Bellerophon Gemlab

# Colored Gemstones

## Color Reference Chart

M.P.H. Curti

Bellerophon Gemlab

# COLORED GEMSTONES

## Color Reference Charts

M.P.H. Curti

Bellerophon Gemlab
16 Place Vendome, Paris 75001
www.bellerophongemlab.com



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# INTRODUCTION

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When Bellerophon Gemlab establishes the color of a gemstone or compare the colors of two gemstones side-by side, several factors must be considered:

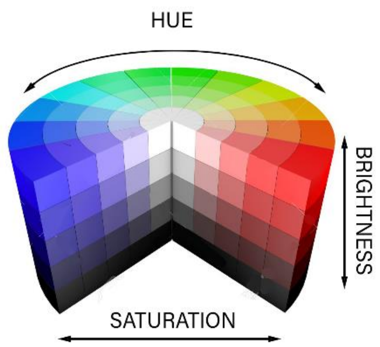
1. Use a consistent, standard source of light with known illumination characteristics.
2. The observation should take place in an appropriate surrounding environment that is neutral in its color appearance.
3. A defined geometry should be used between the light source, the object, and the observer.
4. If the gemstone color is to be compared to that of another gemstone, the latter should be a standard color reference.
5. Observations must be made by a person with normal color vision.

Because any of these factors can influence the visual perception of a gemstone color, they all must be controlled if accurate and consistent results are to be obtained.

## Color Description of a Gemstone

Color is a continuum that can be defined and described in terms of three attributes:

1. Hue, the attribute of colors that permits them to be classed as, for example, red, yellow, green, blue, or anything in between. Hues are expressed in degree from 1 to 360.
2. Saturation, the strength or purity of the color. (the intensity of the hue). Saturation is expressed in percentage, with 0 being no saturation (white) and 100 being the most saturated (vivid).
3. Brightness is the relative impression of lightness to darkness of the color. (the white and black component of the color). Brightness is expressed in percentage as well, with 0 being black and 100 being fully illuminated.



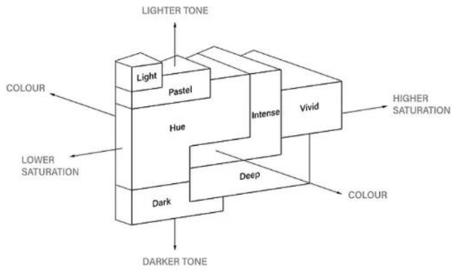

## The Color Grading Light Box

The most important characteristics are: the light source, the lamp type, the measured correlated color temperature (a term used to describe the color of a light source, such as yellow or blue white light), its illuminance (the amount of light per unit area on a surface, multiplied by the spectral sensitivity of the eye), and a calculated color rendering index (a measure of the degree to which the perceived color of objects illuminated by a given light source conform to those of the same objects illuminated by a standard light source) and lastly the calculated index of metamerism (a measure of the degree to which pairs of colors with different spectral characteristics appear the same under a standard light source and different under a “test” light source). These characteristics all contribute to a person’s ability to distinguish colors while using a particular light source.

## Viewing Angle Geometry

A colored gemstone has a number of color differences, and these differences are often subtle. Therefore, both the position of the gemstone in the viewing box, and how the stone is held, are important. The gemstone’s face up color is evaluated most consistently when the light source is positioned directly above the gemstone, the gemstone being placed in a white Teflon tray and/or held by tweezers and by tilting the gemstone to about 30 degrees in all directions from the table. The distribution of the color is evaluated in relation to the stone’s total face up area.

## Main Color




The Bellerophon Gemlab system describes a single color as being “the main color” of the gemstone as a whole (except in case of bi-colored or multi-colored gemstone). We define this single color as the overall color sensation seen when the stone is viewed face-up. Obvious surface reflection and dispersion are not graded, while windowing (see through areas), and/or extinction areas are averaged with the main hue. To help determine the characteristic color, the grader moves the gemstone slightly by rocking the tray. This process of moving the gemstone through a slight angle minimizes the effects of surface reflection, dispersion, windowing, and extinction. The “color grade” that a colored gemstone receives on a Bellerophon Gemlab laboratory report is a description of this characteristic color using standardized terms. All hues are divided by the combination of saturation and brightness. Some color defined as hue may be a different saturation and brightness of a main hue. Such as Pink being a lower saturation and lighter tone of Red, the same is true of Brown and Orange. Therefore, there is no pastel Red and no Deep Pink.

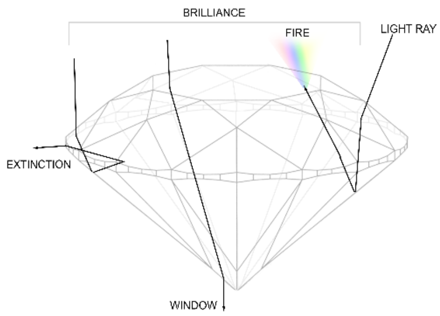
## Using Instruments to Measure Color

Certain attributes of color appearance can also be measured with instrumentation, such as a VIS spectrometer, spectrophotometer and/or a colorimeter. The color space of Bellerophon Gemlab color grades is ultimately defined in HSB color coordinates. Color measurement may provide finer color distinctions for some materials. The accuracy of such measurement is greatly influenced by the shape, size, the path length of the light and the color homogeneity of the stone. Bellerophon Gemlab always uses instruments to measure the color of a gemstone, but ultimately the human eyes through the grader within the HSB color coordinates, references gemstones and controlled environment decide the grading. Deriving a consistent set of standards for both visual observation and instrumental measurement of color in gems remains a great challenge.

## Cutting Factors in Color Grading

Cutting by the decision making of the axis (for pleochroic stone), shape, proportions, facet sizes, facet numbers, facet angles, internal features orientation and polishes affect the behavior of the light inside the gemstone, therefore cutting may play an important part of the final color grading of a gemstone. It is not uncommon for a color grade of a gemstone after recutting to be different by several order in the grading system.

## Color Grading Light Behavior




Fire: *Flashes of rainbow colors due the dispersion (the breaking of incident light into its component colors) of certain mineral.*
Window: *See-through area within a gemstone body face-up, leading to a lower saturation due to the facet angle being below the critical angle of the mineral refractive index*.
Extinction: *Dark area within a gemstone body face-up, leading to lower lightness due to the facet angle being much higher than the critical angle of the mineral refractive index.*
Brillance: *The overall return of light in percentage of the gemstone face-up.*

## Color Distribution Grading

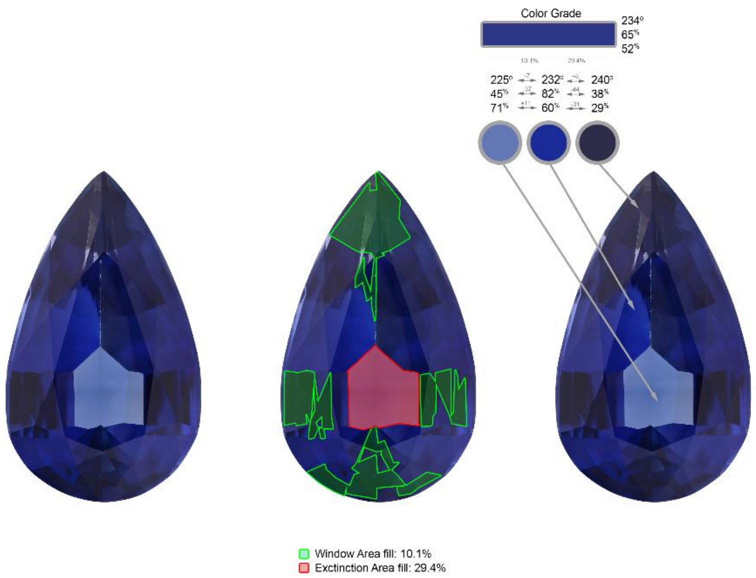
The color distribution or the uniformity of the color throughout a gemstone influence greatly a color as well. The color homogeneity may depend on a combination of color distribution and/or light behavior from the cutting angles. Exception made for bi-color gemstone: each color homogeneity is treated separately.

## Color Distribution Grades

Uneven: *Hues within a gemstone with a deviation superior to 30º.*
Even: *Hues within a gemstone with a deviation inferior to 30º.*

## Acknowledgements

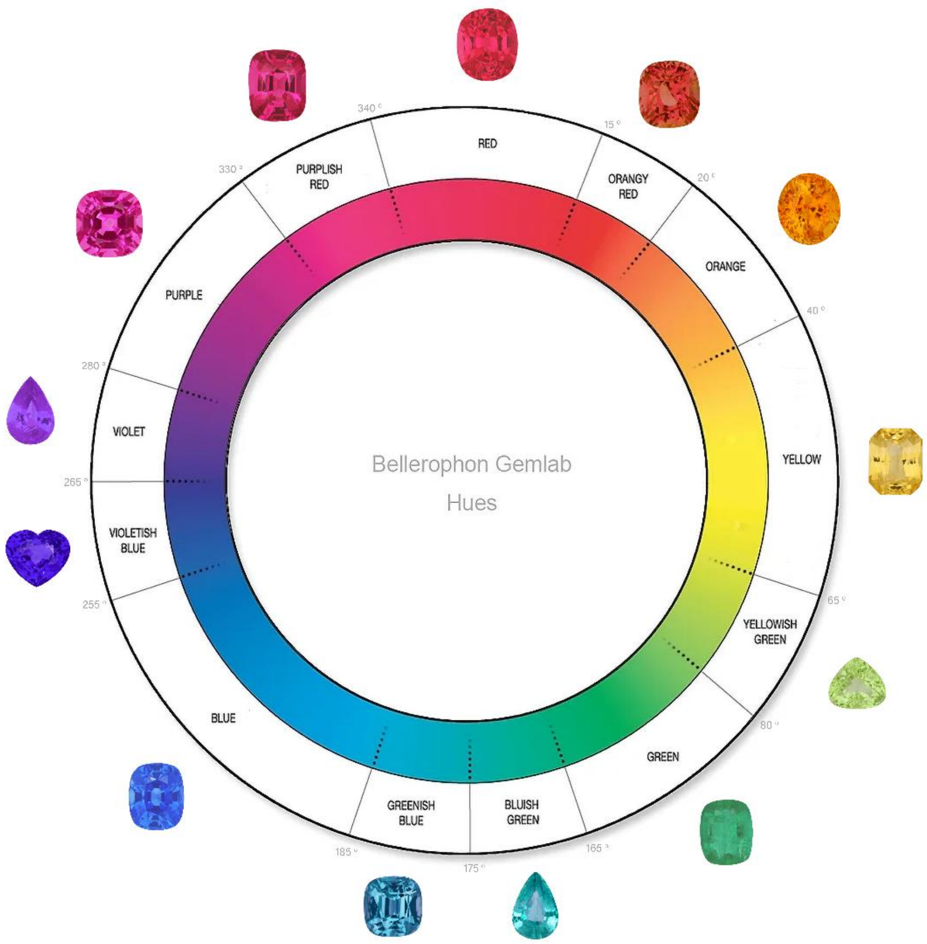
Gemstones photography for the reference color chart is taken from Bellerophon Gemlab Paris and Bellerophon Gemlab Bangkok reference collection.

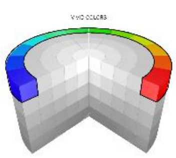



Example of a grading of a gemstone color. Note that the main body color, window, and extinction area are measured and quantified. The final color grade is an averaging of each color weighted by their sizes face up.

The subtle color appearances of gemstones in the Bellerophon Gemlab color grades of all the grade spectrum are not reproduced in the following charts. Also, please note that this chart contains photos trying to illustrate subtle distinctions in color. Because of the inherent difficulties of capturing the color subtility and controlling color in printing, the color in a macro photography may differ from the actual color of the gemstone and ultimately the grades.

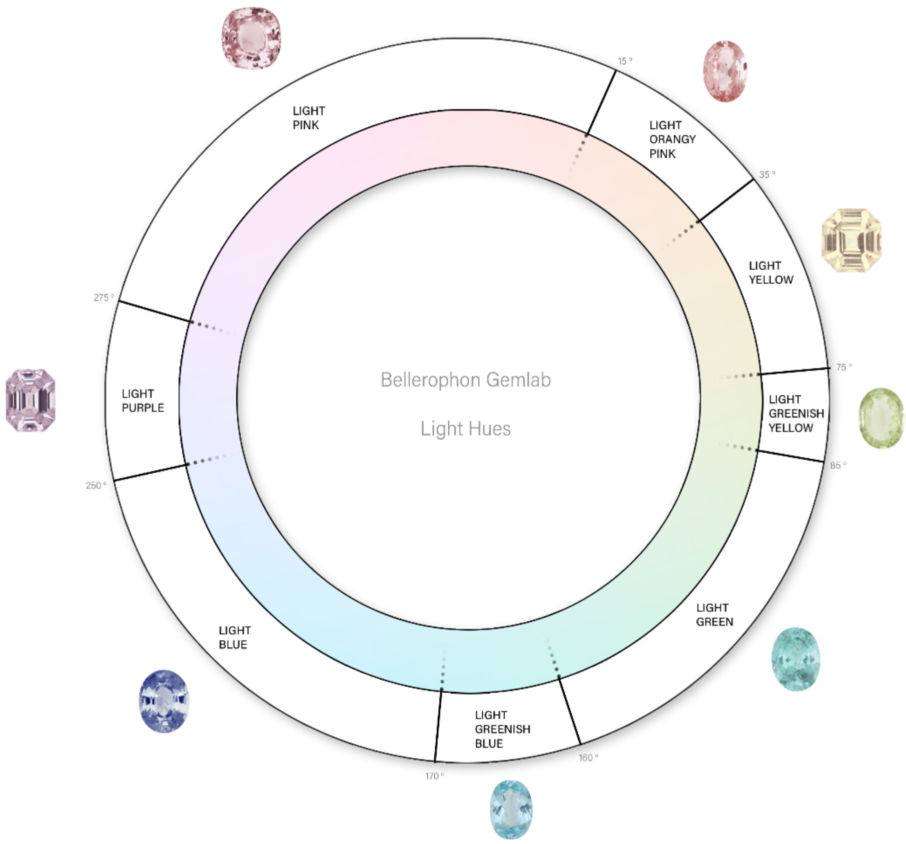
Vivid to Intense Hues

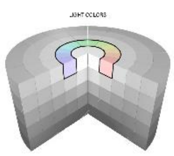


Bellerophon Gemlab uses 15 vivid hue names with their corresponding colors (Pink, brown being absent).
Most gemstones are illustrated at a vivid to intense saturation level.
The image on the left illustrates the placement of the colors on the HSB 3D graph.
This present continuous wheel above displays the whole 360° of hues
at 100% saturation and 100% brightness.

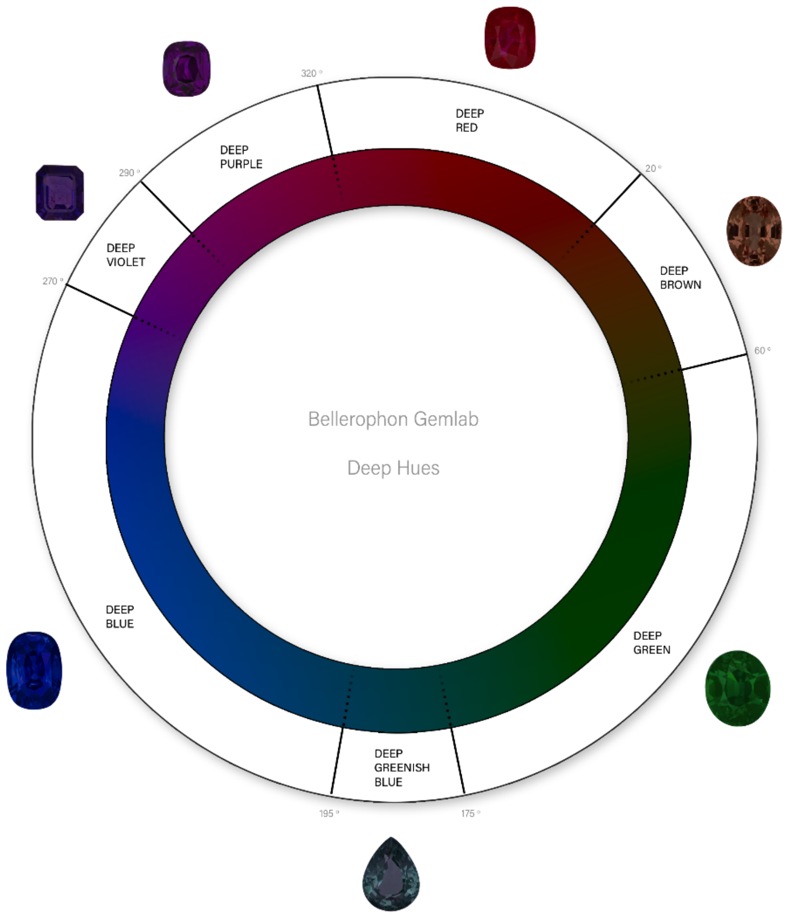
Light to Pastel Hues

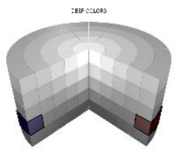


Bellerophon Gemlab uses a total of 8 light hue names with their corresponding colors.
Most gemstones are illustrated at a light to pastel saturation level.
The image on the left illustrates the placement of the colors on the HSB 3D graph.
This present continuous wheel above displays the whole 360° of hues
at 20% saturation and 100% brightness.

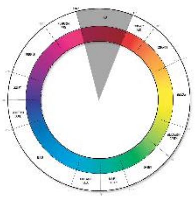
Deep to Dark Hues



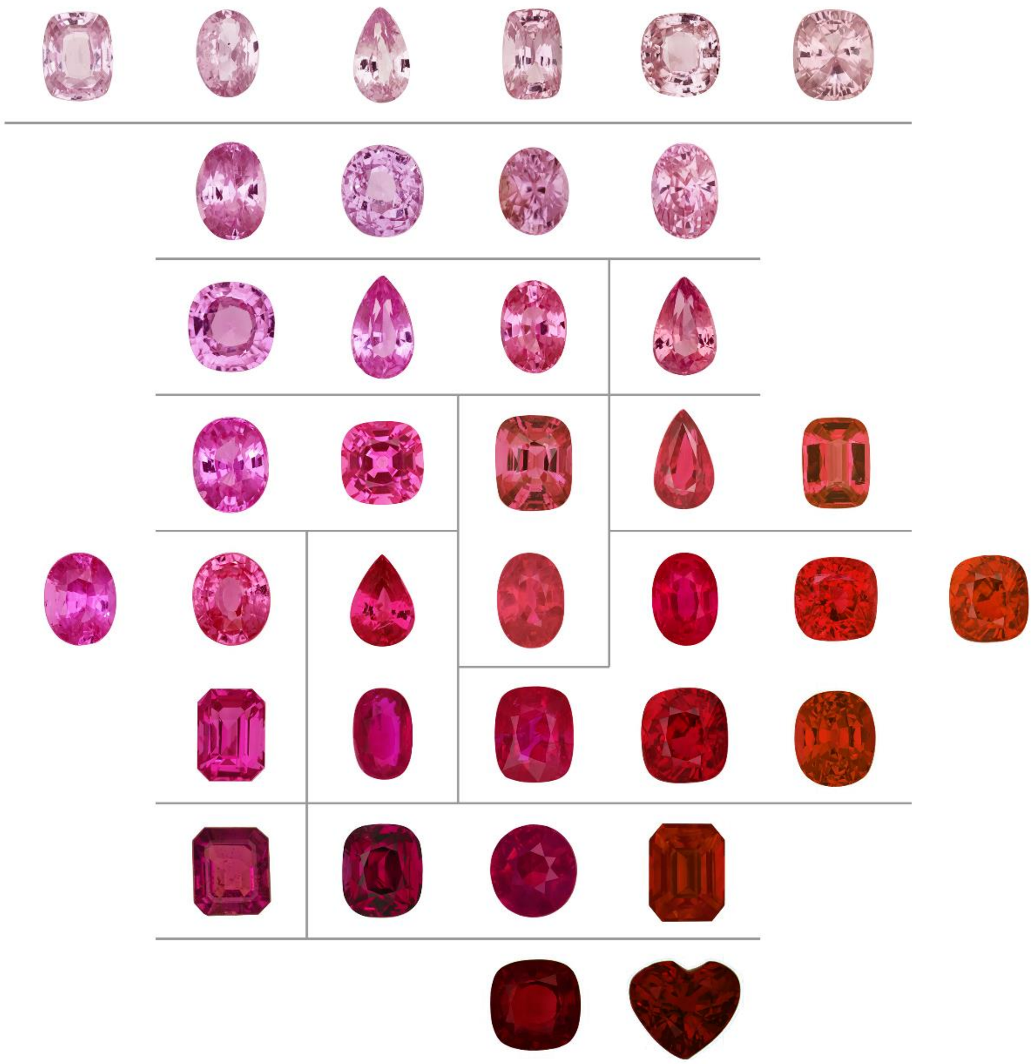



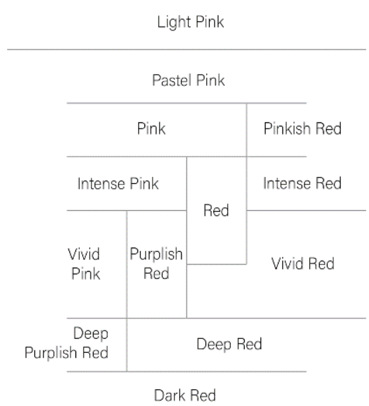
Bellerophon Gemlab uses a total of 7 deep to dark hue names with their corresponding colors.
Most gemstones are illustrated at a deep to dark saturation level.
The image on the left illustrates the placement of the colors on the HSB 3D graph.
This present continuous wheel above displays the whole 360° of hues
at 100% saturation and 30% brightness.

Red, Purplish Red & Pink Hues—340 to 15°



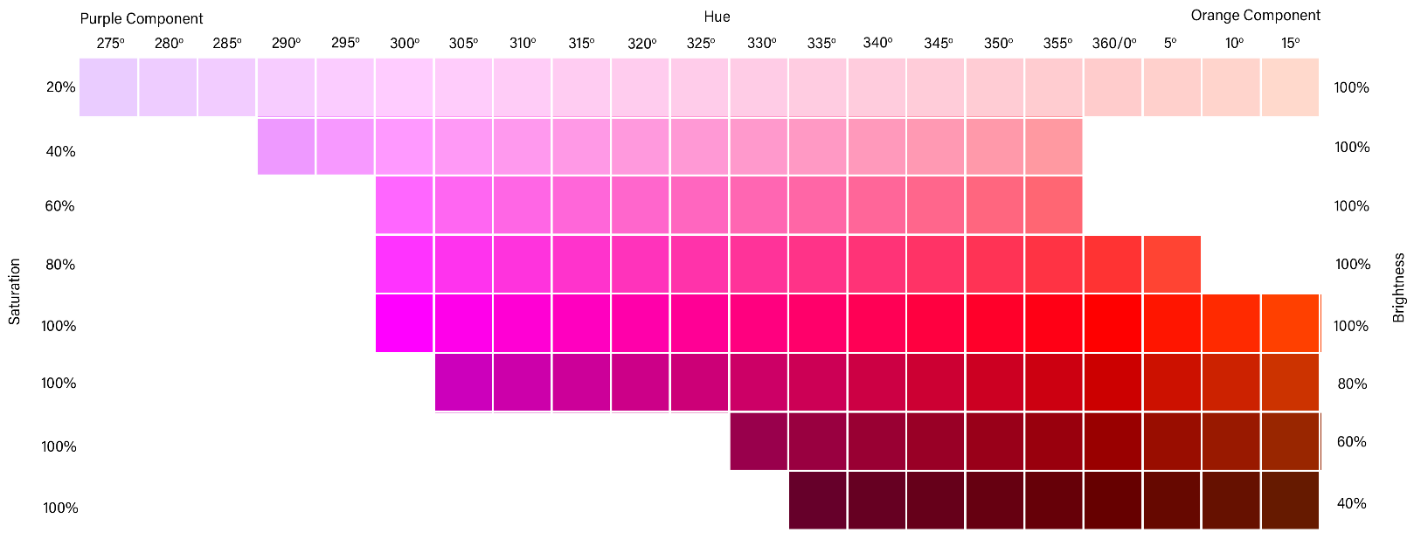
This page illustrates gemstones in red hues. At lower saturation red become pink this specific page displays mainly the red & pink gemstones of most brightness and saturation from 340° to 15° of the hue wheel.

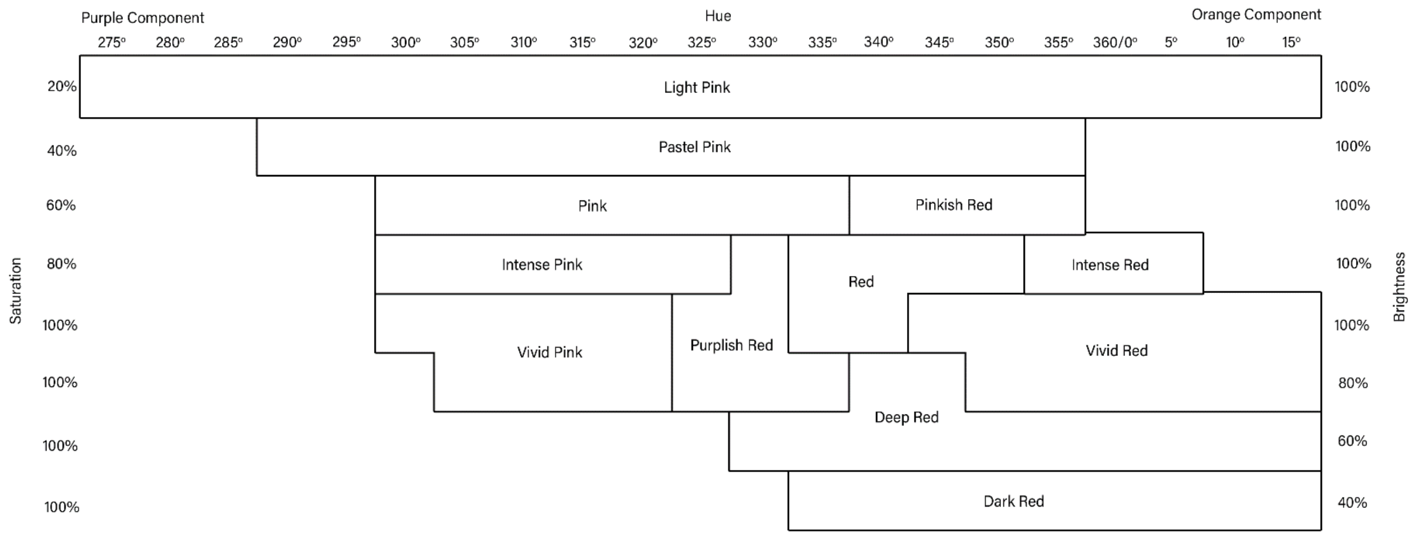





Gemstones on the left tend toward the purple at 340° while gemstones on the right tend towards the orange at 15°. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.

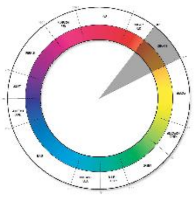
Red, Purplish Red & Pink Hues—Part 2



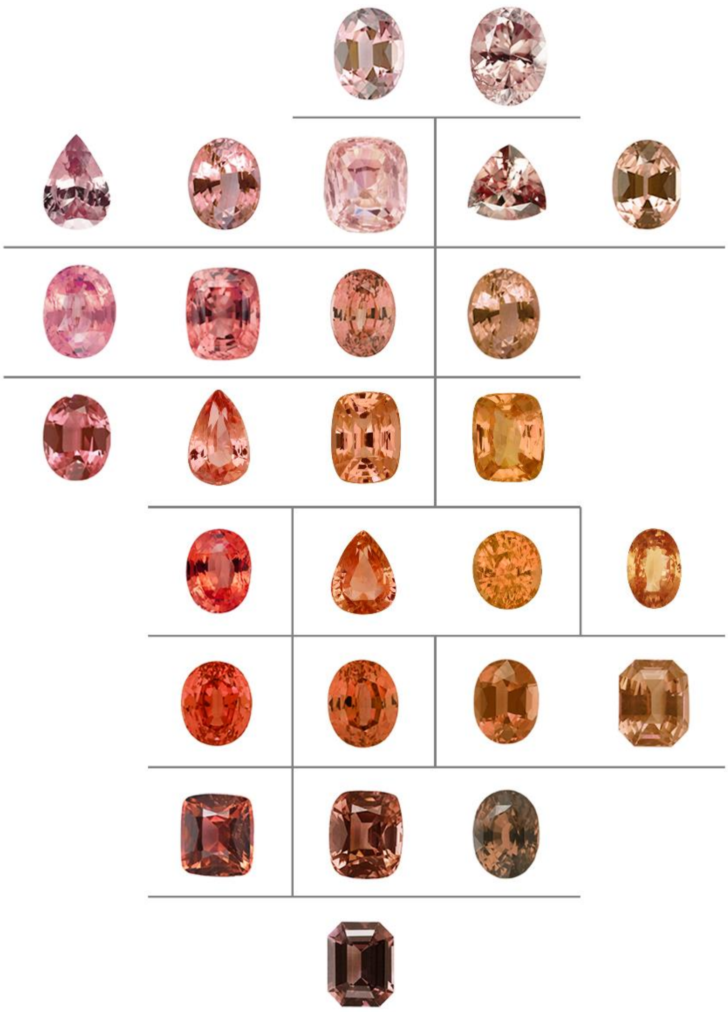



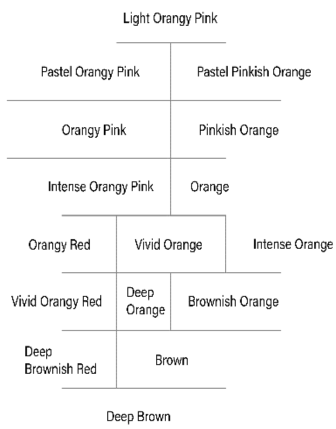

This illustration presents all the combinations of red, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

## Orangy Red to Orange Hues—15 to 40º



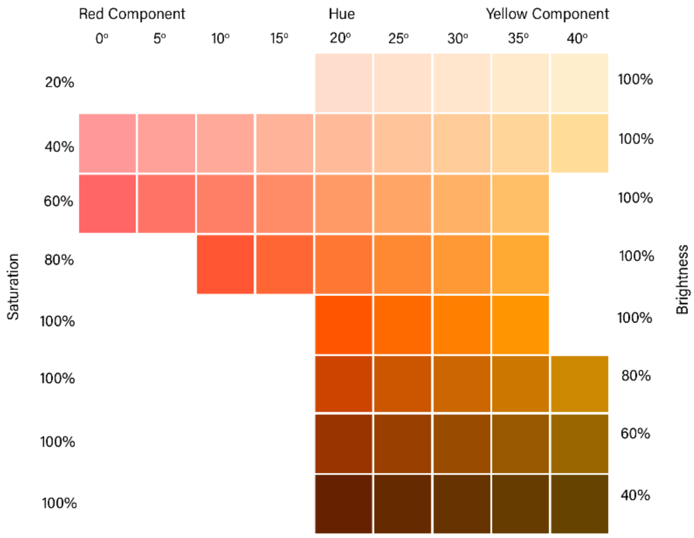
This page illustrates gemstones in orange hues. At lower saturation orange become pink While at lower brightness orange becomes brown, this specific page displays mainly the orange & orangy red gemstones of most brightness and saturation from 15º to 40º of the hue wheel.

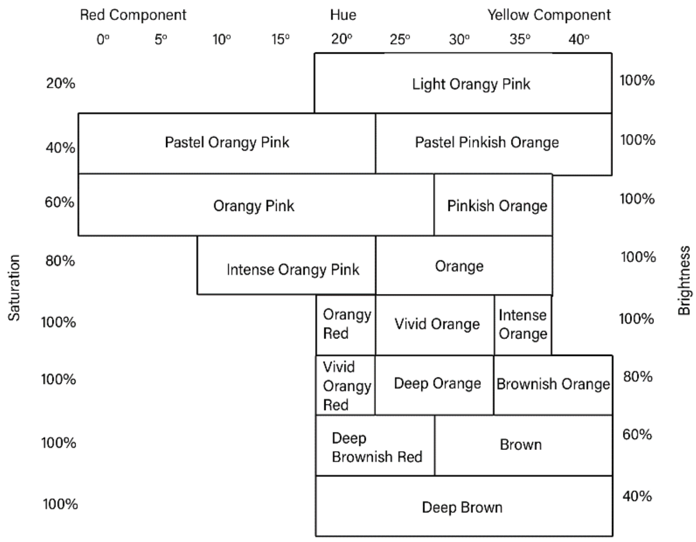





Gemstones on the left tend toward the red at 15º while gemstones on the right tend towards the yellow at 40º. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.

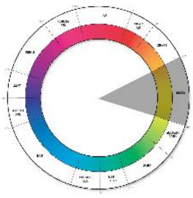
## Orangy Red to Orange Hues —Part 2



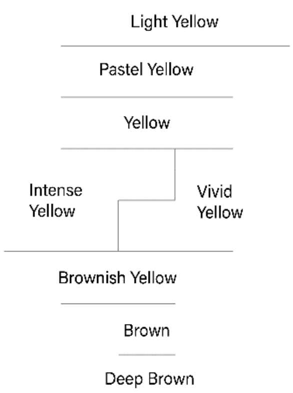




This illustration presents all the combinations of orange, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

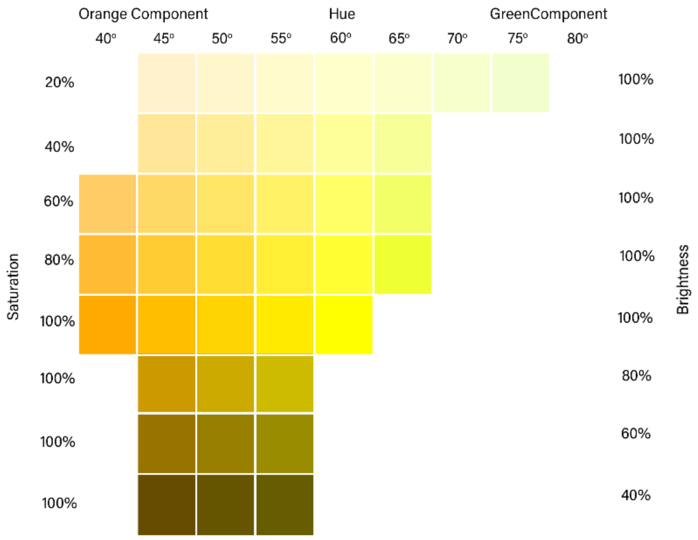
## Yellow Hues—40 to 65º

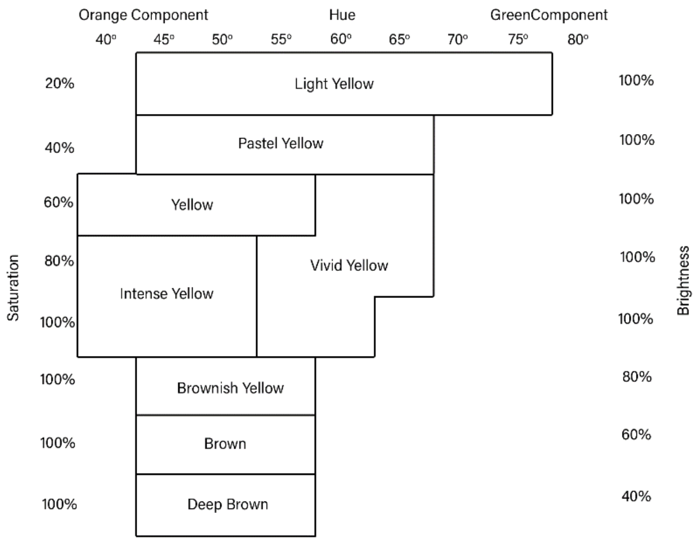


This page illustrates gemstones in yellow hues. At lower brightness yellow becomes brown, this specific page displays mainly the yellow gemstones of most brightness and saturation from 40º to 65º of the hue wheel.



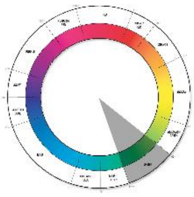

Gemstones on the left tend toward the orange at 40º while gemstones on the right tend towards the green at 65º. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.



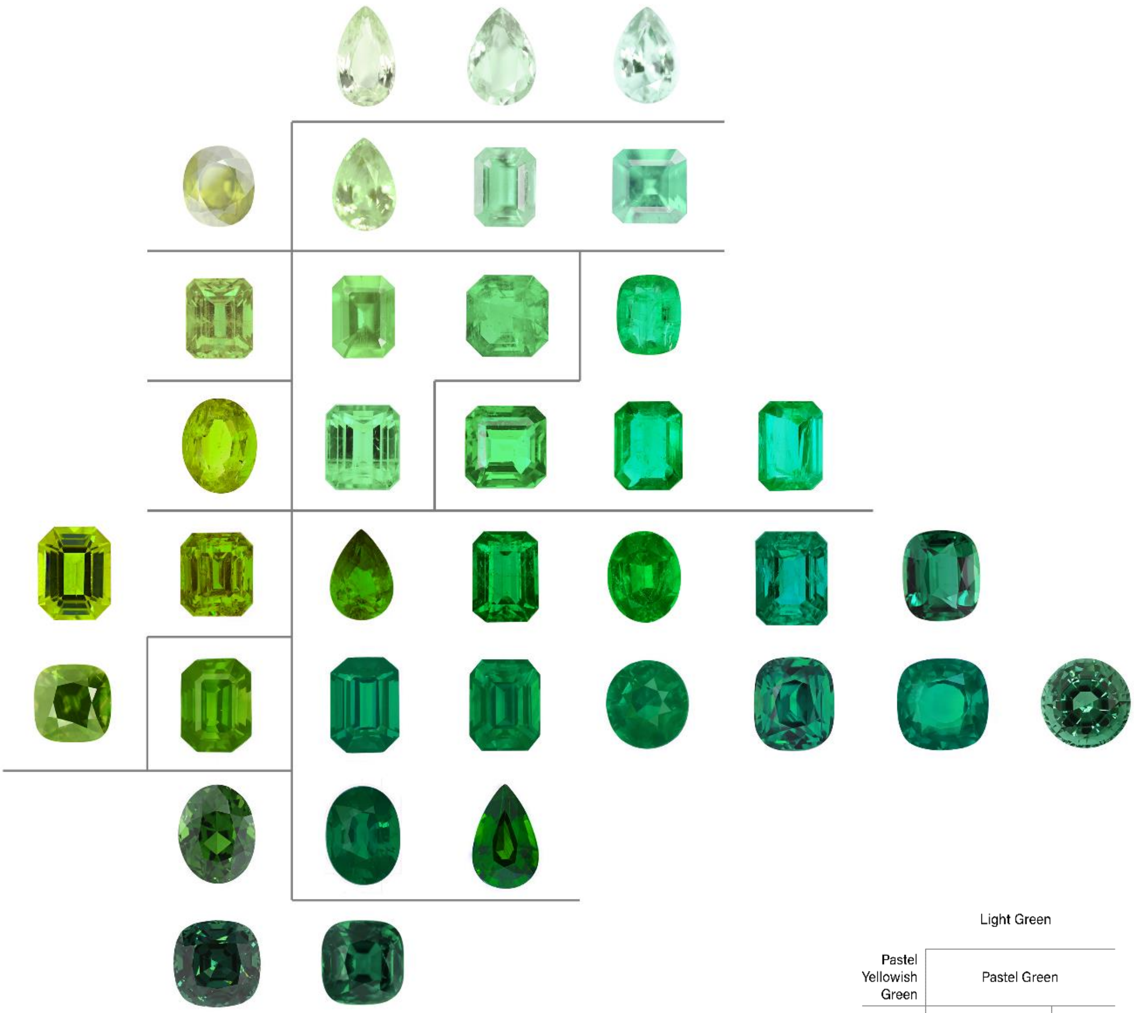



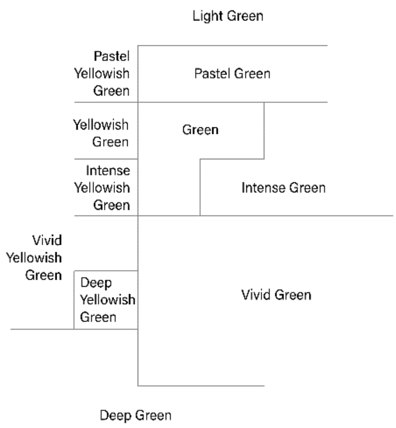

This illustration presents all the combinations of yellow, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

Yellowish Green & Green Hues—65 to 165º



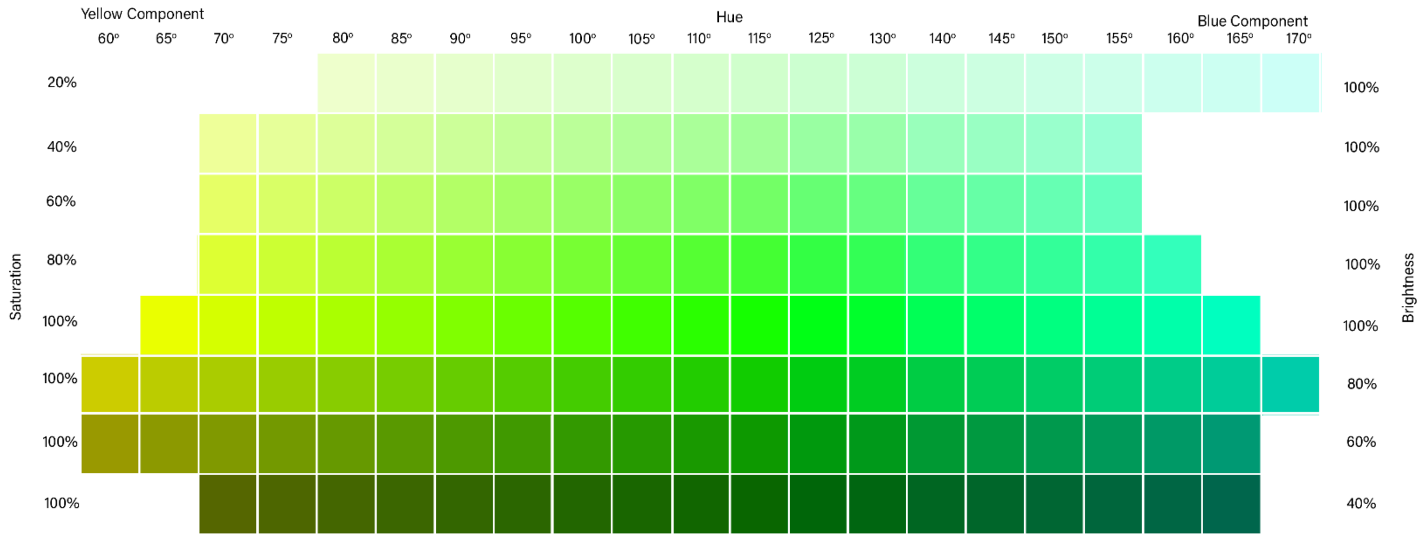
This page illustrates gemstones in yellowish green to green hues. This specific page displays mainly the yellowish green & green gemstones of most brightness and saturation from 65º to 165º of the hue wheel.

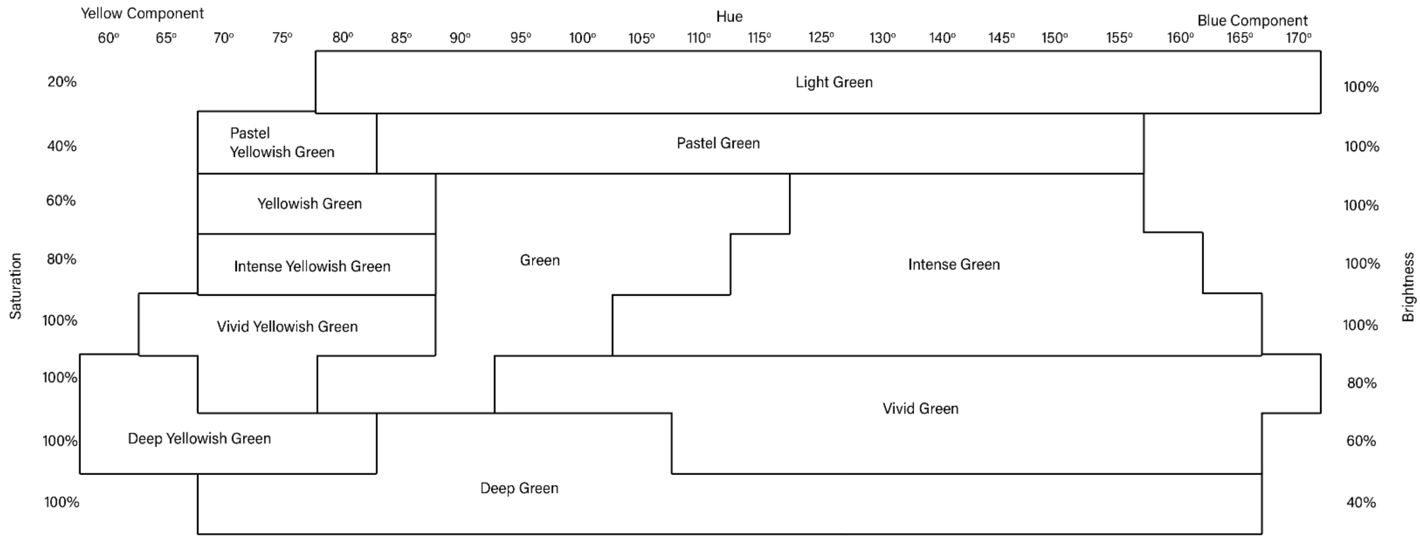





Gemstones on the left tend toward the yellow at 65º while gemstones on the right tend towards the blue at 165º. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.

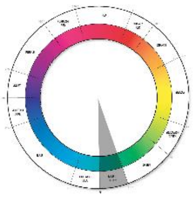
Yellowish Green & Green—Hues Part 2




This illustration presents all the combinations of yellowish green & green, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

## Bluish Green & Greenish Blue Hues—165 to 185°



This page illustrates gemstones in bluish green to greenish blue hues. This specific page displays mainly the bluish green to greenish blue gemstones of most brightness and saturation from 165° to 185° of the hue wheel.

Light Greenish Blue

Pastel Bluish Green | Pastel Greenish Blue

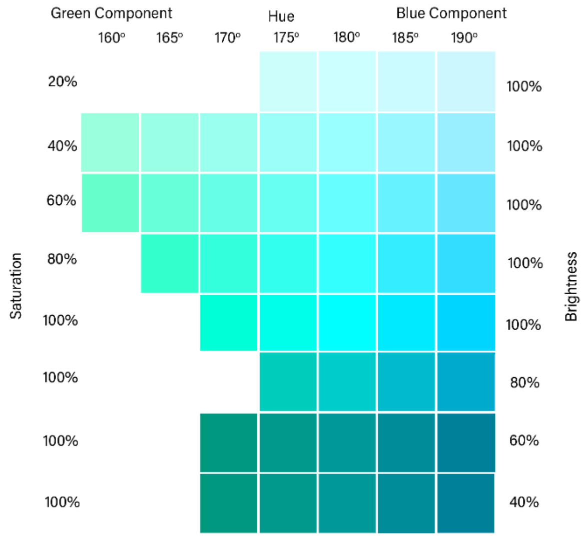
Bluish Green | Greenish Blue

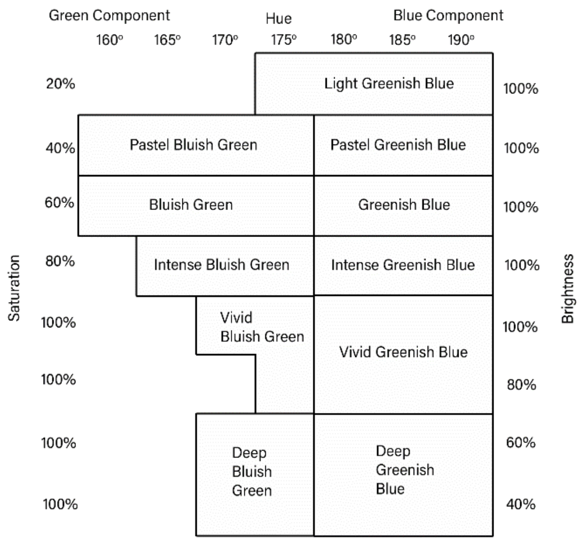
Intense Bluish Green | Intense Greenish Blue

Vivid Bluish Green | Vivid Greenish Blue

Deep Bluish Green | Deep Greenish Blue

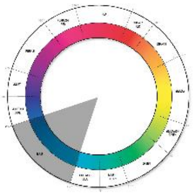
Gemstones on the left tend toward the green at 165° while gemstones on the right tend towards the blue at 185°. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.



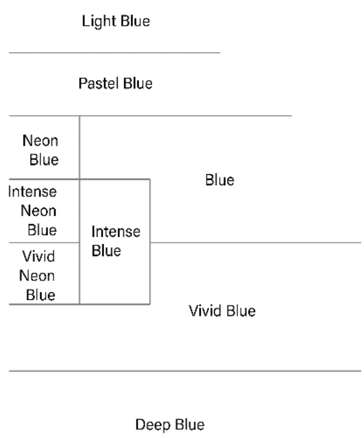




This illustration presents all the combinations of greenish blue to bluish green, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

## Blue Hues—185 to 255°

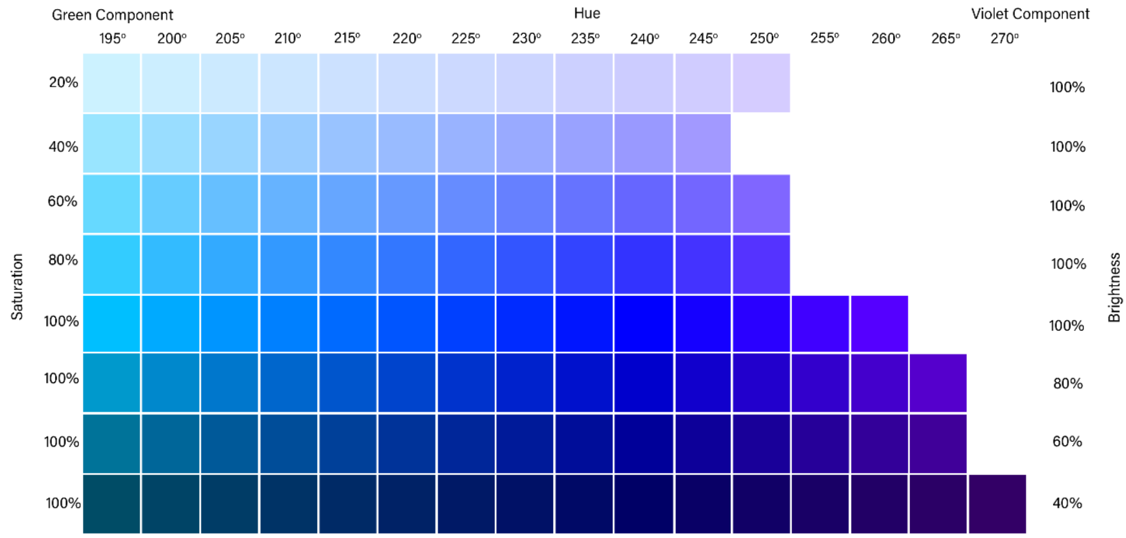


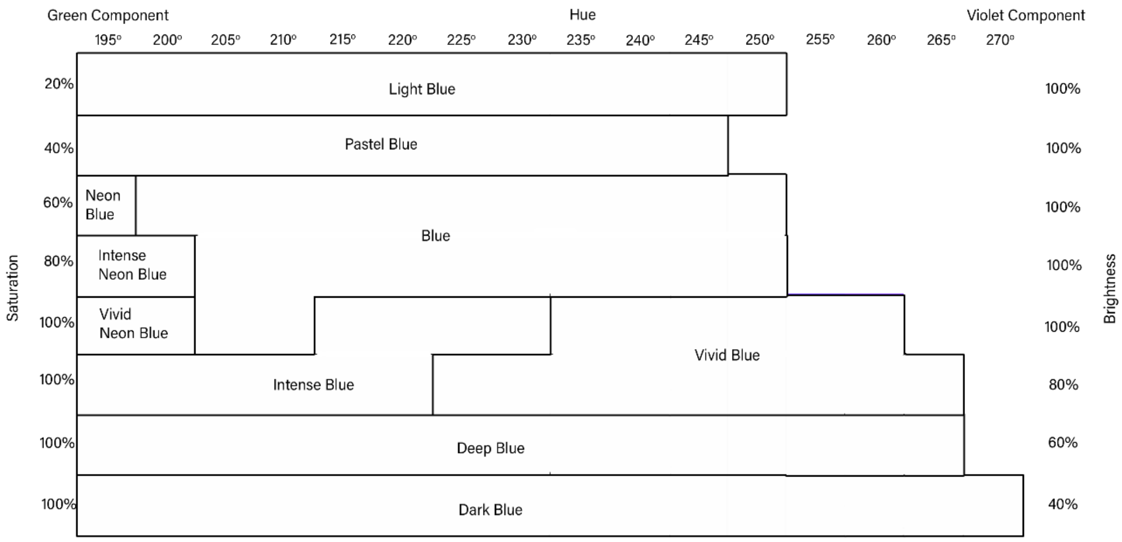
This page illustrates gemstones in blue hues.
This specific page displays mainly the blue gemstones of most brightness and saturation from 65° to 165° of the hue wheel.




Gemstones on the left tend toward the green at 185° while gemstones on the right tend towards the violet at 255°. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.

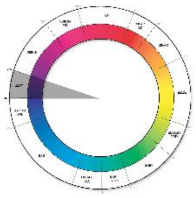
## Blue Hues— Part 2



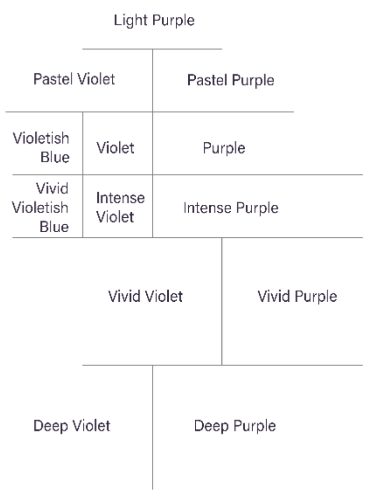




This illustration presents all the combinations of blue, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

## Violet & Purple Hues—255 to 340°

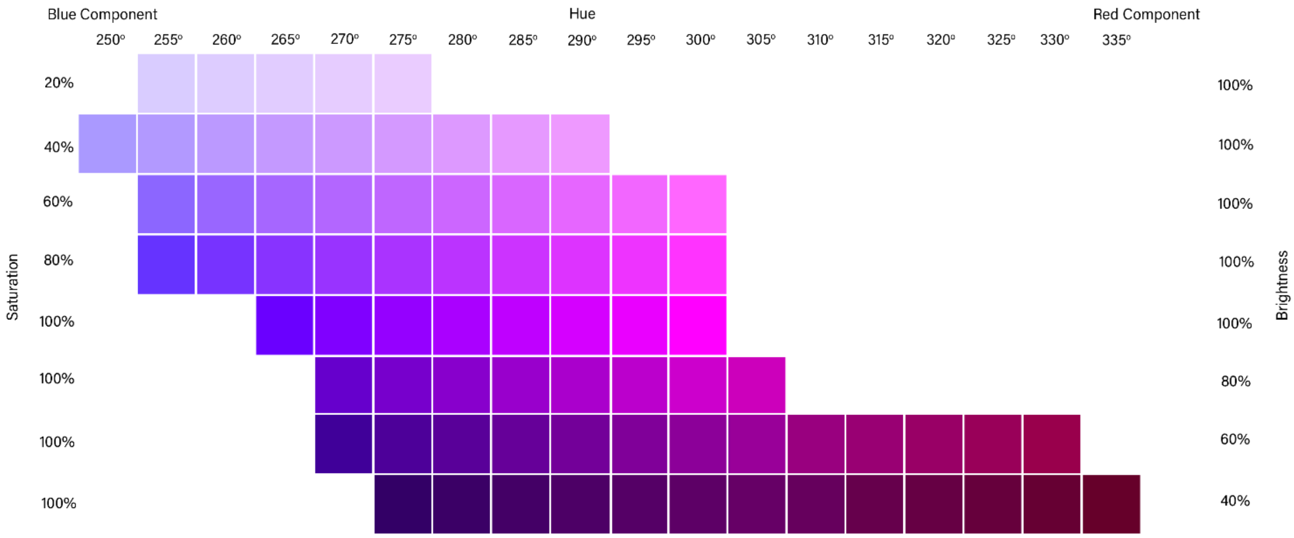


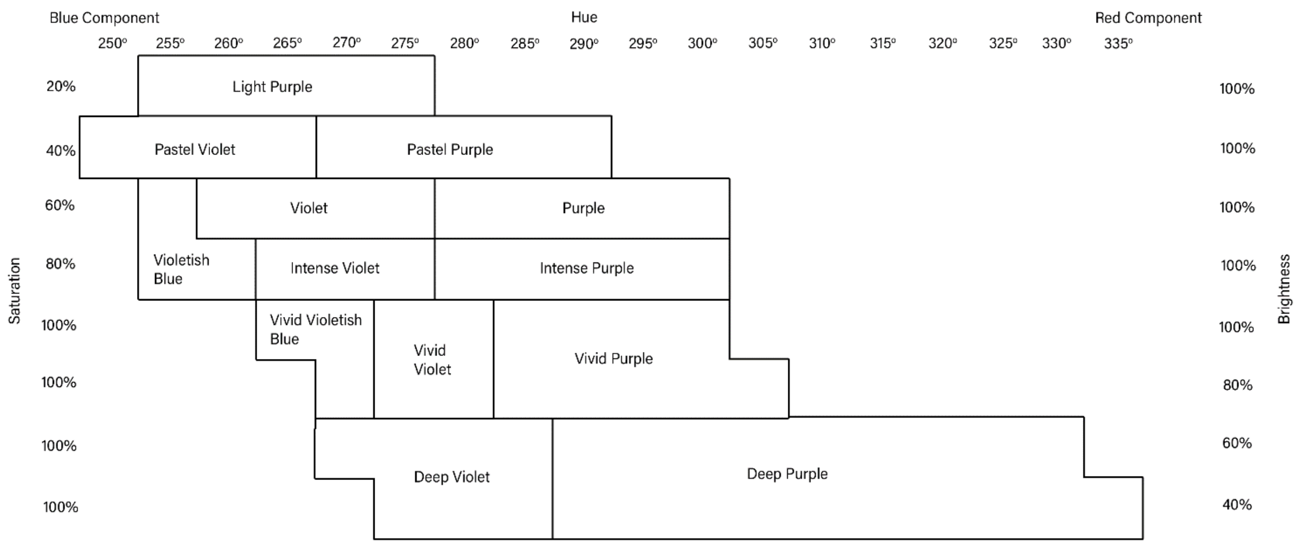
This page illustrates gemstones in the violet and purple hues. This specific page displays mainly the violet and purple gemstones of most brightness and saturation from 255° to 340° of the hue wheel.




Gemstones on the left tend toward the blue at 255° while gemstones on the right tend towards the red at 340°. Saturation increases from top at 20% to the middle at 100%, while brightness decreases from the middle at 100% to the bottom of the page at 30%.

## Violet and Purple Hues— Part 2




This illustration presents all the combinations of violet, purple, saturation and brightness present in the Bellerophon Gemlab gemstones color chart, use this page with the accessory included in this book to compared against your gemstone.

## IMPORTANT NOTES

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### The Human Eyes and The Bellerophon Color Model

Color originates in the mind of the observer; "objectively", there is only the spectral power distribution of the light that meets the eye. In this sense, any color perception is subjective. However, successful attempts have been made to map the spectral power distribution of light to human sensory response in a quantifiable way.

It is important to note that a color model presupposes specific viewing conditions (such as the retinal locus of stimulation, the luminance level of the light that meets the eye, the background behind the observed gemstone, and the luminance level of the surrounding light). Only if all these conditions stay constant will two identical stimuli with thereby identical values create an identical color appearance for a human observer.

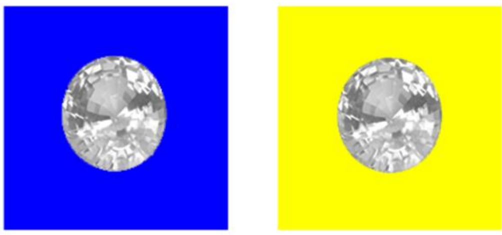
Therefore, if viewing conditions vary, the color model used may become irrelevant.

Furthermore, our eyes developed a chromatic adaptation, that is the human visual system's ability to adjust to changes in illumination in order to preserve the appearance of colors. It is responsible for the stable appearance of colors despite the wide variation of light which might be reflected from an object and observed by our eyes.

A gemstone may be viewed under various conditions. For example, it may be illuminated by sunlight, the light of a fire, or a harsh electric light. In all of these situations, human vision perceives that the object has approximately the same color. On the other hand, a camera with no adjustment for light may register the object as having varying color. This feature of the visual system is called chromatic adaptation, or color constancy; when the correction occurs in a camera it is referred to as white balance.

Though the human visual system generally does maintain constant perceived color under different lighting, there are situations where the relative brightness of two different stimuli will appear reversed at different illuminance levels. As such the perception of color depends heavily on the context in which the perceived object is presented.

It is important to conclude that color is a feature of visual perception by an observer. There is a complex relationship between the wavelengths of light in the visual spectrum and human experiences of color. Although most people are assumed to have the same mapping, some cultures have been found to categorize colors differently from most Westerners and are able to easily distinguish close shades barely discernible for most people. Adding an extra untouched layer of complexity.



Gemstone color experience is greatly influence by its surrounding environment.

## The Importance of Cutting in Color Grading

The color grading of a transparent material adds a level of complexity. When we grade the color of a transparent to semi-transparent gemstone we ultimately grade the overall color experience, which is greatly influenced by the return of light the gemstone is providing.

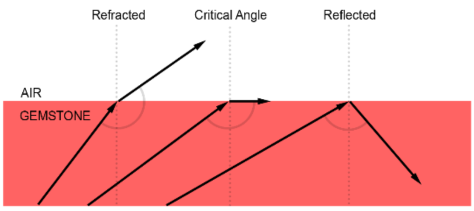
A gemstone color is caused by atomic impurities (in most cases); therefore, the intensity of a color is greatly influenced by the number of these impurities. However, the amount of impurities alone does not dictate the overall color, these layers of crystal structure absorb and/or transmit a portion of the light it receives. As such the amount of layers the light passes through also greatly impact the color experience.

The main goal of gemstone cutting (in most cases) is to optimize this effect.

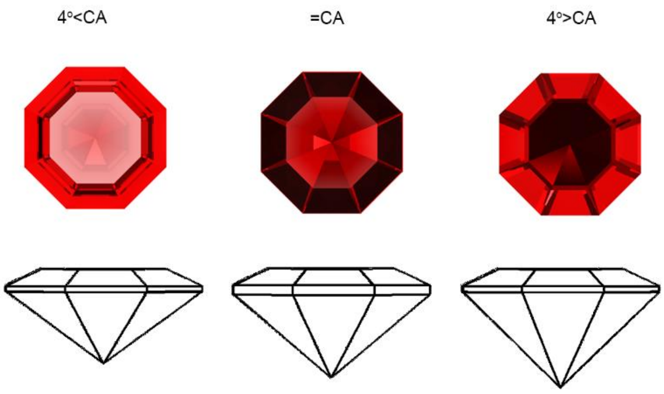
When a light ray meets a different refractive medium it may depending on their angles: refract (pass through); or being reflected (bounce back).

To greatly simplified a gemstone with the exact same amount of chromophores (chemical impurities giving its color) being seen from the perspective of these two rays will have a different color intensity: the refracted rays will have passed once in its crystal, giving it a windowing area, while the reflected ray will have passed twice in its crystal, giving it a deeper color, too much of bouncing may also create dark or extinction area.

To conclude the return of light based on the cutting of gemstone has a very important factor in the gemstone color grading overall experience, especially in its intensity (hues as well in the case of pleochroic gemstone). A deep colored stone by its poor cut with important area of windowing may get a better grade in its color while a lighter colored stone with carefully crafted excellent cut may actually receive a higher grade as well. Therefore, when grading the color of gemstone one implicitly also grades its cutting performance.




Light behaviors inside a gemstone.



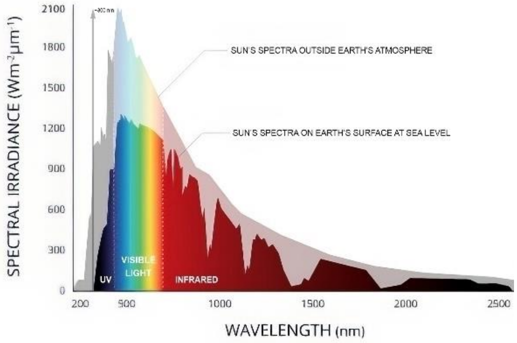

3D rendering of a gemstone using the exact same color value for the three octagons, the only difference is in the pavilion angles. From left to right: 36.5° which is 4 degrees below the critical angle; 40.5° at the critical angle; 44.5° which is 4 degrees above the critical angle.

These three stones will definitely not get the same color grade.

## The Importance of Fluorescence in Color Grading

Many gemstones display fluorescence phenomena. Fluorescence is the emission of light by a gemstone that's absorbed light. Usually when talking about fluorescence in a gemstone for color grading the absorbed light is in the form of long wave ultraviolet light.

The sun emits a particular spectrum with long and short-wave ultraviolet components, however the short-wave ultraviolet is completely filtered by the atmosphere and does not reach the earth's surface. On the contrary plenty of long-wave ultraviolet reaches us. As such using short-wave ultraviolet in color grading is completely irrelevant on this planet.

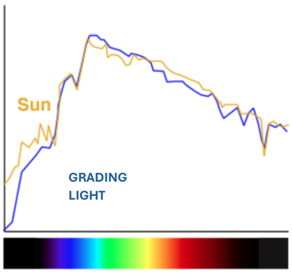



Fluorescence in some gemstones plays a very impactful role in its color, therefore, grading a gemstone with or without ultraviolet light component may yield very different color grades.

Fluorescence a good or bad thing? The question is beyond the scope of color grading, and the answer probably depends on whom you are asking. However, it should be noted that in colorless diamond, fluorescence is seen mainly as a negative feature, expressed with a discount on the (mostly blue) fluorescence. It is speculated that this negative sentiment is due to diamonds being graded with a part of its blue fluorescence component, so two diamonds of the same color grade under daylight, one with strong blue fluorescence and the other without fluorescence will present a different grade under an electric light without any ultraviolet component. The strong blue fluorescence if activated by the grading condition will mask a part of its yellow component and as such making him slightly more colorless than without.

On the opposite it must be noted that the red fluorescence in rubies is seen as a positive feature and highly sought after, expressed by the premium it commands as well as its almost mandatory presence in the grading of the color trade name pigeon's blood by numerous gemological laboratories. It is speculated that this positive sentiment in rubies is due to similar reasons as the negative one in diamonds, the red fluorescence in rubies produces an additional layer of pure red, boosting greatly its color when activated by the grading environment. The only difference is in the eyes of the beholders.

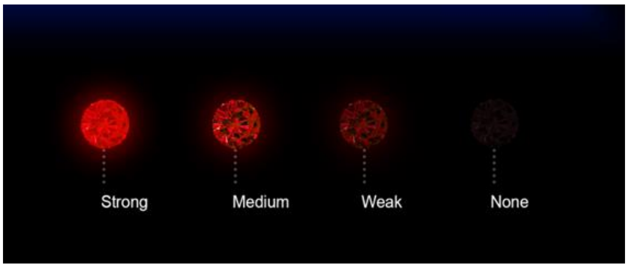
When grading a gemstone at Bellerophon Gemlab we use a D50 & D65 light, that mimics the sun's spectra and intensity with an ultraviolet component equivalent to the averaged sun's rays on the earth's surface at sea level on our planet. However, we also grade separately a gemstone fluorescence, the fact that it may be a positive or negative feature does not concern us, but its influence on a gemstone overall color grading does concern you. The stronger the fluorescence the stronger its impact on the color.




One of the lights used at Bellerophon Gemlab compared to the Sun.

No Fluorescence Fluorescence

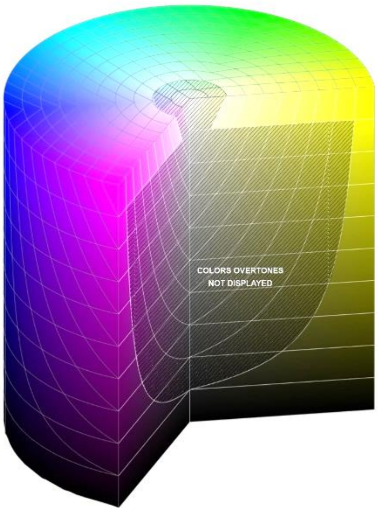
Same strongly fluorescent ruby under the same lighting D50. The picture on the left is taken with a UV filter between the light and the stone to remove any UV induced color.

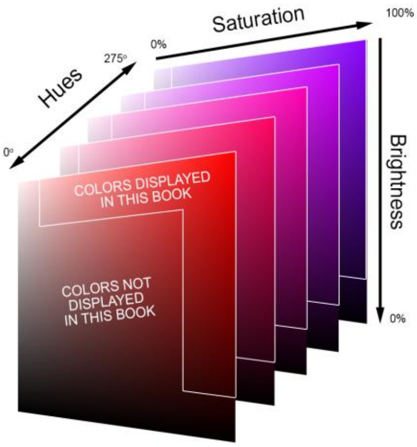



Intensity fluorescent grades.

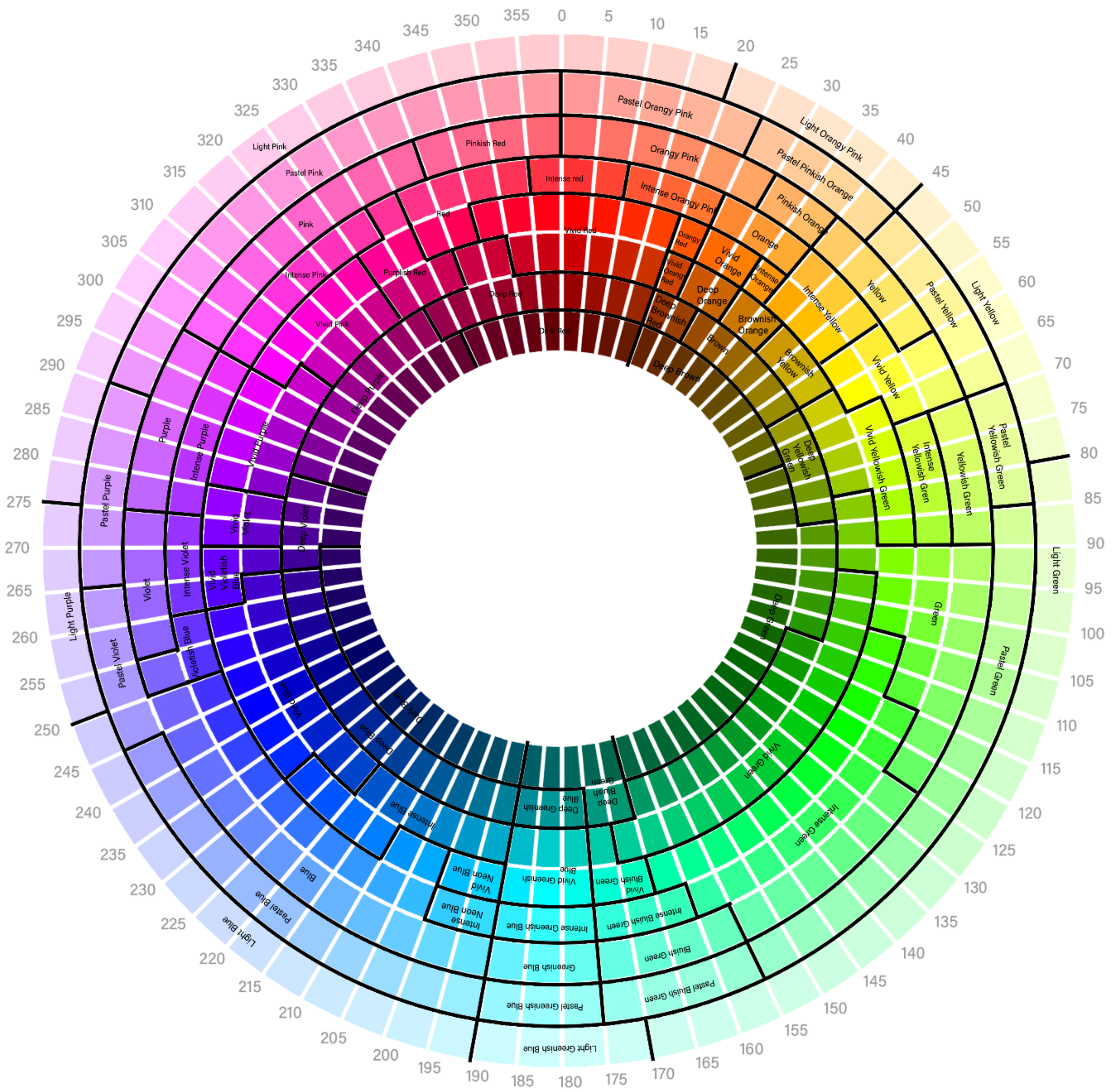
## Special Notes on Bellerophon Gemlab Color System

The color system used at Bellerophon Gemlab is based on the HSB system. All the above colors displayed in this book do not include the white, black and grayish overtone. Our system tends to disregard them whenever possible, but keep in mind that other unusual hues or color descriptions are possible outside the one disclosed here.

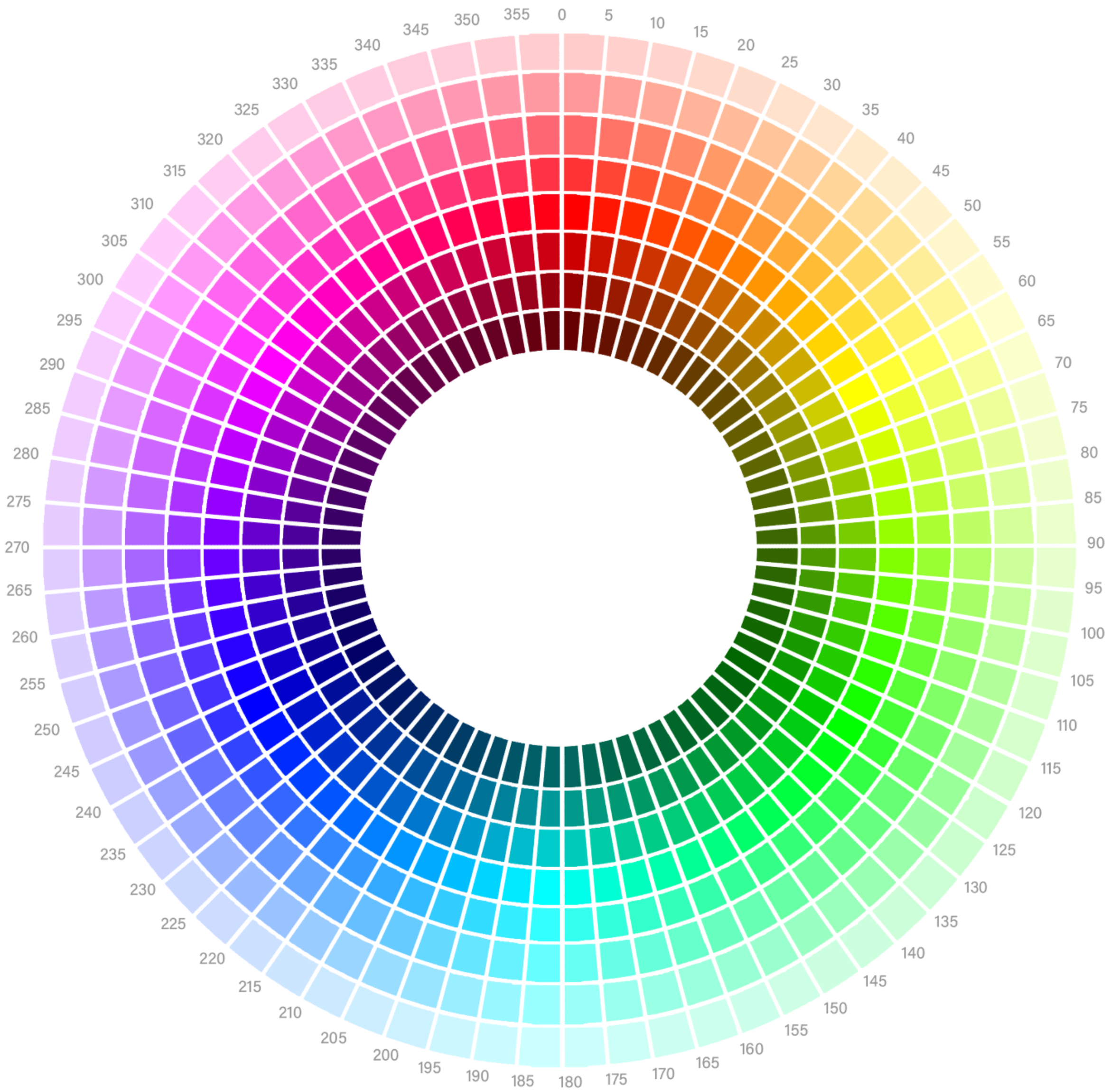


## Full Colors Wheels with Legends



Full Colors Wheels without Legends



**Trade Name**

## COLOR TRADE NAME

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Color trade name are adjectives used to describe a gemstone, for some since generations, although their actual meaning and color description may have drift based on the different cultures and time using them, they remain today, first as very present wording used in the gem trades, and secondly as an overall gage of quality by merchant, connoisseur, and hobbyist to describe a gemstone.

Their use by gemological laboratories was not unanimously welcomed since their first apparition decades ago in a gemological report. Nevertheless, and as objectively as possible their mentions and clear explanation must be present when talking about color grading in gemstones.

The provenance of the color trade name is packed with history, yet not everyone agrees upon their original meanings. Nevertheless, the English translation or derivation of the color trade name words used persist today. However important is the provenance of the actual wording used, trade name as use today combined an impressive amount of gemological science:

Trade name implies the gemstone identity and variety such as Pigeon Blood for rubies only, some trade name goes as far as to be confused with actual mineral variety like the Padparadscha sapphire, they also describe a specific color in terms of hue, saturation, and brightness as well as color homogeneity. They add a fluorescence characteristic for some, implies clarity and cut grades. They are even limited to specific treatments or lack of it and go as far as to be directly or indirectly through the necessary criteria requirement to be origin specific.

In conclusion, trade name presupposes a combination of high quality and rarity based upon the mineral color, with the incorporation of clarity, cut and treatment criteria.

At Bellerophon Gemlab we chose not for trade name to be origin specific. The main reason being first that no laboratory including us today, can ascertain the geographic origin of a gemstone. Geographic origin determination being a comparative non-absolute science, therefore with a statistical implied amount of inexactitude, it is scientifically difficult to bring such opposable result in a quality grading. On the opposite end quality grading can be very close to absolute and much more easily quantifiable, however you choose to define the quality criteria, once defined, it should be measurable. Lastly it seems to us ethically not correct to apply certain trade name with geographic specific definitions such as Paraiba to all origin, while others do not. It is theorized that more than often the refusal of a trade name to an origin is the result of political and economical agenda which a laboratory shall take no part in.

It is important to note that some origin by their average chemical composition provides a much higher statistical chance to get a specific trade name, while others have chances very close to none. It is not surprising that usually the deposit with the highest chances is the one from which the trade name originated, and more than often with the most important historical background, as such these deposits created a standard of quality based on themselves for the rest of the world to follow.

To conclude why tie an adjective synonym of quality to an origin, should this geographic origin produce better quality it should not need to fear others deposits as quality talk by itself.

## PIGEON BLOOD

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### Provenance

Pigeon blood ruby is traditionally used to describe the finest colors of Burmese (Myanmar) ruby. The Burmese legend of the first ruby in the Mogok Valley describes it as having been mistaken for the purest blood by a magical being. The legend is described in Jesseph Kessel's "Valley of the Rubies" as follows:

*"A huge piece of fresh flesh was shining on the side of a hill. And this flesh was of such quality that the old eagle, who had hunted so long above the boundless world, had never seen it before. It was the color of the brightest, purest, sweetest blood. And all the light of the day seemed made for it, so sparkling was it. [...] It was not a piece of meat that glistened in the grass of the hill, but a miraculous and sacred stone, a stone like no other, made of the fire and blood of the earth. [...] This stone was the first ruby in the world."*

This legend goes back at least to the Middle Ages, the earliest mention known to us of Pigeon blood is the story of the famous royal ruby or Nga Mauk ruby described as being of the color of pigeon's blood.

Another legend mentions that Burmese warriors in medieval times put rubies in contact with their blood to gain invulnerability in battle. The ancient Greeks believed that rubies were a remnant of a god's blood.

Red has always been associated with blood, sacrifice and courage. Modern studies in Europe and the United States show that red is the color most associated with heat, passion, sexuality, love and joy. In China, India and many Asian countries, red is the color that symbolizes happiness and good fortune.

It is therefore not surprising that pigeon blood, which most probably recalls the red color of a pigeon's fresh blood or the blood-red ring surrounding a pigeon's eyes, became the historical adjective describing the best red, first by the Burmese and then by the traders along the Silk Road. It may have been the best red they could find at the time, or it may be a poetic term reminiscent of a long-lost Burmese legend.

## Definition

**Color** has the greatest influence on the value of a ruby. Pigeon's blood describes rubies with a pure red to very slightly purplish red hue, with a vivid saturation, which can in rare cases range from intense to deep.

**Fluorescence** of pigeon's blood rubies in the long-wave ultraviolet (365 nm) is preferably strong to medium, with some rare cases of faint red. The almost magical " glowing " red produced by the ruby's absorption of the sun's ultraviolet light to produce an additional layer of pure red (699 nm) adds an important component to its color. It is therefore not surprising that many of the rubies we may call "pigeon's blood" come from low iron rubies with very strong red fluorescence, such as Burma (Myanmar) with Mogok and Mong Hsu, and Vietnam with Luc Yen. However, mafic-ultramafic rubies, such as those from Mozambique and Madagascar, with low to medium iron content, can also show spectacular fluorescence, thus fulfilling all the color requirements to be called "pigeon's blood".

**Clarity** has a very important influence on the value of a ruby. Pigeon's blood ruby must be flawless, preferably clean to the eye, or at least transparent, without pronounced inclusions that are very visible under the table. The color uniformity must be evenly distributed.

**Cut** plays a very important role in the color of a ruby. Pigeon blood rubies should have excellent to good proportions to maximize total internal reflection. Pigeon blood rubies should not show significant windowing (transparent area) and/or extinction when viewed face up.

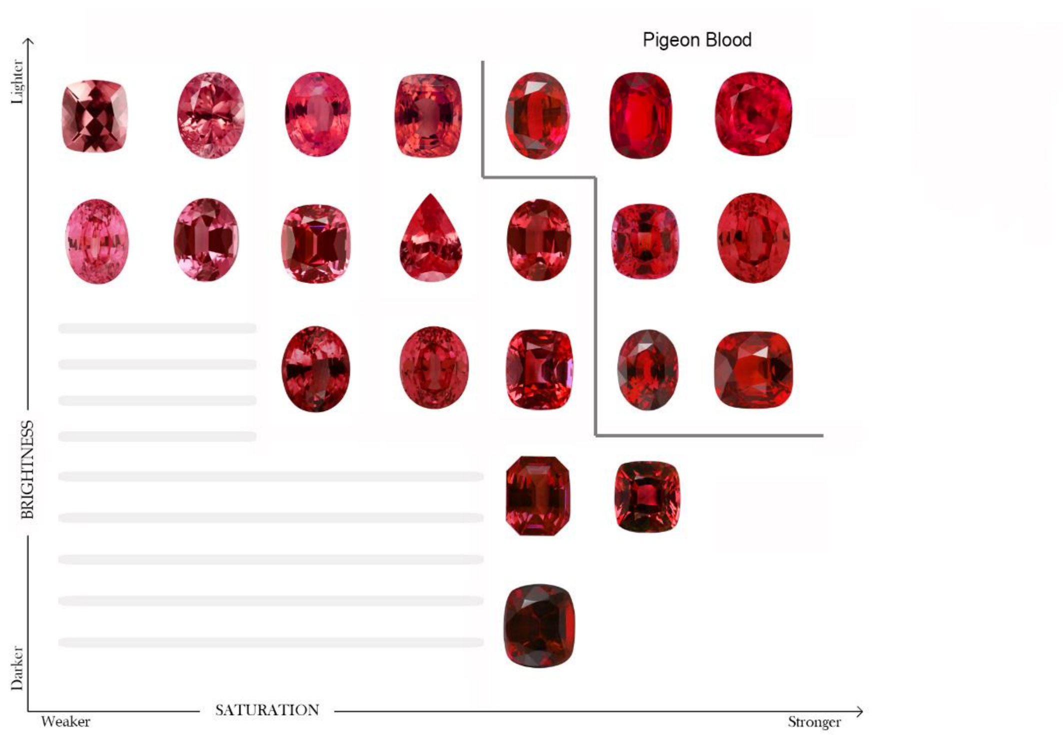
**Treatment** of pigeon blood rubies is acceptable only for no treatment or traditional heating. Therefore, any other treatment such as diffusion of foreign ions into the ruby lattice, such as beryllium, fracture sealing with resin, or lead and silicate glass, will not qualify for Pigeon blood.

Pigeon blood ruby fluorescence and under daylight illumination. Reference collection Bellerophon Gemlab

The adjective "pigeon's blood" combines many facts about a ruby. The hue, saturation and brightness must fall within a predetermined range for the ruby to be considered "pigeon blood".

The red color of rubies is the result of a major chromophore: chromium. It replaces some of the aluminum atoms in the structure, the more chromium, the redder the ruby, and the stronger the fluorescence, this is true up to a point, too much and the ruby will be dark to almost black, and the fluorescence will be greatly reduced. The approximate chromium content in most rubies is between 0.1 and 4%. Two other chromophores almost always play a role in ruby: iron and titanium ($Fe^{3+}$ alone and/or $Fe^{3+}$ in pairs, and $Fe^{2+}$ in pairs with $Ti^{4+}$). The iron content tends to make the ruby orange, decreasing the red saturation and decreasing its brightness as well as killing the fluorescence, while titanium (in pairs with iron) makes the ruby purplish.

Quantifying the chromophores present in a ruby provides a good starting point for color comparison without the influence of other factors such as the path of light through the stone and reflections. By combining this method with natural long-wave ultraviolet spectrophotometry to correctly quantify the fluorescence present, as well as the overall proportions of the stone, we can analyze the most influential color factors separately and compare them to our reference collection of "pigeon's blood" rubies.



# Pigeon Blood Criteria

| | |
|---|---|
| Mineral: | Corundum |
| Variety: | Ruby |
| Hue: | 345º to 15º |
| Saturation: | 80% to 100% |
| Brightness: | 100% to 80% |
| Color Grade: | Intense Red; Vivid Red; Deep Red |
| Color Distribution: | Even |
| Fluorescence: | Medium to Strong Red |
| Clarity: | Flawless to transparent without visible inclusion below the table. |
| Return of Light: | >60% without major windowing and/or extinction |
| Cut Grade: | Excellent to Good |
| Color Origin: | Natural or Heated |
| Clarity Origin: | Natural or Heated with residues |
| Provenance: | All |

## ROYAL BLUE

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Provenance

The name "royal blue" appeared between 1810 and 1820. The "royal" in the name comes from the British royalty, where this shade of blue is said to have been created by a tailor in a competition to make a dress for Queen Charlotte in the early 19th century.

The blue associated with royal blue has actually changed over time. Prior to the 1950s, the original royal blue was considered much deeper than the official one approved in the 1980s by the World Wide Web Consortium, which associated the now lighter blue, along with its RGB code, with the name "Royal blue".

The original royal blue appears on the flag of the United Kingdom and is the colour closest to that used today for royal blue sapphire.

Royal Blue describes the sapphire with the most vivid and deepest saturation. It was probably first used by British gem trader to describe sapphire when Ceylon (now Sri Lanka) and Burma (now Myanmar) was part of the British Empire.

The symbolism of royal blue includes tranquility, as blue is the color of the sky and the ocean, both of which are known to promote feelings of peace. The color blue is synonymous with significance, importance, and confidence. This is where the blue corporate suit and the blue uniforms around the world come from.

## Definition

**Color** has the greatest influence on the value of a sapphire. Royal blue describes sapphires with a pure blue to very slightly violetish blue hue, with a vivid saturation, which can in rare cases range from intense to deep.

**Clarity** has a very important influence on the value of a sapphire. Royal blue sapphire must be flawless, preferably clean to the eye, or at least transparent, without pronounced inclusions that are very visible under the table. The color uniformity must be evenly distributed.

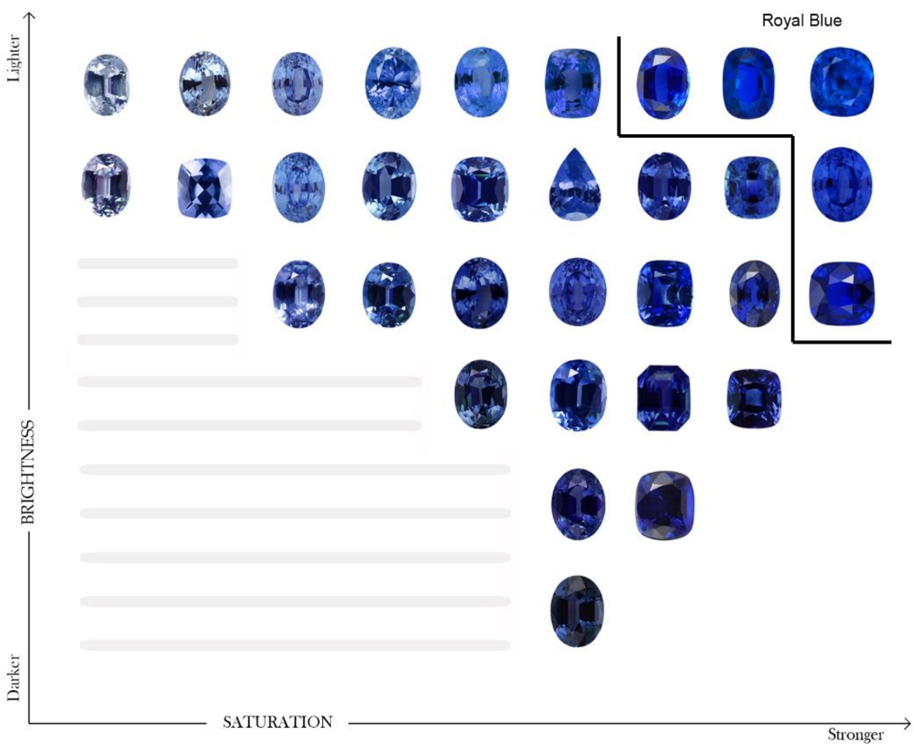
**Cut** plays a very important role in the color of a sapphire. Royal blue sapphires should have excellent to good proportions to maximize total internal reflection. Royal blue sapphires should not show significant windowing (transparent area) and/or extinction when viewed face up.

**Treatment** of Royal blue sapphire is acceptable only for no treatment or traditional heating. Therefore, any other treatment such as diffusion of foreign ions into the sapphire lattice, like beryllium or titanium, fracture sealing with resin, or lead, cobalt and/or silicate glass, will not qualify for Royal blue or any other color grading.

The adjective "Royal blue" combines many facts about a sapphire. Classifying the color of a transparent anisotropic material like a blue sapphire is not as simple as it sounds. The hue, saturation and brightness must fall within a predetermined range for the sapphire to be considered "royal blue".

The blue color of sapphire is the result of a major chromophore: iron with titanium in pairs. It replaces some of the aluminum atoms in the structure, the more iron and titanium pairs, the bluer the sapphire all the way to black. The approximate iron and titanium content in most blue sapphire is between one to couples of tens of pairs of atoms per million. Two other chromophores almost always play a role in blue sapphire: iron and chromium. The iron content tends to make the sapphire green, decreasing the blue saturation and increasing its brightness, while chromium makes the sapphire violetish.

Quantifying the chromophores present in a sapphire provides a good starting point for color comparison without the influence of other factors such as the path of light through the stone and reflections. By combining this method with the overall proportions of the stone, we can analyze the most influential color factors separately and compare them to our reference collection of "Royal blue" sapphires.



# Royal Blue Criteria

| | |
|---|---|
| Mineral: | Corundum |
| Variety: | Sapphire |
| Hue: | 220° to 265° |
| Saturation: | 80% to 100% |
| Brightness: | 100% to 60% |
| Color Grade: | Intense Blue; Vivid Blue; Deep Blue |
| Color Distribution: | Even |
| Fluorescence: | None to Strong Red or Orange |
| Clarity: | Flawless to transparent without visible inclusion below the table. |
| Return of Light: | >60% without major windowing and/or extinction |
| Cut Grade: | Excellent to Good |
| Color Origin: | Natural or Heated |
| Clarity Origin: | Natural |
| Provenance: | All |

# PADPARADSCHA

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## Provenance

Padparadscha sapphire is traditionally used to describe the most beautiful orange-pink sapphire colors of Sri Lanka. The ancient Sinhalese used the word "*Padmaraga*", literally "color of the Lotus" in Sanskrit, to describe a similar sapphire color from at least the early Middle Ages.

The sacred lotus flower is intimately linked to Buddhist philosophy. Legend has it that Gautama Buddha took seven steps after his birth and at each step lotus flowers bloomed. It symbolizes the emergence of beauty with its bright petals in the midst of dark, muddy waters.

In the Hindu religion, the orange-pink lotus is considered the seat of the goddess of wealth and good fortune "*Lakshmi*", who appeared on a lotus and was known as "*Padma*".

Whether adorning temple walls, being eaten, used as a cosmetic and perfume, or offered as a sacred flower for worship, the lotus flower has great significance on the gemstone island. In fact, one of the oldest paintings of a lotus is found in an ancient temple in Matale.

It is easy to assume that with such a legacy, this delicate and extremely rare blend of colors was first cherished by early gem dealers in Sri Lanka due to its association with good fortune and religious heritage, later travelling to the Western world via the Silk Road and the British Empire. Today, the Padparadscha sapphire is cherished by royalty, such as Princess Eugenie's 2018 engagement ring, as well as gem connoisseurs around the world.

## Definition

**Color** has the greatest influence on the value of a sapphire. Padparadscha describes sapphire with a delicate blend of orange pink, the pink being the dominant hue, with a low to medium saturation.

**Fluorescence** of Padparadscha in the long-wave ultraviolet (365 nm) is often strong to medium orange. The almost magical " glowing " apricot color produced by the Padparadscha sapphire absorption of the sun's ultraviolet light to produce an additional layer of orange adds an important component to its color. It is therefore not surprising that many of the sapphires we may call "Padparadscha" come from low iron type sapphires with strong orange fluorescence, such as Ceylon (Sri Lanka).

**Clarity** has a very important influence on the value of an orangy pink sapphire. Padparadscha sapphire must be flawless, preferably clean to the eye, or at least transparent, without pronounced inclusions that are very visible under the table. The color uniformity must be excellent to evenly distributed.

**Cut** plays a very important role in the color of a sapphire. Padparadscha should have excellent to good proportions to maximize total internal reflection and should not show significant windowing (transparent area) or extinction area when viewed face up.

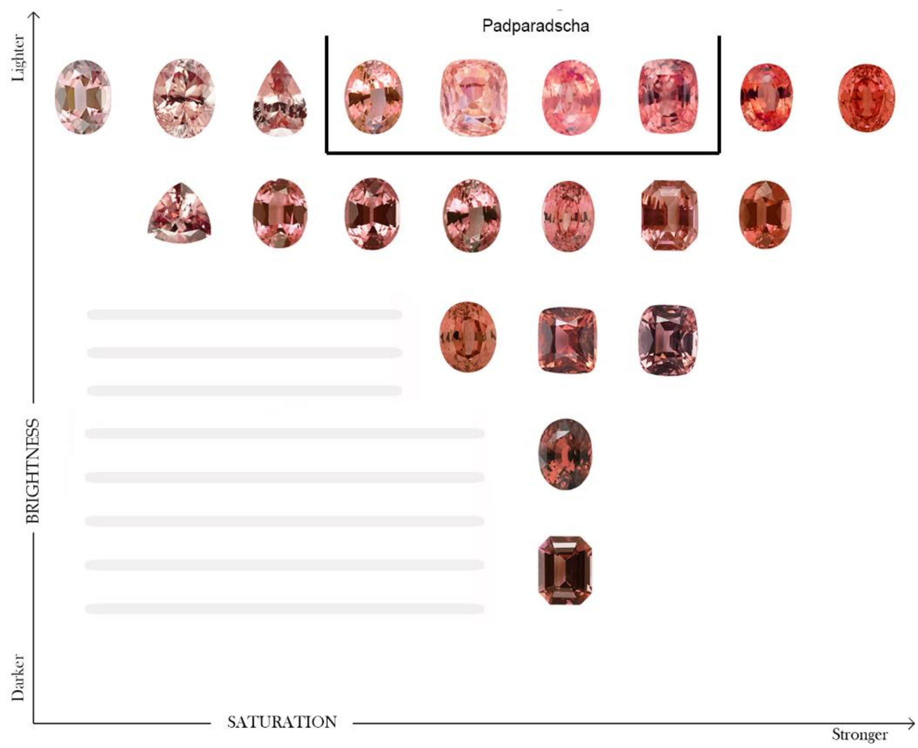
**Treatment** of Padparadscha sapphire is acceptable only for no treatment or traditional heating. Therefore, any other treatment such as diffusion of foreign ions into the sapphire lattice, such as beryllium, fracture sealing with resin, or lead and silicate glass, will not be qualified for Padparadscha.

## Science

The adjective "Padparadscha" combines many facts about a sapphire. The hue, saturation and brightness must fall within a predetermined range for the sapphire to be considered "Padparadscha".

The orange pink color of sapphires is most of the time the result of two chromophores: chromium for the pink and iron as a color center (iron associated with a trapped hole) for the orange. It replaces some of the aluminum atoms in the structure, the more chromium, the pinker the sapphire, and the more iron as a color center the orangier the sapphire. The orange fluorescence is speculated to be related to the presence of trapped hole as well. The approximate chromium content in most Padparadscha is between 20 to 300 atoms per million and about 2 to 8 iron color centers per million. However, the orange color in sapphire can be produced by 3 other chromophores, iron alone and in pairs, iron as a color center and chromium as a color center. Making the proper definition of Padparadscha chromophore complicated. To add to the subtility, orange epigenetic filler in fissure (iron stain) if well placed when cutting a sapphire may add an orange color modifier to the gemstone.

Quantifying the chromophores present in a Padparadscha provides a good starting point for color comparison without the influence of other factors such as the path of light through the stone and reflections. By combining this method with natural long-wave ultraviolet spectrophotometry as well as the overall proportions of the stone, we can analyze the most influential color factors separately and compare them to our reference collection of "Padparadscha" sapphires.



## Padparadscha Criteria

| | |
|---|---|
| Mineral: | Corundum |
| Variety: | Sapphire |
| Hue: | 0° to 40° |
| Saturation: | 20% to 60% |
| Brightness: | 100% |
| Color Grade: | Light Orangy Pink; Pastel Orangy Pink; Orangy Pink |
| Color Distribution: | Even |
| Fluorescence: | None to Strong Red; Yellow or Orange |
| Clarity: | Flawless to transparent without visible inclusion below the table. |
| Return of Light: | >60% without major windowing and/or extinction |
| Cut Grade: | Excellent to Good |
| Color Origin: | Natural or Heated |
| Clarity Origin: | Natural |
| Provenance: | All |