NOTES
· AND ·
NEW TECHNIQUES

A NEW CLASSIFICATION FOR RED-TO-VIOLET GARNETS

By W. William Hanneman

The recent article by Manson and Stockton on the classification of red-to-violet garnets should be welcomed by all gemologists. With this work, the Gemological Institute of America has opened the subject for review and revision. The following article presents an overall view of previous red-to-violet garnet classification schemes and proposes a new one that is well within the capabilities of every gemologist.

The major problem confronting gemologists with respect to garnets has been that of "not being able to see the forest for the trees." The modern tendency in gemology is to make more and more measurements on more and more specimens. This accomplishes the characterization of more and more individual trees. Development of a useful classification scheme for garnets requires that we stand back, look at the entire forest, and decide what it is that we wish to accomplish with our classification.

In regard to the red-to-violet garnets, the data reported by Manson and Stockton (1981) represent a prodigious effort. A plot of their data relating refractive index (R.I.) to specific gravity (S.G.) is shown in figure 1. The data points represent the "trees." Now, let us look at the forest.

The black line connecting the pyrope and almandine end members defines the positions we would expect for all pure garnets comprising the pyrope-almandine solid-solution series. Points lying off the line result from either experimental error or the presence of "other factors." Specifically, if we disregard analytical error, points lying above the line suggest the presence of a substance having a positive effect on R.I. and a lesser positive or negative effect on S.G. In this case, the cause may be chromium and calcium substituting for aluminum and magnesium, respectively. Points lying below the line suggest the presence of something that effectively lowers the R.I. relative to the S.G. Such an effect could be produced by manganese substituting for iron or by the presence of inclusions.

Because their statistical analysis indicated a high correlation for R.I., S.G., pyrope content, and almandine content, Manson and Stockton divided the red-to-violet garnet series into three groups: pyrope, pyrope-almandine, and almandine. The divisions between groups were arbitrarily set at ratios of 60% pyrope:40% almandine and 60% almandine:40% pyrope, as determined by microprobe analyses. Data points in figure 1 are color coded to reflect this scheme. The lack of a clear boundary for pyrope, as well as the presence of several serious divergences, indicated that this approach was not completely successful.

Be that as it may, Manson and Stockton devel-

ABOUT THE AUTHOR

Dr. Hanneman is a research analytical chemist and founder of Hanneman Gemological Instruments, Castro Valley, California.

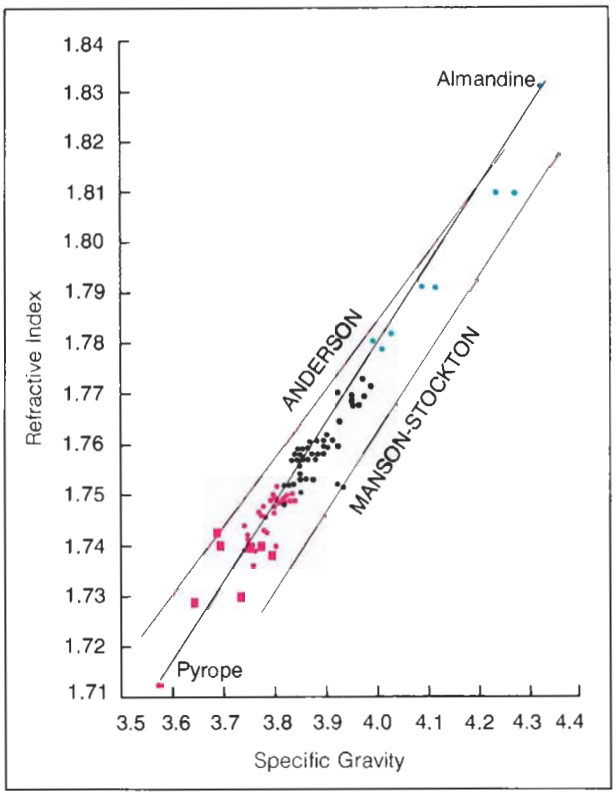

Figure 1. Data reported by Manson and Stockton (1981) relating refractive index to specific gravity and color coded to indicate ratio of pyrope:almandine as determined by microprobe analyses. Red indicates a ratio greater than 1.5:1, black indicates a ratio between 1.5:1 and 1:1.5, and blue indicates a ratio less than 1:1.5. Lines labeled Anderson and Manson-Stockton define an area within which natural red-to-violet garnets have been described. Chrome pyrope values reported by B. W. Anderson (1942) and Manson and Stockton (1981) are designated by red squares.

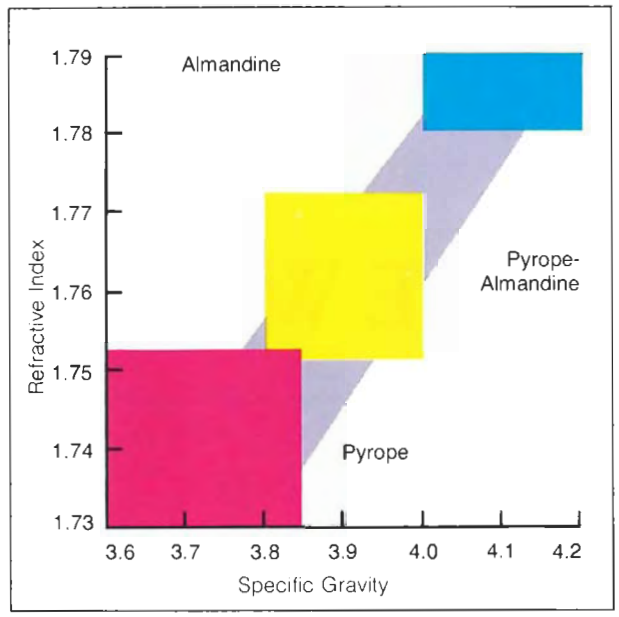

Figure 2. Graphical representation of refractive index and specific gravity limits for pyrope, pyrope-almandine, and almandine garnets as proposed by Manson and Stockton. The lavender areas, although lying between the Anderson and Manson-Stockton lines, are undefined. Note overlap of areas.

oped what they stated to be a "more specific definition of the widely accepted terms *pyrope, almandine,* and *rhodolite* for meaningful gemological classification." These authors proposed replacement of the term *rhodolite* as a garnet group by the term *pyrope-almandine,* and set R.I. and S.G. limits as illustrated in figure 2. In order to evaluate this new definition, it is useful to reexamine their data (as reproduced in figure 1) and relate it to previous publications of B. W. Anderson (1942, 1980) and R. Webster (1975).

COMPARISON OF THE B. W. ANDERSON AND MANSON-STOCKTON SCHEMES

Two red lines have been drawn in figure 1. Effectively, they form the limits of the red-to-violet garnet forest. The lower line, labeled Manson-Stockton, can be considered a "base line." All of the garnets studied by these workers lie above this line. The upper line, labeled Anderson, was derived from B. W. Anderson's diagram of the pyrope-almandine series, which was reproduced by Webster (1975, p. 149). This line can be considered an expression of the upper limit of the red-to-violet garnets, as determined experimentally by Anderson. The fact that it does not coincide with the theoretical pyrope-almandine line indicates the influence of other factors in "real-world" garnets.

For nearly 50 years, the Anderson scheme has been in use practically everywhere except in the United States. The scheme employs three divisions—pyrope, pyrope-almandine, and almandine—precisely those now advocated by Manson and Stockton. This author accepts without reservation the Manson-Stockton recommendation that the term *rhodolite,* as it has been used by U.S. gemologists, be replaced by the term *pyrope-almandine.* The question to be addressed here is whether the newly proposed Manson-Stockton scheme presents sufficient advantages to displace the B. W. Anderson scheme.

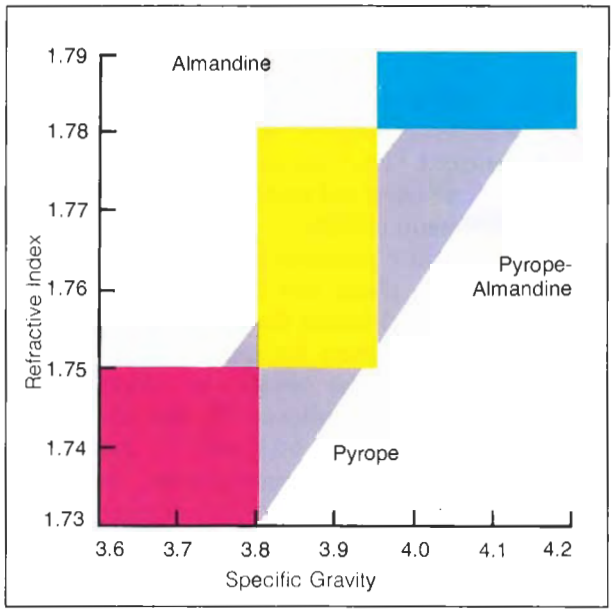

Figure 3. Graphical representation of refractive index and specific gravity limits for pyrope, pyrope-almandine, and almandine garnets as proposed by B. W. Anderson. The lavender areas, although lying between the Anderson and Manson-Stockton lines, are undefined.

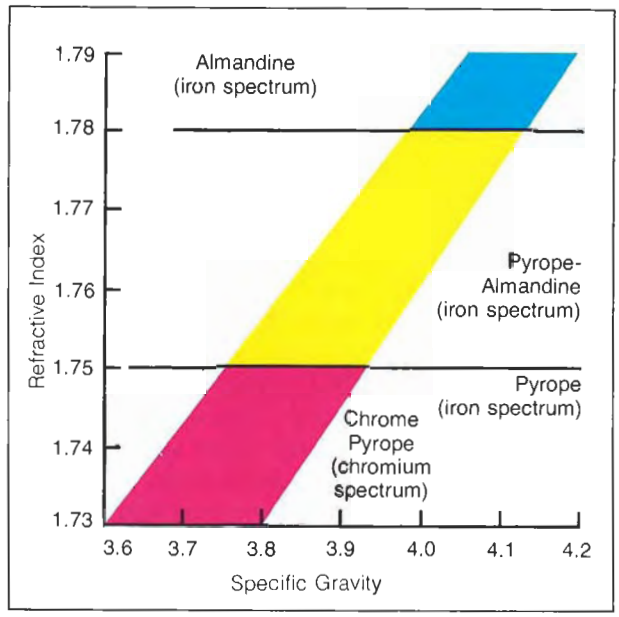

Figure 4. Graphical representation of proposed scheme for the classification of the red-to-violet garnets on the basis of refractive index and visible spectrum. All colored areas lie between the Anderson and Manson-Stockton lines.

It appears reasonably safe to postulate that almost all red-to-violet garnets likely to be encountered by a gemologist will have R.I.-S.G. coordinates somewhere between the Anderson and the Manson-Stockton lines. Therefore, the merits of any classification scheme ought to be related to how well that scheme covers all the possibilities. The R.I. and S.G. limits for the Anderson and Manson-Stockton schemes are graphically illustrated in figures 2 and 3. The lavender areas represent "possible" R.I.-S.G. coordinates that are not covered by the schemes and are potential sources of problems for gemologists. It is evident that neither scheme covers the entire range of possibilities.

If it is accepted that the purpose of a classification scheme is to enable the gemologist to make a decision on the basis of his test results, the presence of an undefined area or an area of overlap is undesirable inasmuch as it makes any such decision impossible. The Anderson scheme (figure 3) could be improved by changing the arbitrary limits of S.G. from 3.95 to 4.00 for the pyrope-almandine mixture, and from 3.80 to 3.85 for pyrope. The Manson-Stockton scheme (figure 2) suffers from a gap in R.I. values between 1.774 and 1.779. In addition, there is an overlap in the pyrope and pyrope-almandine ranges: i.e., R.I. = 1.751 to 1.752, S.G. = 3.81 to 3.86. These deficiencies are unacceptable in light of the fact that the divisions are purely arbitrary, and there is no fundamental characteristic that dictates that there should be any divisions at all.

Now, if neither of these schemes can be judged fully satisfactory, there is room for improvement. In the following paragraphs an alternative scheme is presented.

BACKGROUND FOR PROPOSED GARNET CLASSIFICATION SCHEME

If one's concern is limited to only the red-to-violet garnets, the assumption can be made that the red color is due to the presence of iron and/or chromium. It is generally accepted that the iron is associated with the almandine end member and the chromium with the pyrope. Consequently, irrespective of their calcium or manganese contents, all red-to-violet garnets have traditionally been considered members of the pyrope-almandine series.

The spectral characteristics of the red-to-violet garnets are well described in the Manson-Stockton article. However, since pure pyrope garnet is colorless, it is the iron (almandine) that produces the

color and the spectrum that is the hallmark of the pyrope-almandine series.

Spectral evidence also indicates that pyrope forms another series in which chromium substitutes for aluminum and produces a red color. Mineralogically speaking, one might call this a pyrope-knorringite series. However, gemologically speaking, this series does not appear to be very extensive and this author proposes that its gem members be classified under the color variety chrome pyrope. This nomenclature is believed to be gemologically consistent with varieties such as chrome tourmaline and chrome diopside. With its intrinsic chromium content and unique absorption spectrum, chrome pyrope deserves recognition as a distinct variety and should not be buried in the pyrope-almandine series.

Finally, the determination of physical constants should provide information on which to base a decision as to classification. Both R.I. and S.G. measurements reflect the same elements of composition. Anyone who has tried to identify gems by S.G. measurements is well aware of the difficulty of obtaining accurate results as well as the problems caused by inclusions. The R.I., however, is determined more easily and precisely. Consequently, the scheme proposed here employs R.I. determinations only, without S.G.

PROPOSED RED-TO-VIOLET GARNET CLASSIFICATION SCHEME

Acceptance of the preceding ideas leads to the conclusion that the red-to-violet garnets could be classified into two categories: pyrope-almandine series and chrome-pyrope color variety. Insofar as neither the colorless pyrope nor the almandine end members are known as gems, it would be reasonable simply to call all the members of this series pyrope-almandine mixtures for the purposes of a gemological classification. They are all characterized by a typical almandine (iron) spectrum. Tradition, however, militates against this, so the old divisions are retained.

The proposed scheme is very simple. Chrome pyrope is characterized by its chromium spectrum and by R.I. values below 1.750. Members of the pyrope-almandine series are characterized by their iron spectrum. Pyrope exhibits an R.I. of 1.750 or less, while almandine exhibits an R.I. of 1.780 or more. Specimens exhibiting intermediate R.I. values are designated pyrope-almandine. The scheme is illustrated in figure 4.

In the final analysis, this scheme is little more than the B. W. Anderson scheme with the S.G. limits removed. The problem of differentiating chrome pyrope from red spinel has been fully covered by Anderson (1980).

The remaining problem is that of assigning a classification to those low R.I. (<1.750) garnets that show spectral bands due to both chromium and iron. The criterion for making this distinction is based on the results of Manson and Stockton and is as follows: If the three iron absorption bands at 504, 523, and 571 nm can be observed with a hand spectroscope, the stone should be classified as pyrope; chrome pyrope will exhibit absorption bands at 675 and 687 nm, and will absorb virtually all light below 570 nm. If sufficient chromium is present to mask at least two of the iron bands, the stone should be classified as a chrome pyrope.

SUMMARY

Because of gaps and overlaps, the Manson-Stockton scheme for red-to-violet garnets cannot be considered acceptable. A different interpretation of their data leads to the B. W. Anderson scheme, which is already in use outside the United States. The S.G. limits of this scheme, however, are too narrow. Given the problems of determining S.G. measurements, a simplified scheme based on R.I. and spectral considerations has been presented. The "official" recognition of the color variety *chrome pyrope* is recommended.

EPILOGUE

If any revisions to garnet classification schemes are to be accomplished, it is imperative that input be received from many sources and a consensus reached. In an attempt to encourage a dialogue on this subject, D. V. Manson and C. M. Stockton, whose work was discussed above, have been invited to comment on this paper. Their response follows.

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