# Nail-head Spicules as Inclusions in Chrysoberyl from Myanmar

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Multiphase inclusions developed in the form of nail-head spicules in a colourless chrysoberyl crystal from Myanmar were examined by optical means and by Raman microspectroscopy. The growth tubes of the multiphase inclusions contain $CO_2$, and the grains attached to the ends of these tubes are most likely chrysoberyl crystals (based on Raman spectra and observation of birefringence), some of which are partially covered with an iron-bearing substance, and possibly also negative crystals.

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## Introduction

Nail-head spicules are sometimes found as inclusions in synthetic gem materials (e.g. synthetic emerald or quartz), but occasionally also in natural gems such as sapphire, spinel, tourmaline and quartz (Schmetzer et al., 1999, 2011; Choudhary and Golecha, 2007). Recently, one of the authors (KS) examined a group of rough and faceted, slightly yellow, greenish yellow or colourless chrysoberyls from Myanmar that afforded an opportunity to augment the foregoing list. The samples had been obtained from a collector, who bought them in the trade. The chrysoberyls were said to originate from the Mogok region of Myanmar. One of them contained nail-head spicules, and this note describes that crystal's morphology and its inclusions.

## Results

The colourless chrysoberyl (Figure 1a) consisted of a 6.2 × 5.2 mm tabular crystal with broken ends. The main tabular face was determined by optical means (i.e. by the position of both optic axes; see Schmetzer, 2011) as the **b** {010} pinacoid. Because the crystal was broken at both ends, we could determine only two additional forms: a smaller **a** {100} pinacoid and a small **m** {110} prism. Several complete slightly yellow or colourless crystals from the same group showed a similar tabular habit with a dominant **b** pinacoid, and one typical example is depicted in Figure 2.

The subject crystal contained several growth tubes running parallel to the c-axis, with colourless or slightly yellowish brown inclusions at one end of the elongated cavities (Figure 1a,b). One of the two larger growth tubes (labelled A in the figures) was completely trapped within the colourless host, but the second (labelled B) was open at its end to the surface of the broken crystal. With permission from the owner of the crystal, one of the **b** faces was polished to allow better examination of the inclusions. Growth tube A was colourless with a homogeneous, transparent appearance, while tube B was partly filled with an inhomogeneous-appearing yellowish brown fine-grained material (Figure 3).

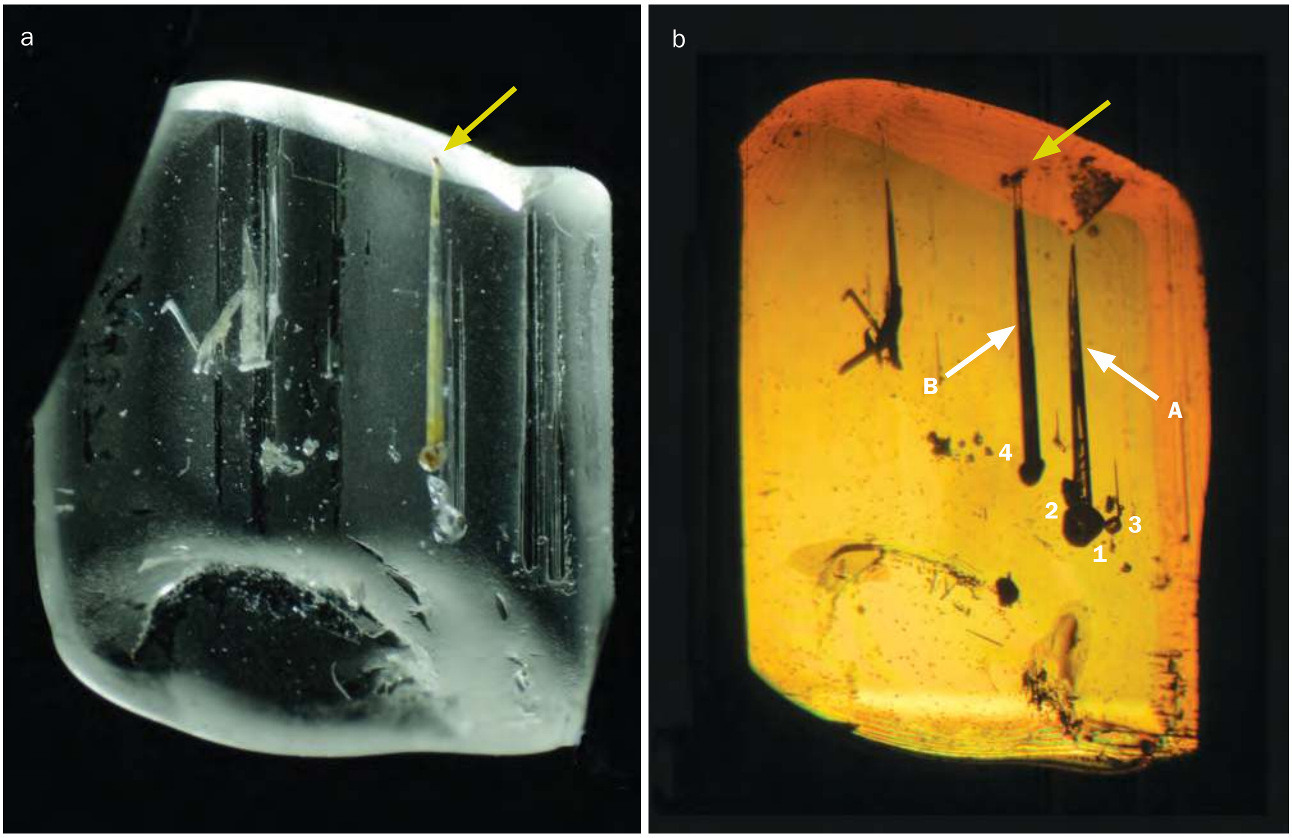



*Figure 1: This colourless tabular chrysoberyl crystal (6.2 × 5.2 mm) reportedly from the Mogok area of Myanmar was studied for this report, and is shown in reflected light (a; photomicrograph by M. S. Krzemnicki) and in immersion between crossed polarizers (b; photomicrograph by K. Schmetzer). It contains multiphase inclusions consisting of growth tubes (labelled A and B) with attached grains (labelled 1–4). Growth tube A is completely trapped within the chrysoberyl host, while tube B is open at its end to the broken surface of the host (yellow arrows).*

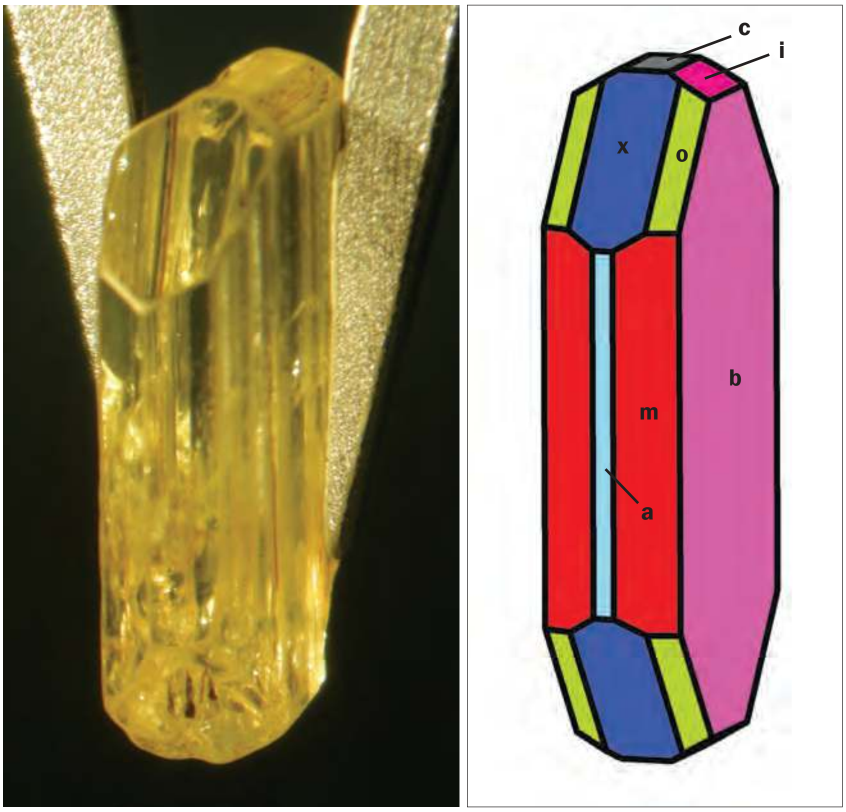



*Figure 2: This yellow chrysoberyl crystal (2.8 × 10.4 mm) reportedly from the Mogok area of Myanmar shows a tabular habit parallel to **b** {010}; similar crystals were frequently seen within the group of samples examined. The crystal forms determined are the pinacoids **a** {100}, **b** {010} and **c** {001}, the prisms **i** {011}, **x** {101} and **m** {110}, as well as the dipyramid **o** {111}. Photomicrograph and crystal drawing by K. Schmetzer.*

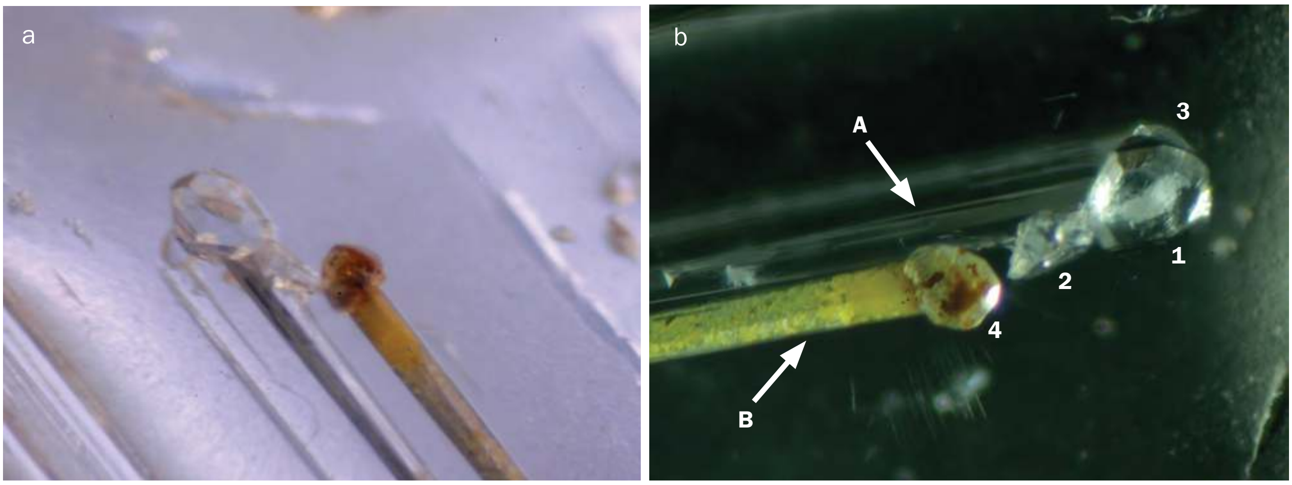
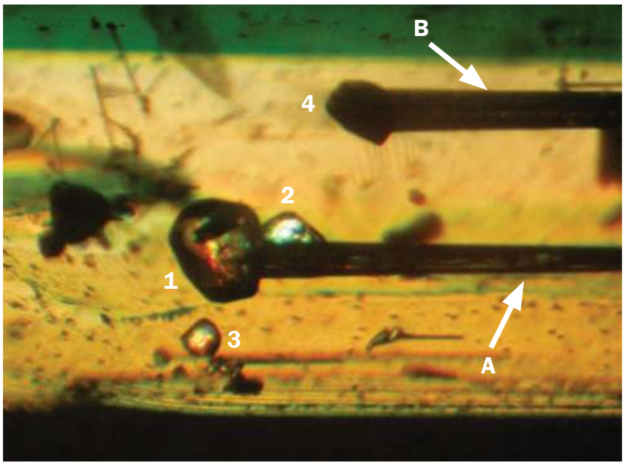



*Figure 3: The colourless chrysoberyl crystal contains multiphase inclusions in the form of nail-head spicules. These inclusions consist of growth tubes (A and B) with attached grains showing euhedral crystal forms (1, 3 and 4) or irregular shapes (2). The high-relief appearance of the crystalline inclusions in photo b is due to the use of reflected light with a dark background to obtain the maximum contrast for these tiny colourless inclusions. The field of view of the images is 2.0 × 1.5 mm (a) and 1.8 × 1.3 mm (b); photomicrographs by M. S. Krzemnicki.*

Attached to the end of tube A we observed one irregularly shaped colourless inclusion (labelled 2) and one colourless inclusion (labelled 1) with a tabular habit and clearly visible crystal faces (Figure 3). Within the tabular inclusion 1 was a central area that appeared milky white. Close to this assemblage we observed an additional colourless inclusion (labelled 3) attached to a small growth tube (not labelled in the figures).

At the end of tube B, another inclusion (labelled 4) with plane faces was seen, and part of the surface of this inclusion was covered with a yellowish brown phase (Figure 3). Between crossed polarizers (Figure 4), the colourless inclusions (1, 2 and 3) attached to closed growth tubes showed birefringence, but grain 4 attached to growth tube B was opaque.

*Figure 4: Viewed between crossed polarizers, the grains at the end of the growth tubes (A and B) show birefringence (1, 2 and 3) or appear dark (4). The image was taken in immersion with a field of view of 2.5 × 1.9 mm; photomicrograph by K. Schmetzer.*




An examination of the inclusions with Raman micro-spectroscopy revealed the presence of $CO_2$ in growth tube A that was completely trapped within the host chrysoberyl (Figure 5). The various colourless inclusions (1, 2 and 3) at the ends of the enclosed growth tubes showed only the Raman spectra of the chrysoberyl host. Conversely, inclusion 4 at the end of the open tube B, which was at least partly covered with a yellowish brown substance, showed Raman lines for chrysoberyl along with additional peaks corresponding to iron oxides and/or iron hydroxides (Figure 5).

## Discussion

Raman spectroscopy of tiny inclusions trapped in a transparent host frequently reveals a spectrum that consists of the characteristic Raman lines of the host with additional lines of the solid or fluid inclusion. If a solid inclusion is identical to the host, Raman spectroscopy cannot separate the two solid phases. Consequently, a Raman spectrum of an inclusion showing only the lines of the host could indicate either a mineral phase identical with the host or a cavity (i.e. a negative crystal). Grains 1, 2 and

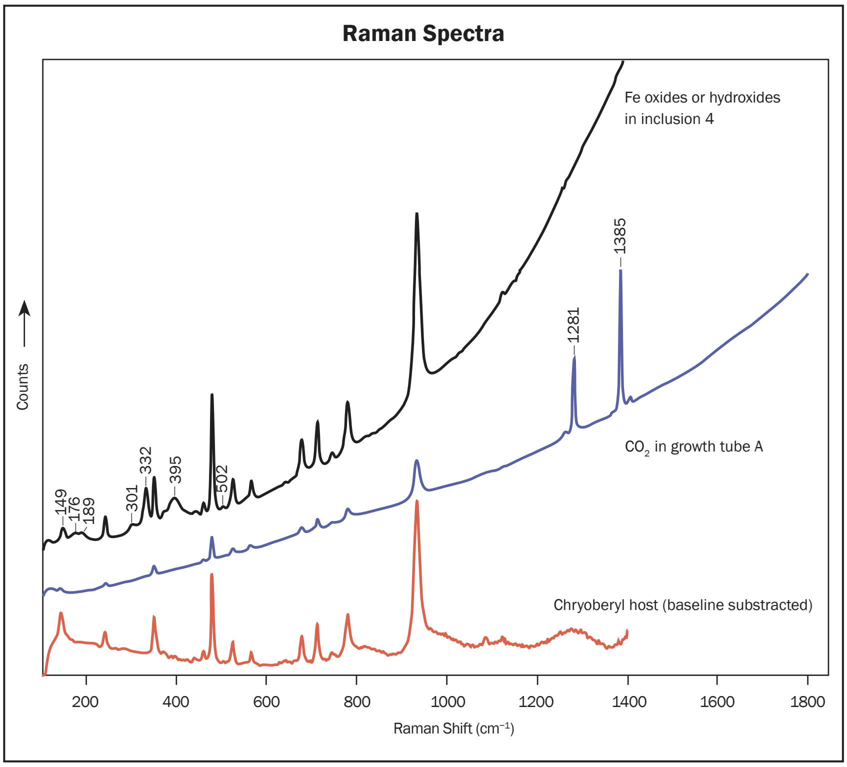



*Figure 5: Raman micro-spectroscopy of inclusions in the chrysoberyl showed the presence of iron oxides or hydroxides in the yellowish brown inclusion 4 at the end of the open tube B (top spectrum) as well as the presence of $CO_2$ in growth tube A (middle spectrum); the bottom spectrum shows only the Raman lines of the host chrysoberyl. Peak labels are provided for the inclusion phases present.*

3 showed the Raman spectrum of chrysoberyl and were birefringent. These results indicate that the grains are chrysoberyl. Such inclusions of chrysoberyl in chrysoberyl are rare but have been described occasionally, such as in alexandrite from the Lake Manyara deposit in Tanzania (Schmetzer and Malsy, 2011). In both that alexandrite and the present sample, the orientation of the chrysoberyl inclusions was different from that of the chrysoberyl host.

For grain 4 at the end of tube B that is open to the surface, the Raman spectrum showed lines for chrysoberyl and an additional iron-bearing phase. The microscopic examination did not show birefringence, but this could be due to the low magnification of the gemmological microscope and/or the presence of the iron-bearing material. The yellowish brown substance could cover the surface of a trapped tiny chrysoberyl crystal; could fill, at least partly, the cavity of a negative crystal; or could adhere to the walls of such a negative crystal. However, because a nail-head spicule requires an obstacle during the growth of the host crystal, the first possibility is most likely.

The fine-grained inhomogeneous material in the open tube B may be of secondary origin, a scenario sometimes described as 'iron staining'. This scenario includes the possibility of iron staining of at least a part of the surface of a chrysoberyl crystal trapped at the end of such an open tube.

Although we could confirm the presence of chrysoberyl crystals at the ends of other growth tubes—and although the trapping of a tiny chrysoberyl crystal with iron staining is the most likely scenario—the possibility of a negative crystal terminating the open tube B could not be completely excluded. Only a destructive examination (cutting the host crystal to expose the surface of the inclusion) might afford a definitive explanation.

## Conclusion

Colourless chrysoberyl, reportedly from Myanmar, may be added to the list of natural gem materials that have been found to contain multiphase nail-head spicules, consisting in this instance primarily of growth tubes with attached euhedral or irregular chrysoberyl crystals.

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