STM JOURNALS

Research & Reviews: Journal of Physics

https://journals.stmjournals.com/rrjophy

ISSN: 2278-2265 (Online)
ISSN: 2347-9973 (Print)
Volume 15, Issue 2, 2026
May–August
DOI (Journal): 10.37591/RRJoPHY

Research RRJoPHY

Physical and Luminescence Studies of Natural Fluorescent Material (Stone)

Arsheen Naaz Ansari[1], Prerit Tandon[1] Kamal Kumar Kushwah[2,*]

Abstract

This study investigates the physical properties (volume and density) and optical behavior of a natural fluorescent stone under ultra-violet (UV) and green/red laser light. The stone exhibits fluorescence, emitting a blue-white glow when exposed to 365 nm UV light, suggesting the presence of minerals like fluorite (CaF_2), scheelite ($CaWO_4$), and calcite ($CaCO_3$). Under 532 nm green laser excitation, the stone displays internal scattering and a green glow, further supporting the presence of fluorite (CaF_2). Also, on excitation by red (650nm) strong fluorescence was observed. The stone's translucency and strong luminescence make it suitable for optical crystal analysis.

Keywords: Fluorescence, luminescence, natural fluorescent stone, UV excitation, optical crystal analysis

INTRODUCTION

Natural fluorescence is a mineral that emits visible light when exposed to ultraviolet (UV) light or other forms of electromagnetic radiation, depending on its nature. This glowing effect is caused by the stone's unique chemical composition, which has made them popular for both scientific and decorative purposes.[1]. A common example is fluorite and calcite minerals, which exhibit bright, vibrant colors under UV illumination.

Natural stones are solid mineral materials formed over millions of years through geological processes and quarried from the earth for construction and decoration owing to their durability, unique mineralogical patterns, color, and strength. They exhibit long-term structural resilience in a range of climates and remain popular for both functional and aesthetic applications [2–4].

The phenomenon associated with these materials is luminescence, which refers to the emission of light by a substance without heating. It arises when electrons within a material are excited through various energy inputs, such as light, electricity, chemical reactions, or radiation, and then release light as they relax to lower energy states [5–9].

***Author for Correspondence**
Kamal Kumar Kushwah
Email: kamal_kushwah2005@yahoo.com

[1]Student, Department of Applied Physics, Jabalpur, Engineering College, Jabalpur, India
[2]Professor and head, Department of Applied Physics, Jabalpur, Engineering College, Jabalpur, India

Received Date: March 10, 2026
Accepted Date: May 30, 2026
Published Date: June 15, 2026

Citation: Arsheen Naaz Ansari, Prerit Tandon, Kamal Kumar Kushwah. Physical and Luminescence Studies of Natural Fluorescent Material (Stone). Research & Reviews: Journal of Physics. 2026; 15(2): 38–47p.

Luminescence classification in widely accepted categories is mentioned here:

1. *Photoluminescence:* Light emission after absorption of photons (encompasses fluorescence and phosphorescence).
2. *Electroluminescence:* Light generated in response to an electric current or field (e.g., LEDs).
3. *Chemiluminescence:* Light produced via chemical reactions (e.g., glow sticks).
4. *Bioluminescence:* A specific form of chemiluminescence that occurs in living organisms (e.g., fireflies).

5. *Cathodoluminescence:* Light emitted when electrons bombard a material (common in cathode-ray imaging).
6. *Radioluminescence:* Light produced by exposure to ionizing radiation, such as X-rays or radioactive decay.

Luminescent materials exhibit luminescence properties when excited by different energy sources. It is observed that semiconductor materials tend to emit light in the visible spectrum [10–13].

UV Excitation: UV excitation is the process in which UV light energizes a material, causing its electrons to jump to higher energy levels. When they return to their normal state, they release visible light, which is fluorescence. It is commonly used to make natural fluorescent stones glow under UV light [1, 14, 15].

Excitation by Green Laser: A green laser is a type of laser that emits visible green light of wavelength of 532 nanometers (nm). The energy associated with this excites the electrons to a higher energy state. When the electrons return to their ground state, they emit light of longer wavelengths. This is a common technique used in various fields, such as fluorescence microscopy and spectroscopy [16, 17].

Excitation by Red Laser: It refers to the process in which a red laser beam of wavelength 650 nm is used to excite electrons.

Fluorescent stones are minerals that emit visible light when illuminated. This may be due to the fact that trace impurities or intrinsic activators absorb the corresponding energy and re-emit it, producing a characteristic glow of colors [18].

Various types of fluorescent stone with example

Igneous

- *Fluorite (CaF_2):* Named after its fluorescence behavior, it glows blue under uv owing to the presence of activators such as Eu^{2+} or other rare-earth ions.

Metamorphic

- *Scheelite ($CaWO_4$):* Intrinsically fluoresces bright blue under UV; molybdenum impurities can shift it toward white yellow, while iron can quench it.
- *Calcite ($CaCO_3$):* Fluoresces in shades ranging from red/orange to green/yellow, depending on impurity activators such as Mn^{2+}, Pb, and Ce, whereas pure calcite generally does not fluoresce.

Sedimentary

- *Aragonite ($CaCO_3$ polymorph):* Often fluoresces yellowish-white under UV, commonly with greenish or white phosphorescence, driven by trace activators.
- Other types of calcite specimens in sedimentary form (e.g., limestone and travertine) also fluoresce depending on their impurity content.

In the present work, we conducted two separate studies on natural fluorescent stones. In the first part of our study, we calculated the volume and density of the samples based on the Archimedes principle. According to this principle, the volume of water displaced by a submerged object is equal to the volume of that object. It is very useful for volume measurement of objects that are not regular in shape. In the second part of our work, fluorescent stones were excited with three sources: natural white light, ultraviolet (UV) light, and green laser light, and their effects were recorded and analyzed.

EXPERIMENTAL SECTION

Determination of Volume and Density of Natural Stone

Although several other techniques, such as Stokes' law, the Mohr–Westphal balance, and similar methods, are available for density determination, each has its own advantages and limitations depending on the nature and form of the sample. However, Archimedes' principle remains the most reliable and accurate method for irregularly shaped solids, as it provides a direct and precise measurement of volume through fluid displacement, thereby yielding a more accurate determination of the density of natural stones and minerals.

The Archimedes principle was used to determine the volume and density of the natural luminescent stone. First, we determined the volume and density for regular cuboid stone to confirm the process, whether it is right or wrong.

Volume of Regular Cuboid Stone

We have taken a cuboid stone, as shown in Figure 1, with dimensions of length (l) = 5 cm, breath (b) = 5.5 cm, and height (h) = 2.2 cm.

We know the volume of cuboid is $V_{c1} = 5 \times 5.5 \times 2.2 = 60.5\ cm^3$

Again, Volume of Same Regular Cuboid Stone by Archimedes Principle

We took 200 ml in beaker of distilled water in a 500 ml, as shown in Figure 2. The inner radius of the beaker was measured to be 3.6 cm. The height of the water column was 3.7 cm.

Now, we have to put the cuboid stone in the beaker (refer to Figure 3) and observe the increment in the water column (h_{ci}) by 1.5 cm. This increased volume of water will be the volume of the cuboid stone, as proposed in Archimedes principle.

i.e. volume of displaced water by cuboid stone = volume of cuboid stone

$V_{c2} = \pi r^2 h_{ci} = 3.14 \times 3.6^2 \times 1.5 = 61.04\ cm^3$

Thus, the volume estimated using the Archimedes principle almost matches the geometrical calculation, confirming that our process is correct.

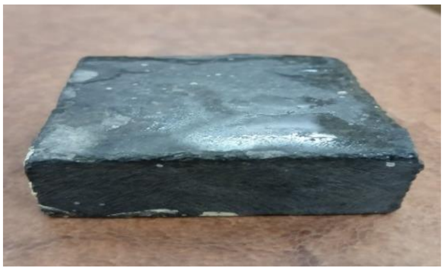

Figure 1. Regular cuboid stone.

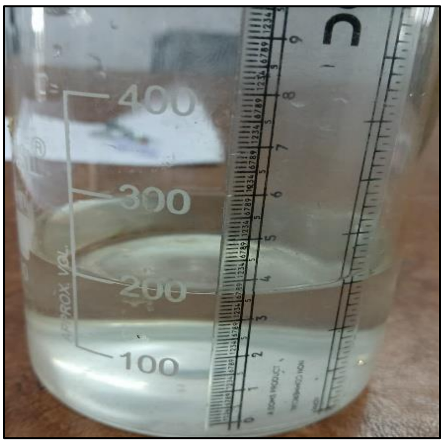

Figure 2. Beaker of 500 ml filled with 200 ml distilled water.

Figure 3. Regular cuboid stone immersed in 200 ml distilled water.

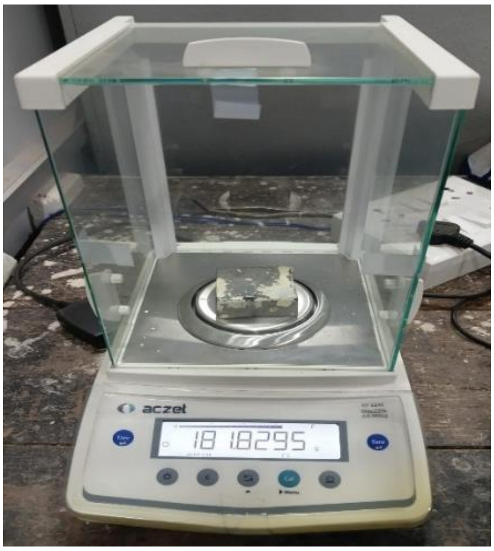

Figure 4. Regular cuboid stone on weighing machine.

Density of Regular Cuboid Stone

To calculate the density of a cuboid stone, we must first measure its mass. The measurement is shown in Figure 4, and its value is 181.8295 g.

1. Density of cuboid stone when its volume is calculated geometrically:

$$D_{c1} = M_c/V_{c1} = 181.83g/60.5cm^3 = 3.00g/cm^3 = 3005.45\ kg/m^3.$$

2. Density of cuboid when its volume is calculated using Archimedes principle:

$$D_{c2} = M_c/V_{c2} = 181.83g/61.04cm^3 = 2.97g/cm^3 = 2978.87kg/m^3.$$

We determined the volume and density of the natural fluorescent stone used in our study.

Volume of Natural Luminescent Stone by Archimedes Principle

The volume of displaced water (refer to Figure 5) by the unknown stone will give its volume V_s

$$V_s = \pi r^2 h_{si} = 3.14 \times 3.6^2 \times 0.5 = 20.35cm^3$$

Figure 5. Natural Luminescent stone when immersed in 200 ml distilled water.

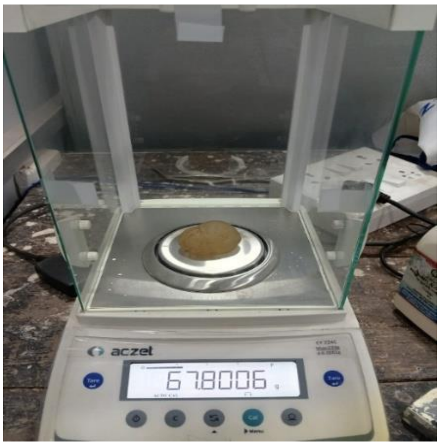

Figure 6. Natural Luminescent stone on weighing machine.

Table 1. Experimental determination and comparison of the volume, mass, and density of regular cuboid and natural luminescent stones using the water displacement method.

Type of stone	**Initial Volume of water**	**Initial height of water column (h_1)**	**Final height of water column, when stone was immersed in water (h_2)**	**Increase in height of water column h= ($h_1 - h_2$)**	**Volume of apparently Increased water (V) V= π R^{2}h**	**Real mass of stone using weighing machine (M)**	**Density of stone (Mass/ Volume)**
Regular Cuboid stone	200ml	3.7 cm	5.2 cm	1.5 cm	*61.04 cm^3	181.83 g	2.79 g/cm^3 or 2878.87 kg/m^3
Natural luminescent stone.	200ml	3.8 cm	4.2 cm	0.5 cm	20.35 cm^3	67.80g	3.33 g/cm^3 or 333.1kg/m^3

**Volume of regular cuboid stone using geometry* = $L \times B \times H$ =$5 \times 5.5 \times 2.2 = 60.5\ cm^3$

Density of Natural Luminescent Stone

To calculate the density, we measured the mass to be 67.80 g, as shown in Figure 6.

Therefore, the density of Natural Luminescent stone is
$D_s = M_S/V_s = 67.80g/20.35cm^3 = 3.33g/cm^3 = 3331.70kg/m^3$

Table 1 shows the observed volume, mass, and density of the regular cuboid stone and natural luminescent stone.

LUMINESCENCE STUDY

The experiment was performed under different excitation photon energies, and the change in optical behavior was recorded.

Under Natural White Light

The stones were placed under natural light (Figure 7). It appears as a yellowish or tan, rounded stone or mineral. The texture was smooth but not polished, with visible surface cracks or patterns.

Figure 7. Natural Luminescent stone under natural light.

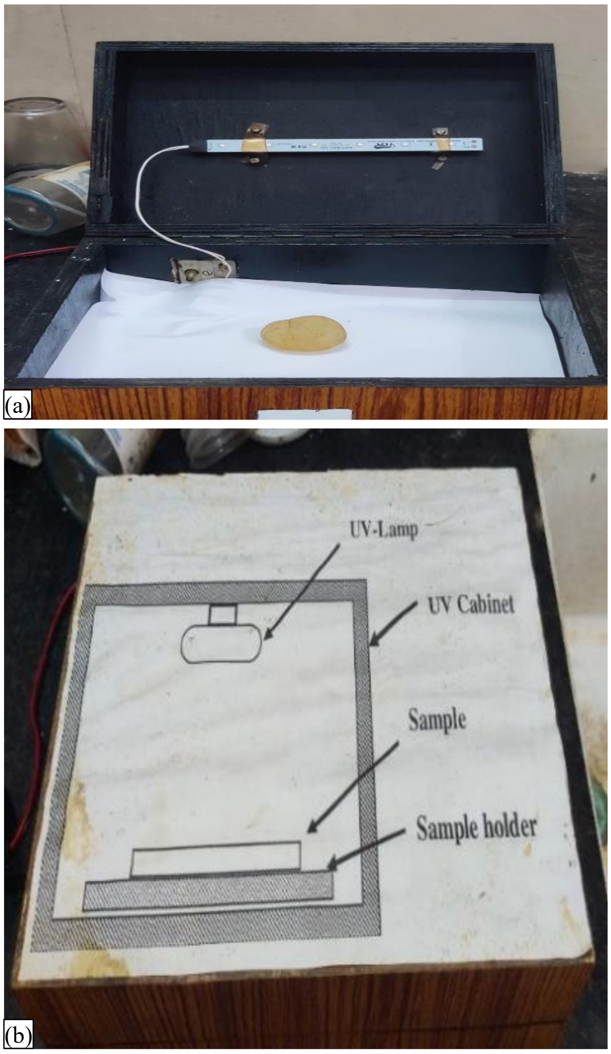

Figure 8. (a) Natural Luminescent stone in UV excitation chamber; (b) Schematic diagram of UV excitation chamber

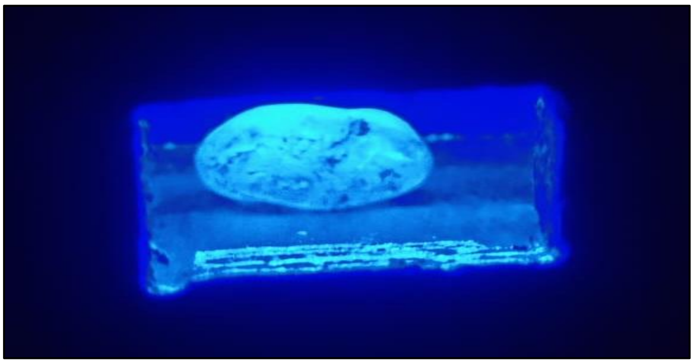

Figure 9. Natural Luminescent stone under UV light of wavelength 365 nm.

Figure 10. Natural Luminescent stone under green laser light of wavelength 532 nm.

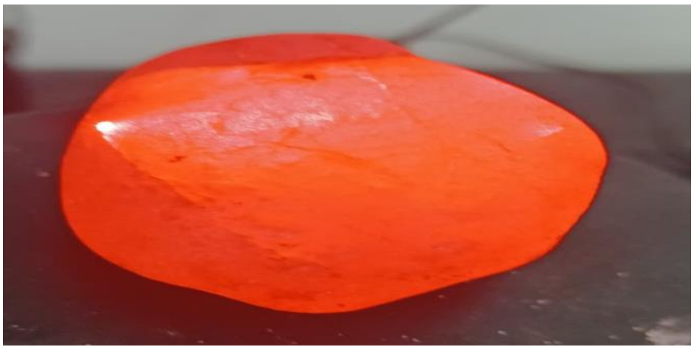

Figure 11. Natural Luminescent stone under Red Laser light of wavelength 650 nm.

Under Ultra-Violet (UV) light

The stone was placed in a UV excitation chamber with dimensions 0.75F × 1F (Figure 8). The UV excitation wavelength was 365 nm with an operating voltage of 24 V. Under UV light, it glows blue (Figure 9).

Under Green laser light

When the stone is placed under the green laser light of wavelength 532 nm with an operating voltage of 3.7 V. It strongly glowed green (Figure 10).

Under Red Laser Light

When the stone is placed under red laser light with a wavelength of 650 nm and an operating voltage of 220 V. It strongly glowed red (Figure 11).

Table 2 shows observation and remarks of sample stone under different sources of excitation.

Table 2. Observation and remarks of sample stone under different sources of excitation.

Type excitation source	Observation	Remarks about crystal
Normal illumination	Yellowish or tan, smooth but not polished, with some crakes and patten	Fluorite or calcite
UV Photon of wavelength 365 nm	Glowed blue	Fluorite, calcite or scheelite
Green Photon of wavelength 532 nm	Glowed bright green	Fluorite
Red photon of wavelength 650 nm	Strong Red fluorescence	Calcite or Quartz

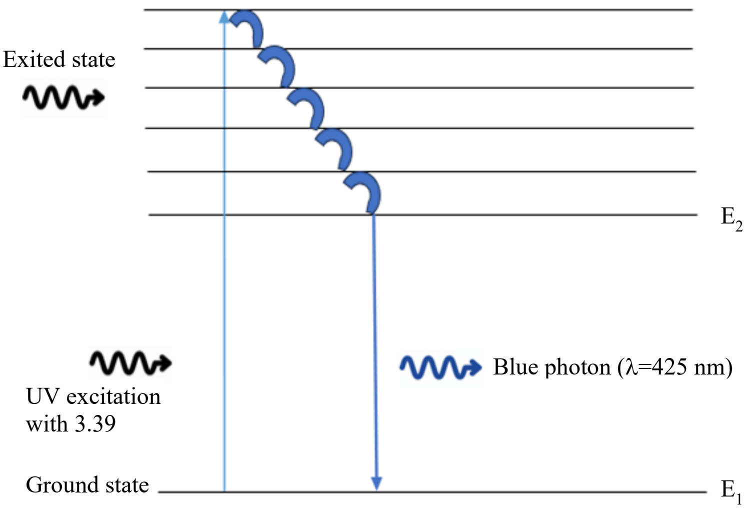

Figure 11. Energy Transition diagram for blue photon emission.

RESULT AND DISCUSSIONS

We calculated the volume and density of the natural luminescent stone using Archimedes principle. These parameters were $20.35cm^3$ and $3331.70kg/m^3$ respectively. To verify our results, we first tested the Archimedes principle on a regular cuboid stone. The theoretical calculations based on the geometrical formula of the cuboid body were found to be consistent with the experimental results based on Archimedes principle.

However, a slight discrepancy ($\approx 1\%$) is observed between the two calculations, which is obvious in any physics experiment when compared with the standard theoretical calculations.

On the other hand, under natural light, a raw mineral specimen possibly fluorite, calcite, or a type of quartz [19, 20]. and under UV light blue fluorescence was observed, which suggests the mineral has fluorescent properties. This may be due to the presence of fluorite, calcite, and scheelite [21–27]. Moreover, under green laser light, the stone glowed green. This indicates the translucency and internal crystalline structure of the enamel, allowing it to scatter laser light internally. Under red laser light, the stone glowed red. This again indicates the translucency and internal scattering. It confirms fluorite [12, 28–30].

MECHANISM OF LIGHT EMITTING

The stone glows under UV and laser sources because of the presence of fluorescence. As discussed earlier, fluorescence is a type of photoluminescence in which a substance absorbs energy from light, which excites the electrons, causing them to jump to a higher energy level. These excited electrons are unstable and tend to return to their original, lower energy levels. When electrons return to their ground state (lower energy level), they release excess energy in the form of visible light. Fluorescence is an instantaneous process, which means that the glow appears when light is present and disappears when it is removed [6, 8].

Fluorescence occurs when a fluorophore (a molecule) absorbs light of a lower wavelength (higher energy) and causes electrons to jump from the ground state(E_1) to the excited state (E_2). The exited electron then loses some of its energy through nonradiative relaxation (internal conversion). Finally, the exited electron returns to its ground state ($E_2 \rightarrow E_1$) and hence loses the excess energy in the form of light. The light emitted from this is of a longer wavelength (lower energy) [6, 8, 31–33]. This process is referred to as fluorescence. Moreover, the electron spin direction did not change during fluorescence.

CONCLUSION

The stone's properties suggest that it is a natural mineral or gemstone, likely fluorite or calcite, as it exhibits fluorescence under various photon excitations. Its translucency and internal light scattering observed under laser illumination further support this identification. Physical property measurements using Archimedes' principle, a valuable technique for irregularly shaped samples, were employed to characterize the stones. This study demonstrates the utility of simple yet effective methods for mineral identification that are suitable for undergraduate research projects.

REFERENCES

1. Zhang Z, Shen A. Fluorescence and phosphorescence spectroscopies and their applications in gem characterization. Minerals. 2023;13(5):626. doi:10.3390/min13050626.
2. Alves C, Figueiredo C, Sanjurjo-Sánchez J. Rock features and alteration of stone materials used for the built environment: a review of recent publications on ageing tests. Geosciences. 2020;10(3):91. doi:10.3390/geosciences10030091.
3. Viles HA. Durability and conservation of stone: coping with complexity. Q J Eng Geol Hydrogeol. 2013;46(4):370–387. doi:10.1144/qjegh2012-053.
4. Sims I. Quality and durability of stone for construction. Q J Eng Geol. 1991;24(1):285-297. doi:10.1144/GSL.QJEG.1991.024.01.06.
5. Kushwaha K, Shukla P, Durgesh N, Singh P, Ramrakhiani M. Electroluminescence from CdSe/PVA nanocomposites. Nano Vision. 2011;1(2):64-69.
6. Lakowicz JR. Principles of fluorescence spectroscopy. 3rd ed. New York (NY): Springer; 2006.
7. Ramrakhiani M, Gautam NK, Kushwaha K, Sahare S, Singh P. Electroluminescence in chalcogenide nanocrystals and nanocomposites. Defect Diffus Forum. 2014;357:127-169. doi:10.4028/www.scientific.net/DDF.357.127.
8. Valeur B, Berberan-Santos MN. Molecular fluorescence: principles and applications. 2nd ed. Weinheim: John Wiley & Sons; 2013.
9. Dubey S, et al. Binary chalcogenide polymer nanocomposites for electroluminescence and photovoltaic solar cell applications. In: Smart Materials and Applications. New York: Apple Academic Press; 2025. p. 403-426.
10. Ansari P, Kushwah KK, Maurya MR, et al. Opto-mechanical studies of PVA-capped ZnSe and CdSe nanoparticles for optoelectronic applications. Bull Mater Sci. 2024;47:43. doi:10.1007/s12034-023-03122-y.
11. Vishvkarma N, et al. Morphological and optical properties of pure and doped ZnS nanoparticles: a review. J Nanosci Nanoeng Appl. 2018;8(1):1-4.
12. Ansari P, Kushwah KK, Maurya MR, et al. Opto-mechanical studies of PVA-capped ZnSe and CdSe nanoparticles for optoelectronic applications. Bull Mater Sci. 2024;47:43. doi:10.1007/s12034-023-03122-y.
13. Khare K, Singh S, Kushwah KK. Synthesis, characterizations and applications of II-VI quantum dots: a review. Nano Trends. 2019;20(3):36-38.
14. Sidike A, Kusachi I, Yamashita N. Natural fluorite emitting yellow fluorescence under UV light. Phys Chem Miner. 2003;30(8):478-485. doi:10.1007/s00269-003-0341-3.
15. Kushwaha K, et al. Synthesis and photoluminescence of CdSe/PVA nanocomposites. J Phys Conf Ser. 2012;365:012014. doi:10.1088/1742-6596/365/1/012014.
16. Shchegrov V, Umbrasas A, Watson JP, Lee D, Amsden CA, Ha W, et al. 532 nm laser sources based on intracavity frequency doubling of extended cavity surface-emitting diode lasers. Proc SPIE. 2004;5332:148-156. doi:10.1117/12.529449.

17. Silfvast WT. Laser fundamentals. Cambridge: Cambridge University Press; 1996.
18. Gaft M, Reisfeld R, Panczer G. Modern luminescence spectroscopy of minerals and materials. Berlin: Springer; 2005. p. 119-251. doi:10.1007/3-540-26377-2_5.
19. Siegesmund S, Török Á. Building stones. In: Siegesmund S, Snethlage R, editors. Stone in architecture. 4th ed. Berlin: Springer; 2010. p. 11-96. doi:10.1007/978-3-642-14475-2_2.
20. Weldon R. Colored stones and organic materials. Gems Gemol. 2008;44(3):262-282.
21. Ge X, et al. Mineralogical characteristics and luminescent properties of natural fluorite with three different colors. Materials (Basel). 2022;15(6):1983. doi:10.3390/ma15061983.
22. Li Z, Zhang Y, Huang L, Yang Y, Zhao Y, El-Banna G, et al. Nanoscale fluorescent stone: luminescent calcium fluoride nanoparticles as theranostic platforms. Theranostics. 2016;6(13):2380-2393. doi:10.7150/thno.15914.
23. Robbins M. Fluorescent Forum. 1990;65:455-459.
24. Blanc P, et al. Systematic cathodoluminescence spectral analysis of synthetic doped minerals: anhydrite, apatite, calcite, fluorite, scheelite and zircon. In: Cathodoluminescence in geosciences. Berlin: Springer; 2000. doi:10.1007/978-3-662-04086-7_5.
25. Modreski PJ, Aumente-Modreski R. Fluorescent minerals: a review. Rocks Miner. 1996;71(1):14-22. doi:10.1080/00357529.1996.11761532.
26. Bozlee BJ, Misra AK, Sharma SK, Ingra M. Remote Raman and fluorescence studies of mineral samples. Spectrochim Acta A Mol Biomol Spectrosc. 2005;61(10):2342-2348. doi:10.1016/j.saa.2005.02.033.
27. Gaft M, Nagli L, Panczer G, Waychunas G, Porat N. The nature of unusual luminescence in natural calcite CaCO3. Am Mineral. 2008;93(1):158-167. doi:10.2138/am.2008.2576.
28. Burruss RC, Ging TG, Eppinger RG, Samson IM. Laser-excited fluorescence of rare earth elements in fluorite: initial observations with a laser Raman microprobe. Geochim Cosmochim Acta. 1992;56(7):2713-2723. doi:10.1016/0016-7037(92)90355-M.
29. Gaft M, Reisfeld R, Panczer G, Ioffe O, Sigal I. Laser-induced time-resolved luminescence as means for discrimination of oxidation state of Eu in minerals. J Alloys Compd. 2001;323-324:842-846. doi:10.1016/S0925-8388(01)01157-4.
30. Gaft M, Reisfeld R, Panczer G, Blank P, Boulon G. Laser-induced time-resolved luminescence of minerals. Spectrochim Acta A Mol Biomol Spectrosc. 1998;54(14):2163-2175. doi:10.1016/S1386-1425(98)00134-6.
31. Stillwell W. Basic membrane properties of the fluid mosaic model. In: Membrane hydration. Amsterdam: Elsevier; 2016. p. 169-170. doi:10.1016/B978-0-444-63772-7.00009-9.
32. Lakowicz JR. Principles of fluorescence spectroscopy. New York: Plenum Press; 1983.
33. Lakowicz JR. Principles of fluorescence spectroscopy. 2nd ed. New York (NY): Kluwer Academic/Plenum Publishers; 1999.

