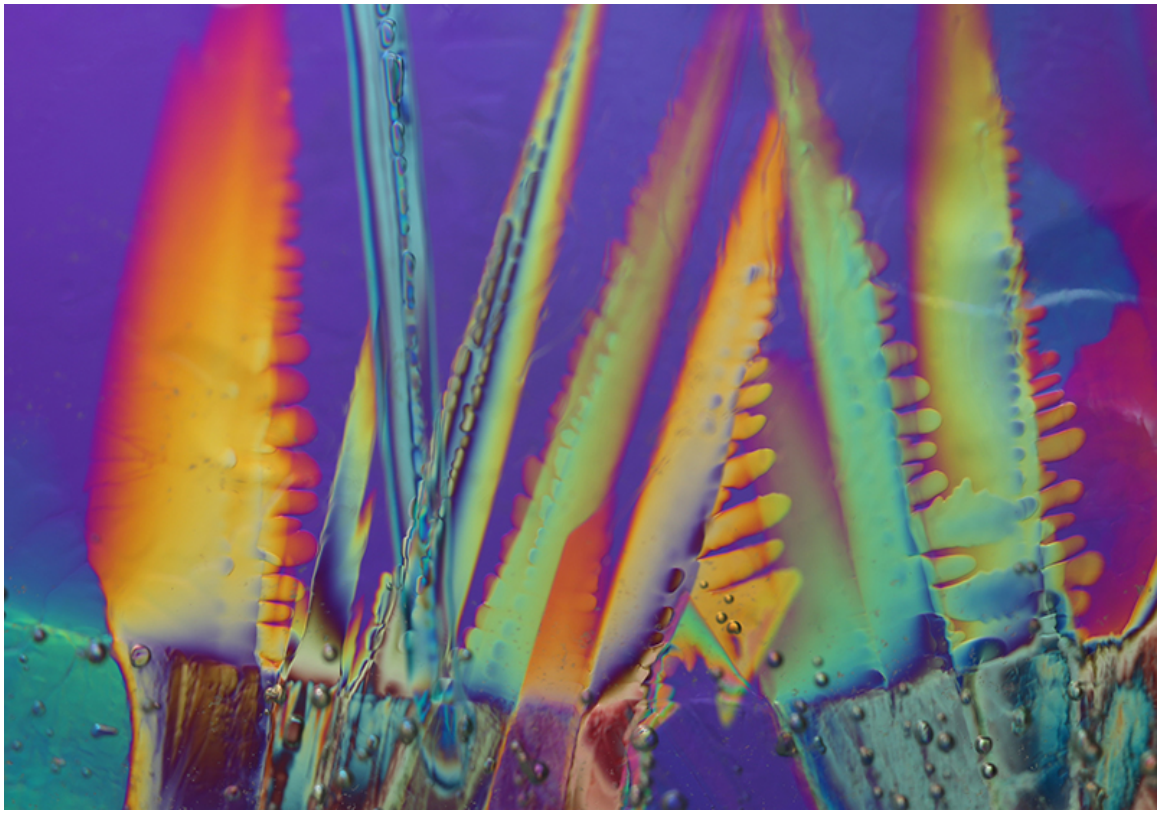
Intro to Polarized Light

: using polarizers to look at materials in a different light.

by
Ted Kinsman
Assistant Professor
Department of Photographic Sciences
Rochester Institute of Technology
February, 2017



Amazing colors can be created in frozen ice crystals. Here ice crystals begin to form as the water freezes. The water was placed in a clear glass petri dish between two polarizing filters. Photographed at about 1x magnification.

Polarized light is light that has waves oscillating all in the same direction. There are two basic ways to get polarized light, from reflection or by using a filter. When light reflects off water or any other flat surface the light becomes polarized in one direction. It is common for fishermen to used polarized glasses to block the reflected polarized light which causes glare so they can see below the water better. The second and most common way to produce polarized light is with a polarizing filter. Polarizing filters were invented by Edwin H. Land in the 1930's. Land developed an inexpensive process to align polarizing crystals and fix them into

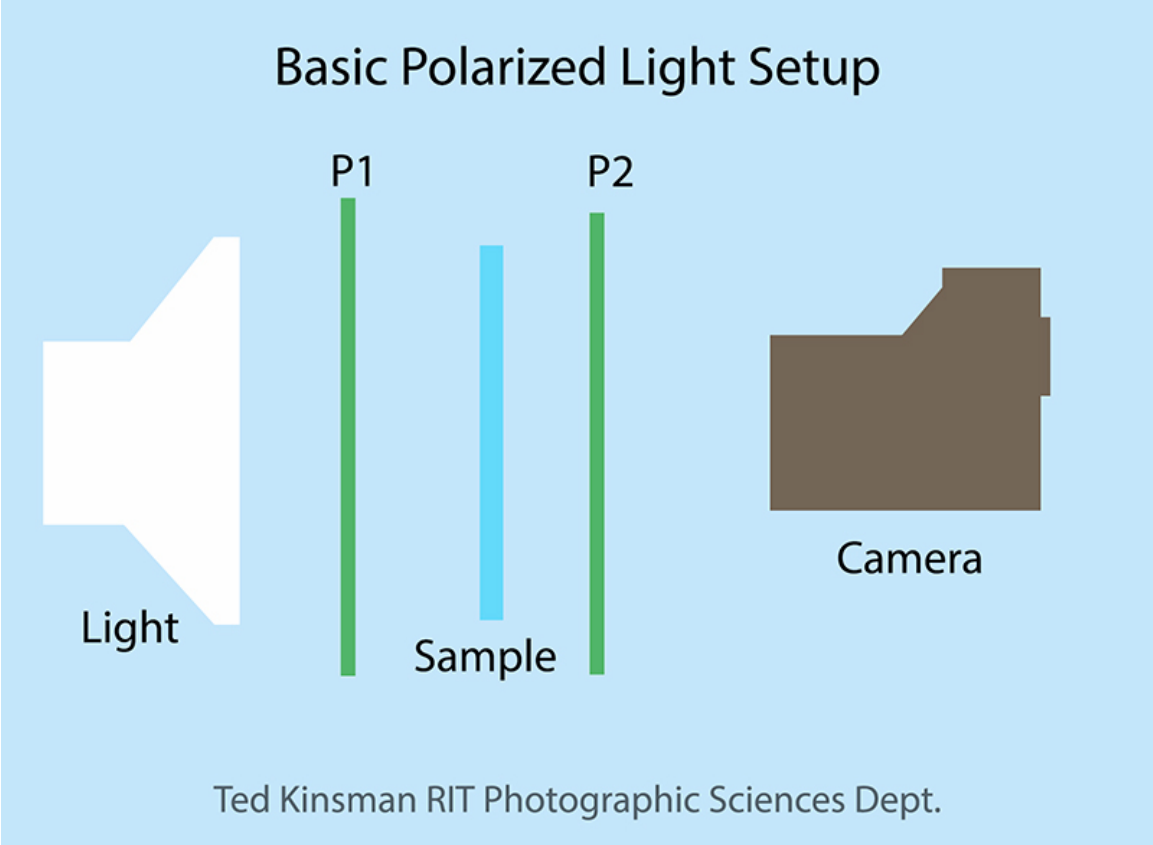
position with a binder. This polarizing filter became the standard for photographic and industrial processes.

Two images of the identical scene. The left image has no polarizing filter, while the right image has a polarizing filter rotated to block the reflected light. Light reflected off the surface of water is strongly polarized, or vibrating in the same direction.

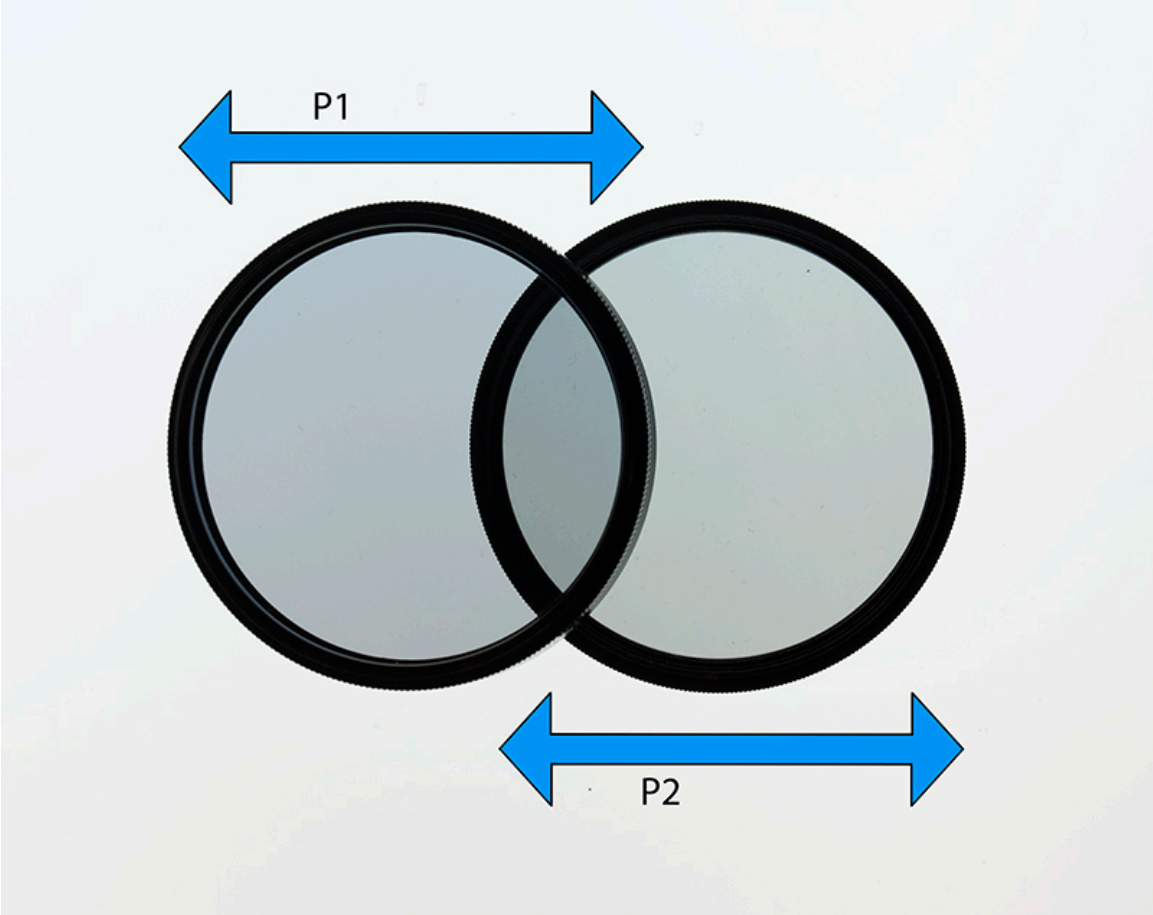
To experiment with polarized light, you will need two polarizers, these can be easily purchased on the internet. There are also other sources for polarizers, like the glasses from a 3D movie or even an old pair of polarizing sunglasses. For best results, try to obtain two relatively large sheets 3 to 4 inches across.

Many materials show internal stress when illuminated with polarized light and photographed with a second analyzing polarizer. This unique property of materials is called birefringence and is caused by the polarized light interacting differently with the stressed material, compared to the unstressed parts. Some of the more common material that exhibits this property are glass, ice, plastic, and many types of minerals. The full list of materials would include thousands of entries.

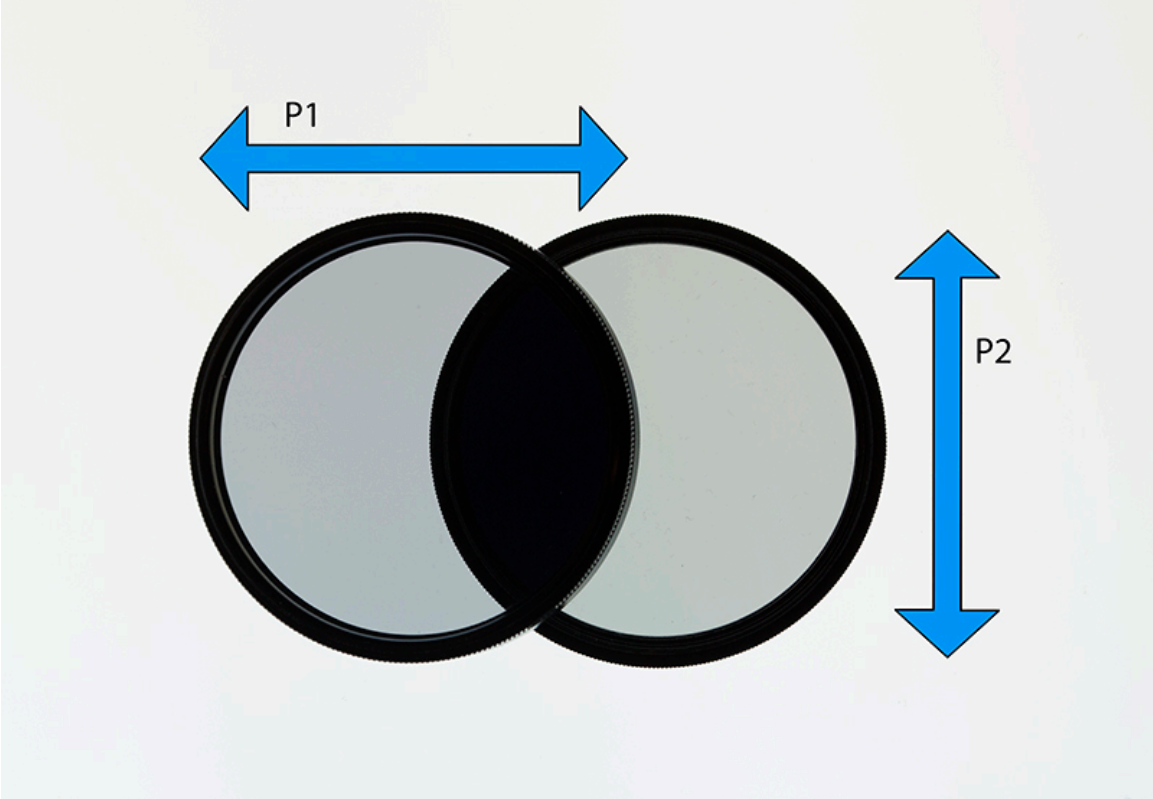
To observe the effects of polarized light on a material, the material is placed between two sheets of polarizing material. The first filter is called the polarizer while the second filter is called the analyzer. If the second filter is placed at a 90-degree angle to the first, the light passing through is almost completely eliminated. The second sheet of polarizing material does not have to be in contact with the sample; it can be placed in front of the observer's eye or in front of a camera. Without the analyzer, you would not be able to observe the birefringence in a sample. I like to think of these systems as a polarizing sandwich where the meat is the object showing the stress, while the bread represents the polarizers.



Equipment setup. P1 is the first polarizing sheet (polarizer), P2 is the second polarizer (analyzer) and on the far right is the camera. The sample is placed between the two polarizing sheets.

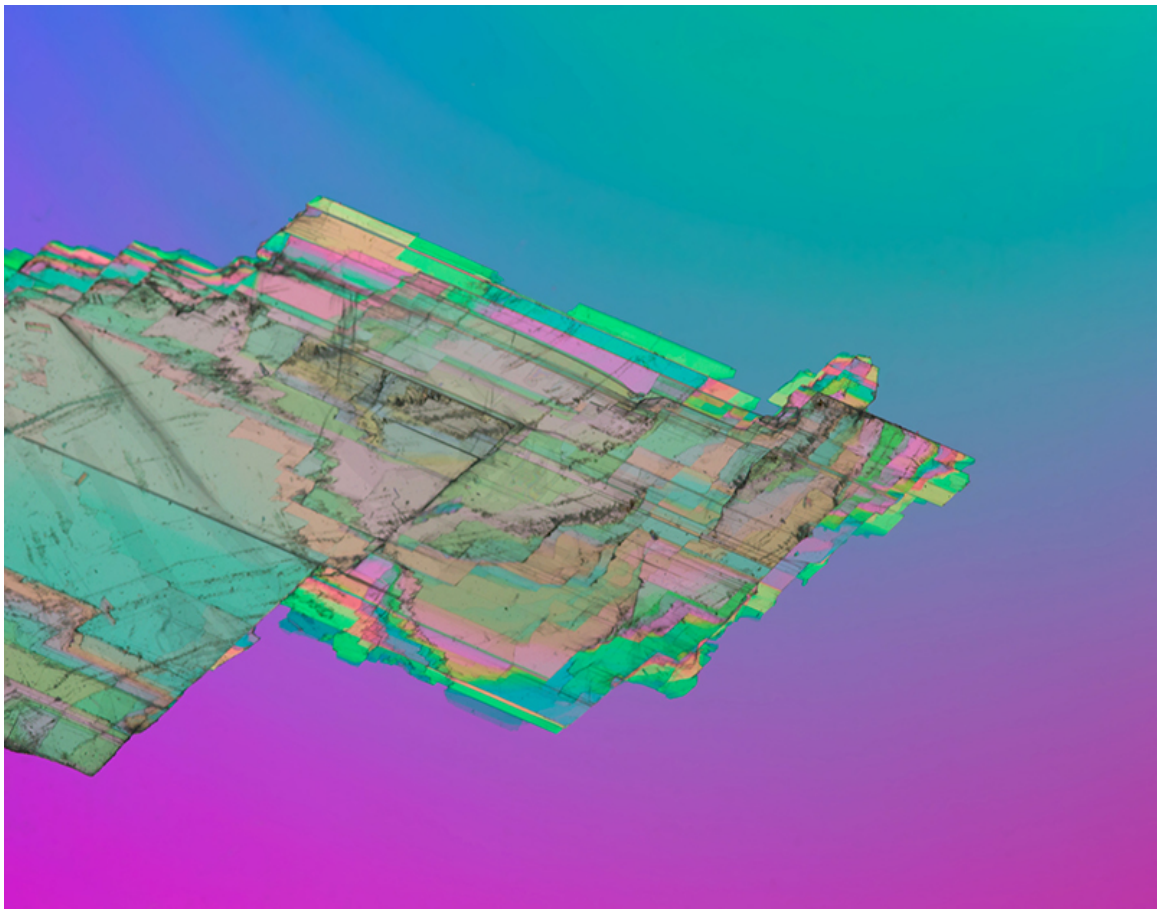


Two polarizers are aligned in the same direction. This orientation allows light to travel. Note: the center section is just a little darker.

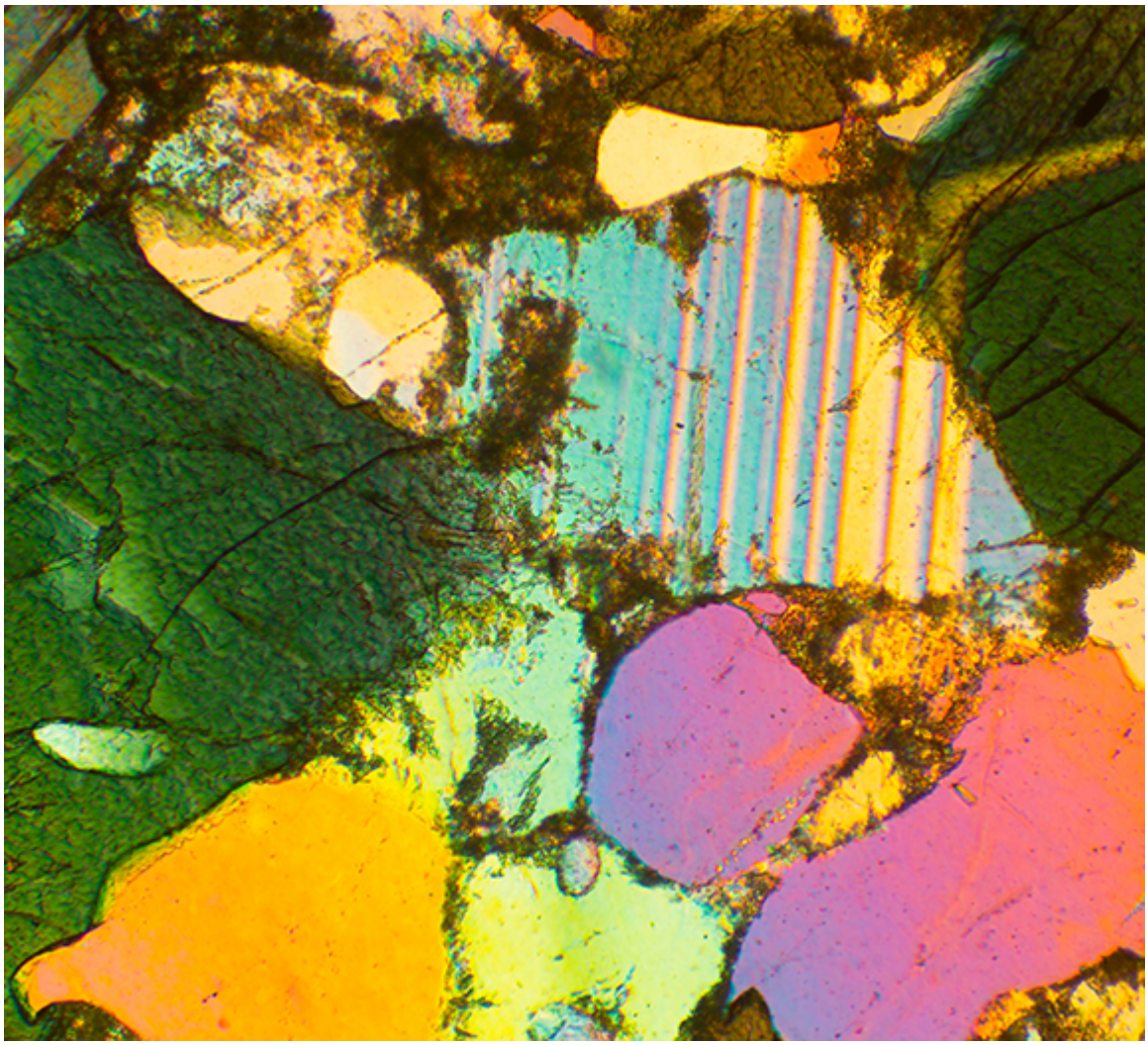


Here the second polarizing filter on the right is rotated 90 degrees to the one on the left. This orientation blocks most of the light.

Here the polarizing filters are in the same orientation as above, but an injected plastic petri dish is placed between the two filters. The stress caused from the manufacturing process allows different colors to pass through. This process is called birefringence and most plastics will exhibit this effect.

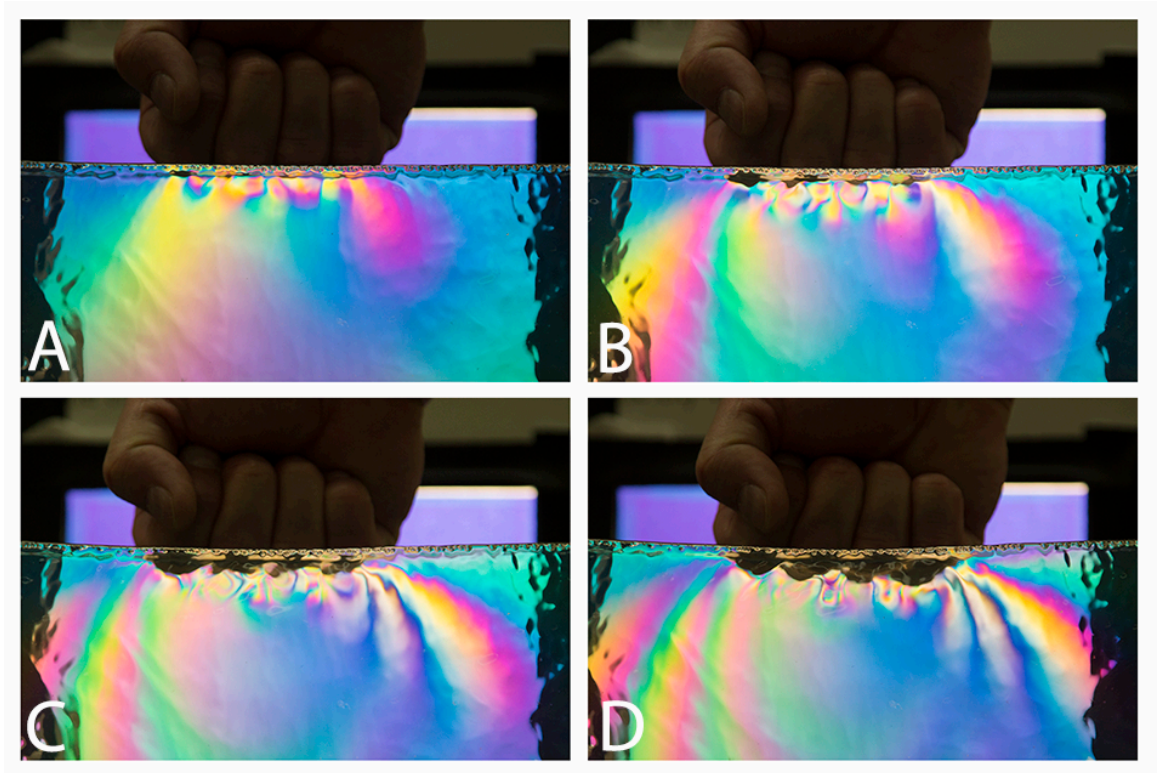


Gypsum crystals demonstrate birefringence, here the different thicknesses of the crystal show up as different colors. The rock sample is placed between two polarizing filters and is about 2 inches wide in this image.

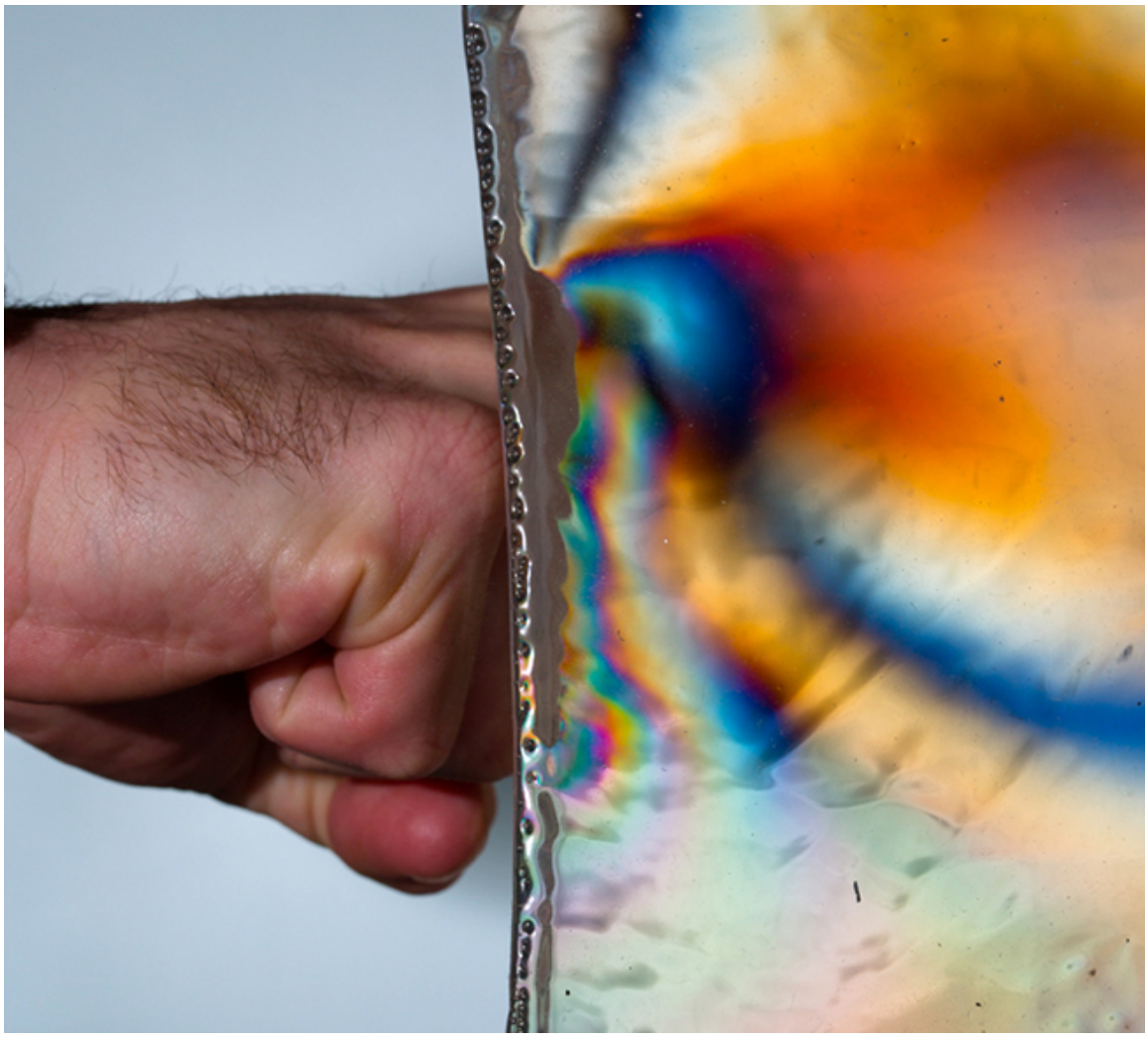


For many years, minerals have been identified by the way thin section sections of rock interact with light in a special polarizing microscope. Here is a sample of hornblende photographed at 80x magnification.

A close-up view of the stress created by a C-clamp with pressure applied to a block of glass.



A sequence of four punches shown at different timings. The pressure from the punch creates stress in a clear plastic gel which in turn exhibits the birefringence. You can see the polarizing filter in the background, while the second filter is in front of the lens on the camera.



A karate punch is visualized in polarized light with the help of a large block of ballistic gel. The gel is basically a polymer that exhibits birefringence. The force of the punch can be clearly visualized with polarized light to show the stress in the gel; created by the punch. This ballistic gel is created to simulate human flesh.

Sources:

Polarizing Sheet
Rosco Polarizing #7300 Filter - 17x20" Sheet
http://www.bhphotovideo.com

Also available from numerous suppliers
On http://www.Amazon.com