NOTES
· AND ·
NEW TECHNIQUES

PASTEL PYROPES

By *Carol M. Stockton*

Pyrope garnets occur in near-colorless to light orange and pink, as well as the familiar red. Because the pale-hued pyropes are unfamiliar to gemologists, their low refractive index usually results in their misidentification as grossular. This note clarifies the means by which these unusual garnets, predominantly from East Africa, can be properly and easily identified with a refractometer and a spectroscope.

The term *pyrope* comes from the Greek word *pyropos,* meaning "fiery-eyed," undoubtedly because of the intense red color for which these garnets are known. Therefore, most gemologists are surprised to learn that pure pyrope is completely colorless; its chemical formula, $Mg_3Al_2Si_3O_{12}$, contains no color-causing agents. The familiar red hue results from impurity ions of Fe^{2+} and/or Cr^{3+}. Pure pyrope is unknown in nature, but almost-pure, colorless material with up to 98 mol.% pyrope was recently found in the western Alps (Chopin, 1984). This material, however, is either too small or too fractured to be used as a gemstone. The same situation exists for high-pyrope (70–77 mol.%) garnets from a number of localities worldwide (Deer et al., 1982), although none approaches the high content of the Alpine samples. Pale-colored, high-pyrope garnets from Arizona have been faceted as gems, but few cut stones exceed half a carat, so their gemological significance has been minor.

Once again, however, East Africa has introduced new gem-quality material: Low-iron, low-chromium pyrope (around 70 mol.%) occasionally turns up in parcels of grossular and malaia (pyrope-spessartine) garnet. Clean, faceted, pastel orange or pink stones can be obtained in 2- to 5-ct sizes.* Because of their low refractive indices, such stones are often erroneously identified as grossular. However, pyrope (figure 1) and grossular garnets can be readily separated by a combination of R.I. and spectroscopy.

Pure grossular, which is also colorless, has a refractive index of 1.734, while the R.I. of pure pyrope is 1.714. Since the presence of coloring agents in either of these garnet types raises the refractive index, any pale-colored garnet with an R.I. below that of pure grossular is pyrope rather than grossular. Theoretically, of course, all sorts of chemical combinations could occur to contradict this conclusion, but no such material has yet been encountered among transparent gem-quality garnets.

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**The largest pink pyrope that the author has seen to date was recently sent for identification to the GIA Gem Trade Laboratory in Los Angeles. The stone is a 63.06-ct pear shape (R.I. = 1.733); the large size resulted in a darker tone reminiscent of rhodolite garnet.*

Figure 1. All four of the garnets pictured here are pyropes. The typical chrome pyrope at bottom left (GIA #13113, 1.08 ct) has a refractive index of 1.740. The orange pyrope (GIA #14400, 1.61 ct) has an R.I. of 1.732 and is colored by iron, and the pink pear shape (GIA #14002, 3.43 ct) is colored by a trace of chromium and has an R.I. of 1.740. The pale orange stone at the top (3.56 ct; courtesy of Tsavo Madini) has a 1.732 refractive index and contains manganese as its coloring agent. Photo © Tino Hammid.

In addition, the coloring agent in gem-quality orange grossular, or hessonite, garnet is Fe^{3+} (Manning, 1969, 1972; Moore and White, 1972; Manson and Stockton, 1982), whereas pale orange pyrope is colored by Fe^{2+} and/or Mn^{2+} (Stockton, 1987). This difference can be observed spectroscopically (Stockton and Manson, 1985). Fe^{3+} in grossular is associated with absorption bands at about 408 and 430 nm, but these are visible with a hand spectroscope only when the orange color is relatively intense or dark. Lighter orange or yellow grossulars show no visible spectrum under normal gemological testing conditions, although the 408 and 430 bands can often be detected with a laboratory spectrophotometer. Fe^{2+} in orange pyrope is related to absorption features at 504, 520, and 573 nm that can usually be observed with a hand spectroscope, unless the color is extremely pale. Mn^{2+} in orange (or any other color, for that matter) pyrope produces strong absorption in the blue, with three bands at 410, 421, and 430 nm. In all cases, the lighter the stone is the weaker (and therefore more difficult to see) the absorption bands will be, and the closer the refractive index will be to that of the pure end member. Thus, on the basis of refractive index and spectrum, any low R.I., light-colored garnet can be identified as either pyrope or grossular. With an R.I. over 1.742, the presence of Mn^{2+} absorption lines denotes pyrope-spessartine (malaia) or pyrope-almandine, depending on the strength of these lines relative to that of other absorption bands present.

Pink pyrope owes its color essentially to the presence of trace amounts of chromium, associated with broad regions of absorption that generally cannot be resolved with a hand spectroscope. Small amounts of Mn^{2+} and/or Fe^{2+} are also present in these garnets, and the related spectral features are usually visible as weak bands. Pink grossular has been found in Mexico for about a

Figure 2. These two pink grossular crystals (12.07 and 18.35 ct) are from Xalostoc, Mexico. Their lack of spectral features distinguishes them from pink pyropes. Photo by Shane McClure.

century (DeLandero, 1891), but recent reports on the material are scarce (Prandl, 1966; Sinkankas, 1976). Although most of the rough is translucent to opaque, transparent material has occasionally been found and faceted. Refractive indices of 1.736 and 1.742 have been reported (Ford, 1915; Stockwell, 1927). Two crystals of this material (figure 2) were examined, and both had a 1.744 refractive index. Reported chemical analyses reveal only Fe^{3+}, Mn^{2+}, and, in one case, Ti^{2+}, as potential coloring agents (DeLandero, 1891; Menzer, 1929; Prandl, 1966). Energy-dispersive X-ray fluorescence on the two stones in figure 2 confirmed these three impurities. However, Fe^{3+} imparts a yellow to orange hue to grossulars, while the effects of Mn^{2+} and Ti^{2+} have not been thoroughly investigated. Cr^{3+} and V^{3+} both produce green in grossulars, so neither can be a significant trace constituent in the pink stones.

TABLE 1. Characteristic and distinguishing properties of colorless to light orange and pink garnets.

Species/ variety	Color[a]	R.I. range	Characteristic absorption bands (in nm)
Pyrope	Colorless to light orange and pink	1.714–1.742	None to one or more of 410, 421, 430, 504, 520, 573
Grossular	Colorless to light orange and pink	1.734–1.760	Usually none; orange may show weak 430 and even weaker 408
Pyrope-spessartine (incl. malaia)	Light orange and pink	1.742–1.780	Strong 410, 421, 430; weak 504, 520, 573
Pyrope-almandine (incl. rhodolite)	Pink	1.742–1.785	Strong 504, 520, 573; weak 410, 421, 430

[a] *All these types of garnet occur in other hues, darker tones, and/or more saturated colors.*

Further study is necessary to determine the cause of color in pink grossulars. In any event, the spectrum of pink grossular would not resemble the Mn^{2+}/Fe^{2+}-related spectrum of pink pyrope. Once a pink garnet has been identified as non-grossular on the basis of spectrum, a refractive index below 1.742 will identify it as pyrope rather than either pyrope-spessartine or pyrope-almandine. Table 1 summarizes the characteristic properties of the various types of light-colored garnets discussed above.

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