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SOME ILLUSTRATIONS OF THE OPTICAL BEHAVIOUR OF IRIDESCENT CALCITE

By A. K. Ramdas

(*Memoir No.* 61 *from the Raman Research Institute, Bangalore*)

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§1. Introduction

The structure and optical behaviour of iridescent calcite formed the subject-matter of a recent paper in these *Proceedings*.[1] The phenomena considered in that paper had their origin in the twinning layers present within the crystal; each of such layers is parallel to one edge of the rhombohedral cleavage and equally inclined to the two others. The present paper is intended as a supplement to the earlier one referred to; photographs are reproduced illustrating the various effects alluded to therein arising from reflection and refraction by the twinning layers. Amongst the phenomena illustrated may be noted particularly the following: (*a*) the formation of image patterns by multiply twinned crystals; (*b*) the vanishing of the reflections and refractions in the symmetry plane; (*c*) the appearance of sharply defined boundaries in the field of reflection and refraction; (*d*) dispersion and interference effects.

Descriptive notes on the individual figures reproduced in the Plates are given below.

§2. Descriptive Notes

Fig. 1, *Plate XIII.*—When a distant source of light is viewed through the opposing faces of a calcite rhomb traversed by more than one twinning layer, a multi-coloured pattern comprising numerous images arranged in geometric order is seen, the number and arrangement of the images being dependent on the number and disposition of the twinning layers traversed by the light. Photographs reproduced in the earlier paper illustrated cases in which three, nine, fifteen and twenty-seven images respectively were observed. In the present photograph it has been possible to record no less than thirty-six images, many of them as doublets.

Figs. 2, 3 *and* 4, *Plate XIII.*—These photographs reproduce the images of a light source observed by reflection and refraction at one twinning layer, light being incident through one face of the calcite and emerging through an adjacent face after such reflection. There are, in general, four reflected images: two in which ordinary and extraordinary waves are reflected as such and two others in which ordinary wave is transformed to extraordinary and *vice versa*. The former are polarised in the normal manner and occur in between the latter which are polarised in the reversed fashion. The angular separation between the four species of reflections and their relative intensities vary markedly with the setting of the crystal. The positions of the images polarised in the normal manner (*i.e.*, the middle two) with respect to the two outer ones are variable. Comparing the cases reproduced as Figs. 2 and 4 it is noticed that the two have interchanged positions, while Fig. 3 illustrates the case when they are superposed.

Fig. 5, *Plate XIV*.—A linear source of white light is viewed through a calcite containing a single twinning layer held in the following manner: the twinning layer is held vertical and the source is viewed through those faces none of whose edges is parallel to the twinning layer. Three images of the slit are seen, the outer two being coloured and polarised. The deviated images are seen cut into two halves by the symmetry plane, but not so the undeviated one. The gain in intensity as we move away from the symmetry plane is clearly seen.

Figs. 6, 7 *and* 8, *Plate XIV*.—A plexiglas screen illuminated from behind by a sodium vapour lamp is viewed through the calcite rhomb held in the manner already explained above. On rotating the crystal about the vertical axis, one sees a division of the field of view into two parts differing in intensity of illumination. A dark and well-defined boundary separates the two parts of the field except where it is cut by the symmetry plane. This boundary becomes more conspicuous away from the symmetry plane in either direction. This boundary separates directions in which ordinary waves give rise to extraordinary waves from those which do not. A slight change in the above arrangement enables one to observe the boundaries at which reflections and refractions respectively of extraordinary waves as ordinary terminate. For this purpose the illuminated screen was held to one side so that the reflected or refracted light came into view and the boundary was seen as a luminous arc separating a bright from a dark field and cut into two halves by the symmetry plane. Figs. 6 and 7 show the reflection and refraction boundaries respectively. Fig. 8 demonstrates the critical transmission boundary recorded with a vertical polaroid in front of the rhomb. Observations with polarised light establish the origin of all these boundaries.

Fig. 9, *Plate XV*.—The calcite rhomb is held in the same manner as indicated for recording Fig. 5 and a linear source is viewed through it. On turning the rhomb about the vertical axis, a stage is reached when incident light grazes the twinning layer and, in addition to the refracted image, a reflected one simultaneously comes into view. Polarisation studies show that extraordinary waves are reflected and refracted as ordinary to give these images. The right and left halves of Fig. 9 represent reflected and refracted images respectively, drawn out into spectra, channelled by interferences and interrupted by the symmetry plane which is horizontal. The plane of the twinning layer is vertical and separates the refracted and reflected wave-trains.

Figs. 10, 11 *and* 12, *Plate XV.*—These have been recorded in the same manner as Figs. 6, 7 and 8, but much away from the symmetry plane. Fig. 10 exhibits the interference fringes accompanying the critical reflection boundary and Figs. 11 and 12 those seen with the critical transmission boundary.

Figs. 13 *and* 14, *Plate XVI.*—These have been photographed in the following circumstances: a narrow slit backed by white light is viewed through the opposing faces of a twinned crystal. In Fig. 13, the two deviated images drawn out into spectra and channelled by two sets of interferences are seen, the central one remaining colourless. The difference in the dispersive powers for ordinary and extraordinary indices results in these dispersed spectra. The two species of interferences arise respectively from phenomena of the same nature as those exhibited by crystalline plates in polarised light and those shown by thin plates. Fig. 14 is an enlarged photograph of one of the deviated images showing dispersion and the two species of interferences.

Fig. 15, *Plate XVI.*—This was taken by arranging the illumination from an extended source of monochromatic light on the calcite rhomb in such a manner that direct transmitted light is received from above, and refracted light by oblique incidence from below. The interference fringes in the optical fields of transmission and refraction are then seen simultaneously. They are clearly seen to be complementary.

In conclusion, the author wishes to express his thanks to Professor Sir C. V. Raman for suggesting the problem and for the many helpful hints he gave me during the course of the experiments.

§3. Summary

The paper reproduces illustrations of various optical effects displayed by twinning layers in iridescent calcite. Brief descriptive notes are appended.

§4. Reference

1. Raman and Ramdas .. *Proc. Ind. Acad. Sci.*, 1954, **40**, 1.

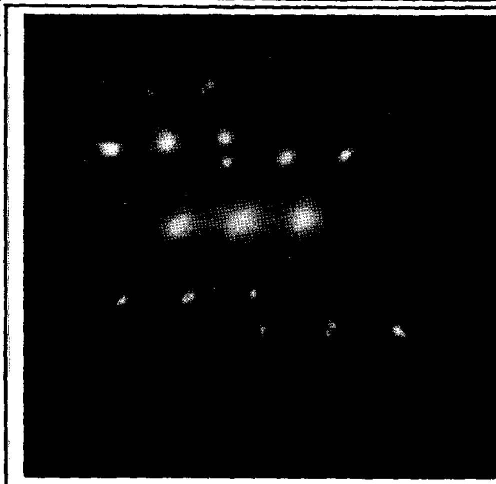

FIG. 1

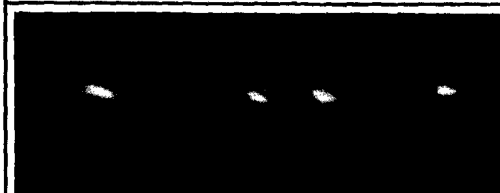

FIG. 2

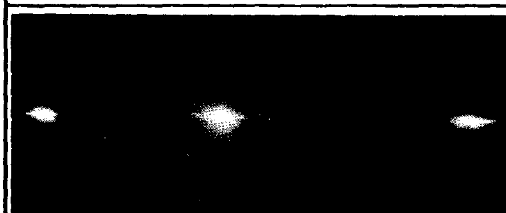

FIG. 3

FIG. 4

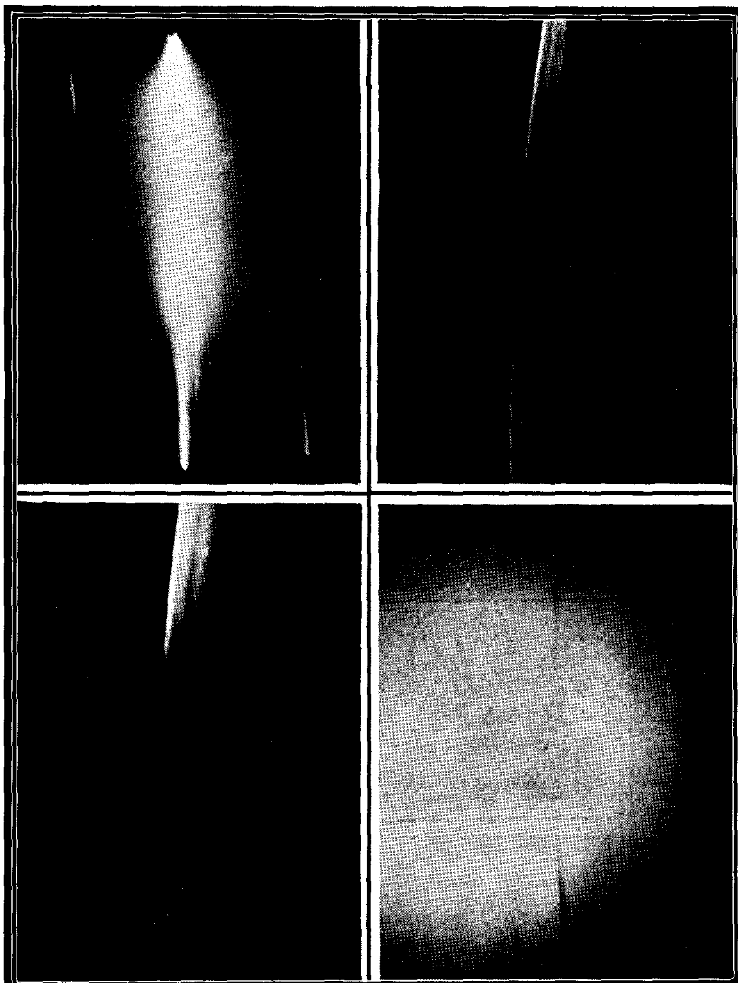

FIG. 5

FIG. 7

FIG. 6

FIG. 8

FIG. 9

FIG. 11

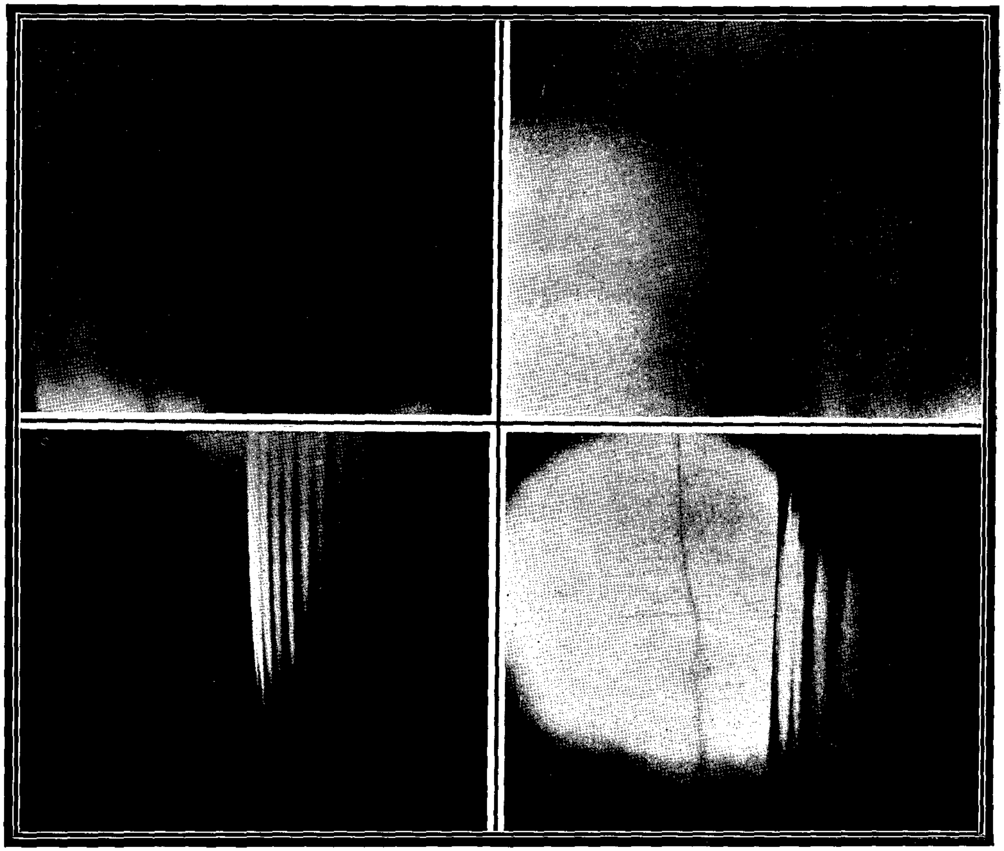

FIG. 10

FIG. 12

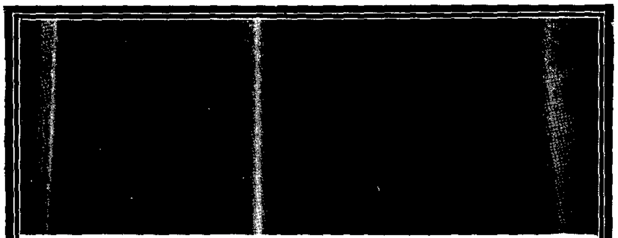

FIG. 13

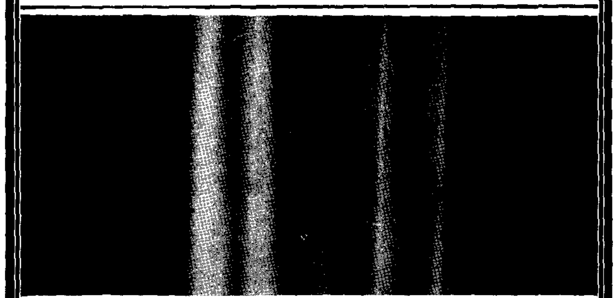

FIG. 14

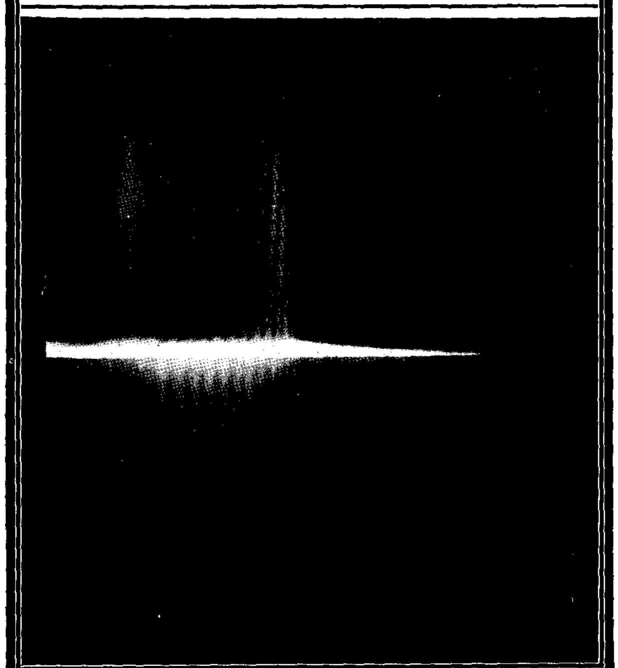

FIG. 15