‘Multiphenomenal’ Quartz from India

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Introduction

Chatoyancy and asterism are the optical effects often encountered in quartz group of gemstones; a special effect known as ‘diasterism’ is also frequently observed in this gem variety where asterism is visible in reflected as well as transmitted light. In general, six rayed asterism is encountered however, multi rayed asterisms have also been reported in greenish yellow varieties in the past originating from Sri-Lanka (see e.g. Schmetzer & Glas, 2003; Kiefert 2003.). As very well known, ‘chatoyancy’ is produced by the reflection of light from one set of parallel needle like inclusions while ‘asterism’ is due to the reflections from multiple sets of parallel inclusions, when cut as cabochons or spheres. In case of quartz, six-rayed asterism is producing by the inclusions lying in the basal plane perpendicular to the ‘c’ axis or ‘optic’ axis, while chatoyancy producing inclusions lie in the planes parallel to these axes. Recently, we at the Gem Testing Laboratory of Jaipur, India encountered an interesting specimen of yellow green quartz weighing 12.08 carats which displayed a strong chatoyant band as well as “ten-rayed” asterism.

Figure 1: This 12.08 ‘yellow green’ quartz displayed a strong chatoyant band was reportedly originated from the Kangayam- Karur belt in Tamilnadu state of India. Photo by G. Choudhary

Materials and Methods

The yellow green specimen of multiphenomenal quartz (figure 1) was submitted for identification at the Gem Testing Laboratory of Jaipur, India. The oval shaped specimen weighed 12.08 carats cut as a cabochon and measuring 15.72 x 11.83 x 9.65 mm. The owner of this stone expected it to be a chrysoberyl since it was mined out from the chrysoberyl mines in Olappalyam in the Kangayam-Karur belt in Tamilnadu. Standard gemmological tests were performed. Refractive index (RI) was measured using GemLED Refractometer. Hydrostatic specific gravity (SG) was measured using Mettler Toledo CB 1503 electronic balance. Exposure to standard long-wave (366 nm) and short-wave (254 nm) UV radiation were used to document fluorescence reactions. The spectrum was observed using a desk-model GIA Prism 1000 spectroscope. We examined the internal features of the samples with a binocular gemmological microscope, with fibre-optic light due to lower transparency of the sample.

Infrared spectrum in the 6000–400 cm^{-1} range at resolution of 4 cm^{-1} and 50 scans was recorded using a Nicolet Avatar 360 Fourier-transform infrared (FTIR) spectrometer at room temperature with a transmission accessory.

Qualitative EDXRF analysis was performed using PANalytical Minipal 2 instrument using two different conditions. Elements with low atomic number (e.g., Si) were measured at 4 kV tube voltage and 0.850 mA tube current. Transition or heavier elements were measured at 15 kV tube voltage and 0.016 mA tube current.

Results and Discussion

Visual Characteristics

The specimen had a bright medium yellow green body colour with a distinct chatoyant band visible at the centre of the stone with a bright vitreous lustre (figure 1); this appearance was very similar to that seen in chrysoberyl cat's eyes, the gem that was expected by the owner of this specimen. However, on turning the specimen in various directions and using fibre optic light we noted a ten-rayed star on sides at the dome (figure 2). The intersection point of this star was inclined approximately 45^{o} to the chatoyant band. Further turning the stone and viewing in direction perpendicular to this chatoyant band i.e. along the girdle end, two wavy rays were seen (figure 3), which intersected each other at slight angle. At an angle, both these effects were also seen together having their distinct emergence (figure 4) i.e. both of them were 'true' chatoyancy and asterism. In the previously documented samples the asterism merely displayed one of the bands of stronger intensity that appeared like a 'cat's eye' (e.g. Johnson & Koivula, 1999). The asterism in this specimen was only visible in reflected light and not in transmitted light i.e. it displayed 'epiasterism'

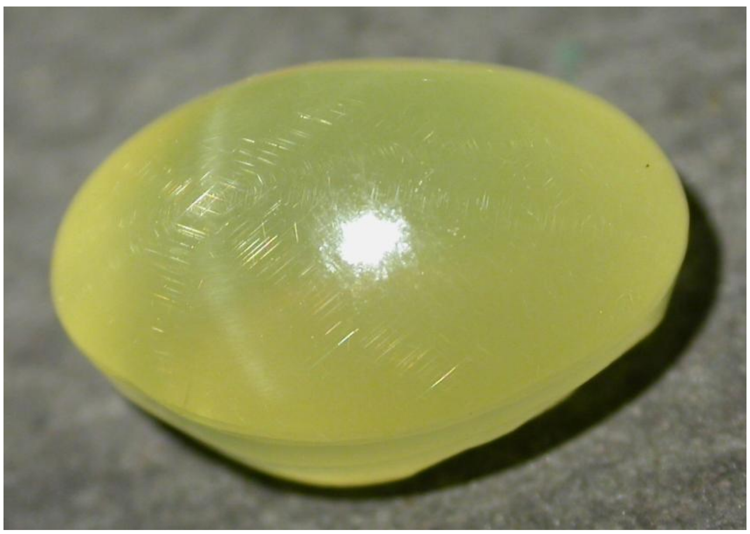

Figure 2: On turning the stone in figure 1 at approximately 45^{o}, pronounced asterism was seen with ten intersecting rays. Note one of the stronger and sharper rays. Photo by M.B.Vyas

Figure 3: When viewed from girdle side i.e. the direction perpendicular to the chatoyant band, two wavy rays were seen intersecting each other at very little angle. Photo by G. Choudhary

Figure 4: In one of the viewing directions, both the 'chatoyancy' and 'asterism' was observed indicating their true nature and not just the extension of each other. Photo by M.B.Vyas

Gemmological Properties

Under Polariscope, the sample displayed anisotropic reaction and a 'Bull's eye' optic figure at the girdle. This immediately identified the specimen as quartz; however other gemmological tests were performed for records. The results of standard gemmological tests are listed in table 1.

Table 1: Gemmological properties of 'Multiphenomenal' quartz tested at Gem Testing Laboratory, Jaipur India

Property	Description
Weight	12.08 carat
Colour	Yellow green
Optic character	Anisotropic; 'Bull's eye' optic figure
Refractive index (spot)	1.540
Specific gravity	2.64
UV fluorescence	Inert to both (LW & SW)
Absorption Spectrum	None
Internal features	Various sets of needles; in total five directions of parallel inclusions – giving rise to ten-rayed star • One directional (stronger) • Intersecting almost at 90^{o} • Intersecting almost at $60/120^{o}$ Fine flaky inclusions in one direction- giving rise to cat's eye effect
FTIR analysis	Absorption band from 3000 – 3700 cm^{-1} with peaks at 3592, 3539, 3480, 3435, 3380, 3310 and 3200 cm^{-1}
EDXRF analysis	Presence of Si, Fe, and Ca

Microscopic Observations

Examination of the specimen with microscope using fibre optic illumination revealed mainly long needles in various directions. Primarily, the needles appeared to be arranged in a random pattern; however with careful observation various sets of these needles inclusions were seen. One of the sets of these needles was arranged only in one direction and was much denser (figure 5) as compared to the others but this did not give rise to the main chatoyant band since, these were inclined to the chatoyant band as well as the 'c' axis. In addition to this, two different sets of intersecting needles were observed. One set comprised two-directional needles which intersected each other at an angle of nearly 90^{o} (figure 6.a) while in another set the needles appeared to be intersecting at approximately 60/120^{o} (Figure 6.b); the latter arrangement of inclusions is often observed in quartz and corundum. The appearance of these needles varied in appearance from white to brown and iridescent.

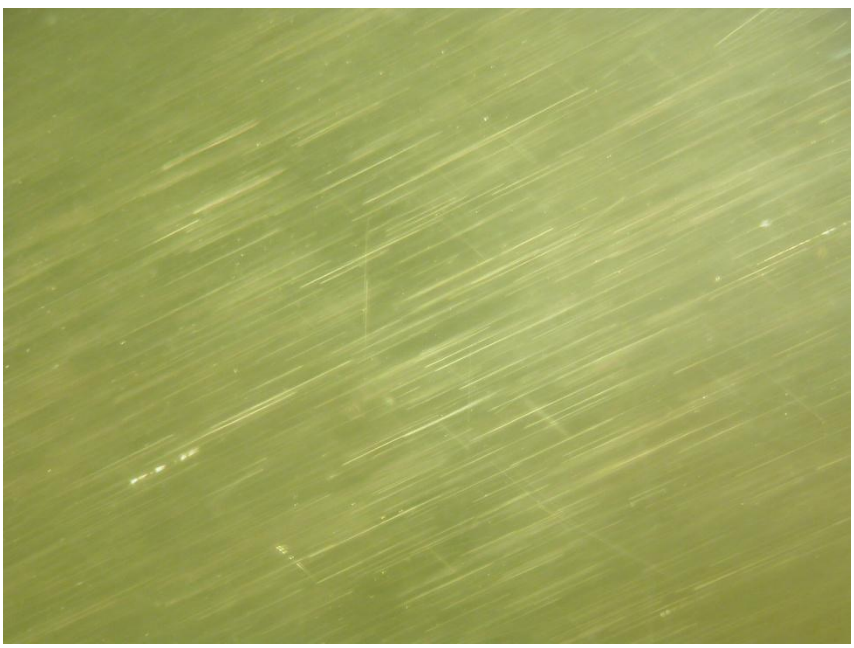

Figure 5: One of the sets of needles was arranged only in one direction and was much denser; this gave rise the stronger ray as seen in figure 2. Photomicrograph by M.B. Vyas, magnified 60x

These sets of needle inclusions formed five different directions and hence this caused ten-rayed asterism in this quartz specimen. Out of various, one of the rays was prominent as compared to the others; this was due to the denser orientation of parallel needles in one of the directions.

Due to the lack of Raman analysis, the exact nature of these needle inclusions could not be resolved; however various minerals have been identified in asteriated quartz. Some of these include sillimanite, rutile, dumortierite and hematite.

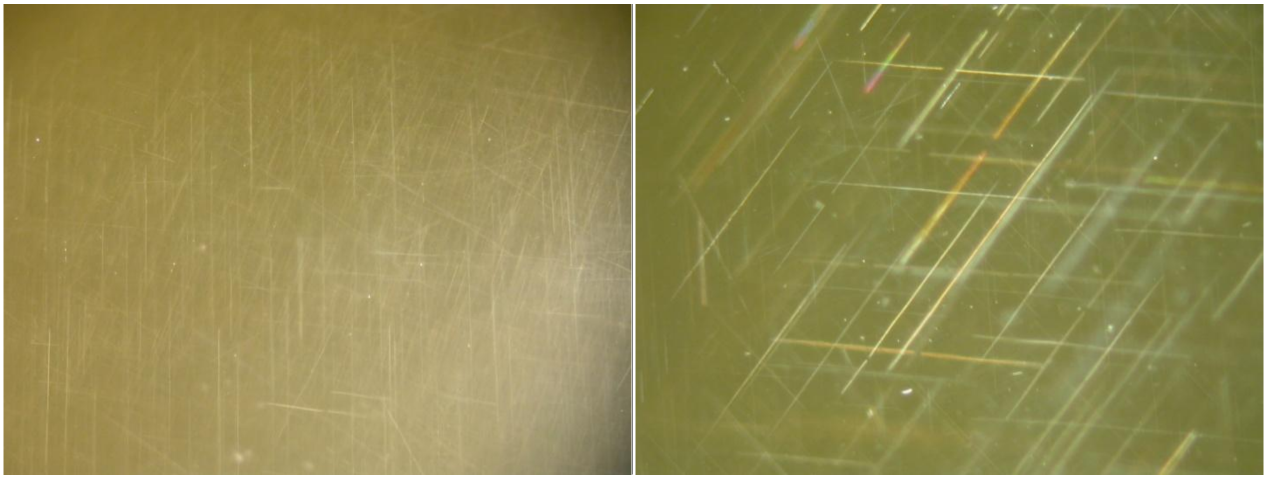

Figure 6: Two different sets of intersecting needles were observed. One set comprised two-directional needles which intersected each other at an angle of nearly 90^o (left) while in another set the needles appeared to be intersecting at approximately 60/120^o (right). Also note the iridescent and brownish appearance of these needles. Photomicrographs by M.B. Vyas (left) and G. Choudhary (right); magnified (left) 60x and (right) 80x

The cause of main chatoyant band was still under question since none of the sets of needles were oriented perpendicular it. With careful observation using a strong fibre optic light when moved around the specimen and reflected off the surface, fine 'flaky' inclusions could be resolved (figure 7). These flaky inclusions were densely packed and oriented perpendicular to the main chatoyant band and parallel to the 'c' axis causing milkiness in the stone; these inclusions were responsible for the cat's eye effect in this quartz specimen. Similar inclusions have also been reported by Kiefert.L (2003).

Figure 7: Fine flaky inclusions oriented in one direction along the 'c' axis and perpendicular to the chatoyant band was responsible for the cat's eye effect in this specimen. Photomicrograph by G. Choudhary, magnified 80x.

FTIR analysis

FTIR spectra recorded in the region 6000 – 400 cm^{-1} displayed complete absorption of wavelengths up to 2200 cm^{-1} and an absorption band ranging from 3000 – 3700 cm^{-1} which consisted of many peaks. The region was zoomed out to locate the position of peaks (figure 8) and found to be at around 3592, 3539, 3480, 3435, 3380, 3310 and 3200 cm^{-1}. These peaks are consistent with those found in natural quartz (Kiefert L, 2003).

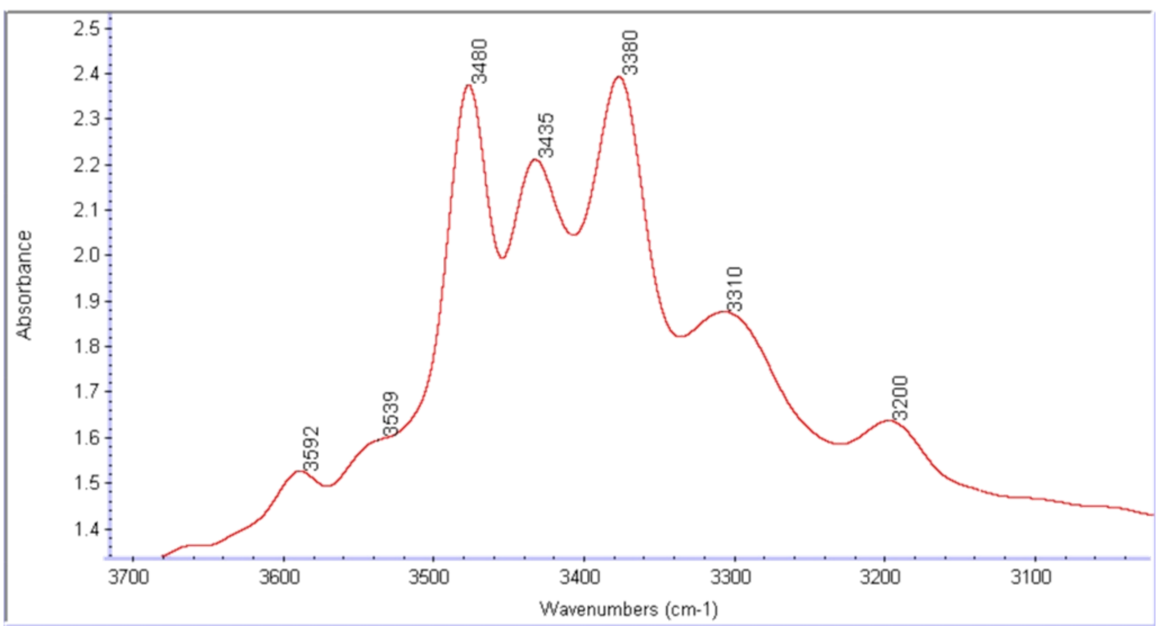

Figure 8: Infrared spectrum of this multiphenomenal quartz in the region 3000 – 3700 cm^{-1} shows peaks that are consistent with natural quartz

EDXRF analysis

Qualitative EDXRF analysis revealed the presence of Si as expected for Quartz. In addition, traces of Ca and Fe were detected. Hence, elemental analysis did not indicate any nature of the needle inclusions.

Conclusion

Multi-rayed stars in quartz are quite common which also includes disorientation of star rays causing a cat's eye effect. The specimen reported here was encountered at the Gem Testing Laboratory of Jaipur, India originating from Kangayam- Karur belt in Tamilnadu state of India revealed distinct 'chatoyancy' and 'asterism' and not merely an extension of one of the star rays. It was quite unusual to encounter both these effects in the same specimen and during the literature search the authors did not find any reports of such specimens. In addition, a ten-rayed asterism in a gem variety is itself unusual.

References

Johnson M.L. and Koivula J.I., (1999) Gem News. Twelve rayed star quartz from Sri Lanka. *Gems & Gemology*, Vol. 35 No. 1, pp 54-55

Kiefert L (2003) Gem News International. "An unusual star quartz", *Gems & Gemology*, Vol. 39, No. 3, pp 234-235

Schmetzer K & Glas M (2003) Multi-star quartzes from Sri Lanka. The *Journal of Gemmology*, Vol. 28 No. 6, pp 321-332

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