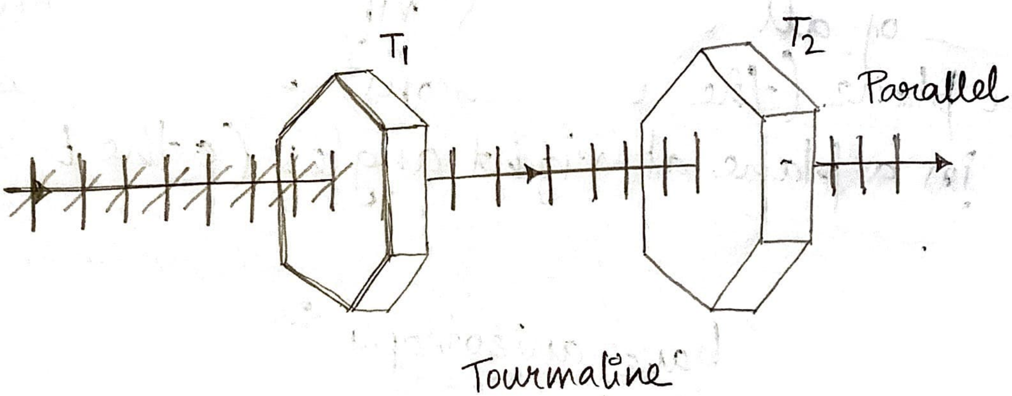
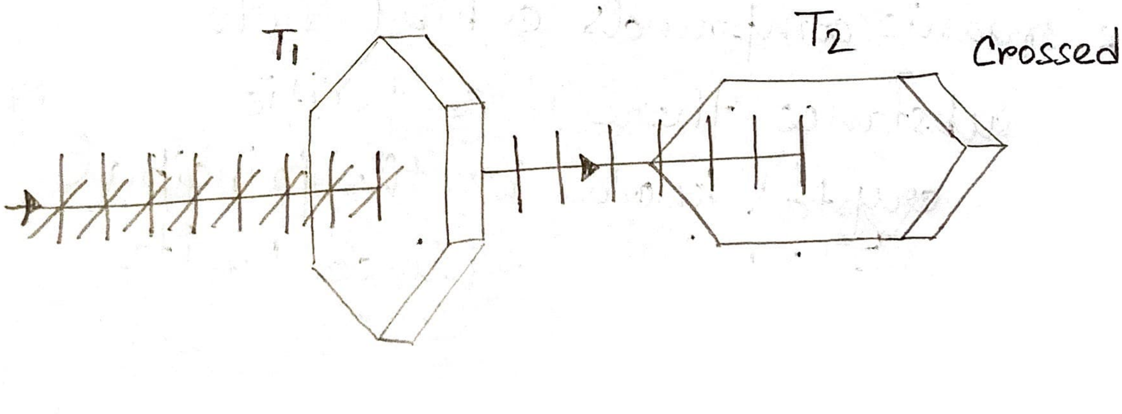
DICHROISM :-

Dichroism refers to the selective absorption of one of the two orthogonal plane-polarized state components of an incident unpolarized beam, by crystals like tourmaline.





When a pencil of ordinary (unpolarized) light is sent through a thin slab of tourmaline like T_1, the transmitted light is polarized.

This can be verified by a 2nd crystal T_2:
When T_1 & T_2 are parallel (transmission axes) to each other the light transmitted by the 1st crystal is also transmitted by the 2nd. When the 2nd crystal is rotated by 90°, no light gets transmitted by the 2nd.

The above is due to a selective absorption by tourmaline of all light rays vibrating in one particular plane (the O vibrations) but not those vibrating in a plane at right angles (the E vibrations).

Dichroic Crystals have anisotropy in their crystalline structures. A no. of mineral crystals & some organic compounds exhibit dichroism.
In this substance there is a specific direction within the crystal known as the principal or optic axis, which is determined by its atomic configuration.
The elec. field component of an incident lightwave that is perpendicular to the

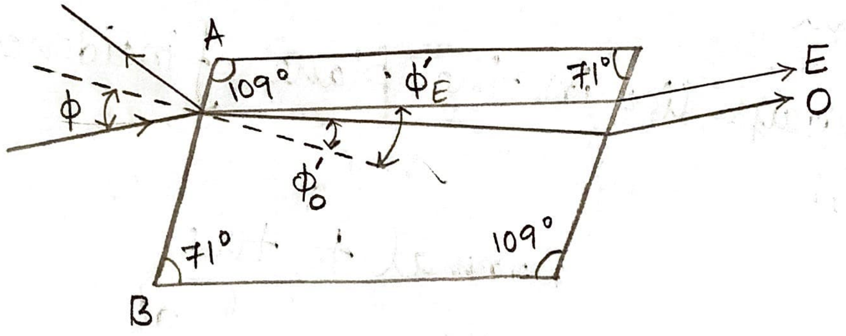
principal axis is strongly absorbed by the crystal. The crystal then acts as a linear polarizer, as the principal axis of the crystal becomes the polarizer's transmission axis.

DOUBLE REFRACTION / BIREFRINGENCE :

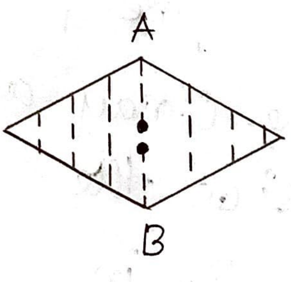
When a beam of unpolarized light is incident on a calcite or quartz crystal, there will be, in addition to the reflected beam, two refracted beams. ~~in place of the usual~~

This phenomenon is called double refraction, or birefringence.

The refracted ray for which the Snell's law of refraction holds is called the ordinary or O ray & the other is called the extraordinary or E ray.



(a)



(b)

Principal planes (a) cross-section
(b) end-view

Calcite ($CaCO_3$) crystals are found in simple rhombohedral shape, where ~~ac~~ each face of the crystal is a parallelogram whose angles are 78°5' & 101°55'.

Calcite crystals can be struck & made to break along cleavage planes into two or more smaller crystals which always have faces that are parallelograms with oppo. angles of 71° & 109°.

Quartz crystal is pure silica (SiO_2), found in many diff. crystal forms.

Since the two oppo. faces of a calcite crystal are always parallel, the two refracted rays emerge parallel to the incident beam & therefore parallel to each other.

The O-ray always lies in the plane of incidence inside the crystal.

If the incident ray is normal to the surface, the E-ray will be refracted at some angle that is not zero & will emerge from the crystal parallel to the incident ray but displaced from it. The O-ray will pass straight through without deviation.

OPTIC AXIS :

Calcite and quartz are anisotropic crystals, i.e., crystals in which the physical properties vary with direction inside the crystals.
Inside calcite & quartz crystals there is a single direction called the optic axis, such that, if any property, is measured for different directions, it is found to be the same along any line perpendicular to the optic axis.
At any other angles, the property changes, reaching a max. or min. along the axis.

The optic axis is not a particular line through the crystal but a direction. For any given point in the crystal, an optic axis may be drawn which will be parallel to that for any other point.
Crystals having a single optic axis are said to be Uniaxial crystals.
Eg: calcite, quartz.

Double refraction in uniaxial crystals disappears when light is made to enter the crystal in such a way that it travels along the optic axis. There is no separation of O & E rays in this case, as the velocities of both are equal.

The same applies for directions at right angles to the ~~axi~~ optic axis, but in this case the O & E rays have different velocities.
The velo. of the O-ray is the same in all directions within the crystal, and the velo. of the E-ray is diff. in diff. directions.

PRINCIPAL SECTIONS & PRINCIPAL PLANES:

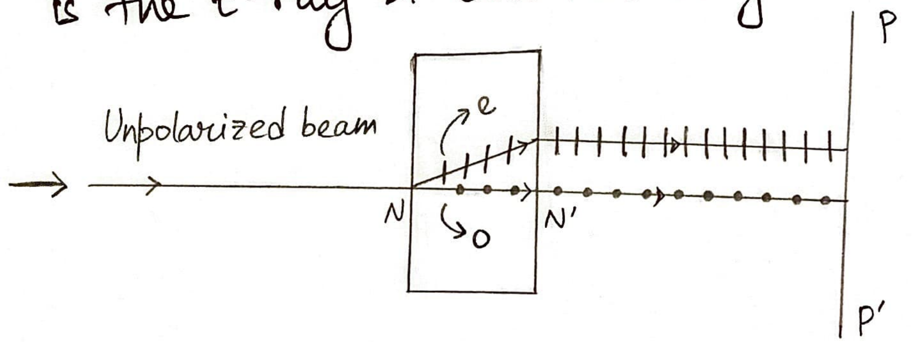
Principal section of a crystal is a plane ~~made by~~ containing the optic axis & normal to any two opposite cleavage faces.
Thus for a point in calcite, there are three principal sections, one for each pair of oppo. crystal faces. A principal section of a calcite crystal always cuts the surfaces ~~of a~~ in a parallelogram with angles of 71° & 109°.
All other planes parallel to ~~the~~ a principal section are also principal sections.

Principal plane of the O-ray is a plane containing the optic axis & the O-ray.
Principal plane of the E-ray is the one containing the optic axis & the E-ray.

The O-ray always lies in the plane of incidence. The principal planes of the two refracted rays do not coincide ~~exp~~ except for cases in which the plane of incidence is a principal section.

POLARIZATION BY DOUBLE REFRACTION :-

When an unpolarized light beam is incident on a calcite crystal, it usually splits up into two linearly polarized beams.
For a normal incidence, the beam which travels underiated is the O-ray & obeys Snell's laws of refraction.
The 2nd beam ~~gets~~ travels after getting deviated is the E-ray & does not obey Snell's laws.



If a polaroid PP' is placed behind the calcite crystal & rotate about NN', then it is seen that for two positions of the polaroid (when its transmission axis is perpendicular to the paper), the e-ray will be completely blocked & only O-ray will pass through.

Again when the transmission axis of the polaroid is in the plane of the paper (along PP') then the O-ray will be completely blocked & only the E-ray will pass through.

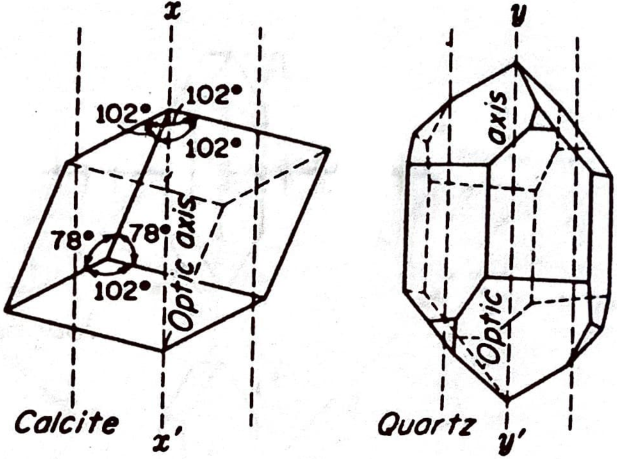


FIGURE 24I
Calcite and quartz crystal forms. The direction of the optic axis is indicated by broken lines.

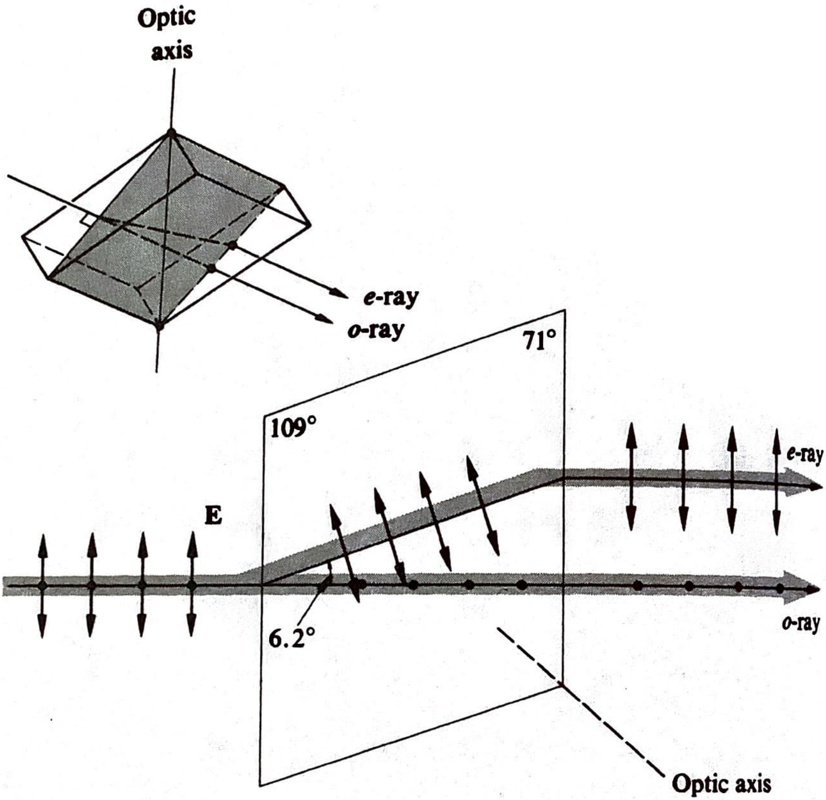


Figure 8.19 A light beam with two orthogonal field components traversing a calcite principal section.

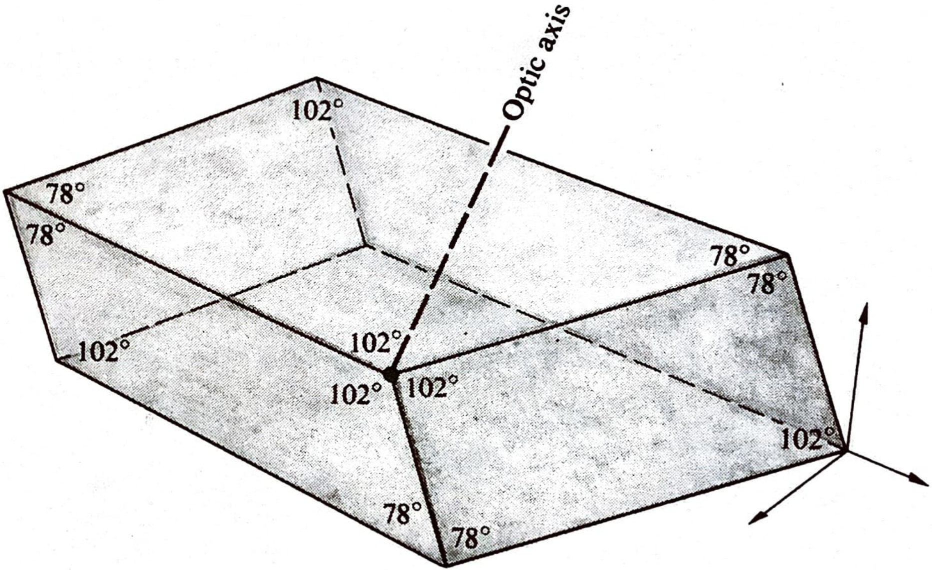


Figure 8.18 Calcite cleavage form.