

AZIMUTH 180° . Light polarised 0° and 90° . E' is polarised 90° to right. O vanishes with O, and is fainter and redder than E'.

B1. *Face inclined $5^\circ 28'$ to B.*

In AZIMUTH 0° . With bright sun-light the spar pencil E is distinctly polarised about 14° to the right.

AZIMUTH 0° . Light $+45^\circ - 45^\circ$. E' and O' polarised about 13° to left.

AZIMUTH 0° . Light polarised 0° and 90° . E is polarised about 50° to the right, and O' vanishes with O.

B2. *Face inclined $12^\circ 8'$ to B.*

With common light, a small quantity is polarised in the plane of reflexion.

As the azimuth approaches to 90° on either side of the principal section, the light is polarised about 90° out of the plane of reflexion, much *bright blue* light being left. At small incidences the *blue* becomes brighter and purer. The light is orange when the principal section of the analysing rhomb is in the plane of reflexion, as if red light was polarised 90° out of the plane of reflexion, and blue light in that plane.

The experiments described in the preceding pages form but a small portion of those which I have made, both with artificial and solar light on the action of the surfaces of calcareous spar on common and polarised light. In submitting them to the Society, it is proper that I should mention the great difficulty of obtaining precise results in such observations. The extreme faintness of the reflected light; its imperfect polarisation in many cases at the angle of maximum polarisation; and the loss of one-half of the light in the analysing prism, render it very difficult to determine the deviation of the reflected pencil, especially when it is partially polarised, or unequally double; and I have been surprised at the great difference in the results obtained at different times with the same surfaces, when the observations were in both cases recorded as satisfactory.

The following general results, however, are sufficient to show the importance of this class of researches, in reference to certain questions in the undulatory theory which have not yet been solved, and perhaps to guide the mathematician to their solution.

1. In the reflexion of light, the surfaces of calcareous spar in contact with fluids, act in some cases as ordinary uncrystallised surfaces in the polarisation of light.

2. In reflecting common light, they polarise it out of the plane of reflexion,

the deviation from that plane varying with light of different colours, and with the angle of incidence.

3. In reflecting polarised light, they change its plane of polarisation, sometimes as in refraction, and sometimes as in reflexion.

4. In certain azimuths, and at certain incidences when the pencil is not completely polarised, much light, apparently unpolarised light, is left; and in many cases, upon all the surface, A, B, C, D and E, the reflected pencil consists of two oppositely polarised pencils, as in the reflexion of common light from the surface of murexide, chrysammate of potash, and a few other bodies.

5. The changes in the planes of polarisation, both of common and polarised light, are related to the axis of double refraction, that is, to the short diagonal of the primitive rhomb of calcareous spar.