LAB UPDATE

A RARE COLORLESS GARNET

By GIT – Gem Testing Laboratory

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Introduction

Garnet is one of the oldest and common gemstones used by humans for centuries. It is a group of gem minerals with an extensive range of species and varieties. Among those, the common species are almandite, spessartite, pyrope, grossularite, and andradite that come with a huge variation of colors or varieties. In the grossular species, hessonite (an orangey red variety) and tsavorite (a green variety) are among the most popular gem garnet in the trade. By contrast, the colorless variety of grossularite (aka "leuco garnet" or "leuco grossular") is considered a rare mineral and has been one of the sought-after stones for gem collectors. The colorless grossularite has been reportedly found in a few deposits, such as in (Mogok) Myanmar, Sri Lanka, (Mali and Tanzania) Africa, (Quebec) Canada, California, and China (Grande and Augustyn, 1992).

A 0.38 carat colorless stone was recently submitted to the GIT-Gem Testing Laboratory (GIT-GTL) for identification. The gemological properties and advanced analyses we examined revealed that the stone was a colorless natural grossularite garnet.

Gemological properties

The stone is a rectangular step mixed cut (Figure 1). Standard gemological testing revealed the following properties: colorless, singly refractive, refractive index (RI)---1.731, specific gravity (SG)---3.615, inert in both long- and short-wave UV lights.

Figure 1: A 0.38 ct sample of colorless garnet submitted to GIT-GTL for identification (photo by C. Kamemakanon)

Microscopic features

Examination of the sample, using a gem microscope attached with Canon EOS 7D camera under dark field illumination, showed several features, such as growth line, minute particles, and tubes (Figure 2 (a-d).

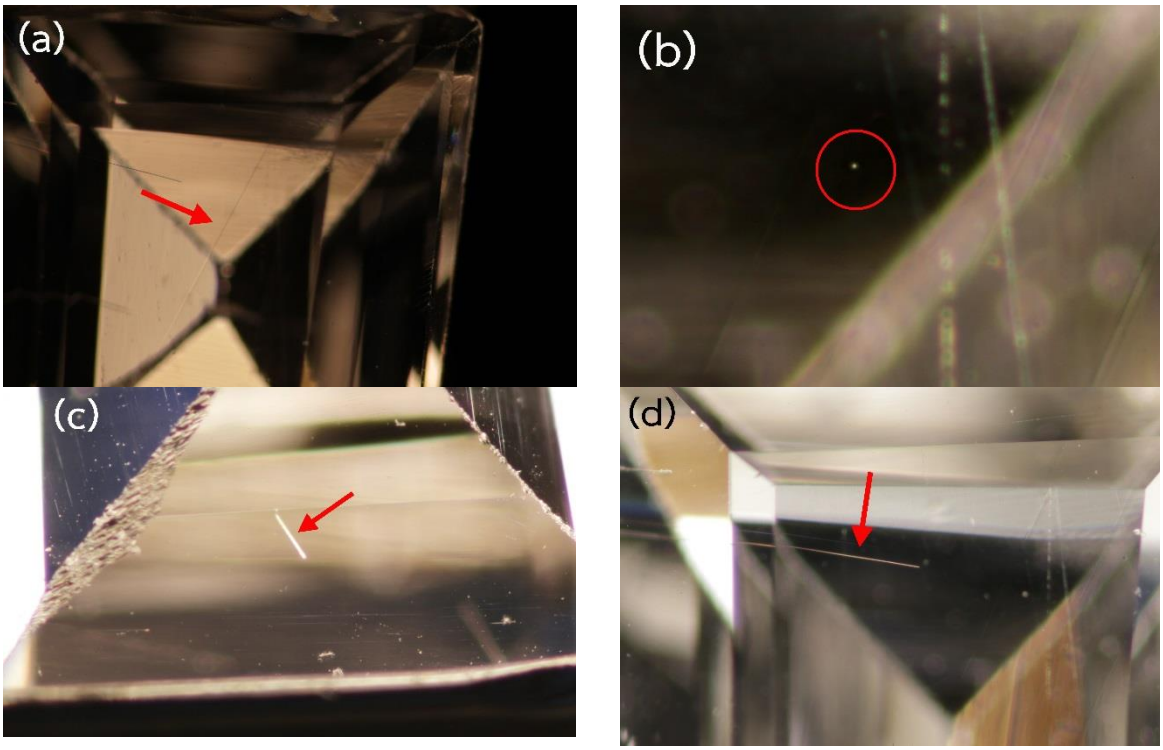

Figure 2: Microscopic features of the garnet sample shows growth line (a, magnified 20X), minute particle (b, magnified 125X), short tube (c, magnified 50X) and long tube (d, magnified 50X). Photomicrographs by P. Bupparenoo

Advanced spectroscopic analyses

Raman Spectroscopic Analysis

The Raman spectrum, collected with a Renishaw inVia spectrometer using 532 nm laser excitation, showed dominant peaks (Raman shifts) at 375 and 880 cm^{-1} and other smaller peaks at 246, 278, 548, 828 and 1007 cm^{-1} (Figure 4). The pattern perfectly matched the spectra of other grossularite garnets, such as mali garnet, tsavorite and hessonite from the GIT reference samples.

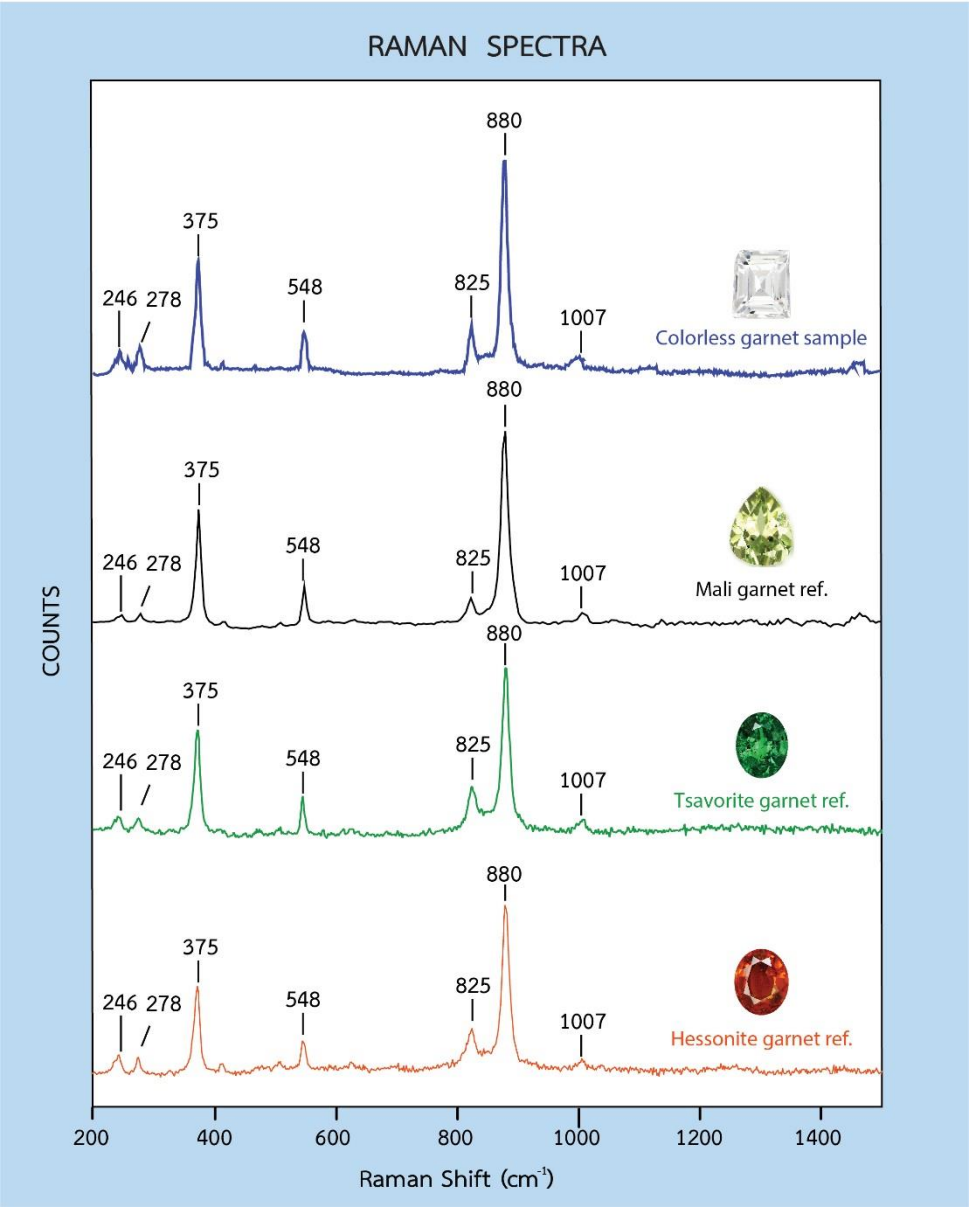

Figure 4: Raman spectra of the sample (blue line) as compared with other grossular garnets, namely, mali garnet (black line), tsavorite (green line) and hessonite (red line) from the GIT reference samples.

Chemical analysis

The semi-quantitative chemical analysis of the stone, obtained by an energy-dispersive X-ray fluorescence (EDXRF) Quant'X spectrometer, revealed major contents of Ca, Al and Si with trace amounts of Mg, Fe, Ti and Mn (Table 1).

Table 1: The chemical analyses of the colorless garnet sample and other grossular garnets, such as mali garnet, tsavrlite and hessonite from the GIT reference samples by EDXRF

Oxide% (wt)	Sample	Mali garnet	Tsavorite	Hessonite
SiO_2	37.15	37.94	38.68	37.52
Al_2O_3	21.66	17.57	21.75	20.90
CaO	40.46	36.14	36.34	37.15
MgO	0.22	0.73	0.66	*bdl
total Fe	0.22	7.15	0.09	4.09
TiO_2	0.26	0.20	0.34	0.12
MnO	0.03	0.25	0.79	0.20
Cr_2O_3	*bdl	*bdl	0.08	*bdl
V_2O_5	*bdl	0.02	1.28	0.02
Sum	100.00	100.00	100.00	100.00

*bdl = below detection limit

Overall, this chemical data, which was normalized to 100wt.%, is consistent with the composition of pure grossular garnet ($Ca_3Al_2Si_3O_{12}$). Its major constitutes (Ca, Al Si) are fairly similar to other grossular garnets, namely, mali garnet, tsavorite and hessonite, except that our sample contains somewhat lesser amounts of chromophores----- V, Cr, Mn and Fe (see Table 1). The chemical data also suggest that our sample is a rather pure end-member grossularite containing very low color causing elements, and thus in good agreement with the colorless nature of the stone (see also the UV-Vis absorption spectrum of the sample in figure 4 below).

UV-Visible Spectroscopic Analysis

UV-Vis absorption spectrum of the sample in the range of 300–800 nm, collected by a PerkinElmer Lambda 1050 spectrophotometer, exhibited nearly flat absorption feature in the visible range with very weak bands approximately 480 and 525 nm (Figure 5). As such the white light can pass through the stone without absorption, and thus giving rise to its colorless nature. When compared with the absorption spectra of other grossular garnets, the mali garnet showed small broad bands approximately 375 and 433 nm (due to Fe^{3+}) and 525 nm (related to Fe^{2+}) (cf. Sangsawong et al., 2016; Sriboonjan et al., 2016); the tsavorite displayed the strong broad bands at approximately 430 and 610 nm (due to V^{3+} ; Promwongnan and Buathong, 2018); and the hessonite exhibited a continuous increase of absorption from around 650 nm toward the UV region with small bands at approximately 370 and 433 nm (due to Fe^{3+}).

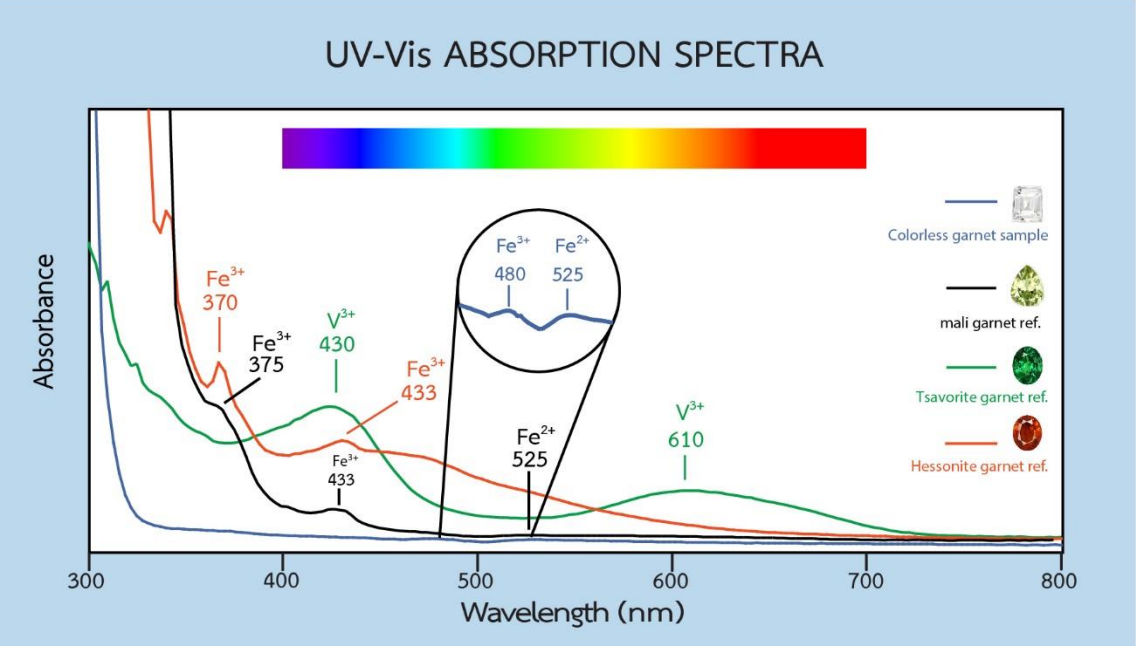

Figure 5: UV-Vis spectra of the colorless garnet (blue line) as compared with the mali garnet (black line), tsavorite (green line) and hessonite (red line) from the GIT reference samples.

Discussion and conclusion

Based on the stone gemological properties, i.e., singly RI--1.731, SG--3.615 and its internal features, such as minute particles, and short and long tubes, this colorless sample proved to be a natural grossularite garnet. The Raman spectra also confirmed that the stone belonged to the grossular species similar to the spectra of mali, tsavorite and hessonite from the GIT reference samples. The chemical data and the UV-Vis absoption spectrum further suggested that the stone we examined was a rather pure end-member grossularite containing extremely low chromophores, thus giving rise to the colorless nature of the stone.

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