

# OPTIMIZING FACE-UP APPEARANCE IN COLORED GEMSTONE FACETING

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The human visual system interprets visual cues to perceive different intensities of brightness. Patterns of light and dark contrast create impressions of brightness in faceted gemstones. These patterns generally remain coherent in the viewer's eye when the gemstone is tilted or rotated. Using computer-generated color-coded contrast maps in facet planning can improve apparent brightness, optimizing a gemstone's appearance.

There are many challenges in choosing a facet arrangement that optimizes a colored stone's face-up appearance. What contributes to an attractive appearance? In the field of cognitive science, experts have identified rules that govern our perception of visual cues such as line, color, form, brightness, contrast, and motion. The subconscious processing of these cues is the work of each person's "visual intelligence system," wherein every aspect of our visual experience is framed. In gemstones, brightness depends on how we process visual cues, so some patterns appear brighter than others even when the measurable light return is identical. Studying these rules can help formulate design strategies to make gemstones brighter and more interesting. Tools exist for exploring these aspects of appearance. Using these, cutters can choose elements that will optimize the design. Effective design requires an exploration of the best angle combinations and placement of facets for a given material. Nevertheless, *choices about appearance are personal*. And while preferences vary, this study assumes the goal of improving scintillation while maintaining as much brightness as possible. Most colored stone cutters understand their own preferences regarding visual contrast, depth of color, spread (shallow or deep), brightness, and scintillation. By understanding certain aspects of optimization, they can modify designs to suit their own preferences. Ultimately, this

will lead to a faceted gemstone with maximum appeal given the constraints of the material at hand. This paper focuses on gems with colors that are not easily weakened by pronounced brightness or darkness, similar to the medium range of tone and strong saturation found in peridot (figure 1).

## UNDERSTANDING BRIGHTNESS AND CONTRAST

Understanding what creates the impression of brightness can help us map and plan areas in a gemstone to enhance observed brightness.

Cognitive scientists understand much of the complexity of the stimuli processed by our visual system. For example, even though variations in lighting result in varying wavelengths of light reflected from a colored surface, our visual intelligence system actually works as a subconscious processor, assigning a constant hue, saturation, and tone (which scientists refer to as "lightness"). This collaboration between the visual system and the brain is constantly extracting information from a flood of sensations to construct a visual world. In the words of leading cognitive scientist Donald Hoffman (1998), "You are a creative genius. Your creative genius is so accomplished that it appears, to you and others, as effortless. Yet, it far outstrips the most valiant efforts of today's fastest supercomputers. To invoke it, you need only open your eyes."

These scientists work primarily with two-dimensional printed (opaque) images or flat images on a computer monitor, and they consider brightness a subjective attribute or property of an object being

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See end of article for About the Author and Acknowledgments.

GEMS & GEMOLOGY, Vol. 49, No. 2, pp. 64–81,  
<http://dx.doi.org/10.5741/GEMS.49.2.64>

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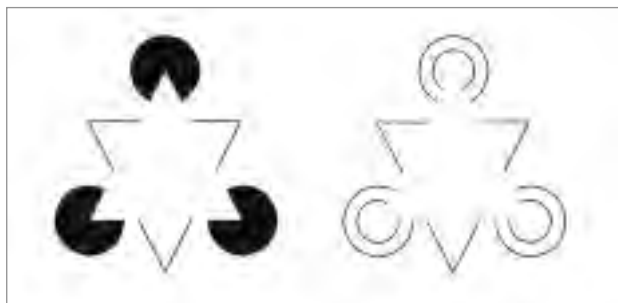
Figure 1. The concepts dealing with brightness, scintillation, and overall appearance are best evaluated in a gem whose color is not easily weakened by making it bright or overly dark, such as peridot. Photo by Robert Weldon, © GIA.

observed. Gemstones are three-dimensional and transparent, and the light reflected from within them has a greater impact on their face-up appearance than the light reflected from the surface. Our visual intelligence processes visual cues so we see a gem that seems to generate light from within itself, in a pattern that changes as the gem moves. This pattern is generated by the interaction of light with the faceting design.

Jose Sasián, a professor of optical sciences at the University of Arizona, explains that while looking at a gem, the observer appears to see more facets than actually exist. Sasián (2007) calls these “virtual” facets. These perceived facets are a result of different levels of contrast, caused by light striking all the facets and then splitting, creating the appearance of many more facets.

How we interpret visual cues is critical to understanding what creates a gemstone’s beauty, and by studying these cues we can identify the elements to include in gem design.

Figure 2. Observers see a bright, luminous triangle in the center of both figures, even though there are no defining lines. Cognitive scientists attribute this “invisible surface map” to how our brain interprets visual cues provided by the contrast of light and dark. From Kanizsa (1955).

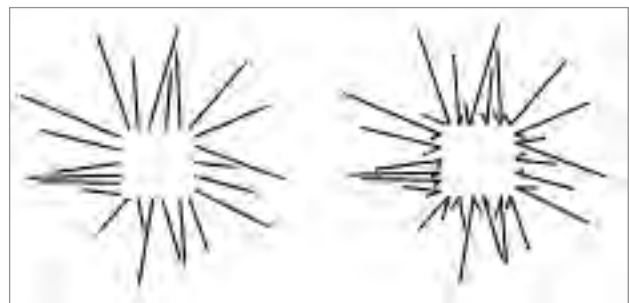


The following is a general overview of the visual cues relevant to faceted, transparent gems.

**Invisible Surfaces.** Termed by some vision scientists as “the invisible surface that glows,” the illustration created by G. Kanizsa (1955) shows two different triangles that are more luminous (i.e., brighter) than the background, and whose borders are easily observed even though there are no lines defining them (figure 2). Using a photometer, one cannot detect any edges of the triangle. The borders and luminosity are purely the construction of the observer’s visual intelligence system. The brain uses a variety of cues to construct these images, which we will refer to as “invisible surface maps.” In figure 3, the invisible surface map on the left has a more luminous square area than the map on the right. How the brain perceives the lines that resemble small “check marks” causes this duller effect.

In the three “plus-symbol” outlines in figure 4, the first contains a square luminous area in the center. In the second image, the sides of the square bow inward

Figure 3. The visual contrast cues in this pair of invisible surface maps are different, causing our brain to interpret the left square as brighter than the right square. From Albert (1955).



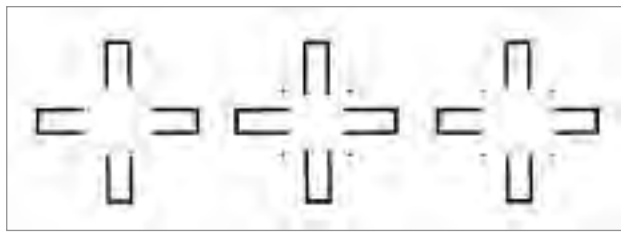


Figure 4. These “plus-symbol” outlines have slightly different visual cues. The first contains a square bright middle area. In the second, the square appears to have concave sides due to the four dots. With the third, the bowing has been removed by shifting the four sets of lines. From Petry (1987).

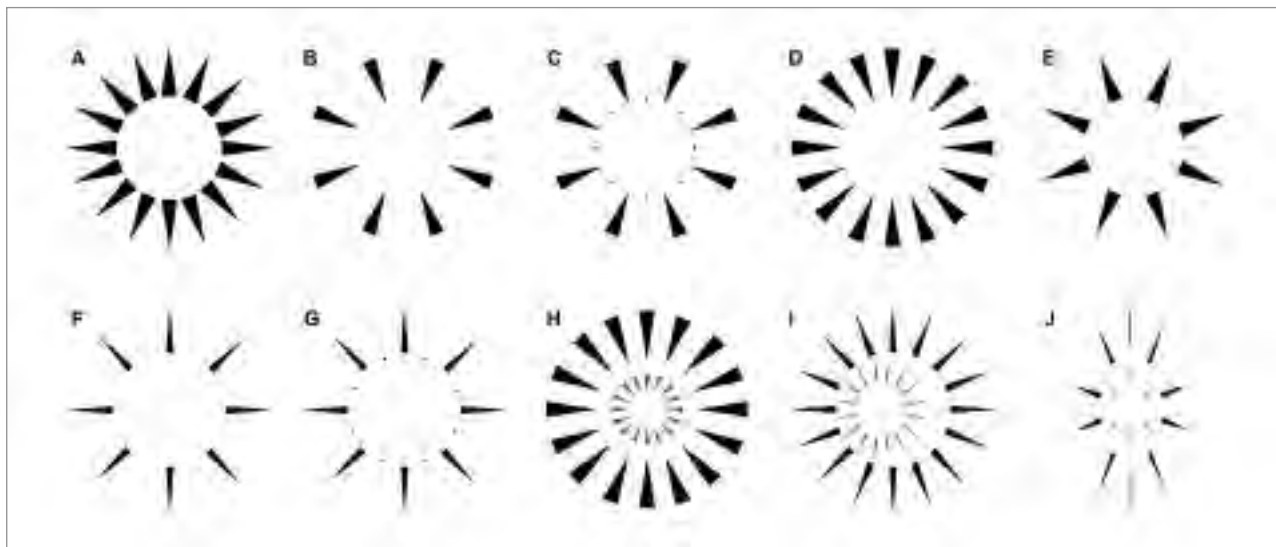
due to the addition of visual cues (the four black dots). In the third image, the bowing disappears because the four sets of lines have been shortened to square up with the black dots. (Note: The brain can interpret visual cues in more than one way. For example, some see a circular rather than a square luminous area in the leftmost image.)

Varying combinations of bright and dark can cause the observer to perceive different intensities of brightness. This does not address personal preferences for different combinations. For example, the invisible surface maps in figures 5A–5G demonstrate various visual cues that create a bright circular area in the center. In each of these examples, the different cues and their arrangements result in varying degrees of perceived brightness, leading to the impression of

an edge that is not really there—the invisible surface. Different types of pattern elements (such as blunt lines, dots, or wedges) can produce similar appearances, depending on how they are arranged. Elements of varying brightness can also be embedded or stacked within each other (figures 5H–5J), creating multiple bright areas. Shifting the center of these embedded areas (figure 5I) does not disturb the impressions of brightness; the center has moved along with the areas of contrast. Although these areas show strong contrast, they are still coherent and bright, much like when a faceted gemstone is rocked. They are also present in non-round shapes such as the marquise or oval, as shown in figure 5J.

The ability to see these illusory bright areas in an invisible surface map is enhanced by movement. When the image in figure 6 was “flickered” rapidly on a computer monitor, the illusory center became brighter. When the flickering image was also rotated, the apparent brightness increased significantly. The flashing of light and dark patterns caused by rotating and flickering the image equates to the scintillation seen when we move a gemstone back and forth. Stronger contrast (black or gray areas against white backgrounds) also equates to stronger scintillation. Vision scientists have found that in certain cases an image stays organized or coherent in a viewer’s mind when the direction of observation is changed, as through movement.

Figure 5. These invisible surface maps have slightly different contrast cues, resulting in the impression of bright or luminous circles (A–G). Contrast cues can also be stacked or embedded within each other (H–J) to give the impression of multiple areas of brightness.



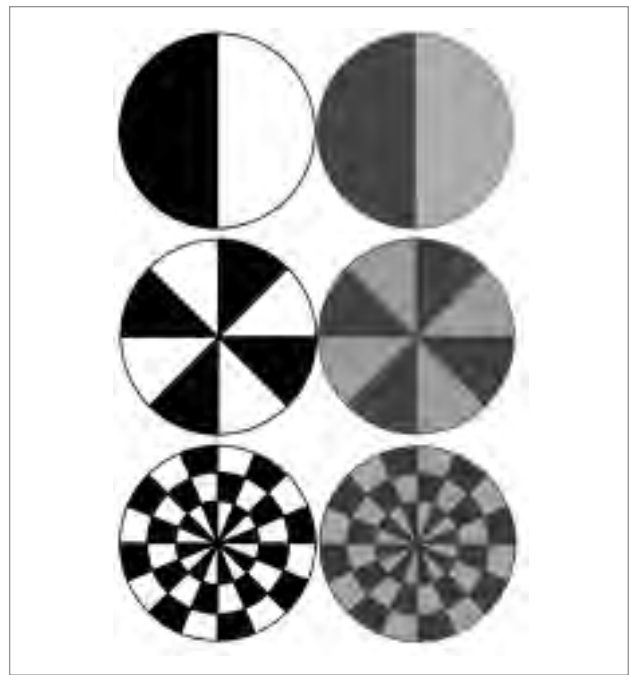
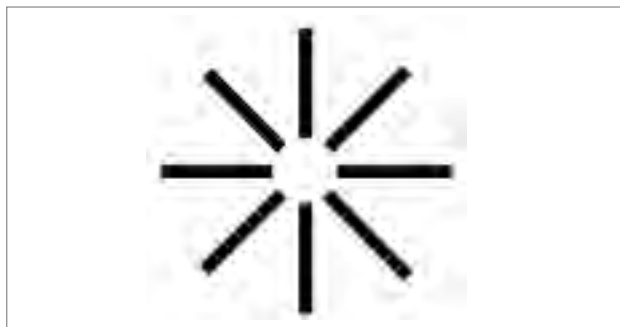
**Brightness Contrast.** Appraiser Michael Cowing, FGA, has published several articles on evaluating diamond cut quality, coining the term “brilliance contrast” to describe how contrast causes the brightness observed in diamonds (2009). Each of the circles in figure 7 is 50% dark and 50% light by surface area. A light meter confirms that each one is equally bright when printed on paper (even the gray ones). The checkered pattern of the bottom left circle makes it perhaps the most visually interesting. If a gem were able to return 100% of the light (all white), and no dark areas were visible, it would measure

### In Brief

- A gem’s brightness and attractiveness depends not only on how much light is returned but also on the contrast pattern or contrast distribution created by virtual facets.
- An idealized contrast plot shows the types of contrast distribution that contribute to effective gem designs to be used by faceters.
- Following rules for optimization, such as creating a design with the right contrast distribution, improves a gem’s appearance and increases its fire.

brighter than a stone with dark areas of contrast—but its appearance would be far less appealing. For instance, the right column in figure 7 seems duller than the left due to weaker contrast. These images show that while good light return is an important aspect of “brilliance,” contrast is a critical factor in face-up brightness. Obviously, there comes a point when too much darkness or a poor distribution of darkness is less pleasing.

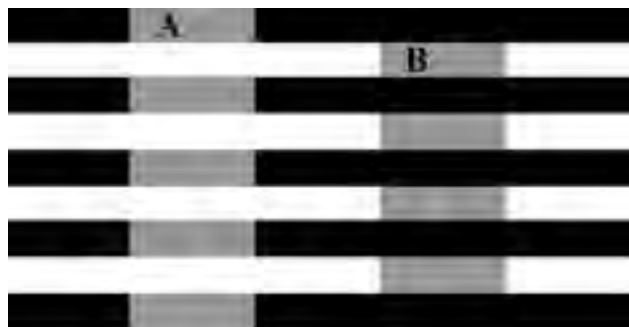
*Figure 6. Observers see a markedly increased brightness in the center circle when this invisible surface map is flickered on a computer monitor. When the image is rotated and flickered simultaneously, the brightness further increases. From Petry (1987).*



*Figure 7. Each of these circles is 50% dark and 50% light by surface area. Yet the circles on the right are dull due to weak contrast. A gemstone’s visual interest depends on good contrast. If it returned all light and had no contrast, the gemstone would be uninteresting.*

Figure 8 shows a common optical illusion known as “White’s Illusion.” Although the rectangles in B seem darker than those in A, they are actually of equal luminance. In fact, they have the same gray color. The gray areas embedded in dark stripes (A) appear brighter than the gray areas embedded in white stripes (B). This illustrates the concept of “lateral inhibition,” in which the perceived brightness of an area depends upon its surroundings (White, 1979).

*Figure 8. The rectangles on the right appear darker than those on the left, but they are actually the same shade of gray. This demonstrates that the perceived brightness of an area depends on the surroundings and the contrast. From White (1979).*



In figure 9, the horizontal stripe and all six boxes have the same brightness and color, but the squares' apparent brightness depends on the contrast of the surrounding area. In this illusion demonstrating "simultaneous lightness contrast" (an example of lateral inhibition), apparent lightness is different from quantitative lightness, the real measurement of the total lightness reflected from an object. The phenomenon also occurs when a colored area is placed on a dark background, making it appear clearer, brighter, or more luminous. In figure 10, for example, the navette shapes at the bottom are identical, but they appear to be different colors when placed on alternating light and dark backgrounds (C). The difference is accentuated with the addition of an interwoven background (A and B).

**Summary of Vision Science.** Combining the ideas of invisible surfaces and brightness contrast, we can derive that darker contrast, placed in the right locations, can give faceted gems a brighter appearance. The areas of contrast need to be evenly distributed and not grouped together; this is particularly true for areas under the table. Our eye tends to gravitate toward the center to gather an overall impression of brightness. The diagrams in figure 11 illustrate how the placement of dark areas affects brightness. The patterns are identical but contain varying levels of contrast. The image of highest contrast (bottom right, for most observers) also has the brightest-looking center. This is a common goal in facet design, as dark centers, or "nail heads," are undesirable in the jewelry trade.

From cognitive science we know that the apparent brightness of an invisible surface of definable

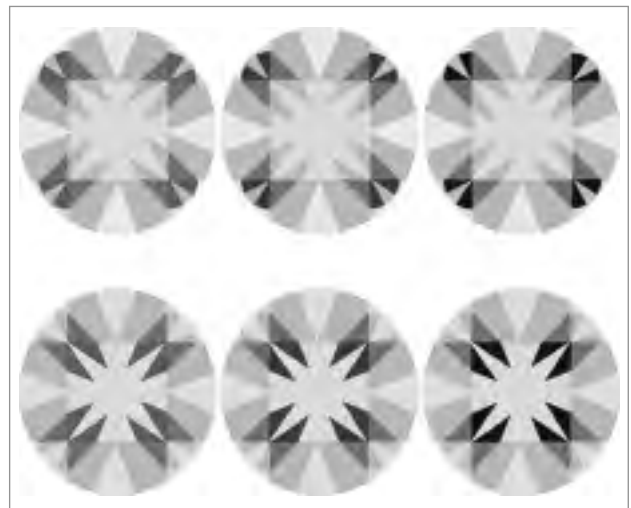
*Figure 9. The stripe and the small squares are all the same shade of gray, again illustrating that perceived brightness relies upon its surroundings and the contrast, which changes as the environment changes. From Purves (2011).*



*Figure 10. The navette shapes throughout this image have the same tone but appear darker or lighter depending on the adjacent areas. From Sarcone and Waeber (undated).*

shape results from certain visual cues relating to differences of light and dark. The effect is further enhanced by movement, and invisible surfaces can be stacked or embedded within each other. Strong contrast makes a gemstone appear brighter and more appealing, and the position of the contrast is also

*Figure 11. Varying the levels of contrast affects the appearance of brightness. Each circle has the same pattern, but the areas of contrast vary in strength. The circle with the highest contrast (bottom right) has the brightest-looking center.*



important. Scintillation is more dynamic when there is strong contrast between adjacent virtual facets.

If we understand what causes the cues for brightness in any shape, we can use this information to design effective facet patterns by using strong contrast and ending the lines of contrast to produce a bright center. A gem's brightness and attractiveness depends not only on how much light is returned—angles are still important—but also on the contrast pattern created by virtual facets. Once an effective pattern is established, the major elements of that pattern must remain in effect when the gem is tilted to maintain the appearance of brightness. This means that the pavilion angles cannot be cut near an angle that allows the gem to "window," letting light leak through. If the slightest tilt interrupts the pattern due to a window, the pattern is not effective because the contrast pattern has been eliminated. The impact of these effects may vary according to the level of brightness, as dictated by refractive index and color saturation.

### TOOLS FOR ASSESSING CONTRAST

If contrast is an important part of faceting various gem materials, there needs to be a reliable method to determine elements of contrast. Most critical is the contrast caused by the reflection of the observer's head and torso. Harding (1975) first identified this critical element: the effect of an observer's head blocking rays of overhead illumination. He calculated the rays returned from the gem to the viewer's eyes, as well as the illumination blocked by the viewer's head.

Regarding head obstruction, Harding writes, "For ultimate liveliness it should be possible to see reflections in the table from both sides of the pavilion with both eyes at once. At a viewing distance of one foot, as shown in [figure 12], the angle between reflections to both eyes (two different rays) is about  $12^\circ$ . To see reflections from both sides with both eyes, therefore, the minimum external table reflection angle must be at least  $6^\circ$ ." While not directly discussing the need for contrast, Harding alluded to its importance. Of course, liveliness stems from scintillation, the result of strong contrast between neighboring facets when the gem, the light source, or the observer moves.

This concept was also part of Kazumi Okuda's groundbreaking work in about 1980. His experiments with reflectors—"hearts and arrows" viewers have evolved from these devices—led to the FireScope™ introduced by JDM in Japan. JDM used the black reflection of the lens as a dark contrast against a red reflecting field (figure 13). Studying the black reflection, they determined the importance of certain reflection

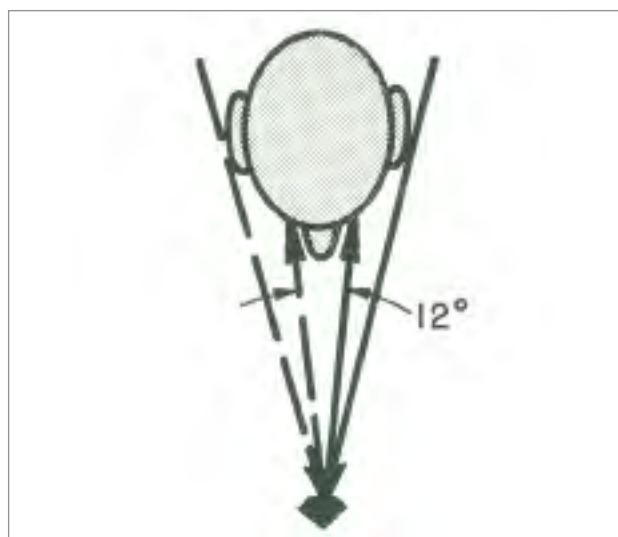


Figure 12. A gemstone's liveliness is the result of scintillation: the strong contrast between neighboring facets when the gem, the light source, or the observer moves. An observer's head (shown from above) obstructs overhead light, causing a sharp change in the light streaming into the gem. Note that at a viewing distance of one foot (approximately 30 cm), the angle between the two reflected rays that return to both eyes is about  $12^\circ$ . From Harding (1975, figure 8).

patterns in diamond appearance, as shown in an undated FireScope brochure, circa 1987.

It should be noted that an observer both blocks light from the rear and reflects light from the front or side. In most environments, however, far less light

Figure 13. The FireScope by JDM uses the black reflection of the viewing lens as a dark contrast against a red reflecting field. Studying the patterns of different diamonds, JDM concluded that the most attractive diamonds have a certain contrast pattern. From an undated FireScope brochure, circa 1987.



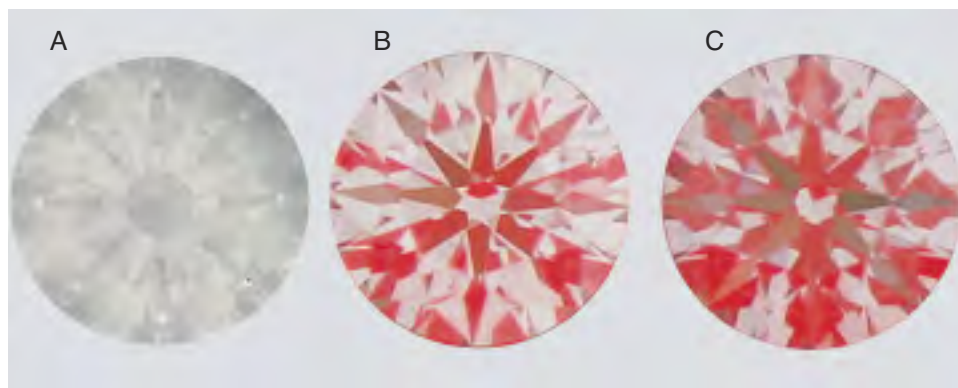


Figure 14. These photos show the same gemstone under different viewing conditions: (A) under totally diffused white light; (B) under the same environment, with the observer wearing a red mask and garment; and (C) with the observer standing closer. From these, it is apparent that the observer sees much of their own reflection, as dark contrast in the gemstone.

is reflected into the gem from the observer's head and shoulders than from around and above the observer. The observer's reflection therefore serves as the major source of contrast in the lighting environment.

To better understand this, consider what a faceted gem might look like in a totally diffuse white-lit environment (figure 14). If the gem reflected nothing but white light, it would have no contrast (A). If you were to cover your face and shoulders with a fluorescent red mask and view the gem in the same environment, you would see red contrast (B). If you moved closer to the gem, there would be even more red reflected throughout it (C).

In 1997, this author started experimenting with color coding of light (and contrast) entering a stone from various angles ("Reflector technologies," undated). By constructing a hemisphere or dome with concentric rings of color (figure 15) and viewing the stone through an aperture at the top of the dome, one can see that the gem gathers its light from the colored rings. DiamCalc, a 3D modeling program introduced in Russia in March 1999, uses ray tracing to alter the proportions and angles of a diamond image viewed on a computer monitor. By 2000, color-coded lighting environments were added, allowing the modification of angle of arc as well as color. DiamCalc can model virtual polished gemstones in a variety of realistic lighting environments, including GemCad's ISO and COS, Fire Scope™, Ideal-Scope, ASET (Angular Spectrum Evaluation Tool), and AG,

the author's own environment. GemCad is a popular computer-aided design (CAD) program used to create accurate 3D models of a faceted gemstone. DiamCalc accepts GemCad and other designs and allows changes in table size and girdle thickness, as well as facet angles and azimuths, for a variety of standard shapes. DiamCalc can also create motion pictures of a gem being rocked or otherwise moved from side to side in these lighting environments. The software is widely used in the diamond cutting industry to plan rough and design new cuts. It can accept files from GemCad (.asc format), Sarin (.srn), Helium (.mmd), and Autodesk (.dxf or .stl), as well as certain .txt files. It can generate the following file formats: Autodesk DXF (.dxf), GemCad (.asc), and binary and ASCII STL (both in .stl format). For colored stone cutters, it allows variations in refractive index for modeling various gem materials.

DiamCalc does not model double refraction, so the effects of a closed or dark c-axis cannot be predicted. Many stones are dichroic, which means one sees different colors in different directions through the gem. Some gems with this property will show nearly identical colors in all directions, while some will show only differences in color density (darker or lighter tone). For example, tourmaline often has extreme dichroism, and this characteristic is referred to by many gem cutters as a "closed c-axis" or "dark c-axis." In other words, light does not pass through one axis (direction) of the stone, or only passes in a limited amount.



Figure 15. Gemstones gather light from the surrounding viewing environment. When placed under a hemisphere lined with concentric rings of various colors (left and center), a gemstone (right) returns the colors of the dome.

**Comparison of Two Important Models.** While DiamCalc supports a variety of lighting environments, this paper deals with two of particular value in design optimization: AG and ASET (figure 16). These are variations of the color coding of light entering a diamond from specific surrounding arcs, patented in 2000 (Gilbertson, 2003) and 2004 (Caudill et al. 2008), respectively. While either can be used as a primary environment for planning or as a secondary double check, the AG environment offers certain advantages as the primary. Comparing the three-color ASET and the five-color AG patterns for the same stone, observe how their angles of light orientation differ. Key information about both the observer (black, 83°–90°) and the lower angles of light entry likely producing a strong contrast (dark violet, 40°–55°) are not represented well in the ASET image. Three color-coded zones do not provide enough information, as certain patterns with strong contrast (black) can produce some of the visual cues leading to different preferences.

If a design is planned with AG and then checked with ASET, however, nuances and slight weaknesses in design can be captured and modified later. These examples represent diamond's RI and the sets of angles considered optimum for diamond appearance. Since individuals may prefer different patterns,

which can vary depending on RI, it is advisable to determine personal preference before analyzing patterns with AG and ASET lighting.

DiamCalc also allows the background to be color-coded. A black background is the default setting for both the AG and ASET environments, but white is also available. Areas where light passes through the gem from the background ("windows"), are indicated as white in the contrast plot when using the white background.

### PRACTICAL APPLICATION

Past work can be useful for further understanding the AG lighting environment. For example, both GIA and the American Gem Society have determined that the most appealing round brilliant-cut diamonds have a balance of contrast and brightness (GIA, 2006; Sasián, 2007). The contrast maps of a typical well-cut diamond are shown in figures 16 and 17 to illustrate the relative balance of the various color-coded light entry angle ranges. Much like the invisible surface map examples in figure 5, these color-coded contrast maps can explain the pattern seen in the cut gem with AG lighting (figure 17).

With the AG environment, note that there is very little black (83°–90°). The black areas representing the retro-reflection of the observer should be minimized

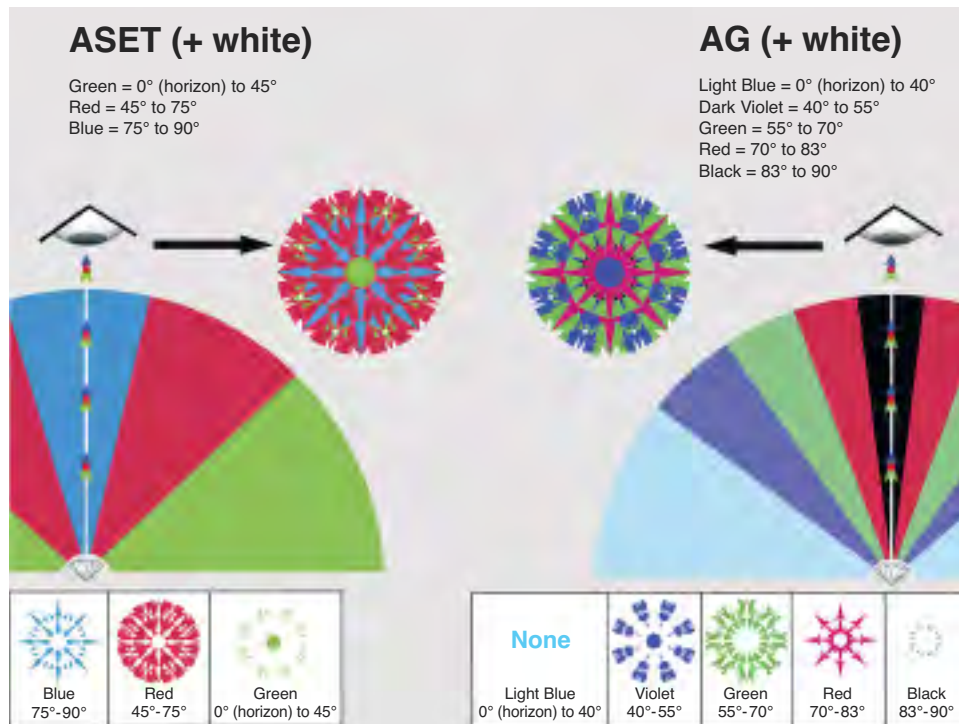


Figure 16. Two of the light color-coding models supported by Diamcalc—AG and ASET—can be used for mapping contrast in gemstone designs. Different aspects of contrast in the same gemstone can be seen using the three-color ASET environment and the five-color AG environment.



or removed in planning colored stones. The lowest angles of light entry represented by violet (40°–55°) will appear darker, along with any areas of windowing, which produces a very nice balance of varying contrasts within the gem. These examples are comparable to the dark areas in the invisible surface maps.

The contrast maps display a substantial amount of green, which is represented by light coming from around the observer's head (55°–70°). The red (70°–83°) is arranged in a narrow, wagon-wheel pattern from the girdle edge to the near-center. Red areas can appear dark or bright, depending on the observer's proximity to the gem or how much it is tilted. Both of these colors indicate the primary areas of brightness in a gem, comparable to the white area in the invisible surface maps. An effective design requires these areas of brightness to be prominent and well distributed, with the dark areas creating a balanced, contrasting pattern in the gem.

Contrast maps are similar to a much more complex stacked invisible surface set (such as figure 5H–J). As the invisible surface maps are moved and rotated, the apparent brightness increases dramatically and remains organized in a viewer's mind even when the direction of observation is changed. This means that movement (rotating and flickering) of the invisible surface maps is comparable to the scintillation seen when a gemstone moves back and forth. With the proper types of contrast in adjacent virtual facets of the red areas, the gem will be more interesting and attractive, and in many cases appear brighter. Note that while brightness may be the goal, too many areas of brightness can lighten the saturation of the color in large portions of the gem, lowering its market value.

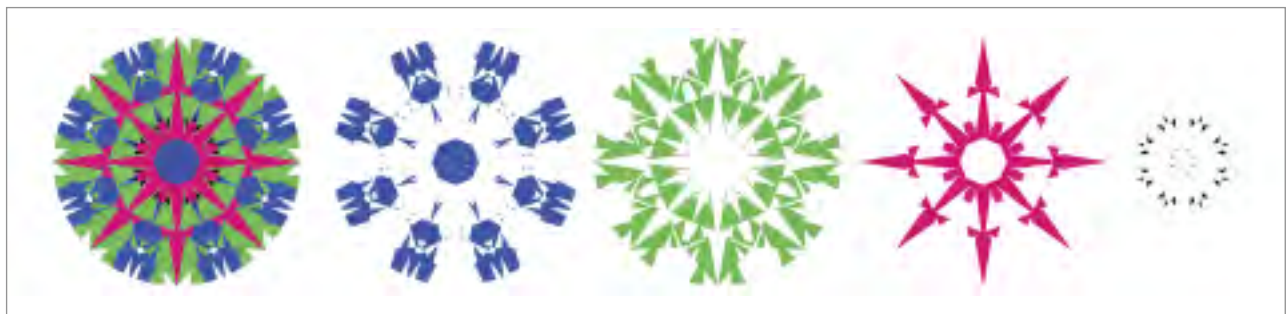
## EXAMPLES

Figure 18 shows examples of various gems purchased from the trade for GIA's Dr. Eduard J. Gübelin Collection. The individual gems were scanned using a non-contact measuring device to derive the facet angles and arrangement. A photo of each gem, showing the representative pattern viewed face-up, is accompanied by an AG contrast map derived from DiamCalc. The observer's face and torso are about 18–20 inches from the stone, and the photo captures a good representation of what the observer would typically see in the gem. The following is a brief discussion on the appearance of each gem.

Figure 18A: This native-cut golden sapphire (RI near 1.77) is particularly bright because the center of the gem reflects light gathered from around the observer and returns that light to the observer. Yet the outer areas window slightly, and in lighter colored gems this is distracting. This view can be explained by looking at the color-coded contrast map (AG with white contrast map). Red and green indicate higher-contrast areas that provide some brightness in those parts of the gem. Note that these extend out to the girdle, which is very important. The outer areas contain blue, resulting from lower-angle lighting. The outer white areas are the windows where the observer sees through the gem.

Figure 18B: When gently rocking this apatite (RI near 1.64), the observer sees much of their own dark reflection in the middle. The apparently bright outer edges in the photograph of the stone are actually dull; the observer sees through the gem. This produces a stone that is not very attractive or visually dynamic. The black area of the color-coded contrast map (AG

*Figure 17. For this sample gemstone, there is little black (retro-reflection of the observer) in the AG environment. Red reflection (70°–83° arc) is arranged in a narrow, wagon-wheel pattern from the girdle edge to the near-center. Red will be bright when the gemstone is held at some distance, but dark if the gem is close to the observer. The evenly distributed green shows where light is returned from around the observer's head (55°–70° arc). Violet (40°–55° arc) comes from a low angle on the horizon and is generally dark. The lowest angles (0°–40° arc) would be seen as light blue. Together, these work to compose a uniformity of varying contrasts within the gem.*



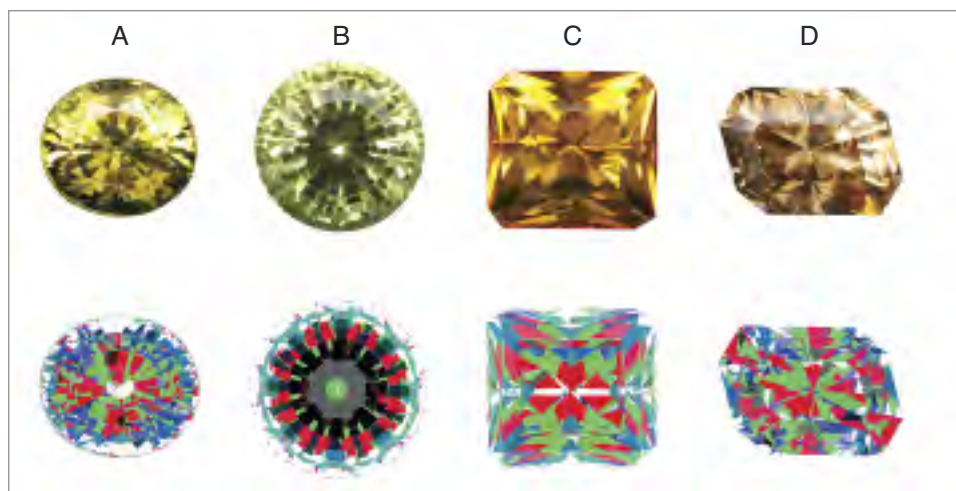


Figure 18. Four gemstones from GIA's Dr. Eduard J. Gübelin Collection were scanned using a non-contact optical measuring device to obtain a 3D image of each. Photos showing the representative patterns when viewed face-up are equated to the AG contrast maps derived from DiamCalc.

with white contrast map) is a reflection of the observer. Red and green indicate higher contrast areas of brightness, and some of the outer areas contain dull blue-green, resulting from lower-angle lighting. Again, the outer white areas are windows.

The next two examples show better cut optimization:

Figure 18C: Despite this amber's soft appearance (RI near 1.54) caused by facets that are slightly rounded and less crisp, its brightness—even when rocked—comes from effective use of high-angle entry light to provide dynamic contrast and minimal observer reflection (black). In the red areas of the map, the observer's reflection may come into view when the gem is slightly tilted. The prominent green areas represent a large amount of bright light entering the gem. The even distribution of red and green from culet to girdle adds to the attractiveness. Minimal areas of blue (lower-angle lighting) and white (windowing) keep this gem bright.

Figure 18D: This grossular garnet (RI near 1.74) is bright and does not window easily, even when rocked. Its brightness comes from the effective use of high-angle light entry to create a good mix of dynamic contrast, with little reflection of the observer. Red areas indicate that when the gem is slightly tilted, the observer's reflection may come into view. The abundance of green areas helps by directing bright light into the gem. For maximum visual appeal, the red and green areas should be evenly distributed and extend from culet to girdle. In this map, there is little blue (lower-angle lighting) or white (windowing).

### APPLICATION TO GEMCAD-BASED OR 3-D WIREFRAME DESIGNS

The following discussion provides examples of how to read and interpret the AG contrast maps to optimize

cutting schemes. Six different GemCad designs specifically for quartz (or other gems with an RI near 1.55) were chosen from the DataVue file of GemCad designs. The name of the design, the creator, and the publication where it first appeared are listed. Each shows a table where the pavilion depth and crown height change by 1% of girdle width (and all pavilion and crown angles change accordingly). The resulting angles can be obtained from the GemCad file, but for simplicity this article uses crown and pavilion percentage differences. The table size is constant, as altering it would result in many more combinations. The original design's proportions are outlined and marked "original." For reference, the graphic design is also shown, accompanied by a contrast plot for an idealized round brilliant. The idealized contrast plot demonstrates the types of color distribution that contribute to effective designs. It serves as a visual reference for the types of dominant colors and balance that might be desired.

Design 13022 (figure 19): This design performs well with a variety of angle differences. It is a very forgiving design that can be used with a variety of crown heights to better utilize the rough. But note that all of these contrast plots have a predominance of green in the middle. Where does the contrast belong? Green represents brightness, but brightness alone is not terribly interesting. For more visual interest, a cutter could try a 46% pavilion/21% crown or a 47% pavilion/12% crown modification to add contrast. As mentioned before, trying several patterns will help identify which specific elements are the brightest and most attractive.

Design 13061 (figure 20): This example demonstrates the need for caution in trusting a cutting plan, regardless of the source. The original gem is fairly dull, perhaps due to a typographical error in the plan, a design not meant for quartz, or incorrect entering of the angles. While a large amount of red around the

## London Shield

Norman Steele, *Seattle Facet Design*, Oct. 1988, p. 3

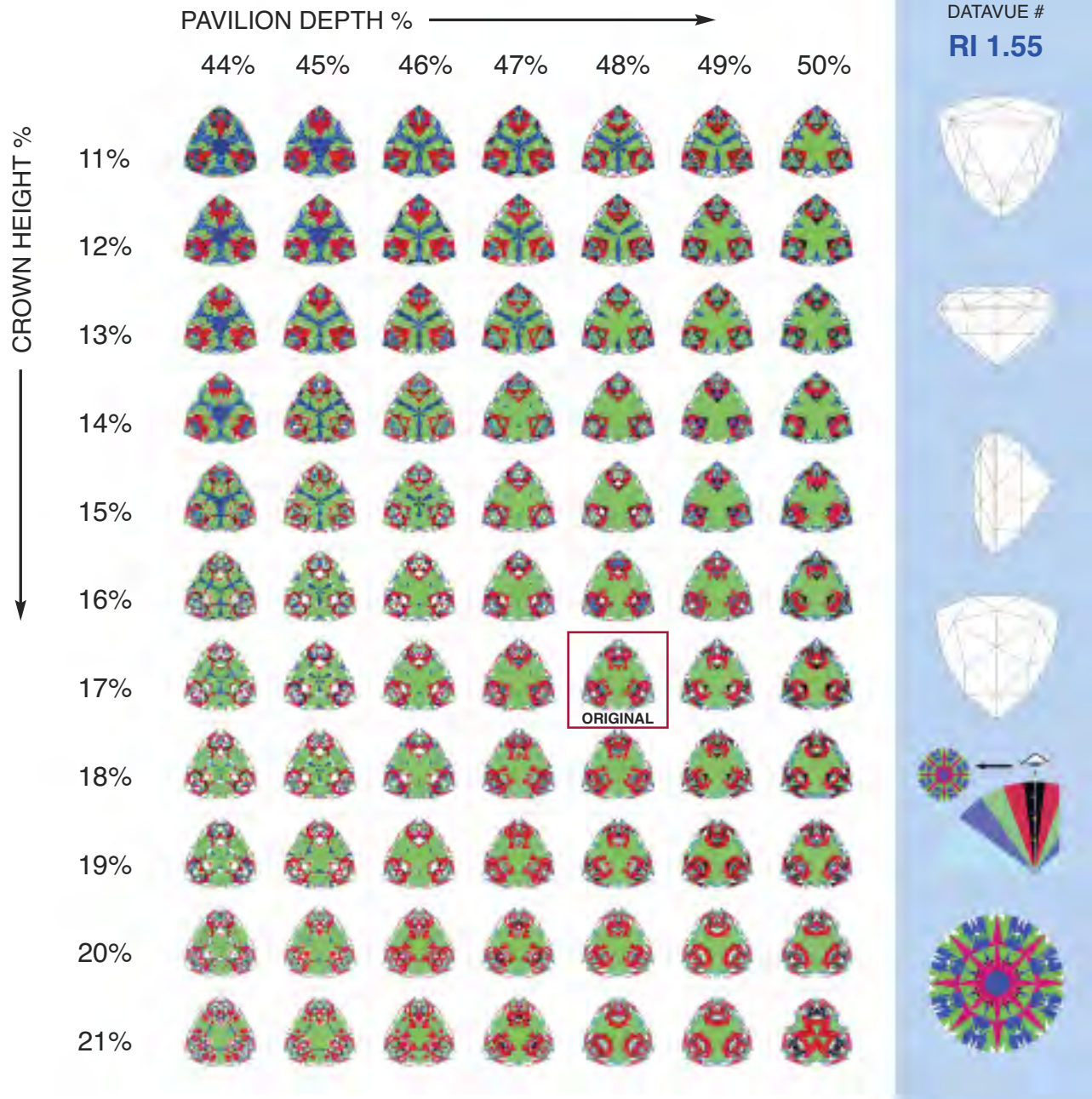


Figure 19. In this design, the six center pavilion main facets tend to gather light from the same direction, without breaking it up much (seen here as large green center areas). For more visual interest, a cutter could try a shallower crown and pavilion, which would give it more contrast into the center.

girdle edge does not always produce the best design, the 41% pavilion/11% crown combination may provide the most contrast, with some blue at the girdle edge to break up the red.

Design 13096 (figure 21): This design offers

abundant contrast, and the resulting gemstone would be quite dynamic. Whereas the contrast areas with combinations of red and red/black can slightly darken the stone, green/red is generally a better combination. Designs should minimize blue

## Barion Old Mine Triangle

Ben Dawson, *Facets*, June 1989

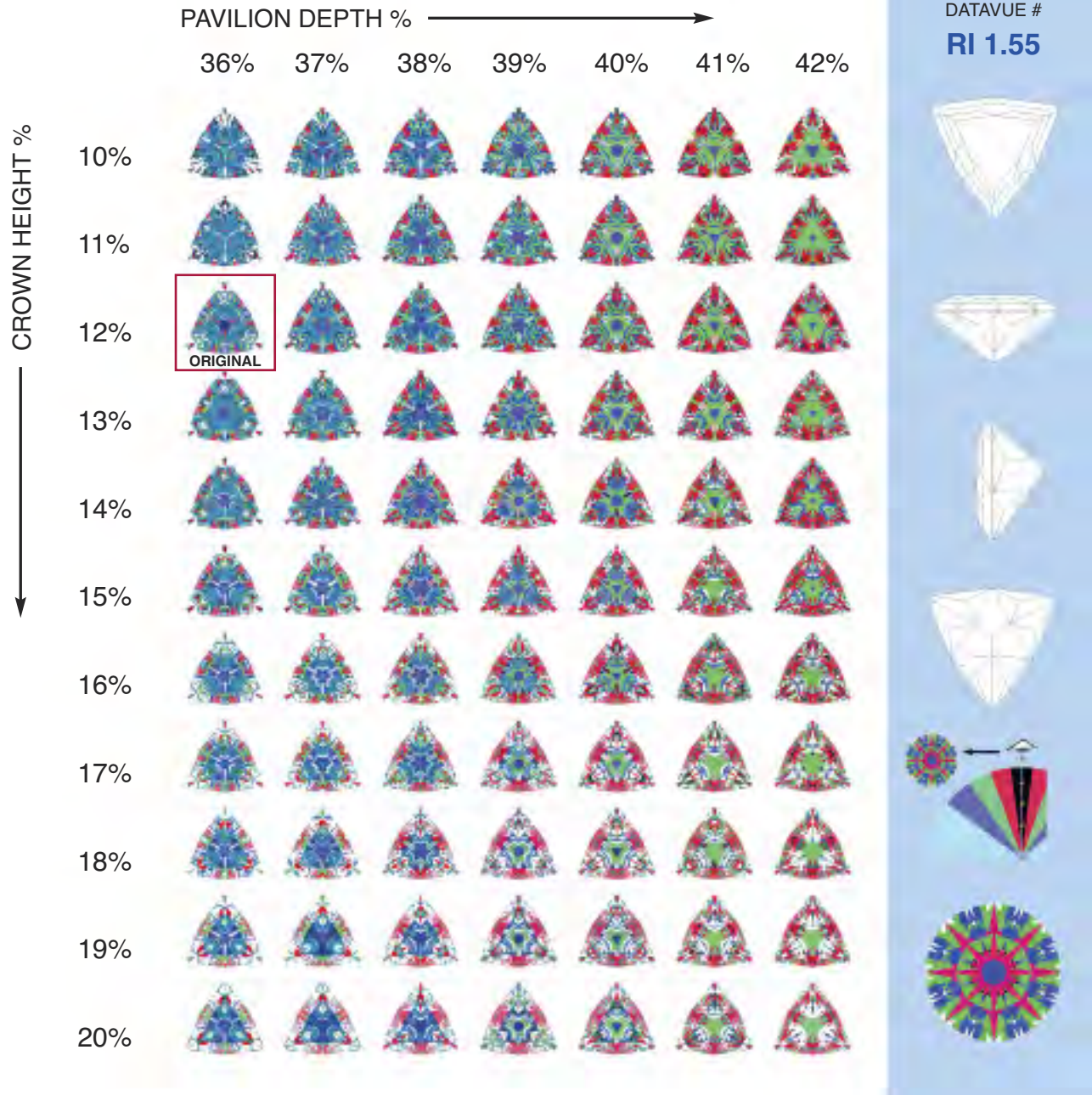


Figure 20. This design is fairly dull, and a much steeper pavilion and shallow crown would dramatically improve its appearance.

points in the center. For this design, a 45% pavilion/11% crown or 41% pavilion/17% crown would be more effective.

Design 13138 (figure 22): Of the triangular designs chosen for these illustrations, this is probably the

most dynamic example. It is another forgiving design and also has high contrast all the way into the middle of the stone, with greens and reds throughout. While the original proportion set has a little too much blue in that quadrant of the plots, it would still produce a

## GemFaire 94

Jim Summers, *New Mexico Facetor*, Aug. 1994

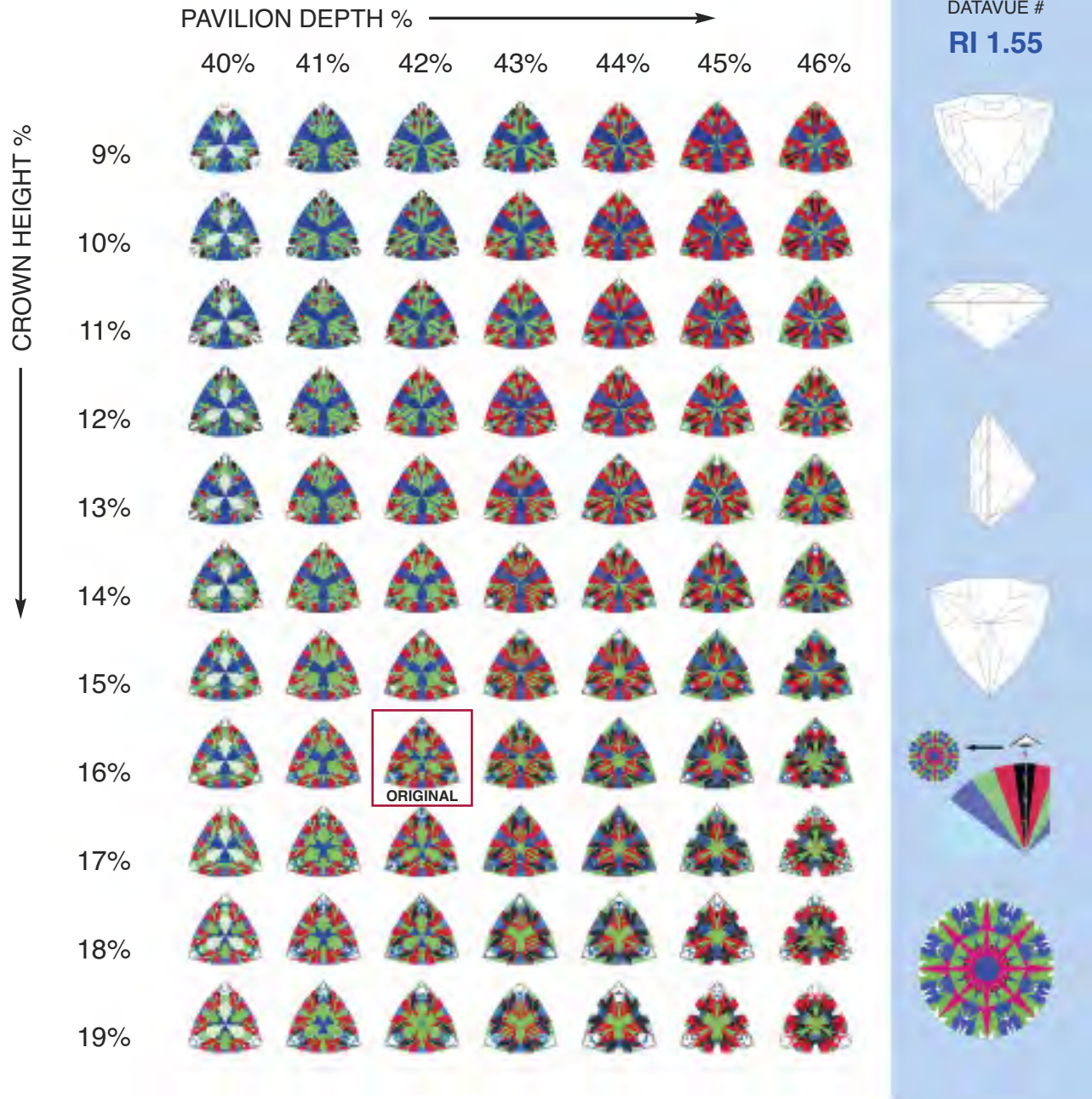


Figure 21. This design presents high contrast. The cutter merely needs to choose steeper pavilion angles ( $\geq 44\%$  pavilion depth) and slightly shallower crown angles to avoid windowing.

very good appearance. Slightly increasing the pavilion depth—for instance, 47% pavilion/14% crown—would improve the design.

Design 13141 (figure 23): Note the prominence of red among these choices. The red areas start to pick up reflections of the observer (black areas) when

slightly tilted, sometimes darkening the stone slightly. Therefore, this design should not be used with dark material, and only with slightly light or medium colors. The original angle combinations offer a good balance between contrasts of different light-entry angles. If the material is slightly dark, a

## Trilogy

Robert Strickland, *TFG Newsletter*, Oct.-Dec. 1996, Vol. 17, No. 4, p. 18

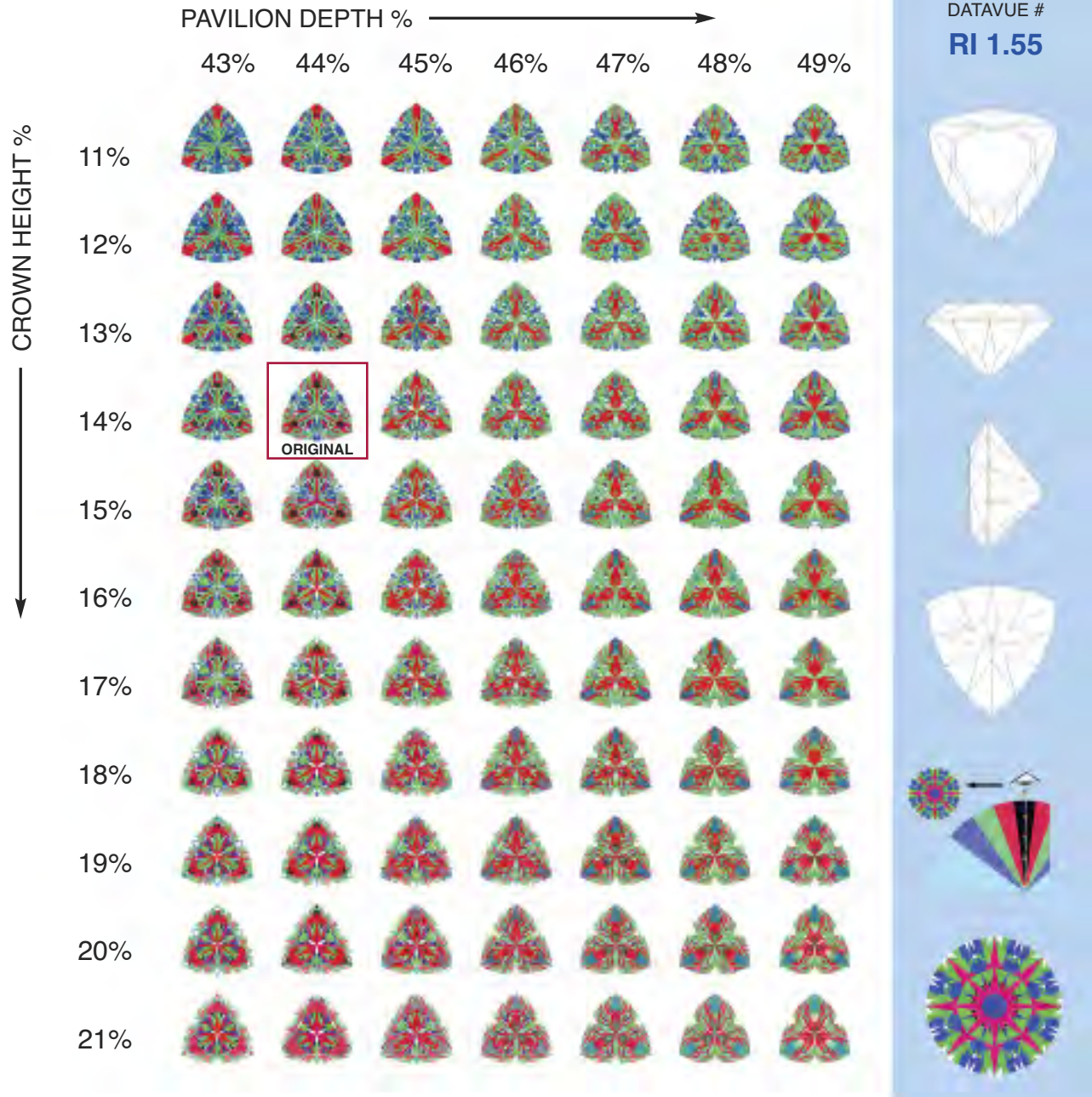


Figure 22. This is a forgiving design with high contrast into the center. With pavilion depths from 43% to 49% and a crown ranging from 12% to 17%, all working effectively, this design can be adapted to shallow or thick rough.

44% pavilion/12% crown will produce a little less darkness in the stone.

Design 13146 (figure 24): Note that this gem has a narrow range of feasible pavilion depth. At 45%, there is strong windowing, which also occurs in the white area in the 46% column. While not shown here, tilting

the example in the 46% column will also produce windowing. At 50%, the substantial amount of blue (low-angle light entry) does not allow much brightness. The original proportions will work very well, but higher proportions of green in a contrast map—for instance, 48% pavilion/17% crown—are generally preferable. To

### Brazil Cushion Triangle 1

Richard C. Walker, *Facets*, Sept. 1988, p. 3

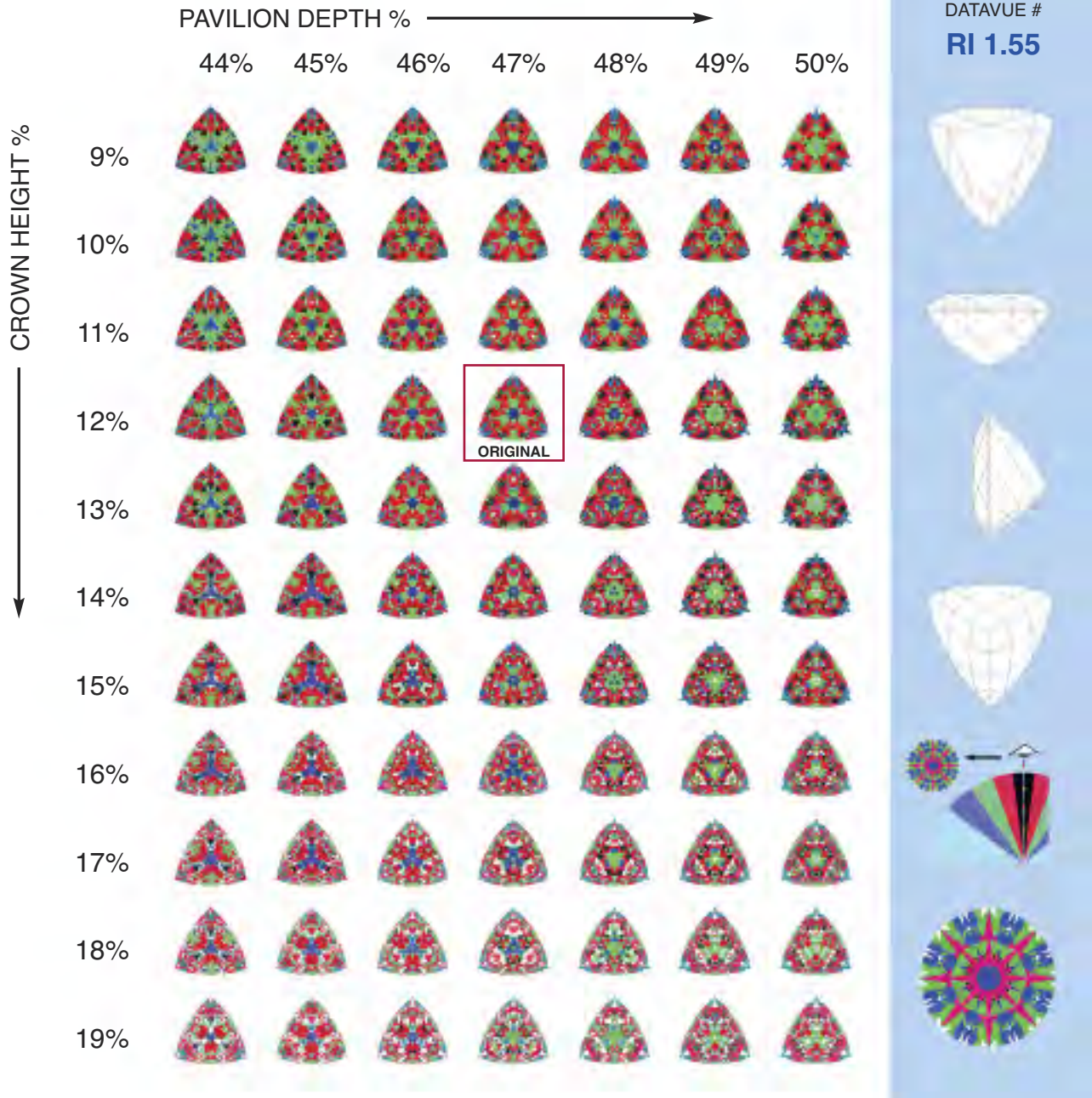


Figure 23. Another forgiving design with high contrast, this should be used with lighter materials. The red areas start to pick up reflections of the observer when the stone is tilted, darkening its appearance.

achieve good contrast, the adjoining facets need to have offset angles. This design only does so in a very narrow range of proportions.

Computer modeling can assist in effective design by simulating the best angle combinations and/or

modifying the design (adding or removing facets, or changing their placement). By using lighting schemes such as AG and ASET in design planning, facet arrangement can be optimized to produce the most visually interesting results.

### Third Millennium

Ernie Hawes, *New Mexico Facetor*, Nov.-Dec. 1999

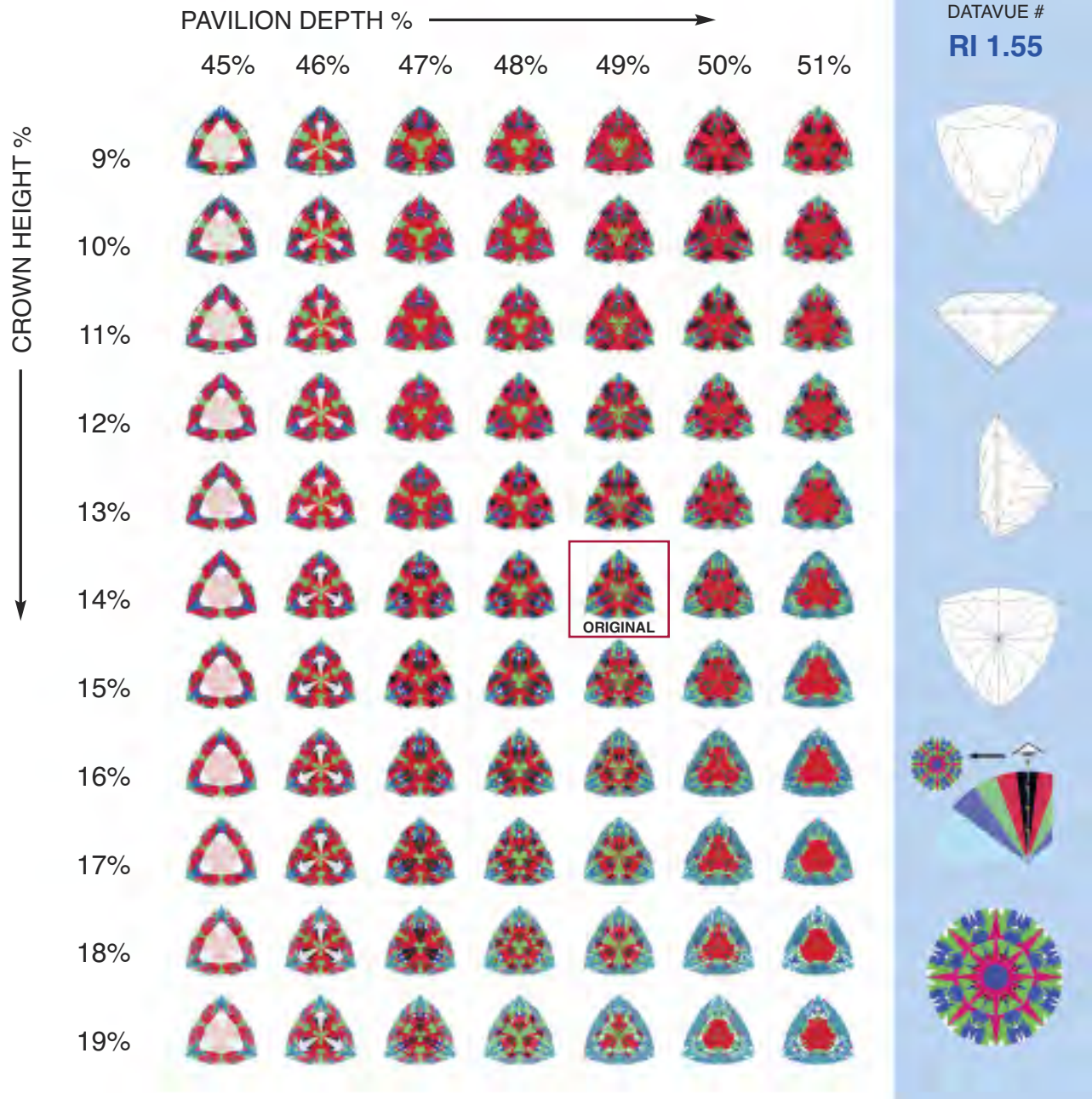


Figure 24. This design is effective in a limited range of proportions and should be used with lighter materials.

#### GENERAL CUTTING CONSIDERATIONS

1. Designs for equal-sided gems (e.g., square, round, equilateral triangular) can easily be made more dynamic. Elongated shapes are inherently more difficult to optimize to the same degree.

2. Step cuts are more difficult to optimize. With the addition of four or more rows on the pavilion, the difficulty increases. In optimizing step cuts, very careful attention must be paid to step width, as well as the design execution.





Figure 25. Each image shows a 2° rotation clockwise from the previous image. A spot light source contributes a small amount of fire (seen here as red, blue, green, or yellow virtual facets). As the gem is rotated, some virtual facets go from light to dark (examples are circled). As a facet nears the border between light and dark, the observer will see fire. Some of these flares of color last through larger degrees of rotation than others (larger red circles). While not illustrated, when a facet only slightly darkens or lightens, fire is faint. Strong changes in contrast create stronger fire. More fire is exhibited by materials of higher dispersion values.

3. Some designs are more effective for certain RI ranges than others. For example, the standard round brilliant is far more effective for gems with a high RI (diamond, zircon, etc.) than for lower-RI materials.
4. The gem's physical size also dictates design considerations. For example, when cutting a 10 mm gem, a simple single-cut design with eight pavilion and eight crown facets (plus the table facet) is not as effective as a 57-facet round brilliant design. A 181-facet design, for instance, does not succeed unless the gem is of substantial size, because tiny facets are less distinct and look "fuzzy."
5. Adding small facets to designs that contain large facets is rarely practical. For example, splitting stars into three small facets while leaving the others at a normal size will have little effect and may actually diminish the design. Often that center facet provides less contrast than if there were only two facets.
6. Every now and then, faceters concern themselves with dispersion, which jewelers refer to as "fire." It is a measurement that indicates how much light is spread by different materials. Generally, lower-RI gems do not contain much visible fire. Adding color saturation to the material hides what little fire might be there. On the other hand, highly dispersive gem materials (with dispersion values above 0.039) provide some unique opportunities to display fire. This effect depends on two considerations:
  - a. Lighting environment: Where the lighting is primarily diffused (e.g., reflected from a white ceiling with no direct spot-type

source directed at the gem), the observer will see little fire. If the lighting environment provides strong contrast, using bright spot-lighting against a dark background, fire is strongly enhanced.

- b. Strong contrast: Areas of strong contrast in the gem will create fire as those areas alternate between dark and bright when the gem is rotated. Figure 25 shows a gem being rotated in 2° increments with the light source in a fixed position. As the gem is rotated, the movement of facets causes them to fluctuate between dark and light. At the threshold between light and dark, the observer will see fire. If the gem is moved slowly, with facets only slightly changing in relation to the light source and the reflection to the eye, the change in color of the facet will be gradual. If movement is sudden, the observer may only see where the facet is dark and then light, without seeing the fire. When a facet only slightly darkens or lightens, fire is faint.

Following these rules for optimization, such as creating a design with strong contrast, will also improve the appearance of a gem and increase its fire.

Before implementing personal preferences, the faceter should be aware that the colored gem market is very focused on color: hue, saturation and tone. Color quality is critical, but often suffers in lightly colored gems when the design is modified toward brightness. Instead, optimization may be needed to enhance the color first and foremost, with scintillation a secondary priority. Understanding the elements of brightness can help the faceter achieve it without compromising color.

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Mr. Gilbertson is the project manager of cut research for GIA in Carlsbad, California.

#### ACKNOWLEDGMENTS

The author acknowledges Dr. Ilene Reinitz for her many helpful

suggestions and the organization of this paper. The author greatly appreciates comments and suggestions about content from Dale Carriere, Lisa Elser, Nathan Renfro, Michael Cowing, and Wayne Emery.

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