Module B. Colour from the Cosmos

Lesson 12: Colour, Light and Optics 1

Anisotropic Minerals and Double Refraction

Anisotropic minerals are those that exhibit more than one refractive index. Materials that belong to the tetragonal and hexagonal crystal systems have two distinct refractive indices and those of the monoclinic, triclinic, and orthorhombic systems have three distinct refractive indices. The orientation of these refractive indices is related to the unique crystal structure of each mineral, and the absolute difference between the refractive indices is called birefringence, Δ*n*:

A result of this anisotropy is that light entering an anisotropic medium will be split into two distinct light rays. In media with a high birefringence, the difference between the refractive indices is large and the difference in lights paths is significant. Consequently, light transmitted through the medium appears "doubled" (see figure below). In media with a low birefringence, the difference between refractive indices is small and the difference in lights paths is minimal; consequently the resulting image looks more blurry than doubled.

Double refraction of printed text as viewed through a single calcite crystal. The doubling of text is due to the high birefringence of calcite (Δn = 0.172).

The concepts of isotropy and anisotropy are very useful in identifying gemstones. With the proper observations many different species can be ruled out using this physical property of a gemstone.

Titanite is a rare gem mineral (but common mineral) that has a high birefringence (Δn = ~0.105) and in this photo you can see the doubling of the gem's rear facets. If you were to see this optical effect in a gemstone, no matter how subtle, it means the gemstone is anisotropic (ie, has more than one refractive index and is NOT isotropic). Titanite also has decent dispersion and although this idiochromatic gem has a strong green colouration, some 'fire' can still be seen near the center-left of the gemstone. Photo courtesy of Smithsonian Institute.