

Quadrant III – Notes

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Subject	: Geology
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Course Title	: Mineralogy
Unit	: IV
Module Name	: Uniaxial Indicatrix
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Notes:

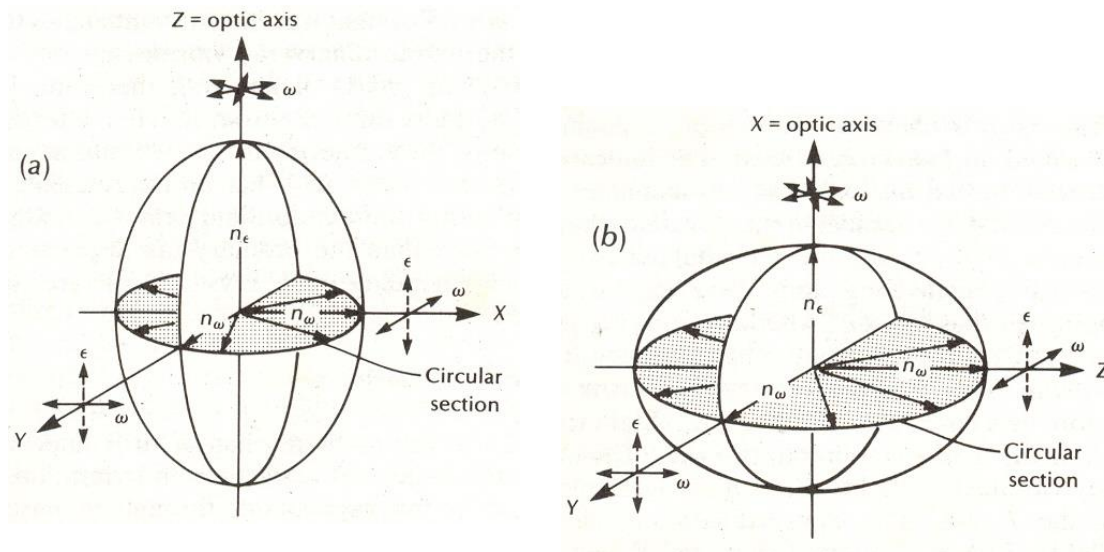
UNIAXIAL INDICATRIX:

In crystals belonging to the tetragonal and hexagonal systems, there is only one direction along which a ray of light does not suffer double refraction. In all other directions, a ray is split into two plane-polarized rays vibrating in mutually perpendicular planes and having different refractive indices. When several sections of a mineral are examined, we find that one of the two refractive indices has a constant value. *This is the refractive index of the ordinary ray and is denoted by the Greek letter ω (omega). The refractive index, which varies from section to section, is that of the extraordinary ray, denoted by the Greek letter ϵ (epsilon).* Either one of these may be greater than the other.

When a figure is constructed by using the values of refractive index as radii in the respective directions of vibration we obtain an ellipsoid of rotation. This is the optical indicatrix of a uniaxial crystal.

The ellipsoid has a single circular section whose radius is equal to ω . The semi axis normal to this section may be greater or smaller than the radius of the circular section. If it is greater, the ellipsoid is prolate, ($\epsilon > \omega$), and the mineral is *optically positive*. If it is smaller, the ellipsoid is oblate, ($\epsilon < \omega$), and the mineral is *optically negative*. The direction normal to the circular section (and coinciding with the crystallographic c-axis) is the optic axis of the crystal. Light incident normal to the surface of a section cut at right angle to the optic axis, will be vibrating in the plane of the circular section of the indicatrix, wherein “n” is the same

in all the directions. Hence it will not be doubly refracted and the mineral section will behave as if it were isotropic. The refractive index of such a ray will always be ω .



Prolate Spheroid
(Positive uniaxial indicatrix)

Oblate Spheroid
(Negative uniaxial indicatrix)

Light incident normally on the surface of a section cut in any other direction will be doubly refracted. Let us consider a beam of light incident on a surface, which is not at right angles to the optic axis. The section of the ellipsoid cut normal to the beam of light will be an ellipse. The major and minor axes of this ellipse mark the vibration directions of the two refracted rays; the magnitudes of these semi-axis gives the values of their respective refractive indices.

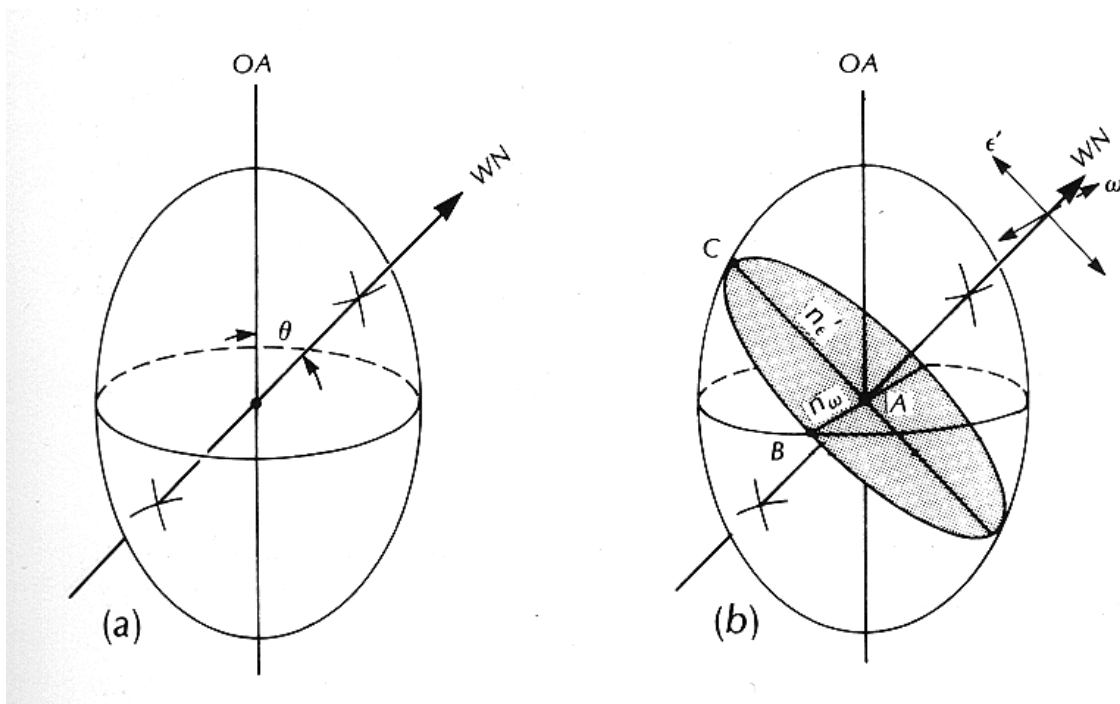
All elliptical sections of the indicatrix will have one semi-axis the same and equal to the radius of the circular section. i.e. the refractive index is the same as that for the ray incident parallel to the optic axis. This represents the ordinary ray refractive index ω .

The length of the other semi-axis varies from section to section, the value ranging between two extremes given by (1) the radius of the circular section and (2) the length of the ellipsoid semi-axis normal to the circular section. The variable semi-axis of the elliptical section represents the refractive index of the extraordinary ray, ϵ .

It is to be noted that any ray traversing a uniaxial crystal is split into two plane polarized rays, the extraordinary ray vibrating in the plane containing the ray direction and the optic axis. The vibration of the ordinary ray is always at right angles to that of the extraordinary ray.

A section of the indicatrix, which contains the optic axis, is the most elliptical and therefore those mineral sections, which are cut parallel to the optic axis, show the maximum birefringence i.e. $|\omega - \epsilon|$. This is also referred to as the birefringence of the mineral.

As the section of the mineral becomes more and more inclined to the optic axis, the ellipticity of the corresponding indicatrix section decreases, i.e. the birefringence decreases. The limiting value of birefringence is zero, which is given by a section normal to the optic axis for which the corresponding indicatrix section is circular. From the above it is evident that different sections of a uniaxial mineral will show varying birefringence depending on their inclination to the optic axis. It is also clear that the correct value of epsilon can be determined only in a section containing the optic axis.



Random section through the uniaxial indicatrix will give n_ω and $n_{\epsilon'}$.

