ColorCodex™ – A New Tool for the Gemstone and Jewelry Industry

Over the past three years, the author has been developing the ColorCodex™ system to help the industry reference color in gemstones. This innovative and easy-to-use tool best mimics the way that color presents itself in faceted transparent gems and significantly expands the gamut of color over other color systems that have been proposed or developed previously.

By Christopher P. Smith

With its official launch during the Tucson Gem Show in 2019, the ColorCodex™ system has been specifically developed to help the industry in several areas that it continues to struggle with. Applications include:

- Gem dealers, jewelers and suppliers – to better match stones and fulfill inquiries/needs;
- Education – training new gemologists in the nuances of color in various gem species and varieties and how the influence of tone may impact their color appearance;
- Trade organizations – to provide a better understanding of gem varieties and trade terms for communication in the trade and with consumers;
- Laboratories – to establish better criterion and consistency of color descriptions, varietal calls and trade terms.

This article introduces the concepts of the system and demonstrates one of the more specific applications of the ColorCodex™ system, i.e. how the system can be used to bring a more uniform definition and understanding to gem varieties (Figure 1), and how the system can complement objective spectral data to make such criterion for color varieties more robust for groups such as trade organizations, gemological schools and gemological laboratories alike.

It is to be noted that the suggestions put forth are not endorsed or recognized by any of the various trade organizations, gemological schools or gemological laboratories. They are proposals only. They may be used to spark discussions for further refinements and suggestions, but they should not be taken as formal definitions.

Figure 1: The ColorCodex™ is an innovative, easy-to-use tool for the gemstone and jewelry industry to reference color.

Background

Color is a complex world of hues, intensity (saturation) and tone, which all combine to create the particular color that we see, with a seemingly limitless variety of shades and nuances. Gemstones represent an even further dimension in that we are dealing with transparent bodies that have the ability, through faceting, to present a mosaic of brightly colored reflections, more subdued reflections, as well as blackened areas of extinction, which fluctuate and shift as a stone is tipped and rotated. As a result, intrinsically, any color system that presents itself in an opaque, flat, two-dimensional format will struggle to represent color as it is seen in transparent, faceted gems. This is why the ColorCodex™ color referencing system was developed.

The gemstone and jewelry industry have made many attempts to communicate color in a meaningful manner. None, however, have achieved broad industry acceptance for the primary reason that they do not represent the color as it appears in faceted gems. In addition, those systems had a more limited gamut of color, particularly in the more vibrant shades, as compared to gems (Figure 2). The result of the industry not having a color system that adequately represents the color of gemstones has been a contributing factor in the development of trade terms, such as *Pigeon's Blood, Royal Blue, Muzo Green,* and many others. The ColorCodex™ is a color referencing system specifically developed to address this issue and significantly expand the gamut of color over previous systems (Figure 3).

In total, 65 different hues of color are represented on 13 ColorCodex™ sheets. On each page are five individual colors or hues. Each hue is further represented by its own column that is then divided into eight windows that depict the varying intensity or saturation of that specific color.

Each color window is identified by a two-part numbering convention. The first number identifies the specific hue, with even numbers, 10 through 138. The second number identifies the levels of intensity/saturation for each color. These are odd numbers, 03 through 17. Referring to Figure 3, combining these two numeric values (e.g. 22 – 17) defines not only a specific color (column 22), but also its intensity or saturation of color (level 17).

Colors Falling Between Two or More Color Windows

When developing the ColorCodex™ system, it was also recognized that colors may fall in a range that lies in-between two or more color windows. This system was thus purposefully developed with alternating numbers, thereby permitting such intermediate colors to also readily have a ColorCodex™ numeric value. For example, a stone whose color falls be-

Figure 2: Other color systems, utilized by the industry up to now, have struggled to address the intense saturations and vibrant colors that are encountered in faceted gemstones. Shown here is an example from the Munsell color book that is closest in reference to the ruby. As may be readily seen, the gamut of color is too limited to adequately reference the color of such a top-color gem.

tween the color of columns 86 and 88 is represented by 87. Additionally, if the color intensity is seen to reside between two color windows, such as 11 and 13, it is represented by the numeric value of 12.

How The Influence of Tone Is Managed

In the ColorCodex™ system, the values of hue and saturation are handled on the horizontal and vertical axis, respectively, leaving the third important element in color to be managed through the use of gray overlays. Five levels of tone are represented in five ColorCodex™ overlays, labeled G1 through G5.

When referencing a gemstone that displays an element of tone in its color, the appropriate region of color, in terms of the column and level, should be located. Then, various overlays can be used to further refine the matching color appearance.

A Numeric System as Opposed to Verbal Terms

The ColorCodex™ system has not been designed nor is it intended to try and dictate how colors must be defined. The majority of people view color differently from one another. This depends significantly on the region or culture, which one comes from, as well as the manner in which one originally learned about and how to describe colors, in addition to their experience in communicating colors and their familiarity with color science.

A color that one person may describe as "chartreuse" or "greenish yellow," may be viewed as "green-yellow," "slightly greenish yellow" or even just "yellow" by others. As a result, the ColorCodex™ system does not try to dictate how one should describe colors. Although two or more people may or may not describe a specific color the same, using a system that relies on direct color comparison, they would select the same color window or numeric value as the closest match

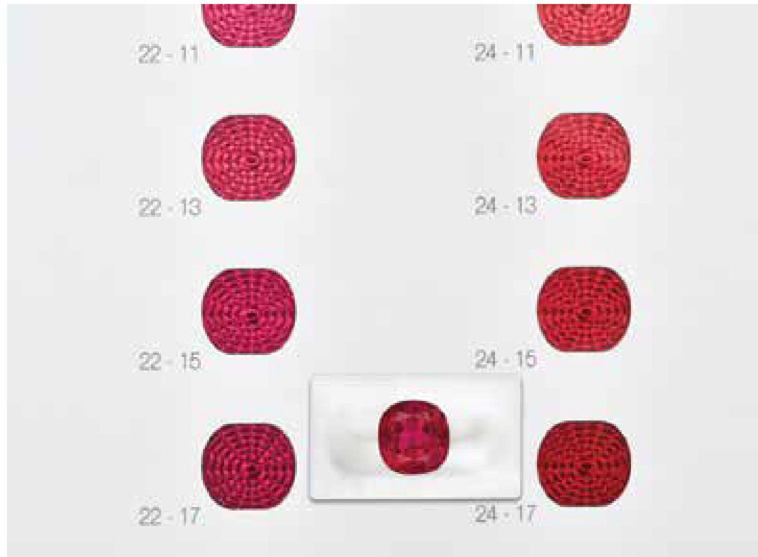


Figure 3: One of the primary advantages of the ColorCodex™ system is its significantly expanded color gamut. As may be seen here, this same ruby can be well referenced using this system and the ColorCodex™ numeric reference of 22 - 17 can be communicated to anyone, anywhere in the world. People/companies using the system will then immediately be able to recognize the color of the gem under discussion. This can help save time and money when requests are given/received, over verbally trying to describe a specific color and shipping stones back and forth for approval.

to a particular faceted gemstone. This way, users of the ColorCodex™ system still have the freedom to describe the color using subjective verbal terms, yet all users of the system can utilize the objective numerical indicators (Figure 4).

Applications – Gemstone Varieties

Many of the mineral species used as gemstones have a classification of varieties that are based on color (as well as other optical, chemical or physical phenomenon). In some instances, there is the potential for more objective (spectral

Figure 4: The nuances of a gemstone's specific color can be difficult to communicate using verbal descriptions, as the intended meaning and perceptions received by such descriptions may mean different things to different people. However, the ColorCodex™ system has distilled such nuances down to a numeric system that can now be referenced by anyone.

and chemical) criterion that can complement the visual color impression, while, in other instances, the varietal designations are based strictly on the observed color. The following are some examples.

Corundum. The mineral corundum has a number of gem varieties that are based on the observed color alone. These include ruby, sapphire (blue sapphire), pink sapphire, padparadscha sapphire, yellow sapphire, green sapphire and so on. Within and between these varieties, there are no clear-cut borders or criteria to separate and distinguish them outside of broadly applied color descriptions.

The industry has long struggled to come up with a definable border for ruby and pink sapphire. Both pink and red color in corundum is the result of chromium (Cr^{3+}). As a result, an objective criterion based on spectral characteristics is not possible. In addition, it has been shown that guidelines following the amount or concentration of Cr in a particular stone also does adequately satisfy the criteria for a variety of reasons. Therefore, the distinction between ruby and pink sapphire remains a strictly visual one.

Attempts have been made to try and establish this border. As an example, a number of years ago the ICA came out with a master set composed of synthetics that featured stones of one particular shade in a range of color intensities (Figure 5). However, the issue of a ruby/non-ruby border is more complex than just an issue of color intensity. There are also borders as the shade transitions to colors with a purplish to purple modifier, as well as shades that transition to a more orangey or orange modifier. And then of course, there is the influence of tone.

Figure 5: To try and help the trade define a border between ruby and pink sapphire, a number of years ago the ICA put together a series of synthetics that ranged from lighter/pink shades to more saturated red shades. However, these stones represented only one hue within the possible range of colors where a potential ruby/non-ruby border exists. (Image: SSEF)

For the first time, all of the variables that may define a ruby/non-ruby border may now be explored using the ColorCodex™ system. Furthermore, we can demonstrate how the variety call of pink sapphire is much more expansive than what many may be familiar with, as the color transitions from a purer pink hue to those shades with a purplish component. On the opposite side of this color range, we can also see where pink sapphires transition to shades with an orangey to orange color component, leading to the varietal classification of a padparadscha sapphire (Figures 6).

Tourmaline. The mineral group tourmaline presents an excellent example of where gem variety definitions based on color can be complemented by and made more robust through spectroscopic/chemical data. For most of the gemstone trade's history, there were two gemstone varieties for tourmalines of a green to blue color (verdite = green, indicolite = blue, see Figure 7). Both of these shades were colored predominantly by iron (Fe^{2+}).

That all changed with the new find of copper-bearing tourmaline in the Paraiba state of Brazil in the late 1980s. For the first time, an entirely unique range of colors in tourmaline were available, where copper (Cu^{2+}) was the dominant chromophore. This included the color range of green to blue.

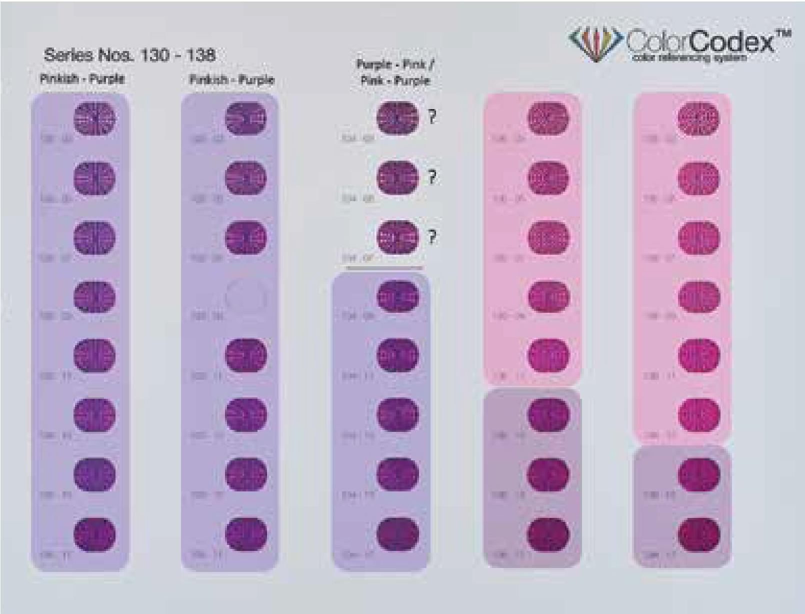
Utilizing chromophores (Fe versus Cu), the industry has made a clear and definitive classification between Paraiba or Paraiba-type colors and those of verdite or indicolite, as well as others (Figure 8). However, the full range of colors and intensities that are classified as Paraiba or Paraiba-type tourmaline remains a topic of discussion within various labs and trade organizations. This particular topic is outside the scope of the present paper, although the ColorCodex™ system is well positioned to help in the resolution of such issues.

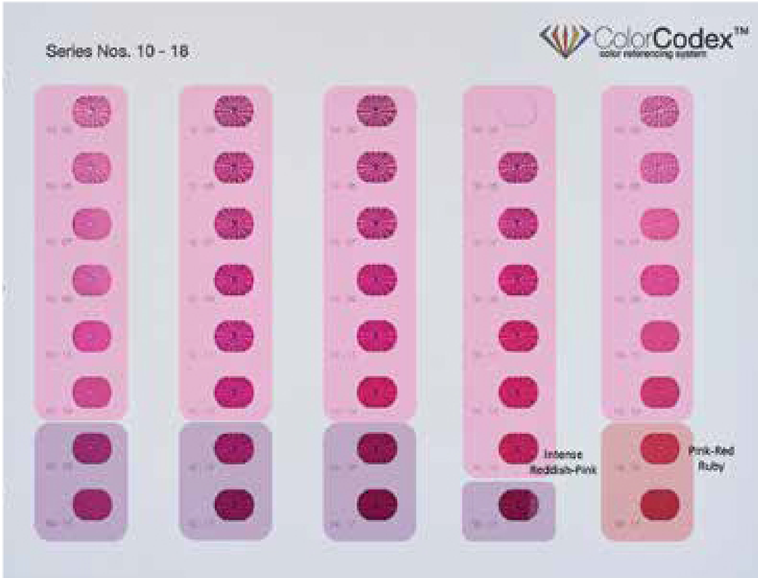
Meanwhile, there still remain other color varieties within the tourmaline group that may also be better defined for the industry using the ColorCodex™ system. A prime example includes the varietal designation of indicolite tourmaline. This distinction is based on iron being the primary chromophore and a specific range of shades.

There is general consensus that the dominant observed color should be blue, hence from which the original term derived. However, are indicolite tourmalines defined as being a pure blue shade or can there be nuances or modifiers of green that are also permitted in this varietal call? If so, how much green is allowed before the shade begins to fall outside of the parameters of an indicolite classification? Based on years of laboratory and trade experience, the author uses the ColorCodex™ to make a suggestion for this particular range of color (Figure 9).

Topaz. Another area that the trade has struggled with includes the varietal designations of imperial topaz and precious topaz. When one searches for the definitions of these varieties/terms, there is a lot of overlap and confusion. As a result, these terms are presently almost synonymous or interchangeable.

Furthermore, we are able to see how the applications of and definitions for gem varieties may change over time and with new deposits/sources. From a more traditional stand-





130 – 138 Series

ColorCodex Reference

Pink Sapphire Variety Call

136 - 03 thru 136 - 11
138 - 03 thru 138 - 13

Fancy Sapphire Variety Call

136 - 13 thru 136 - 17
138 - 15 thru 138 - 17

Purple Sapphire Variety Call

130 - 03 thru 130 - 17
132 - 03 thru 132 - 17
134 - 09 thru 134 - 17

10 – 18 Series

ColorCodex Reference

Ruby Variety Call

18 - 15
18 - 17

Pink Sapphire Variety Call

10 - 03 thru 10 - 13
12 - 03 thru 12 - 13
14 - 03 thru 14 - 13
16 - 03 thru 16 - 15
18 - 03 thru 18 - 13

Fancy Sapphire Variety Call

10 - 15 thru 10 - 17
12 - 15 thru 12 - 17
14 - 15 thru 14 - 17
16 - 17

30 – 38 Series

ColorCodex Reference

Padparadscha Variety Call

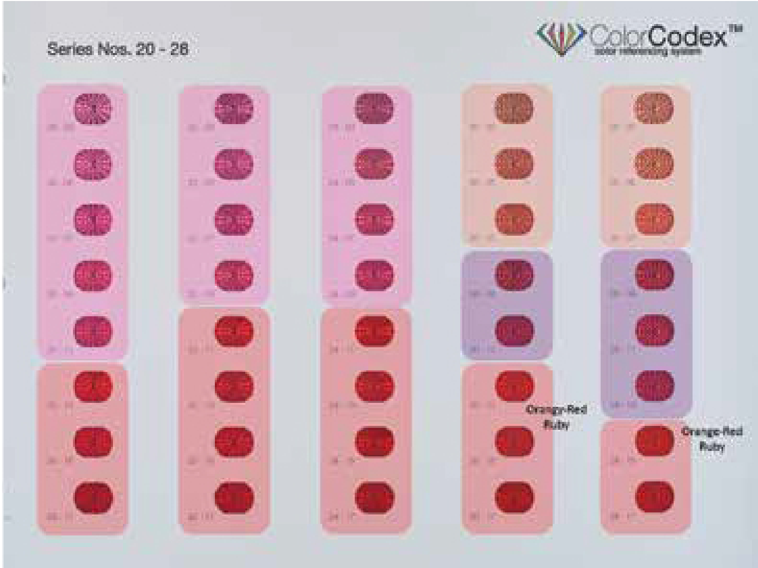
30 - 03 thru 30 - 07
32 - 03 thru 32 - 07
34 - 03 thru 34 - 07

Fancy Sapphire Variety Call

30 - 11 thru 30 - 17
32 - 11 thru 32 - 17
34 - 09 thru 34 - 17

Orange Sapphire Variety Call

36 - 03 thru 36 - 17
38 - 03 thru 38 - 17



20 – 28 Series

ColorCodex Reference

Ruby Variety Call

20 - 13 thru 20 - 17
22 - 11 thru 22 - 17
24 - 11 thru 24 - 17
26 - 13 thru 26 - 17
28 - 15 thru 28 - 17

Pink Sapphire Variety Call

20 - 03 thru 20 - 11
22 - 03 thru 22 - 09
24 - 03 thru 24 - 09

Padparadscha Variety Call

26 - 03 thru 26 - 07
28 - 03 thru 28 - 07

Fancy Sapphire Variety Call

26 - 09 thru 26 - 11
28 - 09 thru 28 - 13

Figures 6: These four sheets of the ColorCodex™ system demonstrate the potential for establishing a robust ruby/non-ruby varietal classification, as well as the full range of colors presently included in the pink sapphire varietal call, in addition to how these colors transition towards purple sapphire, orange sapphire, padparadscha sapphire and fancy sapphire calls.

Figure 7: Traditionally speaking, green and blue tourmalines have been given the varietal names of verdite and indicolite, respectively. However, the range of colors that are accepted with these two varietal names remains broadly related to descriptions of color.

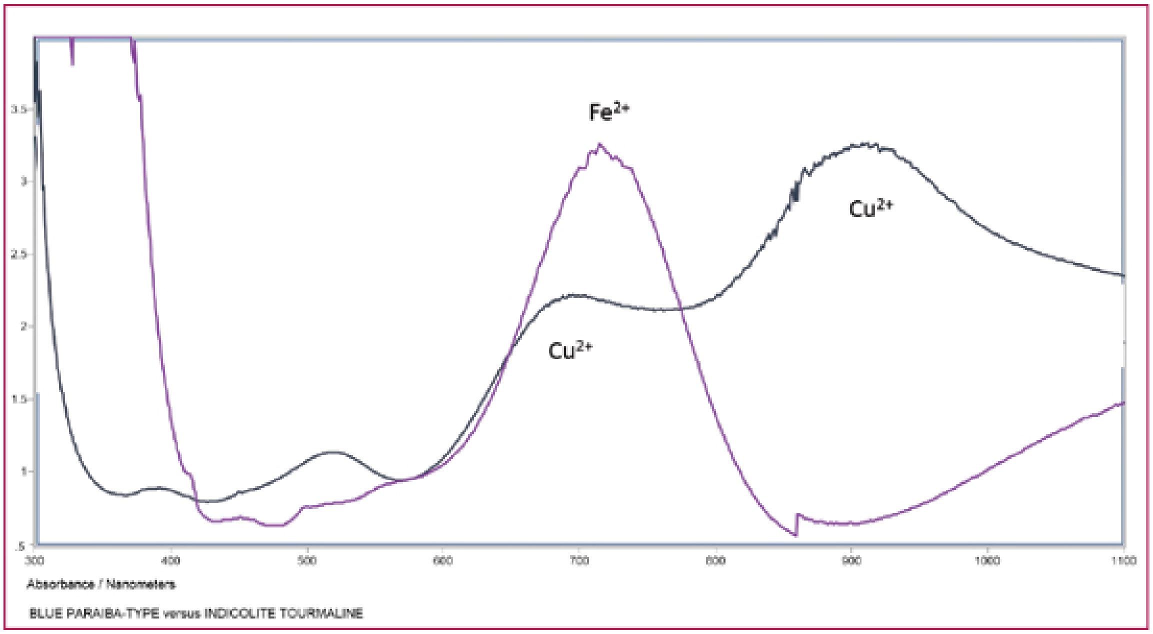


Figure 8: Within the tourmaline group, two varietal designations for stones of a blue color are readily distinguishable using objective/spectroscopic data. Blue tourmalines colored by iron (Fe^{2+}) fall within the indicolite variety, whereas blue tourmaline colored by primarily copper (Cu^{2+}) fall within the Paraiba or Paraiba-type variety.

80 – 88 Series

ColorCodex Reference

Indicolite Variety Call

88 - 03 thru 88 - 17

Increasingly Greenish Color

Non-Indicolite Variety Call

86 - 03 thru 86 - 17

84 - 03 thru 84 - 17

90 – 98 Series

ColorCodex Reference

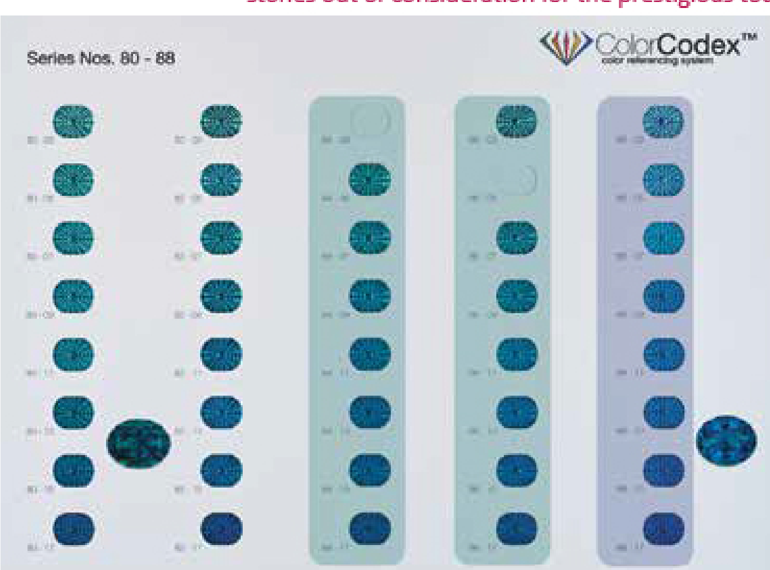
Indicolite Variety Call

90 - 03 thru 90 - 17

92 - 03 thru 92 - 17

94 - 03 thru 94 - 17

Figure 9: These two ColorCodex™ sheets demonstrate the range of colors present within the indicolite tourmaline varietal call, as well as demonstrating how increasing the influence of green takes some stones out of consideration for the prestigious tourmaline variety.



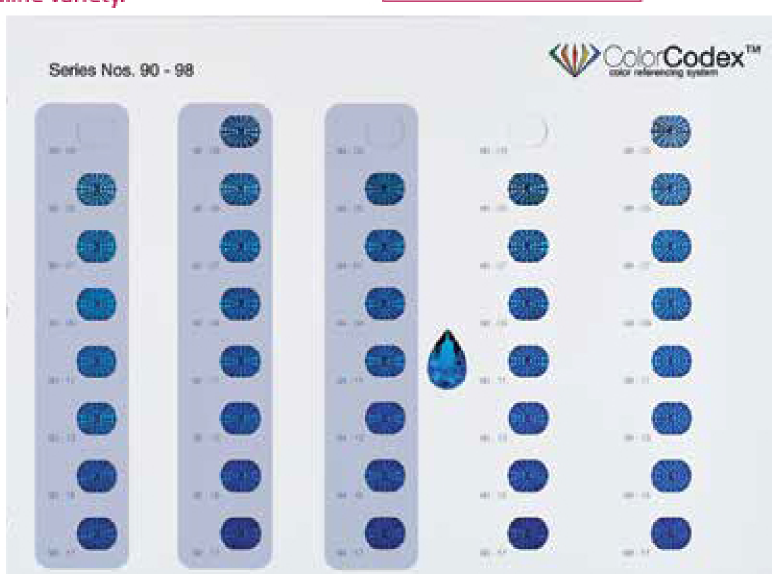


Figure 10: There are two varietal terms in relation to topaz, which up to now have been nearly synonymously used in the trade. However, using objective spectroscopic data and ColorCodex™ references, we can see that it is possible to create a clear distinction, permitting both varietal terms to have their place in the market.

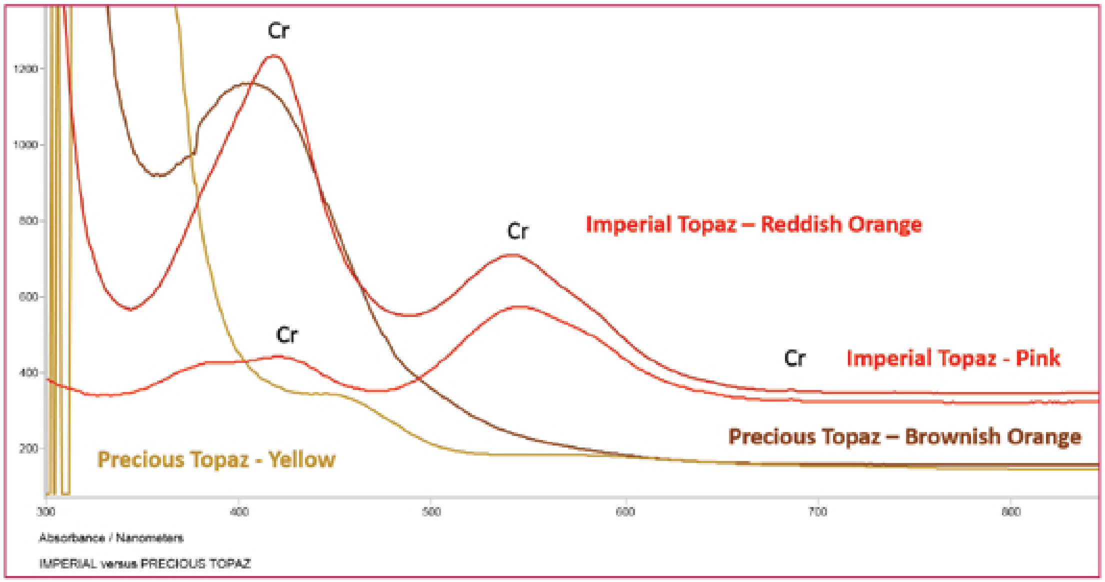


Figure 11: An objective spectroscopic criterion can be established to distinguish between imperial and precious topaz varieties, using the presence of chromium (Cr) in imperial topaz and an absence of chromium in those stones classified as precious topaz.

point, the term imperial topaz came from a special color of topaz that originated in the Ural Mountains in present-day Russia. These stones tended to have a more pinkish color and were rarely recovered. The finds of topaz in the Ouro Prêto region of Brazil, however, had a profound impact on this particular gem variety. These finds were so prolific that they have significantly expanded the color range of this exclusive gem variety and virtually redefined the term imperial topaz, extending the shades from more pinkish hues to stones with a strong orange modifier (Figure 10).*

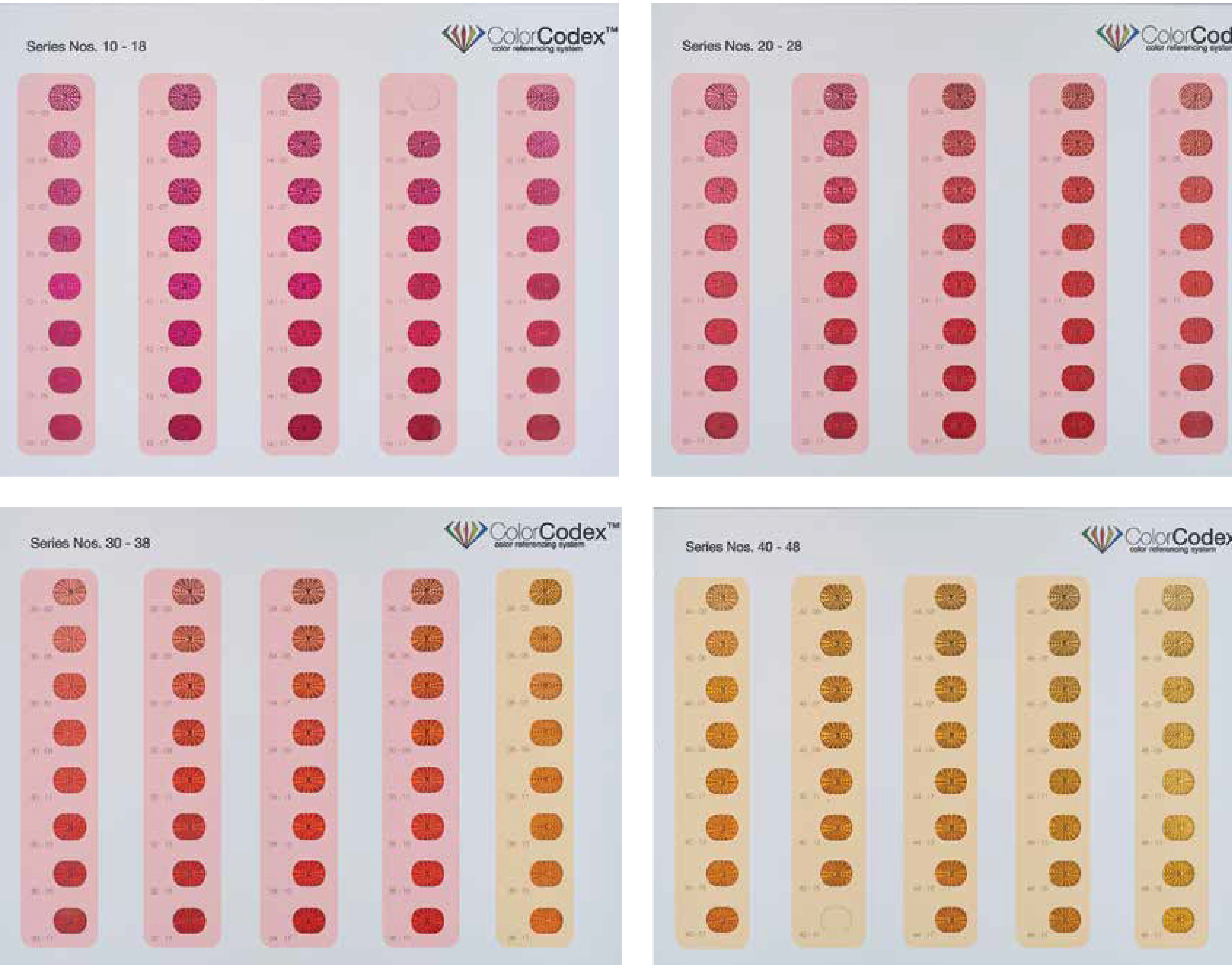
The suggested parameters further clarify the varietal terms of precious and imperial topaz, as they are both color and spectroscopic/chemistry based. The pink to red color in topaz is also related to Cr, whereas the orange to yellow color of topaz is due to color centers. In colors that range from pinkish/reddish-orange to pink/red, the presence of Cr can be recognized in the spectrum of imperial topaz, whereas precious topaz ranging in color from orange to yellow will not possess the absorption related to Cr (Figure 11). This objective spectroscopic data also correlates well with ColorCodex™ references made on a range of stones examined by the author (Figure 12).

Conclusion

The ColorCodex™ system is a new and innovative tool for the gemstone and jewelry industry to reference the color of faceted gems. The color windows of the system best mimic the appearance of transparent, faceted gemstones and they significantly expand the color gamut in terms of saturation over systems that have been available up to now.

As a direct comparative system, the ColorCodex™ is intuitive and easy to use, while permitting reliable and repeatable results for referencing color. This article demonstrates its use to better define color varieties based solely on color, such as

**We have seen the same situation happen more recently with the definition of cobalt spinel. The traditional source of cobalt spinel was the island of Sri Lanka (Ceylon). Cobalt spinel from Sri Lanka was colored predominantly by cobalt (Co^{2+}). The very finest specimens had a bright blue color, although the more common variety had a darker shade of blue. Stones with a distinctly grayish modifier were called simply blue spinel. More recently, the area surrounding the village of Luc Yen in Northern Vietnam started producing vibrantly colored blue spinels that were also due to cobalt. For the first time, the industry and world at large had a small, but consistent supply of cobalt spinel. Not only was this deposit significant for its concentration of cobalt spinel, this source also had a remarkable propensity for producing cobalt spinels with a vibrant blue shade, only very rarely ever recovered from the more traditional source of Sri Lanka. As a result, for many the definition of a cobalt spinel has shifted from the more traditional shade of blue color to a brighter and more vibrant shade. This discussion and classification is also outside the scope of the present paper.*



10 – 18 Series ColorCodex Reference
Imperial Topaz Variety Call
10 - 03 thru 10 - 17
12 - 03 thru 12 - 17
14 - 03 thru 14 - 17
16 - 03 thru 16 - 17
18 - 03 thru 18 - 17

20 – 28 Series ColorCodex Reference
Imperial Topaz Variety Call
20 - 03 thru 20 - 17
22 - 03 thru 22 - 17
24 - 03 thru 24 - 17
26 - 03 thru 26 - 17
28 - 03 thru 28 - 17

30 – 38 Series ColorCodex Reference
Imperial Topaz Variety Call
30 - 03 thru 30 - 17
32 - 03 thru 32 - 17
34 - 03 thru 34 - 17
36 - 03 thru 36 - 17
Precious Topaz Variety Call
38 - 03 thru 38 - 17

40 – 48 Series ColorCodex Reference
Precious Topaz Variety Call
40 - 03 thru 40 - 17
42 - 03 thru 42 - 17
44 - 03 thru 44 - 17
46 - 03 thru 46 - 17
48 - 03 thru 48 - 17

Figure 12: These four ColorCodex™ sheets demonstrate the range of colors present within the imperial and precious topaz varietal calls. The visual color references have shown to coincide well with the spectral criterion, thereby permitting a much clearer and consistent use of these two varietal terms. Tonal values may also apply and the full columns of color are highlighted, however, in practical terms, the author has not encountered stones in the more intensely colored windows of 13, 15 and 17 for stones that were classified as imperial topaz.

the ruby/non-ruby border and other sapphire varieties. It also permits a clearer perspective on the full color range of less well known color varieties such as indicolite tourmaline or ill-defined varietal classifications such as precious and imperial topaz. The ColorCodex™ system is a perfect tool to help gem traders, jewelers, gemologists, appraisers, educators, associations and laboratories alike address issues related to the referencing of color in gemstones. (color-codex.com; AGLgemlab.com)

All images are by the author unless otherwise indicated. ■