LAB NOTE

Exceptional-Quality "MUSGRAVITE"

GIT-Gem Testing Laboratory

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Introduction

A collectors' gemstone is the group of naturally occurred minerals that are rarely found in gem quality. Musgravite [$(Mg,Fe,Zn)_2BeAl_6O_{12}$] or Magnesiotaaffeite is among the rare and sought-after gems by collectors. Faceted musgravites have been firstly found in Sri Lanka and were reported by Demartin *et al*. (1993). Musgravite is also known from some other localities, such as Musgrave Ranges Australia, France, Greenland, Madagascar, Antarctica (Schmetzer *et al*., 2005), Tunduru, Tanzania (Schmetzer *et al*., 2007) and from Myanmar (Renfro, 2013; Leelawatanasuk *et al*., 2014). Recently, the GIT- Gem Testing Laboratory (GIT-GTL) had a chance to identify two exceptional-quality musgravite ever test by our lab.

Gemological properties

The two faceted specimens are a 5.95 ct, rectangular-cushion-cut, dark green stone and a 1.79 ct triangular-cut, light purple stone (figure 1). Their basic gemological properties were recorded for their refractive index (RI) from 1.720-1.730, and specific gravity (SG) about 3.6.

Figure 1: Two faceted stones: the dark green one on the left weighs 5.95 ct and was cut as a rectangular cushion shape; the light purple one on the right weighs 1.79 ct and was cut as a triangular shape. Such exceptional gem-qualities (i.e., colors, clarity and sizes) are rarely seen in the trade. (photo by S. Saengbuangamlam)

Microscopic features

These stones are somewhat transparent with some inclusions. The dark green stone contains a dark crystal with small tension halo (figure 2) while the purple stone carries well-formed apatite inclusions (confirmed by Laser Raman Spectroscopy) and many fine tube-like needles with some iron stains (figure 3).

Figure 2: A dark crystal inclusion with tension halo in the 5.95 ct dark green stone. Photomicrograph by S. Saengbuangamlam; magnified 50x

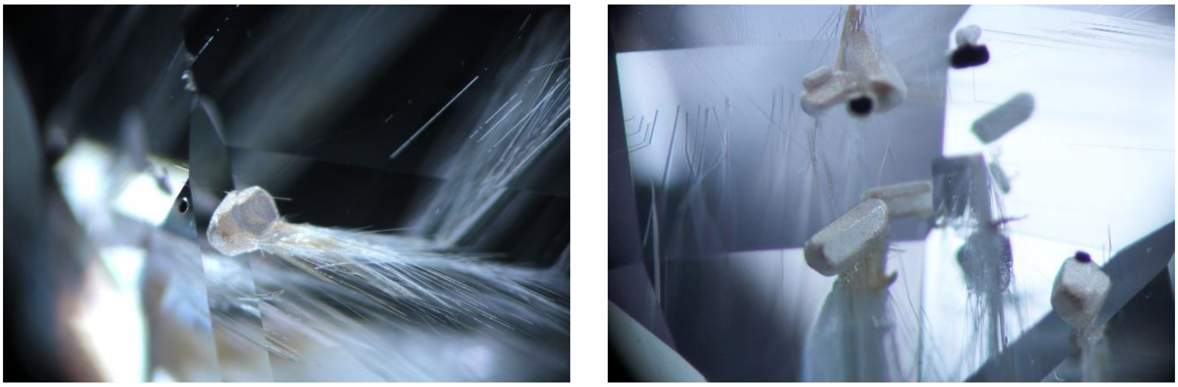

Figure 3: Fine tube-like needles and euhedral apatite crystals in the 1.9 ct purple stone (left and right). Photomicrographs by S. Saengbuangamlam; magnified 50x.

Advanced spectroscopic analyses

Raman spectroscopy confirmed that both the dark green and the purple stones were musgravite. The Raman shift peaks of these two stones were similarly recorded at around 239, 266, 302, 313, 376, 403, **411**, 446, 484, 493, 527, 577, 604, 620, 664, **715**, 756, **806**, 826 and 977 cm^{-1}, respectively. The Raman spectra of these two samples were perfectly matched our reference spectrum of musgravite, rather than Taaffeite spectrum, and also were consistent with the musgravite spectrum given by Kiefert and Schmetzer (1998). The presence of peaks at 411, 715 and 806 cm^{-1} confirm that the two stones are musgravite instead of taaffeite.

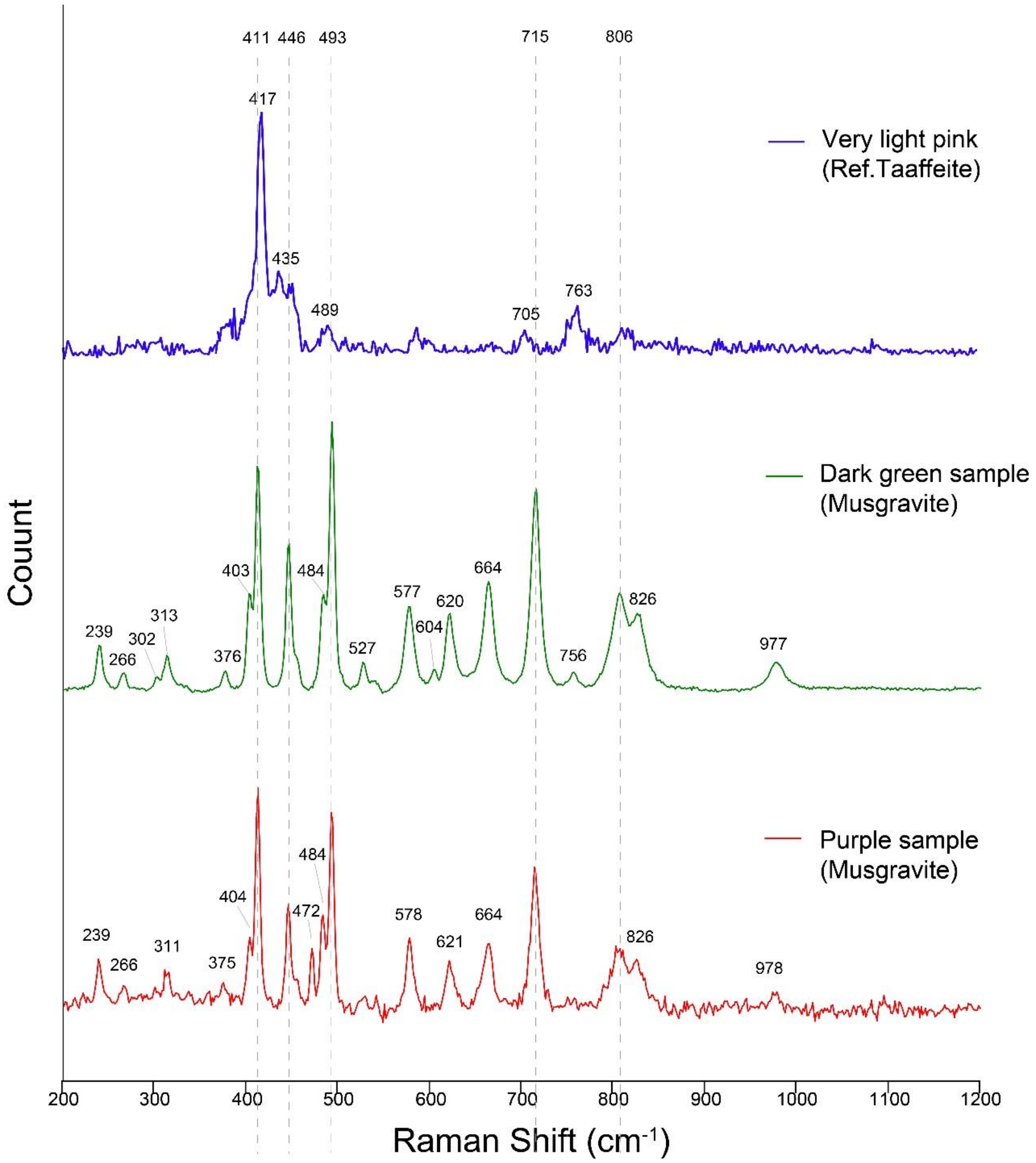

Figure 4: Raman Shift of the dark green and the purple samples in the range 200 – 1200 cm^{-1}

The mid-IR spectra of these stones showed broad transmission in the 3200-1600 cm^{-1} range with weak absorption bands at approximately 2147, 2214, 2332, 2356 and 2448 cm^{-1} for the dark green stone, and 1818, 2147, 2214, 2336, 2356, 2448, and 2514 cm^{-1} for the purple stone (Figure 5). In addition, small peaks at approximately 2855 and 2924 cm^{-1} in the purple sample were due to C-H stretching vibrations, possibly from oil residue in fractures.

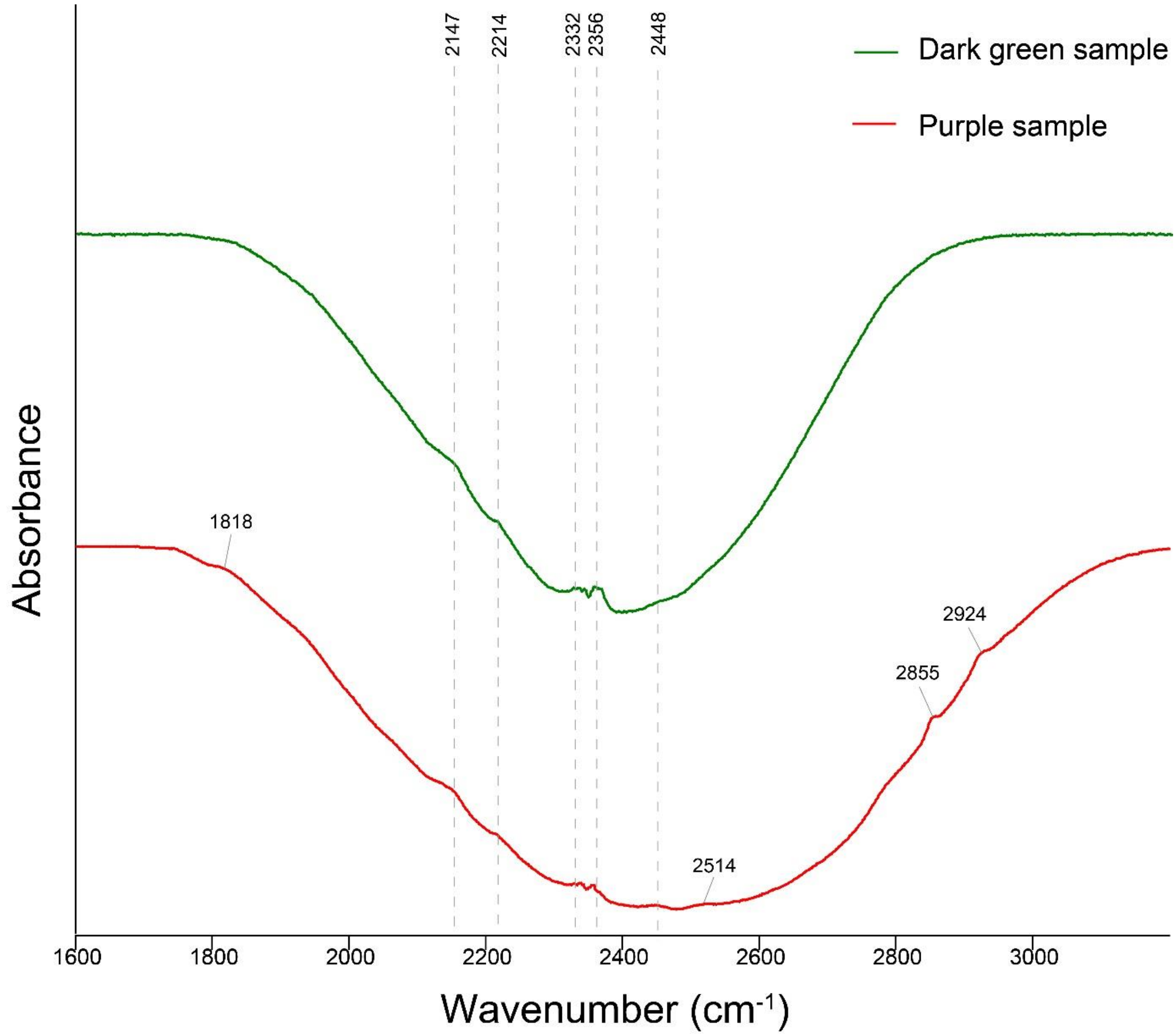

Figure 5: FTIR spectrum of purple and green sample in range 1600 – 3200 cm^{-1}

The UV-Vis-NIR spectra of the dark green stone displayed absorption peaks and bands at approximately 460, 560 and 636 nm with very strong absorption below around 400 nm toward UV region (Figure 6). Such strong UV absorption is attributed to the green coloration of this stone (i.e., intense transmission window in the green region as seen from the visible spectrum) as compared to that of the purple stone. The purple stone, on the other hand, displayed somewhat similarly but relatively weaker absorption peaks and bands at approximately 345, 369, 384, 455, 552 and 630 nm with less absorption toward the UV region. These variations may be the result of the different contents of Fe between these two stones (see Table 1 and later discussion).

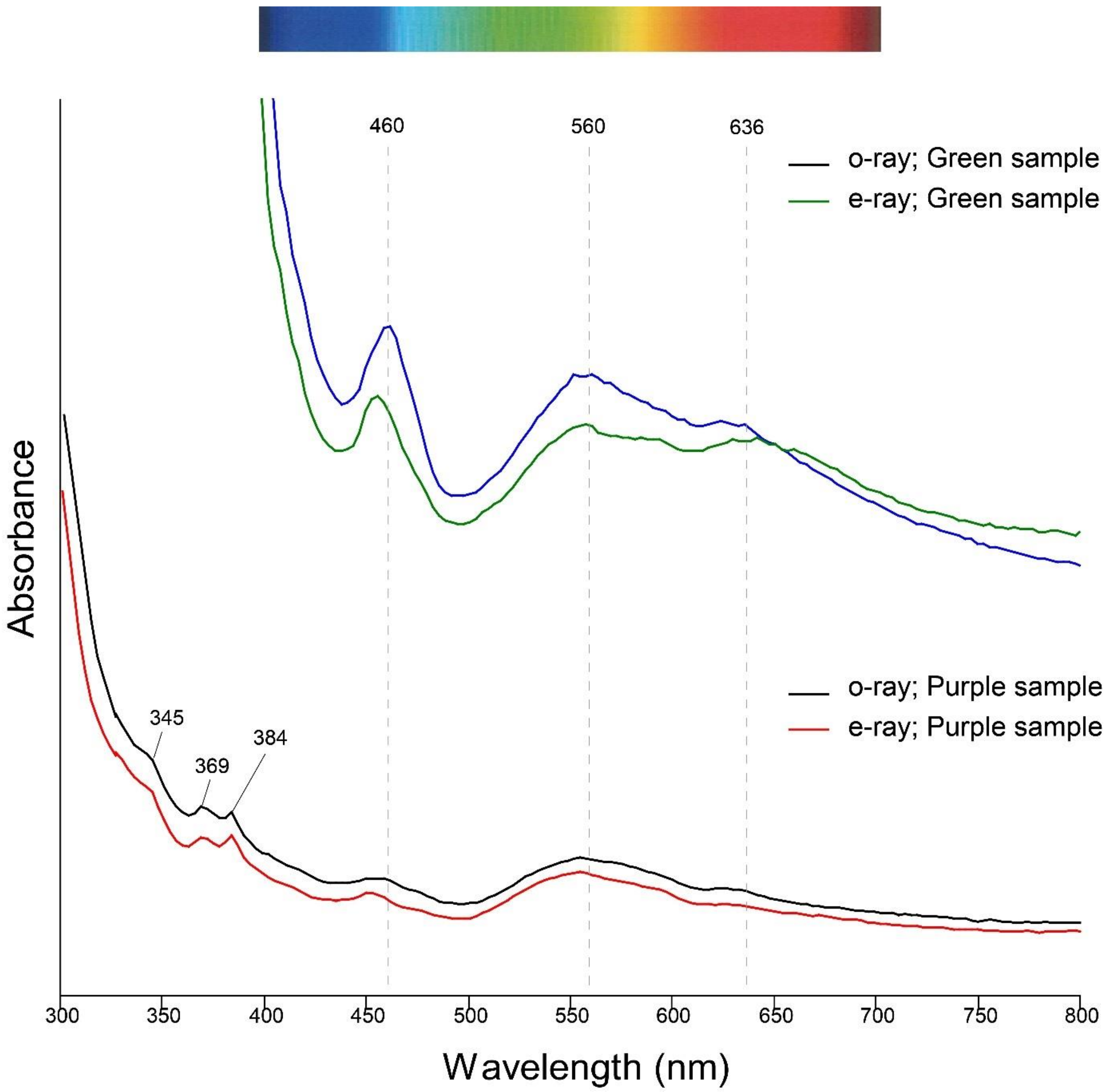

Figure 6: Polarized UV-Vis-NIR spectra of the dark green and purple samples in range 300 – 800 nm, these spectra exhibit a strong broad absorption band at approximately 460 and 560 nm.

The semi-quantitative chemical analyses by EDXRF (see table 1) revealed that the samples contained Al and Mg as the major components. Significant contents of Fe and minor amounts of Mg, Mn, Fe and Zn were also detected. It should be noted that the Fe content (2.95 wt.% Fe_2O_3) in the dark green stone is significantly higher than that (1.09 wt.% Fe_2O_3) of the purple stone; and also that, the Be was undeterminable due to the XRF limitation but it could be assumed to be present at 6.08 wt.% BeO based on the theoretical formula (Schmetzer *et al*., 2007).

Table 1: Chemical compositions of the dark green and the purple musgravite samples by EDXRF (Note BeO was undeterminable due to the XRF limitation but was assumed to be present at 6.08 wt.% BeO based on the theoretical formula (Schmetzer et al., 2007))*

Dark green stone	
Element oxides	Concentration (wt%)
BeO*	6.08
MgO	16.66
Al_2O_3	73.75
MnO	0.07
Fe_2O_3	2.95
ZnO	0.42
Ga_2O_3	0.07

Purple stone	
Element oxides	Concentration (wt%)
BeO*	6.08
MgO	18.08
Al_2O_3	74.53
MnO	0.03
Fe_2O_3	1.09
ZnO	0.11
Ga_2O_3	0.08

Discussion and conclusions

Gem-quality musgravite found in dark green and purple hues such as these two stones are quite rare. Their RI and SG values are closed to musgravite and taaffeite. However, the presence of specific peaks at 411, 715 and 806 cm^{-1} on the Raman spectra of those two stones have confirmed that they are musgravite. Hence, Raman spectroscopy is useful as a non-destructive technique for rapid differentiation of musgravite and taaffeite.

The broad absorption bands and peaks at approximately 369, 384, 460 and 560 nm in the UV-Vis-NIR spectra of both samples (figure 6) have been attributed to the iron-related absorption (Leelawatanasuk *et al*., 2014: Schmetzer *et al*., 2007). However, the strong absorption in the UV region of the dark green stone, which is the main cause of its green coloration, is likely related to its high Fe content (i.e., 2.95 wt% Fe_2O_3; probably causing very strong broad Fe-related absorption band in the UV-region and extending its tail into the visible region).

This study shows that these two stones are the 'natural musgravite' with exceptionally dark blue and purple colors. Such exceptional gem-qualities (i.e., their colors, clarity and sizes) are rare and very valuable.

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