

# Distinction of taaffeite and musgravite

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**ABSTRACT:** Problems associated with the identification of taaffeite and musgravite are discussed. Due to an overlap of gemmological properties, time consuming mineralogical research techniques (quantitative chemical analysis, X-ray diffraction) are needed for a determination of both species. However, recently micro-Raman spectroscopy has been found to be useful as a quick non-destructive routine technique for identification of both species.

The structurally related Be-Mg-Al-oxides taaffeite,  $\text{BeMg}_3\text{Al}_8\text{O}_{16}$ , and musgravite,  $\text{BeMg}_2\text{Al}_6\text{O}_{12}$ , were originally regarded as polytypes of one single mineral. Chemical and structural examinations, however, proved the existence of two independent species with different chemical formulae, unit cell dimensions, space groups and crystal structures. In both minerals a certain amount of isomorphous replacement of Mg by Fe, Zn and Mn may be observed, thus leading to a more complex formula of  $\text{Be}(\text{Mg,Fe,Zn,Mn})_3\text{Al}_8\text{O}_{16}$  for taaffeite and to a formula of  $\text{Be}(\text{Mg,Fe,Zn})_2\text{Al}_6\text{O}_{12}$  for musgravite (Schmetzer, 1983, a,b; Nuber and Schmetzer, 1983).

For almost half a century since the discovery of the first taaffeite as a cut gemstone in 1945, faceted and rough taaffeites were known predominantly from Sri Lanka, a few rare samples were also mentioned from Myanmar (Kampf, 1991; Demartin *et al.*, 1993). In 1993, however, two faceted 'taaffeites' from Sri Lanka were identified as musgravites by means of X-ray single crystal diffraction (Demartin *et al.*, 1993) and, just recently, a third faceted musgravite was determined by X-ray

powder diffraction (Johnson and Koivula, 1997). In this third stone, major amounts of zinc and iron were detected by qualitative EDXRF analysis.

Because the difference in BeO content between taaffeite and musgravite is only 1.56 wt. %, similar physical properties such as refractive indices and specific gravity are observed for both mineral species. In detail, a complete overlap has been found for the properties of the three faceted musgravites described so far (RI  $n_o$  1.725–1.728,  $n_e$  1.719–1.721, SG 3.62–3.69) and for high zinc- and iron-bearing faceted taaffeites from Sri Lanka (RI  $n_o$  1.724–1.730,  $n_e$  1.719–1.726, SG 3.61–3.71; Schmetzer and Bank, 1985; Ponahlo, 1993). Consequently, neither the determination of physical properties such as refractive indices and specific gravity in the range given above nor qualitative chemical analyses with the determination of zinc and iron in major amounts are useful in deciding whether taaffeite or musgravite is present.

Thus, an unequivocal distinction between taaffeite and musgravite has so far only been possible by quantitative chemical analysis or by X-ray diffraction (powder or single crystal techniques). These methods, however, are

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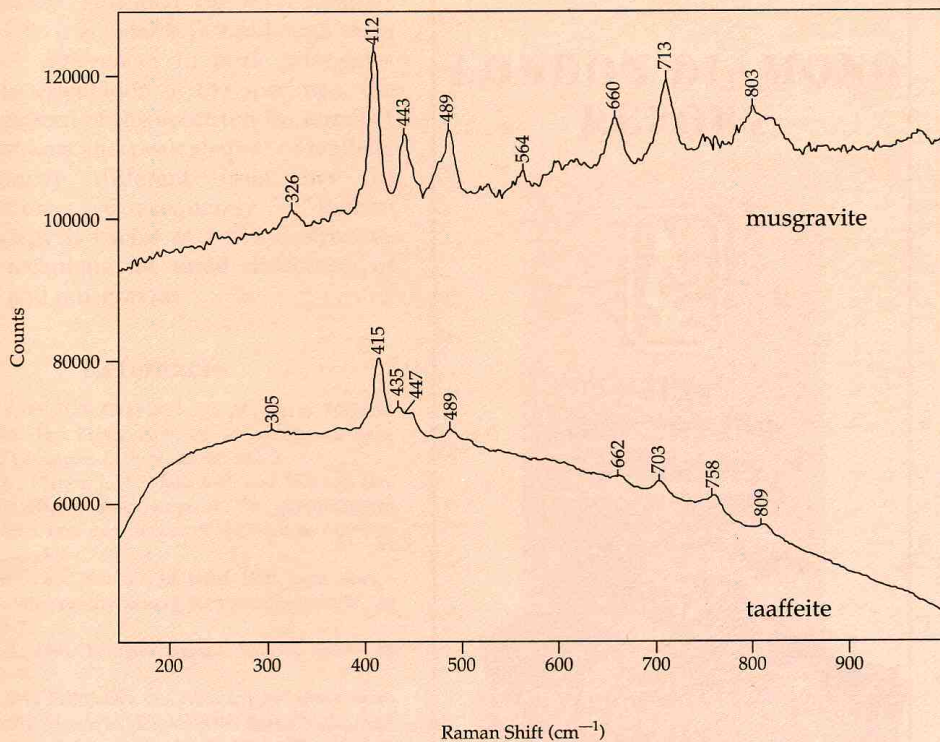


Figure 1: Raman spectra of taaffeite, Sri Lanka, and musgravite, Antarctica.

time-consuming research techniques and not routine methods in gemmology. In addition, for the preparation of an X-ray powder diffraction pattern, a small amount of substance has to be scraped from the girdle of a faceted stone, which is not always wanted or allowed by the owner of a sample to be identified.

With this background, the authors tested the applicability of micro-Raman spectroscopy for the distinction of musgravite and taaffeite. At the end of the '90s, an increasing number of Raman microscope facilities are available at the major gem-testing laboratories around the world and are used as routine instruments for various problems in gem testing (Hänni *et al.*, 1997). To evaluate possible determinations of taaffeite and musgravite by micro-Raman spectroscopy, six taaffeites

(five faceted and one rough gem-quality) from Sri Lanka were examined. Small musgravite crystals were available from the Musgrave Ranges, Australia (type material) and from Casey Bay, Antarctica. For all samples quantitative chemical analyses were performed to identify them as taaffeites or musgravites and for most of them X-ray single crystal and/or powder diffraction data were also available. Raman spectra were recorded using a Renishaw Raman Microscope facility.

As a result, we observed a unique type of Raman spectrum for all taaffeites examined, as well as another Raman spectrum for the musgravites (Figure 1). The six strongest Raman lines were recorded as 415, 435, 447, 703, 758 and 809  $\text{cm}^{-1}$  for taaffeite and at 412, 443, 489, 660, 713 and 803  $\text{cm}^{-1}$  for



musgravite; broad peaks for musgravite are schematically indicated by wavenumbers 564 and 803. It is notable that although there are small differences in peak intensities related to orientation of the specimen, the overall pattern of the spectrum (in terms of peak positions and peak shapes) of taaffeite is distinctly different from that of musgravite. Consequently, Raman spectroscopy is useful as a non-destructive routine technique for rapid distinction of taaffeite and musgravite.

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