

## PHOTOMICROGRAPHY ON GEMSTONE INCLUSIONS FROM THE ARTISTIC ASPECTS

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**Abstract.** This is a systematic literature review on gemstone inclusions as a result of photomicrography technique. The objective of this literature review is to study images from the fields of Earth and Planetary, specifically gemstone inclusions. Gemstone inclusion can be defined as any material that is trapped inside of another mineral while those mineral forms, be it crystal, liquid, or gas. Selected gemstone inclusion was analyzed according to art aspect, especially formalistic aspect. Gemstone is a group of precious minerals and receives high demands from society. Each gemstone has its own shape and pattern, called inclusion. Overall, five (5) inclusion images were chosen based on popularity of types and commonality to be found in a gemstone. These images were taken from popular gemology journals, such as Journal of Gemology and Gems & Gemology as well as gemology websites related to gemstones. This research shows various art formalistic aspects of gemstone inclusion that can be described as art elements, such as lines, look, shape, link, colors, and space as well as design principles, such as harmony, contrast, emphasis, balance, variety, rhythm, and unity.

**Keywords:** Photomicrography, Gemstone Inclusions, Scientific, Artistic.

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### 1. Introduction

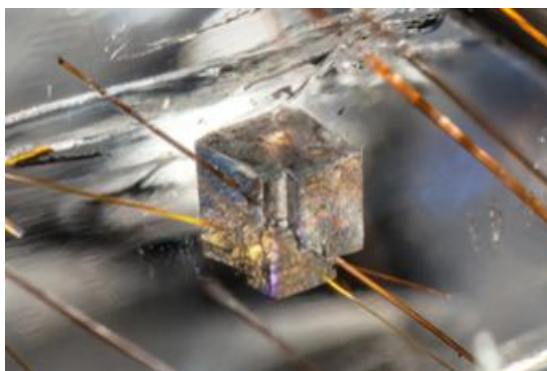
Gemstone is a valuable natural resource and has received a significant demand since a long time ago and has been used by humans for multiple purposes, such as self-adornment, protection, and self-care (Brenda, 2009). Self-adornment consists of necklace, bracelet, earring and others, designed for men, women, and children regardless of age and used for various purposes (Anuar *et al.*, 2021). Meanwhile, for Malays in Malaysia, many still assume that gemstone has unique properties, benefits, and spectacular effects apart from being used as self-adornment (Daud *et al.*, 2021).

Gemstone inclusion is a foreign shape, form or cavity in a gemstone and information regarding inclusion has been used extensively by gemmologists for identifying types, groups, and country of origin of gemstone (Keith Wallis, 2011). Inclusion also means whatever material is trapped in gemstone during its formation, for example crystal, liquid, gas bubble, crack or fracture that is caused by radioactive material embedded in the gemstone (Arem & Clark, 2021).

Gemologists are reliant on inclusion and treatment methods used in determining the origin of gemstone (Vertriest & Palke, 2020). Study relating to inclusion is an essential part of gemmology as it involves observation of the crystal in the gemstone and the only tool required is a gemmology microscope. The common inclusions in most gemstones are crystal inclusion, fingerprint inclusion, needle, or silk inclusion, two-phase or three-phase inclusion and growth banding inclusion (AIGS, 2006).

Crystal inclusion is an easily identifiable inclusion as it has an angular form, which is the main indicator for natural gemstone. Whereas fingerprint inclusion can be found in gas, liquid or solid form (Kilbo Pehrson, 2017). Cavities-like shape, which is formed due to the inclusion through fracture in the gemstone and tiny crystals that create the design is called fingerprints or feathers. While two-phase inclusion consists of a liquid and vapour / condensation bubble that reveals various parts, which usually contains crystal, liquid or air bubbles (Huong *et al.*, 2017).

A photographer, Danny J. Sanchez had succeeded in portraying the inner part of minerals and gemstones in a work called “Otherworldly”. The experience in photomicrography techniques on gemstone inclusion has made him appear like an artist because images produced appear mysterious, spectacular, and exceedingly artistic. Figure 1 (Wiley, 2015).



**Figure 1.** Image of Dolomite in a Quartz

## 2. Photomicrograph Technique

Photomicrograph technique is a special technique in digitally capturing photos using the microscope. Roane and Pepper (2015) asserted that micrography is done for the purpose of arts and scientific study. Analytical technique using photomicrography technique is widely applied currently to evaluate the properties of materials. The technique is done by attaching a camera to the microscope head (Ingham, 2013). This technique suits Nikon SMZ 18 and Nikon SMZ 1500 best with extra lighting from fibre-optic light for excellent results (Vertriest & Palke, 2020). Danny Sanchez (2016) claimed that the experience in photomicrograph technique on gemstone inclusion has made him an artist for the photos captured possessing mysterious effects, breathtaking, and artistic. The photos indirectly have become education resources.

Photomicrography is the photography technique of objects using a microscope. Objects, such as metals or stones are photographed by light reflection using a microscope. According to history, Thomas Wedgwood (1771 – 1805) was the first individual to propose the use of photomicrography technique even though there was no proof

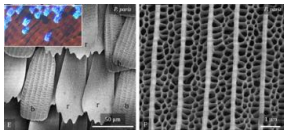
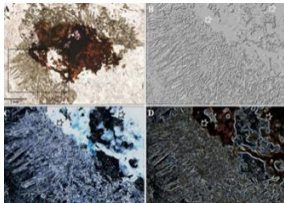
Wedgwood succeeded in capturing any picture using a microscope Overney & Overney, 2011). It was also stated that William Henry Fox Talbot (1800 - 1877) had produced the first photomicrograph using an optic microscope since 1834. Talbot used a small camera to capture pictures on a paper and all photomicrographs were under 20X magnification.



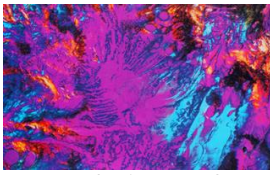
Photomicrography techniques have been produced since the introduction of photography. Since the past, photomicrograph has been a necessity for numerous research, such as chemistry, biology and ophthalmology (Westfall, 2012). Nevertheless, the first observation that was able to be recorded was drawn manually by hand and the process is called micrography. However, around the middle of the nineteenth century, most of the process was replaced with photomicrography, which is a photo observation through microscope that applies camera and photographic chemistry.

Micrography technique has developed and expanded since 1830s in Europe and several names stood out, namely Thomas Wedgwood (1771–1805), John Benjamin Dancer (1812–1887), William Henry Fox Talbot (1800–1877) and Christian Joseph Berres (1796–1844) (Jeremy P. Ingham, 2013). With the recent development in digital visual recording, a rapid change in photography and photomicrography occurs. The picture in the digital form or “softcopy” has aided / facilitated researchers from the aspect of data collection to be inserted into the web, sent and others.

With computer development and a more advanced and sophisticated imaging system, pictures can be digitised to a higher resolution than the traditional photography technique. The picture from a quality photomicrography technique can be a beautiful, fascinating, and joyful object to the observer (Raman, 2011). Telescopes and microscopes revealed objects, processes and patterns that had previously never been observed and the use of cameras offered the possibility of recording and disseminating their images accurately (Berdan, 2018).

**Table 1.** Overview on different discipline articles using photomicrography technique

Author (Year)	Discipline	Photomicrography	Description
Ruangchai et al. (2020)	Biology	 Image of the structure of butterfly wings	Through the usage of stereo microscope and scanning electron microscope, study was performed on wings of different species of butterflies. It was found that the structure of butterfly wings could be observed clearly, uniquely, and interestingly through this technique.
Dias et al. (2020)	Mineralogy	 Image depicts non opaque grains with a thickness of less than 20 µm and size of more than 50 µm.	Since 1884, the usage of petrographic technique had started in petrology and mineralogy. Apart from that, it is used in the fields of forensic medicine and environmental science, textiles, soil, and archaeological sciences. With the emergence of digital images and good processing programmers, photography records have been more accurate / precise to express of geologic events that occur on a microscopic scale

Berdan, (2018)	Biology		Photomicrography can produce art and science because both complement each other. Photomicrography can have two functions: science to show or express something new and art to attract or inspire viewers through shapes, colors, and patterns.
Koivula (2003)	Gemology		Today, almost all professional gemology researchers acquire and publish their own photomicrographs. Photomicrography is very important in gemology because without it, gemology that exists today will almost not exist. Photographers will explore every surface and inner part of a gemstone with a microscope to record in order to convey information hidden from view.
Davidson & Rill (1989)	Chemistry		Since several years ago, microscopes have been an exclusive equipment for biologists to observe and illustrate various specimens in biology. Today, microscopes are used in several different fields, namely chemistry, physics, geology, psychology, material science and many more and is used for micro-art purposes as well.

### *Artistic aspects*

The beauty and uniqueness of gemstone inclusion as part of natural resources make it an amazing art for the distinctive artistic values. As a classic art philosophy of Plato said, art is mimetic by nature; art is an imitation of life. Mimetic in this context is far from direct copying but rather the creativity of the artist to adopt the idea and produce a piece of art that possesses personal image. There are some theories and methods that can be the guidelines for a researcher to interpret, namely iconography, semiotic, concept of the beauty of Islamic art, semantic differential, the KJ method, six principles of traditional Malay arts, and art philosophy. In the context of art philosophy, there are several crucial elements used such as the history of art, formalistic aspects, as well as art critique.

As stated by Fichner-Rathus (2001), artists apply the language of art in coalescing the elements of art and principle of designs via media and suitable techniques to produce a piece of art that has certain forms and meanings to communicate with the observers (Noor & Khairani 2019). The elements of art consist of lines, images, forms, values, weave, and colors (Ocvirk *et al.*, 2012). The principle of design on the other hand consists of harmony, repetition, wave, pattern, variety, balance, rate of appeal, dominance,


movement, and space. The element of art and principle of design are always the key ingredients to make a piece of art by artists whether; separately or jointly.




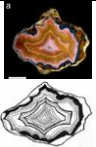
Most artists or designers in the art industry commonly use natural sources as their research materials or subject matter. Mother nature acts as the primary source of reference and imitation for artists. According to Plato (as cited in Mohd Johari, 2004), an influential Greek philosopher around 347 BC stressed that art is indeed a mimic. He introduced “Theory Mimesis’ in his writings defining art as a mimic. In his book *Plato's Theory of Art*, he explained that artists love mimicking nature as a source of reference. It was also stated that artists or poets mimic shapes and designs of natural objects to create a piece of art.

Formalism is things that are associated with aesthetic characteristics or object properties, which combine art elements and principles. This formalism theory emphasizes meaning that exists from an artwork’s formal quality (Ghazali *et al.*, 2019). Data collection and analysis only focused on the formalistic aspect. The advantage of the formalist method as described by Carrol (1999:129) is it can find hidden meaning in an artwork (Noh *et al.*, 2015). Formalistic aspects can be seen through analysis, which is extensive research on each visual piece to identify basic art content and design principle (Ismail & Hassan, 2012). Formal data analysis is comprehensive research to describe art properties that are visual art language elements besides to explore basic material of artwork including analysing design principle (Abdullah *et al.*, 2018). All images were analysed using photomicrography technique and is also a technique to capture images by utilising a microscope for artistic and scientific purposes (Roane *et al.*, 2015).

### 3. Analysis

**Table 2.** Analysis of photomicrography technique of gemstone inclusion from the artistic aspect

No	Author & Year	Inclusions Picture & Description	Element of Art					Principle of Design							
			Line	Shapes	Forms	Texture	Color	Spaces	Harmony	Contrast	Emphasis	Balance	Variety	Rhythm	Unity
1	Aaron C. Palke, (2019)	 <p><b>Needle and Silk Inclusion</b> This inclusion with long and short iridescent silk can be identified in the gemstone originated from Burma.</p>	There are vertical lines and diagonal lines that are highlighted more than the background with different colors.	Elements of form, geometry can be seen in the photo.	Abstract and illusion forms exist in the photo.	Visible links exist due to repetition of line and color elements.	There are color tones on line that appear to glow and a harmony color tones on the background.	Highlighting the perspectives of foreground, middle space, and rear space / background. If viewed, the element is very fascinating and it seems that structured, accurate, and systematic space exists	Portraying cold color and has tone similarity. This may give rise to comforting, uniformity, and unity effects on the crystal.	Clear color difference on the lines and the background.	Clearly displaying a line that is glowing and illuminating compared to the background.	Lines and colors used provide the element of balance, symmetry, on the photo.	Repeated double lines influence the structure of the crystal, making it look sturdy.	Existence of repeating and multiplying lines that make the crystal structure appear solid.	Lines, space, and colors provide the element of balance and harmony in the photo and thus highlights the coherent value of it.

No	Author & Year	Inclusions Picture & Description	Element of Art						Principle of Design						
			Line	Shapes	Forms	Texture	Color	Spaces	Harmony	Contrast	Emphasis	Balance	Variety	Rhythm	Unity
2	Nathan D. Renfro, (2019).	 <p><b>Fingerprint Inclusions</b> ‘Fingerprint’ is liquid arrangement or multiphase arrangement produced from thermal crack / fracture during the forming process as in purple sapphire from Sri Lanka.</p>	Dotted or broken thin lines in this crystal form look or ‘outline’. Displayed lines show motion, direction or path that is spiralling.	Organic form is used in the primary object as it is non-edgy.	Illusional form can be seen in the photo (intangible/ in 3D from).	Visible links exist because of the repetition of dotted, thick, and thin lines elements.	There is color tone on line that seems glowing and harmony color tone on the background	Space emerged from the lines creating the element of highlight in the object.	Repeated dotted lines and balanced use of colors created the effect of the element of harmonious rhythm.	Distinct color difference on the lines and the background	Clearly displaying line element that is glowing and illuminating compared to the background	The placement of the primary object gives symmetrical balance on the photo.	The variety of colors and repetition of lines give a perfect existence of objects.	Result of line repetition and fine dots create circling and spiralling motion and direction.	The use of lines, space, and colors give harmony to the photo and sparks coherence.
3	Nathan D. Renfro, (2018).	 <p><b>Trigons Inclusions Triangle</b> Crack / fracture shape known as trigon, located at diamond octahedral face. Field of view 1.20 mm.</p>	Has thick, thin, and diagonal lines.	Shows precise and structured geometric look. The inclusion is in right triangle shape and form.	Combination of lines and looks form three-dimensional (3D) appearance on the inclusion	Lines and geometrical shapes give an illusion of weave, like 3D.	Combination of warm and cold colors.	The inclusion creates space element, which has perspective that appears embossed or submerging	The use of bold colors to create harmony in repetition of colors and geometrical lines.	Each layer uses contrast and bold colors to create a mass and 3D effect in the picture.	The application of bold and contrast colors creates significant highlights.	Geometric look on crystal triangle shape will create balance and appear stable.	Numerous size and colors on triangles form inclusion.	Lines and colors repetitions create space and link on triangle shape and background	Lines, forms, and space in the picture creates the element of coherence and unity and makes it more appealing.
4	Laurs, B.M., Renfro, N.D (2019),	 <p><b>Dendritic Inclusions</b> These quartz specimens (64 × 81 and 44 × 50 mm) from Leopoldina, Brazil, contain dendritic inclusions with a somewhat plant-like appearance. Photo by Jeff Scovil.</p>	Consists of thin & thick lines to create a plant-like object.	Freestyle and simple organic 2-dimensional form.	The element of concrete form is applied.	Even though there is only the use of visible braids, the oval matching lines give the illusion of tactile braid.	Hot and cold colors are used but not mixed, and give a distinction between background, middle ground, and foreground.	The illusory space between the line and the background creates spaces of significant difference. (Background, middle ground, and foreground)	Thin, thick, and rough lines are also compatible colors that provide an element of harmony.	Dark colors and varied lines create a real contrast as the primary object.	Emphasis in the primary object is created as a result of the use of bright colors as a background.	The symmetrical balance gives the oval image more attractive.	The diversity in line variations provides a dynamic, nature-like/plant-like element as the primary object.	Repetition of lines in a variety of styles such as wavy, jagged, and hairy.	Each of the applications of the principles of lines, colors and diverse spaces has created the value of unity.
5	Jens Götzte, 2020).	 <p><b>Microstructure of Agates and Agate Banding</b> Various types of banding in agate stone; wall layers type (embankment) of agate stone</p>	Has thick and thin circling lines.	The organic appearance creates the effect of a mass -like object.	The oyster -like concrete shape gives a unique effect to the picture.	This visual texture effects result from the lines and colors repeated.	Application of cold colors like blue and brown.	Highlighting space that seems embossed or submerging from the upper view.	The use of a variety of colors and wavy and repetitive lines creates an element of harmony in the picture.	The colors used are colors that contrast with each other giving a difference between each color of the linear tune used.	The appearance, color, contrasting lines give an element of emphasis as it gives a 3D effect to the object.	Asymmetrical balance is realised after the use of varying color contrasts.	Repeat the overlapping lines so as to create a clear braid. This repetition creates an interesting pattern.	Can be seen harmoniously on the repetition of lines and colors. The repetition of lines and colors are seen in harmony.	The result of the use of varied lines, contrasting colors, diversity of design principles, has given an element of unity in the picture.

#### 4. Findings

The basics of design are things related to design elements, design principles and applications. Design elements are related to design elements such as space, shape, value, lines, texture, color, and others. The design principles consist of space, balance, unity, emphasis, and others (Kusumarini, 2005). Based on the example of Egor Gavrilenko's photo collection, a professional gemologist on the web gems-inclusions.com stated that inclusions in gemstones can be translated from various angles of either science or great art if using the right photomicrograph art techniques. The same insight was shared by Dr. Hanco Zwaan FGA (n.d.), in which inclusion can be seen as a painting created by an artist from the expressionism abstract group.

The findings discovered numerous formalistic aspects on gemstones inclusions. Art elements, such as lines, appearances, shapes, forms, colors, and spaces as well as design principles like harmony, contrast, emphasis, balance, diversity, rhythm and unity can be clearly seen in each gemstone inclusions selected. The conclusions for five types of inclusions evaluated are as follows. 1) *Needle and Silk Inclusions* are dominated by solid, firm, and precise vertical and diagonal lines that portray structure-like construction in a particular space. Have interesting perspectives followed by light elements and accentuating volume. This inclusion is particularly unique and modern. 2) *Fingerprint Inclusions* have unique and different properties, where line elements have motion that seem to be circling, spiralling and rhythmic. Motion and link rhythms that appear like human fingerprints. 3) *Trigons Inclusions* have a fascinating geometric look. The results of combinations of lines, looks, shapes, colors, links, spaces, and tones give unity to this type of inclusion. The inclusions are exceptionally captivating and beautiful from the design aspect. 4) *Dendritic Inclusions*: The inclusions' pattern presents a nature-like image compatible with the natural colors. 5) *Microstructure of Agates and Agate Banding*: The inclusions are seen to have similarity with grain look on wood. Have appealing and natural contour lines.

#### 4. Conclusion and Suggestion

Researchers elaborated different approaches regarding gemstone inclusions, which are commonly analysed and discussed in geology and gemmology. Research with the purpose to view gemstone inclusion from the aspects of drawing and design art especially from the angle of formalist art have been interpreted. The review has succeeded in highlighting art elements and design principles like interpretations of artworks that are commonly conducted. The result of this study is suitable to be suggested as subject matter for any artist to produce artwork. As stated by Roger Fry, elements of art can be composed or created based on basic principles of design for the creation of an artwork. Additionally, the diversity of inclusion design can inspire other fields apart from art. The research can be a reference for other academicians and researchers as an exploration on the beauty and the uniqueness of the diverse inclusions. The art on each inclusion has its own distinctiveness and is extremely related or connected to nature. Further research on gemstone inclusion can be conducted because each gemstone has its own splendour, exquisiteness, and uniqueness.

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