

# Some Characteristics of Taaffeite from Myanmar

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Although taaffeite from Myanmar was reported over 30 years ago, few gemmological studies have been published on this material. Five specimens of very pale purplish pink and heavily included taaffeite from the Mogok area were characterized for this report. Chemical analysis revealed 75.2–76.4 wt.%  $\text{Al}_2\text{O}_3$  and 18.2–19.1 wt.%  $\text{MgO}$ , with trace amounts of Fe, Zn, Ga, Mn and other elements. Compared to similarly coloured taaffeite from Sri Lanka and Africa, these Burmese samples showed no significant differences except for lower Fe content.

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## Introduction

Among gem minerals, taaffeite is considered one of the rarest, with only a handful of deposits reported to date. The mineral was named in 1945 after its discoverer, Count Edward Charles Richard Taaffe, a Dublin gemmologist. He noticed a stone within a parcel of spinel from Sri Lanka that exhibited a slight birefringence. He sent the gem to London, where it was eventually confirmed as a new mineral species (Anderson et al., 1951). Its chemical formula is  $\text{BeMg}_3\text{Al}_8\text{O}_{16}$  (Schmetzer 1983a,b), intermediate between chrysoberyl ( $\text{BeAl}_2\text{O}_4$ ) and spinel ( $\text{MgAl}_2\text{O}_4$ ). Since the nomenclature revisions by Armbruster (2002), *taaffeite* has been considered a group name, consisting of the members magnesiotaaaffeite- $6N'3S$  (which used to be called musgravite), magnesiotaaaffeite- $2N'2S$  (taaffeite) and ferrotaaaffeite- $6N'3S$  (pehrmanite). More recently, a new iron-rich end member of the taaffeite group was defined by Yang et al. (2012) as ferrotaaaffeite- $2N'2S$ . For simplicity, in this

article magnesiotaaaffeite- $2N'2S$  will simply be referred to as *taaffeite*.

Due to its scarcity, taaffeite is considered a collectors' stone. The mineral is known to crystallize in metasomatized limestone or in high-grade amphibolite- or granulite-facies rocks (Kampf, 1991; Chadwick et al., 1993). Gem-quality material is mainly known from Sri Lanka (e.g. Schmetzer et al., 1999; Abduriyim et al., 2008), but also has been found in Tanzania (Schmetzer et al., 2007) and Myanmar (Kampf, 1991; Schmetzer et al., 2000). Madagascar was mentioned as a possible source of gem-quality taaffeite by Schmetzer et al. (2007), but this has not yet been confirmed.

Burmese taaffeite was first reported in 1983, when Bangkok-based gemmologist William Spengler found a near-colourless piece of rough in a parcel of spinel from the Mogok Stone Tract (Spengler, 1983). Later, additional Burmese specimens were found. In the Mogok area, taaffeite is associated with spinel in a marble belt that developed along the contact of dolomitic

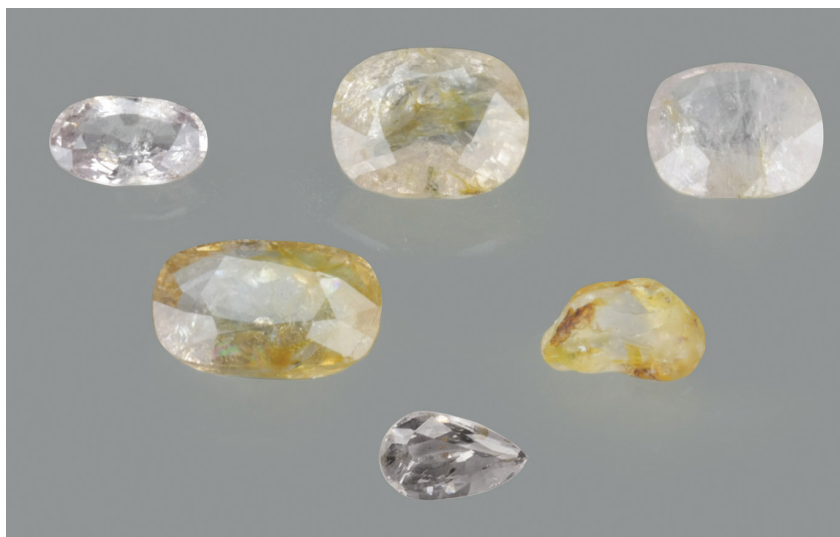


Figure 1: One rough (1.92 ct) and four faceted (1.33–5.16 ct) taaffeite samples were examined in this study. Also shown is a faceted taaffeite from Sri Lanka (bottom; 1.09 ct) that was analysed for comparison. The colour of some samples is obscured by iron staining in surface-reaching fissures. Photo by Jirapit Jakkawanvibul.

limestones with granitic intrusives; the granites provided a source of beryllium for the taaffeite (Drev et al., 2012). The Burmese taaffeite is reportedly found at Chaung Gyi, north of Mogok, in rocks of the Chaung Magyi Group. These rocks have undergone regional metamorphism, followed by contact metamorphism in the vicinity of granitic intrusions (Bender, 1983).

## Materials and Methods

This study was performed on four very pale purplish pink faceted gems and a rough stone, all provided by co-author TTS from his reference collection (Figure 1; 1.33–5.16 ct). All of these samples were originally obtained from gem dealers in Yangon, who reported that they were mined from Chaung Gyi in the Mogok area of Myanmar. For comparison, we also analysed a 1.09 ct pale purple faceted taaffeite from Sri Lanka from the collection of co-author TTS (Figure 17).

Gemmological properties were determined at the Gem and Jewelry Institute of Thailand's Gem Testing Laboratory in Bangkok, using standard instruments such as a refractometer, hydrostatic balance, polariscope, long- and short-wave UV lamp, and binocular microscope. Further testing was carried out on all samples using a Renishaw inVia Raman spectrometer (2000–200  $\text{cm}^{-1}$  range, using 785 nm laser excitation), a PerkinElmer Lambda 950 ultraviolet-visible-near-infrared (UV-Vis-NIR) spectrophotometer (250–800 nm range, with a data collection interval of 3 nm), a Thermo-

Nicolet 6700 Fourier-transform infrared (FTIR) spectrometer (mid-IR range of 400–4000  $\text{cm}^{-1}$ , 4  $\text{cm}^{-1}$  resolution, 128 scans), an EDAX Eagle III energy-dispersive X-ray fluorescence (EDXRF) spectrometer (40 kV voltage, 250  $\mu\text{A}$  beam current) and an Agilent 7500 laser ablation-inductively coupled plasma-mass spectrometer (LA-ICP-MS) with a 213 nm laser, laser output energy of 12–13  $\text{J}/\text{cm}^2$ , carrier Ar gas flow rate of 0.8 L/min, and a 55  $\mu\text{m}$  crater size.

## Results

### Gemmological Properties

The basic gemmological properties are summarized in Table I. The Burmese samples were very pale purplish pink (though some samples were iron-stained) and heavily included. The RIs of the faceted samples were  $n_o = 1.720$ – $1.721$  and  $n_e = 1.716$ – $1.717$ , with a birefringence of 0.004. The SG values ranged from 3.60 to 3.61 for the cut stones, and the SG was 3.57 for the rough sample. All specimens showed a typical doubly refractive character in the polariscope. All were inert to short-wave UV radiation, and some showed weak chalky green or white fluorescence to long-wave UV.

Microscopic examination revealed prominent fingerprint-like fluid inclusions (Figure 2). In addition, several tiny colourless mineral inclusions were observed in the rough specimen. Unfortunately, those inclusions could not be identified by Raman spectroscopy due to their position below the surface.

Table I: Gemmological properties of the studied taaffeite samples from Myanmar and Sri Lanka.<sup>a</sup>

Sample no.	Weight (ct)	RI			SG	UV fluorescence (long-wave/short-wave)
		n <sub>o</sub>	n <sub>e</sub>	Birefringence		
TA01	1.33	1.720	1.716	0.004	3.61	Inert/inert
TA02	4.99	1.720	1.716	0.004	3.60	Inert/inert
TA03	2.86	1.721	1.717	0.004	3.60	Weak chalky white/inert
TA04	5.16	1.720	1.716	0.004	3.60	Weak chalky green/inert
TA05	1.92	1.72 (spot)			3.57	Weak chalky white/inert
TA-SRI	1.09	1.721	1.718	0.003	3.63	Inert/inert

<sup>a</sup> Samples TA01–TA05 are from Myanmar; all are faceted except TA05, which is a water-worn pebble. Sample TA-SRI is from Sri Lanka.

Spectroscopy

Raman spectroscopy confirmed that all five stones were taaffeite. The Raman spectra perfectly matched our reference spectrum for taaffeite and also were consistent with the representative taaffeite spectrum given by Kiefert and Schmetzer (1998).

The UV-Vis-NIR spectra displayed absorption peaks and bands at approximately 370, 385, 460 and 550 nm, with increasing overall absorption toward the UV region (Figure 3). The mid-IR spectrum showed broad transmission in the 3500–1500 cm<sup>-1</sup> range with weak absorption bands at approximately 1937, 1795 and 1674 cm<sup>-1</sup> (Figure 4). In addition, small peaks at approximately 2923 and 2856 cm<sup>-1</sup> are due to C-H stretching vibrations, possibly from oil residue in fractures.

Chemical Composition

Semi-quantitative EDXRF chemical analyses revealed that the Burmese taaffeite samples contained 75.2–76.4 wt.% Al<sub>2</sub>O<sub>3</sub> and 18.2–19.1 wt.% MgO; beryllium is assumed present at 4.5 wt.% BeO according to the theoretical formula (Schmetzer et al., 2007). In addition, EDXRF

measured traces of Fe, Zn, Ga, Mn and Cr. LA-ICP-MS analyses of the Burmese samples showed the expected major elements (Al, Mg and Be), as well as several trace elements (Li, B, Ti, V, Cr, Mn, Fe, Zn, Ga and Sn; see Table II).

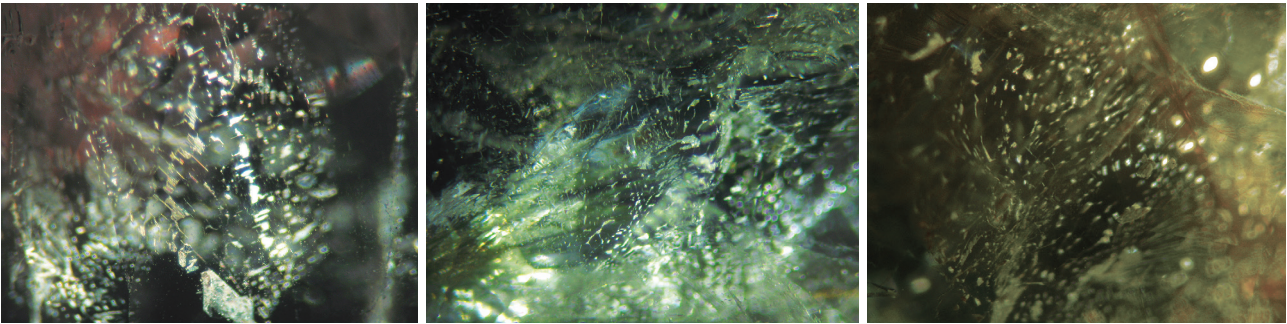
Comparison with Taaffeite from Sri Lanka

Our Burmese taaffeites—and those from the literature—showed no significant differences in RI, SG and UV fluorescence compared to similarly coloured taaffeite from Sri Lanka (i.e. data from the studied sample and from Schmetzer et al., 2006). In addition, the UV-Vis-NIR spectra (see Figure 3) and mid-IR spectra were also quite similar.

Discussion and Conclusions

Our study samples of taaffeite from Myanmar were pale purplish pink and highly included. The most prominent inclusion feature consisted of clusters of fingerprint-like fluid inclusions. Their properties are comparable to similarly coloured

Figure 2: Planes of reflective fluid inclusions hosted by partially healed fissures were prominent in the Burmese taaffeite samples examined in this study. Photomicrographs by Jirapit Jakkawanvibul; darkfield illumination, magnified 40×.



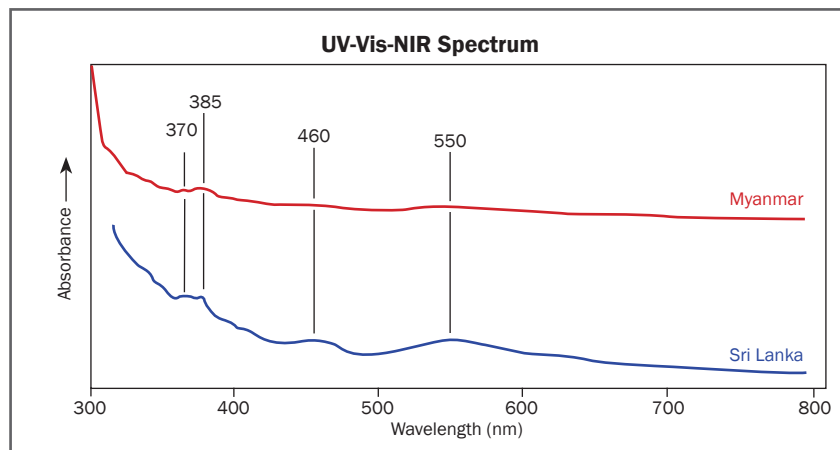


Figure 3: This representative non-polarized UV-Vis-NIR spectrum of sample TA03 shows absorption features due to iron. The same features (though somewhat stronger) are visible in the spectrum of a Sri Lankan taaffeite that was recorded for comparison.

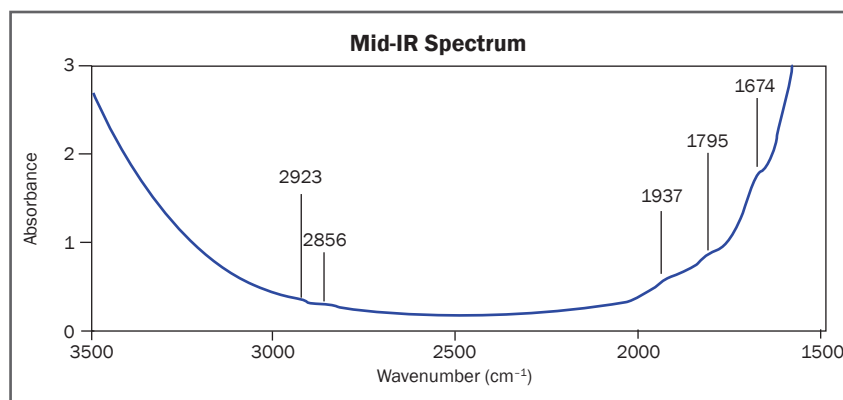


Figure 4: This representative mid-IR spectrum of sample TA03 shows broad transmission in the 3500–1500 cm<sup>-1</sup> range.

Table II: LA-ICP-MS analyses (in ppmw) of selected taaffeite samples from Myanmar and Sri Lanka, compared to data for taaffeite from Africa.<sup>a</sup>

Element	TA01	TA02	TA05	TA-SRI	Samples from Schmetzer et al. (2007)
	Myanmar			Sri Lanka	Africa
Li	24.9	52.6	19.8	13.2	3–22
B	42.2	46.3	44.6	15.8	24–50
Ti	35.9	13.5	14.9	16.1	0.01 wt.% TiO <sub>2</sub> <sup>b</sup>
V	16.4	13.1	17.5	13.3	nd–0.01 wt.% V <sub>2</sub> O <sub>3</sub> <sup>b</sup>
Cr	9.18	3.04	4.06	nd	nd–0.02 wt.% Cr <sub>2</sub> O <sub>3</sub> <sup>b</sup>
Mn	46.7	66.8	32.1	104	0.01–0.05 wt.% MnO <sup>b</sup>
Fe	1150	1190	558	1680	0.31–2.79 wt.% FeO <sup>b</sup>
Co	nd	nd	nd	2.58	nr
Zn	570	633	330	1930	nr
Ga	224	134	207	475	172–610
Sn	5.00	3.97	7.37	2.64	1–9

Abbreviations: nd = not detected, nr = not reported.

<sup>a</sup> For data obtained in this study, the values are averaged from two analysis spots per sample.

<sup>b</sup> Obtained by electron microprobe, and therefore not directly comparable to LA-ICP-MS data.

taaffeites from both Sri Lanka and Africa, although our Burmese samples had lower Fe contents. Research on a violet 4.02 ct taaffeite reportedly from Myanmar also showed it to contain low

Fe contents compared to purple to purplish red samples from Sri Lanka (Schmetzer et al., 2000).

The UV-Vis-NIR spectra of the studied Burmese samples clearly show iron-related absorption



features at 370, 385, 460 and 550 nm, matching previous studies of taaffeite and musgravite from Sri Lanka and Africa (Schmetzer et al., 2007). The main absorption peak of chromium in the visible range is close to the maximum of an iron-related absorption band (Schmetzer et al., 2000), and thus cannot be separated in the spectra of Cr-bearing samples. However, the low Cr contents of our Burmese samples (Table II) probably have little if any influence on the coloration of these samples. The spectra show normal iron-related absorption features, and the very pale purplish pink coloration of the samples is due to their low Fe content (as compared to taaffeite from Sri Lanka or Africa). The low iron content of the Burmese material is the main difference from gem-quality taaffeite from other sources.

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