Sheffield Red Compensator®
User Guide

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Introduction

The Sheffield Red Compensator (SRC) is a combination polariscope, first-order red compensator[1], and loupe. In addition to the usual features of a polariscope, it enables the gemmologist to determine a gemstone's optical character without resorting to a refractometer (making it especially useful for rough and cabochon-cut gems). The SRC will also highlight inclusions and the stress-induced birefringence they can produce within a stone.

[1] The 'first-order red compensator' has many names, including: 'first-order compensator'; 'first-order retardation plate'; 'first-order red plate'; 'first-order plate'; 'full wave red compensator'; 'full wave compensator'; 'full wave retardation plate'; 'full wave red plate'; 'full wave plate'; 'red tint plate'; 'red-one plate'; 'red-1 plate'; 'lambda plate'; 'gypsum plate'; 'selenite plate'; 'quartz plate'; 'violet compensator'; 'violet plate'; 'sensitive red plate'; 'sensitive colour plate'; 'sensitive tint plate'; 'delay filter'; and 'delay plate'.

Using the Sheffield Red Compensator

Setup

As with a standard folding polariscope, the SRC needs to be placed on a flat-light. The SRC is compatible with the Portable LED Flat Light sold by *Gem-A Instruments*. But if space is at a premium a phone or tablet can be used instead. In this case, page three of this guide can be used as an image to display on the device. Make sure to turn the screen brightness to maximum and that any auto-lock feature allows sufficient time to work. Also note that electronic screens are often polarised. The SRC's polarizer has been set at an optimal angle for most screens – assuming the SRC is placed along the length of the screen. But it is worth checking whether the light passing through the SRC is brighter when rotated 90°.

Determining optical character: *Anisotropy*

When a stone is rotated through 360° within a polariscope, one of three things happens:

- **The stone stays white.** Such stones are *polycrystalline* (composed of many crystals).
- **The stone blinks black and white four times.** Such stones are *optically anisotropic*. They are structured according to the *uniaxial* or *biaxial* crystal systems.
- **The stone stays black**. Such stones are *optically isotropic*. They are structured according to the *cubic* crystal system, or else have little structure at all (for *amorphous* stones such as glass). However, stones that would normally blink may sometimes stay black because of the particular angle they are rotated around. It is therefore important to double-check the result by rotating the stone at a different angle.

The slight difference with the SRC is that the background colour is not black but violet. *Anisotropic* stones will therefore blink violet and white (or at least a pale yellow) as they are rotated.

Isotropic stones such as garnets do sometimes blink as they are rotated. This anomalous result is typically caused by strain within the crystal (which might arise from an inclusion). So, to be certain that a stone is *anisotropic*, and to distinguish between *uniaxial* and *biaxial* crystals, it is useful to resolve a stone's *interference figure*…

Determining optical character: *Interference figures*

When an *optically anisotropic* stone is examined within a polariscope a colourful flash of light may be seen. This occurs when the stone is viewed along an *optic axis*. *Uniaxial* crystals have one *optic axis*; and *biaxial* crystals two. It might be assumed, therefore, that finding an *axis* would be easier with *biaxial* crystals. But for *uniaxial* stones we have some pointers on where to look:

- Rough crystals have their *optic axis* parallel to their *c-axis* (i.e. their length).
- Natural corundum is typically faceted with its *optic axis* perpendicular to the table. This presents the richest colour when viewed from above.
- Tourmaline is often faceted with its *optic axis* parallel to the table (to present a lighter colour) and parallel to the stone's longest side (to maximise yield).

But why look for an *optic axis* at all? Because when a conoscope is placed above the flash of light, the colours are 'resolved' to form a diagnostic pattern. These patterns, known as *'interference figures'*, indicate whether a crystal is *uniaxial* or *biaxial*. They can also identify crystals of quartz, which has its own set of *interference figures*.

The Sheffield Red Compensator gives us a further advantage by separating *negatively-* and *positively-birefringent* crystals (as illustrated by the *interference figures* on the following pages).

Fig 1. What can be determined with a polariscope?

Standard polariscope	Sheffield Red Compensator
Uniaxial crystals	Uniaxial negative crystals
	Uniaxial positive crystals
Biaxial crystals	Biaxial negative crystals
	Biaxial positive crystals
Quartz	Quartz

Fig 2. Uniaxial negative crystals (this image is printed on the SRC).

This *interference figure* is characterised by:

- Two violet bands (known as '*isogyres*') that form a "cross pattée" pattern.
- Dark bands in the upper-right and lower-left quadrants of the cross.
- The upper-left and lower-right quadrants being more colourful.

Fig 3. Uniaxial positive crystals.

This *interference figure* resembles the figure for *uniaxial negative* crystals but with the quadrants switched round (or with the image rotated 90°).

Fig 4. Quartz crystals.

This *interference figure* is characterised by:

- Violet *isogyres* that do not cross but instead form a "bullseye" pattern.
- Dark bands in the upper-left and lower-right quadrants.
- The upper-right and lower-left quadrants being more colourful.

For *biaxial* crystals, the coloured bands will be more tightly packed around the *'melatope'* (the centre of the pattern). This makes it especially important to focus on the innermost sets of coloured bands (up to third black / pink band).

Fig 5. Biaxial negative crystals (this image is printed on the SRC).

The *interference figure* for *biaxial crystals* will change as a stone is rotated about an *optic axis*.

With the violet *isogyre* crossing the *melatope* and curving to the upper-right:

- A dark band runs around the upper-right.
- The lower-left is more colourful.

As the stone is rotated the following *interference figures* may also be seen:

Fig 6. Biaxial positive crystals.

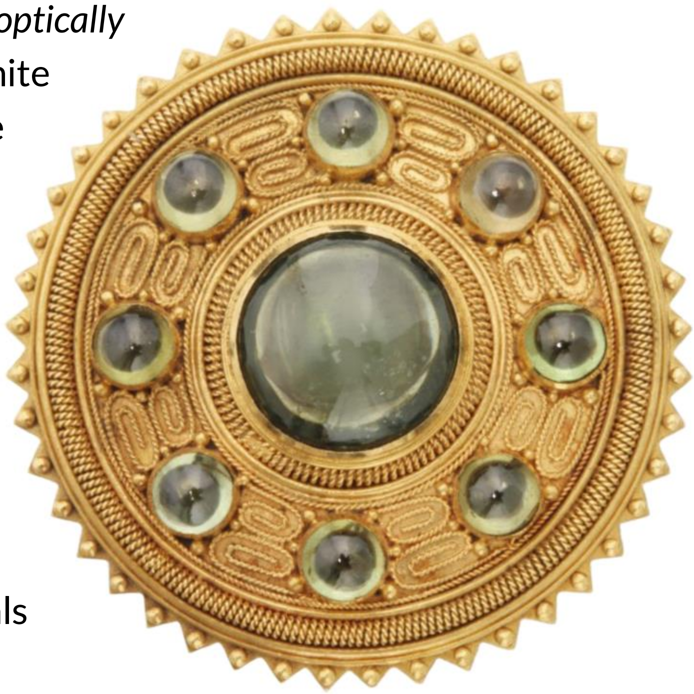
The *interference figure* for *biaxial crystals* will change as a stone is rotated about an *optic axis*.

In all cases, the *figure* for a *biaxial positive* crystal will resemble that of a *biaxial negative* crystal but with the colour of the bands switched round (or with the image rotated 90°).

Observing inclusions

Inclusions of a similar colour to the host gemstone are often easier to observe through a polariscope…

Where the inclusion and host are both *optically anisotropic*, both crystals will blink white and black as the stone is rotated. If the inclusion is white whilst the host is black, viewing the inclusion will be straightforward. But, if the inclusion and host blink in near unison, the standard polariscope will provide little advantage. The SRC may be more helpful, as it has a greater sensitivity to slight changes in *birefringence* (the property of *optically anisotropic* crystals that causes them to blink).



Gold & cabochon-cut zircon brooch, by Carlo Giuliano.

The SRC can also help with *optically isotropic* gemstones, which may show localised *birefringence* due to the internal strain arising from an inclusion.

Summary

Whilst the Sheffield Red Compensator is a useful tool for the observation of inclusions, it is in determining a gemstone's optical character that it excels. This is especially valuable in examining rough or cabochon-cut gems, or where the use of a refractometer is impractical.

Interference figure photographs

Fig 7. Topaz (*B+ interference figure*) with SRC on a portable flat-light.

With its violet *isogyre* crossing the *melatope* and curving to the upper-right, the centre of this *B+ interference figure* is surrounded by colourful bands to the upper-right and darker bands to the lower-left.

Fig 8. **Tourmaline (*U- interference figure*)** with SRC on a phone.

This *U- interference figure* has a violet “cross pattée” at its centre, surrounded by dark bands to the upper-right / lower-left and more colourful bands to the upper-left / lower-right. A grid of pixels from the phone’s screen can also be observed as a shadowy pattern underlying the *figure*.