Gemstones in Malaysia in Accordance with Gemology Basics: A Case Study of Quartz Gemstones in Kelantan

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ABSTRACT

Gemstone is a mineral that has a high value in the market. Out of 4,000 minerals known to man, only 70 minerals are classified as precious gemstones and semi-precious gemstones. Quartz is the most abundant and widely used mineral. This mineral forms in igneous, metamorphic, and sedimentary rocks. Quartz can be found in Malaysia in several locations in Terengganu, Kelantan, Pahang, Kedah, Perak, Johor, Sabah and Sarawak. The objective of the research is to collect information related to physical properties, optical properties, and types of inclusions found in quartz gemstones in Kelantan. The scope of this study is only about quartz gemstones in Kelantan that are analysed using gemological equipment such as hydrostatic scales, gemology microscopes, refractometers, and gem testers. While the weight of the sample ranges from 8.05 to 31.05 carats. Analysis shows that all samples are consistent from the quartz group consisting of amethyst, rock crystal, and rutilated quartz. All samples show RI values around 1.54. S.G. All gemstones are quartz, according to spectroscope tests and also The Gem Tester. This S.G value is consistent with quartz-type gems which show a reading of 2.66 to 2.69. While the Index of Refraction all samples had RI values around 1.54, which were consistent with quartz. The Gem Tester distinguishes the gemstones are quartz. All gemstones are quartz, according to spectroscope tests. The most common inclusions in the sample are solid and tiny solid crystal inclusions, 2 & 3 phase inclusions, -ve crystal, healed fractures, tiger strips Inclusion, fingerprint and silk inclusions, brownish iron-stained needles, rutile needles, tourmaline & rutile quartz, healed fracture, and fracture fills inclusions. For further actions, research can be done on other gemstones in Malaysia such as corundum, nephrite, topaz, tourmaline and garnet. The studies can be done in-depth using more up-to-date gemology equipment such as Raman spectroscopic analysis.

Keywords: Gemstones, Gemology, Quartz, Kelantan.

INTRODUCTION

Gemstone is a mineral that possesses a high value in the market. There are about 4,000 minerals known to man, yet only 70 minerals are classified as gemstones. Out of these, only 17 are classified as precious gemstones which are diamond, ruby, sapphire, and emerald. While gemstones are categorised as semi-precious gemstones such as cat's eye stone (chrysoberyl cat's eye), amethyst, citrine, agate, turquoise, and many more (Jalil Ahmed, et al. 2017), (Wallis, et al. 2011), (Mohd Zamani, et al. 2021). Beauty is the main element for a mineral to be called a gemstone (Bonewith, 2008). Beauty is judged based on colour, clarity, colour pattern, brilliance, and phenomena such as the cat's-eye effect and gemstones must also remain beautiful for a long time. Colour and transparency are the most important aspects in evaluating the beauty of gemstones. Heat treatment is commonly used to change the colour of gemstones so that they are more transparent (Apichate Maneewong, et al. 2016).

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Gemstones in Malaysia

According to JMG (2015), minerals found in Malaysia can be divided into 3 main groups which are metallic minerals, non-metallic minerals, and precious minerals consisting of gold, corundum, quartz, nephrite, topaz, tourmaline, and garnet. There are several locations in Malaysia where quartz gemstones can be found such as Permatang Quartz Klang Gates, Selangor; Gunung Tahan area, Pahang; Tanjung Tuan, Melaka, and Hulu Paka, Terengganu. Likewise with amethyst in Machang, Kelantan and Simunjan, Sarawak; Rose quartz in Keramat Pulai, Chendering and Pengkalan Hulu Pera; Onyx in Stong, Kelantan and Tawau Sabah; Jasper in Gunung Jerai, Kedah and Kapit, Sarawak.

Although Malaysia does not have expensive gemstone resources, quartz-type gemstones can still be discovered in this country such as in Gunung Lambak, Kluang, Johor, and some other places such as Kelantan and Terengganu (Adnan Ibrahim, 2014). According to Yulpisman (2010), gemstone cutters and grinders around the state of Kelantan obtain sources of rock or quartz from suppliers found around Gunung Tebu in Terengganu and also in Kelantan such as in Temangan, Machang, Tanah Merah, Bukit Pelanduk and Bukit Yong in Pasir Puteh.

Kelantan Darul Naim is a state located on the east coast of Peninsular Malaysia with an area of 15,040 km². Kelantan borders Thailand to the north, Terengganu and Pahang to the east and south, and Perak to the west. Based on demographic statistics by state published by the Department of Statistics Malaysia, in the second quarter of 2024, the total population in Kelantan was 1,888.5 thousand people (Yang Fan, Shafa'atussara Silahudin, 2024).

Figure 1: Kelantan Darul Naim, Malaysia

Quartz Gemstone

Quartz is one of the easily found minerals in most types of rocks (sedimentary, metamorphic and igneous rocks) and soil groups. It is mainly composed of silica and oxygen and these two elements make up 75% of the Earth's crust. Because of this, the quartz group of minerals is also called as silica group (Götze, 2009). According to Mohsen (2004), quartz is the most widely found and widely used mineral. Quartz includes many types of quality gemstones of various colours and is widely used as jewellery. Quartz is a good conductor of electricity and is widely used in watchmaking, broadcast emission, and the production of high-intensity halogen lamps in gem-testing devices.

The variety of colours found in quartz is common and it is classified as a semi-precious gemstone. For a long time, various types of quartz have been used to make jewellery, carvings, and other home decoration items (Halfpenny, 2019). Quartz is suitable as a gemstone for jewellery because it has a high solidity level of 7 (Epstein, 2002).

Amethyst is the most beautiful and popular gemstone compared to others and can be found in purple colours from pale lavender to deep royal purple (Northam and Baranoski, 2008). According to GIT (2019), Indonesia

is the main producer of quartz gemstones in the world, and gemstones that can be found are such as amethyst, agate, and chalcedony. Citrine is a rare gemstone from nature related to amethyst and crystal.

Most of the citrine in the jewellery market now is from amethysts that have been treated (heat-treated) and also synthetic types (Ying, Xinyan, Li Xiang, Ye, 2018). Rose quartz is a rare and small type of quartz. However, it is made into an amazing collection and is highly valued as a gemstone. The best quality rose quartz is used to make jewellery, such as beads for necklaces, cabochons, or pendants (Rebollar, 2016).

Quartz Gemstone Inclusions

An inclusion is any foreign shape or cavity in a gemstone. Information related to inclusions is used by gemologists to identify gem types, groups, and countries of origin. Some types of inclusions are common in gemstones. For example, 'two- or three-phase inclusions' consist of 'liquid' together with small crystals and or air bubbles. Other examples such as "mares tails" in demantoid garnet or 'thumb prints' in amethyst gemstones (Wallis et al, 2011). Inclusions can be parted into 3 groups namely protogenetic, syngenetic and epigenetic. Protogenetic or pre-existing inclusions are formed before the complete formation of a crystal, and can usually be found in solid crystals (Cunningham, 2011).

Inclusions make these quartz gemstones fascinating. Quartz contains inclusions that are very clear to see such as 'hematite seed' content and 'rutile needles' (Carter and Norton, 2013). The opinion is in line with Magdalena (2019) who states that if we look at lodolite, we will be able to see a very interesting green scene. Needle-like inclusions and asterisms are common in rose quartz, and rose quartz is known for its light pink to reddish colour. Due to the different shapes, some researchers suggest that it can be categorised into two types, Pink Quartz and Rose Quartz (Zhe Hu and Ying Guo, 2018).

Gemology Basics

According to Iftikhar Ahmad and Mondal (2017), gemology is a field of gemstone science related to identifying gemstones whether natural or synthetic. To learn more about gemstones, the field of gemology often includes several fields of science.

Table 1. Overview on the basic method of gemology among several researchers in the field of gemology

Author (Year)	**Description**	**Method**
Farhad, (2021)	The traditional analytical methods of gemological studies included measuring the specific gravity of gemstones, examining them under a microscope to determine the type of gem, and determining absorption spectra and refractive indices of gems (Kiefert, el at., 2000).	• Physical Properties • Gemology Microscope (Inclusion) • Optical Properties
Vertriest and Saeseaw (2019)	Using the same equipment and there is additional more modern equipment used such as infrared spectroscopy and UV-Vis NIR spectroscopy to get more detailed answers.	• Physical Properties • Gemology Microscope (Inclusion) • Optical Properties • Infrared Spectroscopy • UV-VisNIR Spectroscopy
Renfro, et al.	Stated that the gemology standard equipment used such as a refractometer, hydrostatic weight scale, UV lamp and gemology microscope to measure and obtain findings related to refractive index, birefringence, specific gravity, pleochroism, visible	• Physical Properties • Gemology Microscope (Inclusion)

(2018)	absorption spectra, fluorescence observations and inclusion of each gemstone.	• Optical Properties
Jalil Ahmed, et al. (2017)	Basic gemology refers to the use of a refractometer to determine single refraction (SR), double refraction (DR) or aggregate (AGG). Hydrostatic balance to determine specific gravity and hardness tester equipment for hardness testing. UV lamp helps to identify the properties of fluorescence and phosphorescence, while microscope gemology is used to identify gemstone inclusions.	• Physical Properties • Gemology Microscope (Inclusion) • Optical Properties
Lüle, (2012)	According to the field of gemology, the basic equipment of gemology consists of a gemological refractometer, light source, polariscope, dichroscope, handheld spectroscope, Chelsea Colour Filter, 10X loupe, and tweezers. All of this equipment is relatively cheap and easy to use.	• Physical Properties • Gemology Microscope (Inclusion) • Optical Properties

Based on the overview above, the researcher found that all researchers in the field of gemology use basic equipment such as hydrostatic scales, gemology microscopes, refractometers and ultraviolet (UV) lamps to evaluate gemstones. The use of microscope gemology equipment to show information related to inclusions in gemstones is highly significant in every study. Therefore, the researcher will use the same method in this research especially to answer the first objective of the research.

The selection of local quartz gemstones sourced from the Jeli district in Kelantan by the researchers is based on significant geological and economic factors, as this area has been identified as the only location in Malaysia known to possess high-quality quartz gemstone deposits. The presence of these valuable quartz stones not only positions Jeli as a key site for precious mineral resources but also attracts the interest of the local community, who rely on gemstone mining and collection as a primary source of income. Therefore, the choice of this location aligns well with the objectives of the research, which emphasize the quality of local materials and the potential for sustainable and high-impact development of mineral resources at the national level.

MATERIAL AND METHOD

This research sample uses 8 quartz gems from the state of Kelantan with an average size between 8.05 to 31.05 carats (Table 2). Samples are believed to be obtained from several locations such as Jeli, Machang, and Tanah Merah districts. These locations are the preferred place for collectors and gemstone enthusiasts in Kelantan and outside Kelantan.

The purple gemstone that is amethyst is the most analysed since it is the most valuable type in the quartz group. In addition, other types of quartz gemstones such as rock crystal and rutilated quartz are also analysed.

Table 2. Quartz gemstone samples from the state of Kelantan.

Sample Code	A1	A2	A3	A4
Image				
Sample Code	A5	A6	A7	A8
Image				

According to Pehrson (2017), to identify the type of gemstone, various types of techniques and equipment will be used. By knowing the physical properties of common minerals used to identify gemstones. Commonly used equipment is specific gravity, refractometry and the refraction index, fluorescence as identification, inclusions, and zoning in corundum, and energy dispersive x-ray spectrometer (EDS).

The same opinion was also expressed by Guo, et al. (2020), the standard gemological properties of all the samples were determined with a refractometer, a Chelsea filter, long-wave (365 nm) and short-wave (254 nm) UV lamps, and an apparatus for hydrostatic specific gravity testing. Internal features were observed with a binocular gemological microscope objective using darkfield, brightfield, and fiber-optic illumination. Photomicrographs were captured with a Nikon Digital Camera D3300.

All samples were analysed at Malayan Gemological Laboratory, Petaling Jaya, Selangor Malaysia. Written documents, images, and photos related to gemstone groups, gemstone names, inclusion types, and gemstone purity will be collected and recorded using some basic gemology equipment such as Gemology Microscope, Gems Tester, Hydrosthetic Weight Scale, Polariscope and Refractometer.

RESULT AND DISCUSSION

Visual Observation

The first step in visual observation is the evaluation of the colour. The colour of a stone is described by the term's hue, saturation, and tone. The selected samples were found to be purple, pastel purple, and colourless. Transparency is the freedom of light being passed or transmitted through the stone. Transparency is an important optical quality of a gemstone which affects both its beauty and its value. The various degrees of transparency are Transparent, Semi-transparent, Translucent, Semi-translucent, and Opaque. All samples show a transparent type. The type of cut is oval cabochon and also rough enhedral. Cutting styles are categorized according to the facet shapes and the particular arrangements of these facets. A facet is a flat, polished surface on a fashioned gemstone. The weight of a gemstone can be determined by a weighing balance or estimated by calculation and is usually expressed in units of a 'carat'. A metric carat is the unit of weight for all gemstones and cultured pearls. 1 metric carat (ct) equals 0.20 grams. The 8 samples range from 8.05 to 31.05 carats.

Physical Properties.

The density of a mineral is one of the parameters used for the identification of gemstones. In gemology, a ratio is called specific gravity (S.G). S.G and is also referred to as relative density is used. Specific Gravity is defined as a ratio of pure water at 4ºC at standard atmospheric pressure. By using the hydrostatic method, the Specific Gravity (S.G) value for all specimens is between 2.66 to 2.69. This S.G value is consistent with quartz-type gems. The crystal system for all tested specimens is a trigonal system. Crystallography is the scientific study of the arrangement of atoms in crystals involving the classification and measurement of crystals. In 1669, Nicholas Steno observed that even though all quartz crystals did not look alike, their correspondence was absolutely regardless of the shape or size of the crystal. One of the key qualities of a gemstone is hardness. Hardness is the power a mineral has to resist scratching (abrasion). Every stone can be tested and classified using the Mohs' scale of hardness. All samples showed Hardness MOH 07. There was no difference between all the samples tested.

Optical Properties.

In gemology, reflection, refraction, and dispersion of light in different media are the most valuable properties for

gemstone identification and are routinely applied. Every gemstone species has different luster, chemical composition, physical properties, and often colours which give certain optical characteristics. Refraction of light occurs when light bends as it passes through a material. A value known as the refractive index is used to describe how light will bend as it passes through a material. The type of gemstone can be identified by the refractive index (R.I). Quartz has an R.I. specific to the wavelength of the incident light, it ranges from 1.55

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for red (730nm) light to 1.7 for ultra-violet light (200nm). The RI values, around 1.54, were consistent with quartz for all samples. Gem Tester gives a quick and easy way to separate diamonds/moissanite from coloured gemstones, while also identifying up to 16 coloured gems based on their thermal conductivity and all samples tested showed the type of quartz. The hand-held spectroscope is one of the most difficult portable gemological instruments to master, it can also be one of the most powerful in the field instrument arsenal. Spectroscopic tests show that all samples are quartz.

Microscopic Properties (Inclusion)

The Motic SMZ171 7.5X-50X stereo microscope is used for the determination and quality control of gemstones. In the science of gemmology, all visually recognisable irregularities within gemstones, such as material foreign bodies (minerals, liquids, gases), cracks, colour zoning or twin lamellae, are understood as inclusions. The types of inclusions found in the gemstones that have been analysed are as follows:

Sample code	Description
A1	Solid Crystal Inclusion (Numerous solid crystal inclusions, 2 & 3 phase inclusions, -ve crystal and filled and healed fractures. Heavily included).
A2	Tiger Strips Inclusions (Characteristic tiger strip inclusions, thumbprint, incomplete fracture fill with feathers and silk. Some minor solid colourless inclusions).
A3	Tiger Stripes (tiger stripe-like inclusions, fracture fill, fingerprint and silk).
A4	Brownish purple quartz inhabited by numerous unidirectional brownish iron-stained needles; fracture filled with iron oxide. Numerous tiny solid crystal inclusions and negative crystals.
A5	Rutile Needles (None aligned long elongated golden and brown rutile/ TiO2 needles, healed fractures, fingerprint with solid and negative crystal inclusions).
A6	Tourmaline & Rutile Quartz (Inclusions mainly large elongated black tourmaline/ schrol needles with finer rutile needles/ black and golden embedded in a silky and healed fracture quartz).
A7	Healed Fracture Inclusions (Healed fractures, filed with iron oxide, some appearing like “tiger stripes” and thumbprint).
A8	Fracture fill (Striation on the quartz surface. Numerous inclusions comprising of some solid inclusions, healing fissures, fracture filling / filled with iron oxide or graphite and fingerprint.

Based on the analysis of the inclusions, it was found that all gemstones are natural with no treatment effects. However, the original source of gemstones cannot be identified because the inclusion of quartz gemstones, especially amethyst, is similar in all countries.

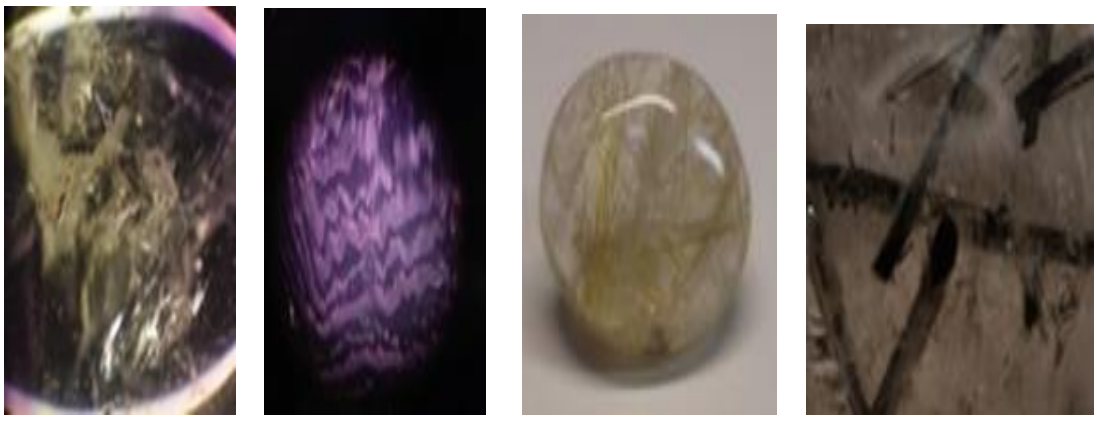

Figure 2. From left, solid crystal inclusion, tiger strips inclusions, rutile needles inclusion and tourmaline & rutile quartz

CONCLUSIONS

Analysis shows that all gemstones are consistent with the quartz group consisting of amethyst, rock crystal and rutilated quartz. According to visual observation, the colour consists of purple, pastel purple as well as colourless. All these gemstones are transparent. There are 7 types of cabochon oval cut and one rough anhedral. The weight ranges from 8.05 to 31.05 carats. This S.G value is consistent with quartz-type gems which show a reading of 2.66 to 2.69. While the Index of Refraction of all samples had RI values around 1.54, which were consistent with quartz. The Gem Tester distinguishes the gemstones are quartz. All gemstones are quartz, according to spectroscope tests.

The most common inclusions in the sample are solid and tiny solid crystal inclusions, 2 & 3 phase inclusions, -ve crystal, healed fractures, tiger strips Inclusion, fingerprint and silk inclusions, brownish iron-stained needles, rutile needles, tourmaline & rutile quartz, healed fracture, and fracture fills inclusions.

For further studies in the future, research can be done on other precious gemstones in Malaysia as stated by the Department of Minerals and Geosciences Malaysia (JMG) in 2015 that Malaysia also has precious gemstones such as corundum, nephrite, topaz, tourmaline and garnet. The studies can be done in-depth using more up-to-date gemology equipment such as Raman spectroscopic analysis or chemical synthesis to create a database that is easily available so that analysed samples can be matched with data to identify their origin and inclusions.

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Conflict of Interest

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REFERENCE

1. Adnan Ibrahim (2014). Lombong Batu Kristal, Setempat, Harian Metro, New Straits Times Press (M) Bhd, Kuala Lumpur, pg.34
2. Apichate Maneewong, Kanwalee Pangza, Nongnuch Jangsawang and Tasanee Charoennam, (2016). Effect of Heat Treatment and Electron Beam Irradiation Tourmaline: UV-Visible, EPR, and Mid-IR Spectroscopic Analyses, Walailak J Sci & Tech 2016; 13(12): 993-1003
3. Bonewitz, R. L. (2008). Rocks & Minerals, The definitive Visual Guide, Dorling Kindersley Limited, London.
4. Carter, C. B. & Norton, M. G. (2013). Ceramic Materials: Science and Engineering, Springer New York Heidelberg Dordrecht London @ Springer Science & Business Media, 4 Jan 2013, Chapter 36 Minerals and Gems.

5. Cunningham, D. D. (2011). Practical Gemmology, NAG Press, Robert Hale, London ISBN 978-0-7198-0431-1.
6. Epstein, C. (2002). Amethyst Care and Cleaning Guide, http://www.gia.edu/amethyst-care-cleaning, 2002 - 2015 Gemological Institute of America Inc
7. Farhad, A. S. (2021). Spectroscopic Identification and Characterization of Gemstone Minerals, Degree Project at the Department of Earth Sciences ISSN 1650-6553 Nr 520, Published at Department of Earth Sciences, Uppsala University (www.geo.uu.se), Uppsala, 2021
8. GIT (2019). Challenges and Outlooks of Global Gem and Jewelry Market 2019, Git Gem & Jewelry Review, Issue 1 / 2019.
9. Götze, J., 2009. Chemistry, Textures and Physical Properties of Quartz-Geological Interpretation and Technical Application. Mineralogical Magazine, 73(4): 645–671, doi:10.1180/minmag.2009.073.4.645
10. Guo, H, et al. (2020). Inclusion and Trace Element Characteristics of Emeralds from Swat Valley, Pakistan, Gems & Gemology Fall 2020.
11. Halfpenny, A. (2019). Can the Source Location of a Coloured Quartz Gemstone Be Determined from NonDestructive Chemical Analysis?, Department of Geological Sciences
12. Iftikhar Ahmad and M.E.A. Mondal (2017). Geochemical fingerprinting of diamonds and other gemstones, National Conference Diamond and Other Gemstone, Department of Geology, Aligarh Muslim University, Aligarh-202 002.
13. Jabatan Mineral dan Geosains Malaysia (JMG), (2015). Menyingkap Kepelbagaian Geologi Malaysia, Batuan, Mineral dan Fosil, Cawangan Pengurusan Maklumat, Ibu Pejabat JMG Jabatan Mineral dan Geosains Malaysia, Aras 9, Menara PjH, No.2, Jalan Tun Abdul Razak, Persint 2, 62100 Putrajaya, ISBN:978-967-0159-25-6
14. Jalil Ahmed (2017), The Classification and Distribution of Gemstones from Northern, Balochistan, Pakistan, Lasbela University Journal of Science and Technology Vol. VI, pp.290-298, 2017, ISSN 2306-8256/ Research Article.
15. Lüle, Ç. (2012). Non-destructive Gemmological Tests for the Identification of Ancient Gems, 'Gems of Heaven' Recent Research on Engraved Gemstones in Late Antiquity, c. AD 200–600 Edited by Chris Entwistle and Noël Adams, The British Museum Press 38 Russell Square London WC1B 3QQ, ISBN 978-086159-177-0 ISSN 1747-3640, The Trustees of the British Museum 2011 Second printing 2012.
16. Magdalena, A. (2019). Facts About Lodolite: Meanings, Properties, And Benefits, https://Gemstagram.Com/Facts-About-Lodolite-Meanings-Properties-And-Benefits/
17. Mohd Zamani, D., Marzuki, I., & Nur Syafinaz, M. A. (2021). Factors That Influenced the Purchase of Gemstone Among Enthusiasts in Kelantan, AIP Conference Proceedings 2347, 020127 (2021); https://doi.org/10.1063/5.0051825Published Online: 21 July 2021.
18. Mohsen, M-D. (2004). Dictionary of Gems and Gemology, Third Edition, Electronic publication under ISBN 978-3-540-72816-0, Editor: Christian Witschel / Kerstin Kindler, Heidelberg, Germany
19. Northam, L., & Baranoski, G. V. G. (2008). A Study on the Appearance of Quartz, Technical Report CS-2008-20, Natural Phenomena Simulation Group School of Computer Science University of Waterloo 200 University Avenue West Waterloo, Ontario, Canada N2L 3G1
20. Pehrson, E. A. K. (2017). Identification Methods of Sri Lankan Corundum in Comparison to Other Common Gemstones, Independent Project At The Department Of Earth Sciences, 2017: 5, Published at Department of Earth Sciences, Uppsala University (www.geo.uu.se), Uppsala, 2017
21. Rebollar, M. C. (2016). The gem quality rose quartz from Oliva de Plasencia, Cáceres, Spain, MINERAL up, Volume 4 n.3, Sept 16', DOI 10.5281/zenodo.3662191.
22. Renfro, N. D., Palke, A. C., and Berg. R. B. (2018). Gemological Characterization of Sapphires from Yogo Gulch Montana, Gems & Gemology, Summer 2018 Volume 54, No. 2, The Quarterly Journal of The Gemological Institute of America.
23. Vertriest, W., & Saeseaw, S. (2019). A Decade of ruby from Mozambique: A Review, Gems & Gemology, Summer 2019 Volume 55, No. 2, The Quarterly Journal of The Gemological Institute of America.
24. Wallis, K. (2011). Gemstones, Understanding-Identifying-Buying, Antique Collectors' Club Ltd, Woodbridge, Suffolk, England, ISBN 13:978-1-85149-630-3.
25. Yang Fan, Shafa'atussara Silahudin (2024), Jurnal Melayu Seduniae-Issn:2637-0751vol. 7, Issue 1, 37-50https://Doi.Org/10.22452/Melayusedunia.Vol7no1.3

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue VII July 2025

26. Ying, G., Xinyan, Z., Li Xiang, & Ye, Z. (2018). Quantitative Characterization Appreciation of Golden Citrine Golden by The Irradiation of [FeO4]4, Journal of Chemistry (2018) 11,918-923, King Saud University Arabian.
27. Yulpisman (2010). Fatzeli Pakar Ukir Batu Permata. Utusan Malaysia, Media Mulia Sdn.Bhd.
28. Zhe Hu & Ying Guo (2018). The Ecological Impact of Mining Rose Quartz with Needle-like Inclusions, Ekoloji 27(106): 1533-1541 (2018).