DETECTION OF IMITATION JADE WITH RAMAN SPECTROSCOPY

APPLICATION NOTE RAMAN-012 (US)

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Abstract

This short application note documents the Raman spectroscopic analysis of four polished stones acquired from internet sources that were advertised to be jade. A TSI ChemLogix EZRaman-I instrument with a 532 nm laser was used for these measurements. We were surprised to see that none of the stones that we purchased were actually jade!

Motivation

Jade is a highly sought-after ornamental rock that is usually green in color. The designation "jade" is applied to two metamorphic materials that are composed of different silicate minerals: nephrite and jadeite. Both of these materials have been extensively used since the prehistoric period for hardstone carving. Nephrite is a calcium-magnesium-iron amphibole with a chemical formula of $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ and jadeite is a sodium- and aluminum-rich pyroxene, $NaAlSi_2O_6$ or $Na(Al,Fe^{3+})Si_2O_6$. These materials are readily differentiated using Raman spectroscopy, as is shown in Figure 1.

Jade is also one of the most often counterfeited gems. Nephrite is not an uncommon material, but is so tough that it can be tedious to carve. The plethora of pseudo-jades that are easier to handle is too tempting to pass up, apparently, and therefore instead of jade, one might be sold items constructed from serpentine, bowenite, white chalcedony, aventurine or Peking glass.[1]

Jadeite, on the other hand, is counterfeited because of its' rarity and value. The variety of minerals used to imitate jadeite include most of the ones on the nephrite list, and green garnet, albite, green agate and green chalcedony.[2]

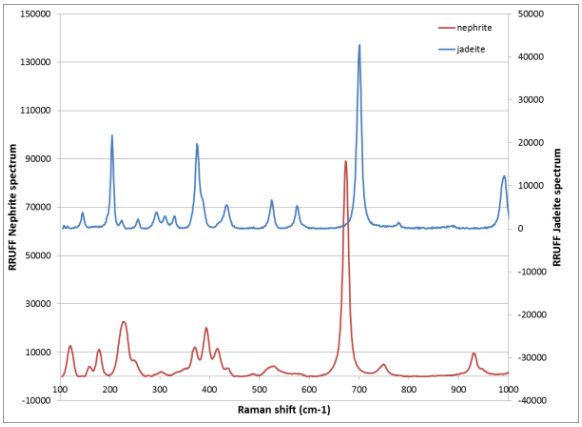

Figure 1. RRUFF Raman spectra of nephrite and jadeite, the two minerals that compose jade.

The global interest in jade and the incredible prevalence of fakes have sparked a real interest in their identification. There are a large number of websites, online videos and other documents devoted to the detection of fake jade, both imitation jade (i.e. other minerals altogether) and processed jade, in which the minerals are heated, chemically altered, dyed or waxed. This work will focus on the detection of imitation jade; future work will address the various classes of processed jade.

Samples

Four small rock samples were purchased online. They were all advertised to be jade. Two of the stones were alleged to be nephrite jade, one was called "jade tumble stone" and the last "African jade tumble stone." They all had highly polished surfaces and were 20 to 25 mm in rough diameter.

Figure 2. "Jade samples" purchased from online vendors

Measurements and Results

A TSI ChemLogix EZRaman-I with 532 nm excitation was used to acquire the spectra of the samples. The stones were set on a table with the probe suspended over them with ring stand and clamp. Approximately 10 mW of laser excitation was used for all the samples and acquisition times from 6-15 s and 10x averages were used to accumulate data. Spectragryph software[3] to perform the comparison against the entries in the RRUFF mineral database, and then RRUFF spectra were superimposed with the sample spectra for demonstration purposes.[4]

The surprising first conclusion is that none of the samples purchased online were composed of either jade mineral.

The first imitation jade was identified by comparison to the RRUFF database as chrysotile. The comparison between the database and the sample spectrum is shown in Figure 3. This mineral is a polymorph of serpentine. The serpentine group comprises hydrous magnesium iron silicate ($(Mg, Fe)_3Si_2O_5(OH)_4$), with green coloration being caused by increasing iron and/or nickel content. Chrysotile is one of three most important polymorphs of serpentine (antigorite, chrysotile and lizardite), and has a fibrous habit, is easily carved, takes a good polish and has a pleasantly greasy feel. Serpentine is sometimes dyed to imitate jade (with the designations "Suzhou jade", "Styrian jade" and "New jade."[5]

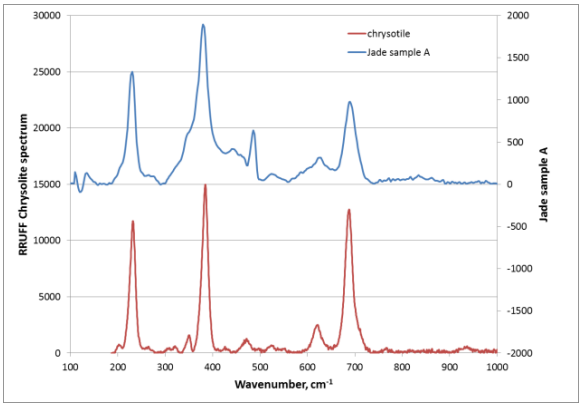

Figure 3. RRUFF Chrysotile and Jade sample A spectra.

In serpentine materials, most of the low wavenumber features are involved with Si-O and Mg-O structures. The Chrysotile feature at 388 cm^{-1} or so is υ_5 (symmetric SiO_4) and the 690 cm^{-1} band has been assigned as Si-O_b-Si vibrations.[6,7]

The second "jade" sample was identified through comparison to the RRUFF mineral database as quartz (Figure 4). Aventurine quartz is a fairly common jade imitation, according to internet sites devoted to the discovery of fake jade.[8] Aventurine's hardness is less than single-crystal quartz, and is fairly easily carved. Quartz is continuous framework of SiO_4 silicon-oxygen tetrahedral with two tetrahedra sharing each oxygen. The overall chemical formula is SiO_2.

The spectral feature at 128 cm^{-1} has been assigned as mode E, the broad feature at 204 cm^{-1} as A_1 (breadth attributed to anharmonic coupling of an A_1 phonon with an acoustic mode), the 352 cm-1 feature to A_1, 390 cm^{-1} to $E_{(TO)}$ and 464 cm^{-1} to A_1 (υ_5 (Si-O-Si).[9,10]

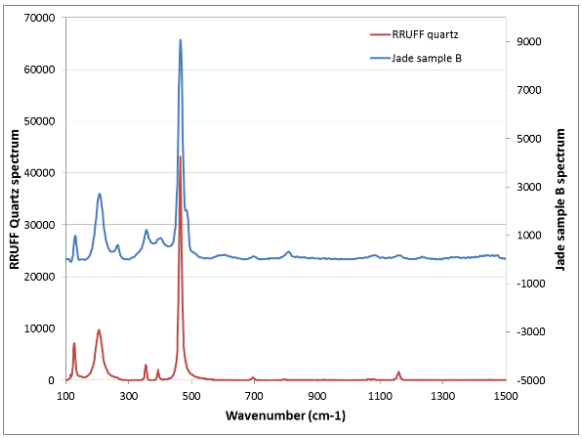

Figure 4. RRUFF Quartz and Jade sample B spectra.

The third and fourth jade samples were purchased from the same internet vendor and were the same material. These were highly polished stones coated with a material that fluoresced when exposed to the laser. After collecting a spectra from the outside surface that was dominated with broadband fluorescence, the sample was broken with a hammer, revealing a surface that exhibited much less fluorescence. This material has chrysotile features, even a better match to the RRUFF representative than sample A. Figure 5 shows the raw spectra of the coating and the inner surface of this rock (baseline corrected). The presence of the fluorescence from the exterior coating is obvious, as is its reduction on the inner surfaces.

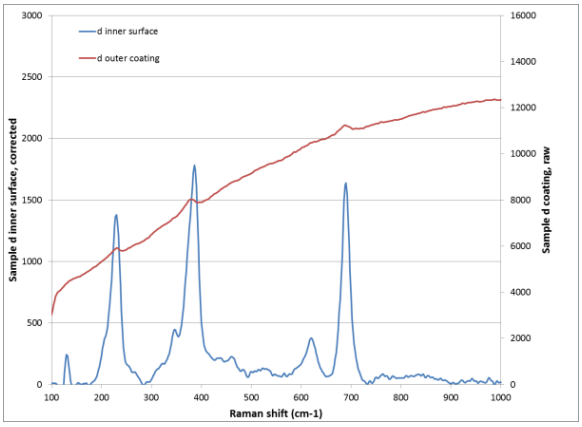

Figure 5. Raw spectra of both outside and inner surface of jade sample d.

In summary, Raman spectroscopy has long been recognized as an effective method for detecting fake and processed gemstones, and our application note demonstrates this aptitude with a TSI ChemLogix EZRaman-I instrument.

As for purchasing jade stones online–let the buyer beware!

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