Illustrated gemmology article

Blue sapphire

From the structure of corundum to shades of blue, teal, colour change and fluorescence.



Pale blue · 1.24 ct



Teal blue-green · 1.29 ct



Blue with a violet modifier · 0.935 ct



Deep blue · 1.118 ct · heated

Every shade of blue

Blue sapphire is the blue variety of corundum, an aluminium oxide with the formula Al_2O_3. Its colour is not a pigment deposited within the stone: it arises from the interaction of light with trace elements incorporated into the crystal lattice. The same atomic structure can produce very different blues, from light to deep, with green or violet secondary hues. The trade term teal describes a colour between blue and green; it denotes neither a mineral species nor a geographical origin. [1] [4]

Understanding this diversity requires connections across several scales: atomic arrangement, growth conditions, inclusions, cutting and lighting. Visual appearance alone is not diagnostic. A blue-green sapphire may retain its colour under different lighting; conversely, some sapphires change from blue to violet when the light source changes. Pleochroism, which depends on the viewing direction, is a separate phenomenon. [5]

Four specimens illustrate this diversity: a pale blue oval weighing 1.24 ct , a teal blue-green cushion weighing 1.29 ct , a blue octagon with a violet modifier weighing 0.935 ct and a deep blue octagon weighing 1.118 ct . The last is heated. Their photographs illustrate distinct hues and responses to light; they do not form a calibrated colour scale.

Crystallography and classification

Corundum crystallises in the trigonal system, crystal class –3m, space group $R\bar{3}c$, no. 167. Its rhombohedral R Bravais lattice is commonly described using the conventional hexagonal setting. In the primitive rhombohedral setting, the unit-cell angle α is approximately 55.28°: this describes lattice geometry, not the inclination of a macroscopic rhombohedral crystal form. The O^{2-} anions form a slightly distorted close-packed arrangement; Al^{3+} occupies two-thirds of the available octahedral sites. The distorted AlO_6 octahedra connect by sharing faces and edges. Fe and Ti substitutions locally perturb this structure without changing the mineral identity of corundum. Colour depends on their charge states and associations, not simply their total concentration. [1] [2] [14]

Reference framework	Classification
Formula	Al_2O_3 · simple oxide
System / Bravais lattice	Trigonal · rhombohedral R
Class / space group	–3m · $R\bar{3}c$, no. 167
Conventional unit cell	a ≈ 4.75 Å · c ≈ 12.97 Å · Z = 6
Crystallographic positions	Al: 12c, (0, 0, z), z ≈ 0.352 · O: 18e, (x, 0, ¼), x ≈ 0.306
Strunz	04.CB.05
Dana	04.03.01.01

1 · Hexagonal setting · $Al_{12}O_{18}$

2 · Distorted octahedron · AlO_6

3 · Periodic arrangement · three unit cells

Drag to rotate; use Pause or Resume to control rotation. The views use Wyckoff positions 12c and 18e in space group R$\bar{3}$c. The first unit cell contains 12 Al and 18 O; the third view stacks three complete unit cells, comprising 36 Al and 54 O. [1] [14]

The positional values used in the models are rounded: Al 12c, z = 0.3522; O 18e, x = 0.3064. The R-centring translations generate 12 Al and 18 O positions within the conventional unit cell, equivalent to six Al_2O_3 formula units. The octahedron is derived from the six oxygen neighbours of an aluminium atom; the third model repeats three unit cells without adding decorative atoms. O is shown in pink and Al in blue. [14]

Formation and crystal habits

Corundum becomes stable when alumina activity is high and silica activity sufficiently low. Quartz and corundum are generally incompatible at equilibrium: in a silica-rich system, aluminium preferentially enters feldspars, micas, sillimanite, kyanite or cordierite. Gem corundum therefore requires a precise petrogenetic window, created by metamorphism, metasomatism, desilication or the evolution of silica-undersaturated alkaline magmas. [2]

Metamorphic deposits sensu stricto

In impure marbles, aluminous gneisses, granulites and certain metamorphosed mafic–ultramafic rocks, decarbonation and recrystallisation reactions can produce corundum, spinel, phlogopite, scapolite, diopside and carbonates. Exchanges between aluminous layers and adjacent rocks control the supply of Cr, Fe, Mg and Ti. [2]

Metamorphic–metasomatic deposits

Fluid circulation and rock–fluid reactions can remove silica from a pegmatite or host rock, forming plumasites, phlogopitites or biotitites, skarns and corundumites. Under high-grade metamorphism, zoning, inclusions and trace-element chemistry record reactions between protolith, fluid and host rock. This category includes sapphire-bearing skarns developed at contacts between marbles and intrusions. [2]

Magmatic deposits and basalt-related settings

Corundum can crystallise in silica-undersaturated magmatic systems. In alkaline basalt provinces, however, many sapphires are xenocrysts or originate from xenoliths entrained from crustal or mantle reservoirs: basalt then acts as a rapid carrier rather than the rock in which crystallisation occurred. Such basalt-related corundum is often richer in iron than metamorphic corundum. [2]

Secondary deposits

Eluvial and colluvial deposits, alluvium and palaeoplacers are not crystallisation environments. Corundum's hardness, density and chemical resistance favour its concentration following weathering and transport. Modern placers form or are reworked by recent processes; palaeoplacers are ancient sedimentary deposits that may be reworked by modern erosion. A single horizon can mix several primary sources and several generations of transport. [2]

Genetic classification	Host rocks and processes	Assemblages or examples
Primary magmatic	Silica-undersaturated alkaline magmas; syenites, lamprophyres and related systems	Iron-bearing corundum; crystals sometimes entrained as xenocrysts
Primary metamorphic	Marbles, gneisses, granulites, amphibolites and mafic–ultramafic rocks	Spinel, mica, rutile, zircon, carbonates

Primary metasomatic	Desilication and rock–fluid reactions; plumasites and skarns	Phlogopite, scapolite, diopside, spinel, carbonates
Secondary	Weathering, transport and hydraulic sorting	Eluvial and colluvial deposits, alluvial placers and palaeoplacers

Theoretical crystal habits in 360° rotation

Crystal habits result from the relative development of crystallographic forms: basal pinacoid c {0001}, prism a {11-20}, rhombohedron r {10-11} and dipyramids. The six models distinguish simple forms from combinations; their texture conveys the appearance of a natural crystal and their labels identify the dominant faces. The fifth model is constructed from the reciprocal normals of the r {10-11} form, rather than arbitrarily adopting the angle of the primitive unit cell. [1] [14]

The computer-generated textures of the six models evoke growth surfaces, striations and irregularities in rough corundum; they do not reconstruct a crystal from which the teal specimen was cut. Crystal habits should not be confused with metamorphic facies, which describe pressure and temperature conditions.

Physical and optical properties

Property	Reference value
Refractive indices	nω ≈ 1.767–1.772 · nε ≈ 1.759–1.763
Birefringence	≈ 0.008–0.010
Optic character and sign	Uniaxial negative; an anomalous biaxial interference figure may arise from internal strain or twinning without making the crystal truly biaxial
2V angle	Not applicable in the ideal uniaxial state
Pleochroism	Dichroism varies with orientation: components are generally blue to blue-green and blue to blue-violet
Dispersion	Low, approximately 0.018
Specific gravity	≈ 3.98–4.10
Hardness	9 Mohs
Cleavage / parting	No cleavage; basal or rhombohedral parting may occur
Fracture / tenacity	Conchoidal to uneven fracture · tough material, but susceptible to chipping
Lustre	Vitreous to subadamantine

The orientation of the rough relative to the optic axis changes the apparent hue, dichroism, extinction and cutting yield. A hardness of 9 indicates strong scratch resistance, not immunity to impact: parting, internal strain and fractures can cause chipping or breakage. [1] [2] [14]

Colour, colour change and fluorescence

Blue: charge transfer and the atomic environment

In many blue sapphires, the principal chromophore involves Fe^{2+} and Ti^{4+}. Absorption involves charge transfer between neighbouring ions, conventionally described as $Fe^{2+} + Ti^{4+} \rightarrow Fe^{3+} + Ti^{3+}$ in the excited state. This broad absorption removes some wavelengths complementary to blue. Pair geometry and the orientation of the light's electric field affect the response: ordinary and extraordinary spectra are not identical. [4]

Fe^{3+} contributes absorptions in the violet and blue. Superimposed on Fe–Ti bands, these contributions can shift the colour towards blue-green. The balance between charge donors and acceptors, other impurities and oxidation conditions also matters. A teal photograph therefore cannot establish an iron content or quantify Fe–Ti pairs. Growth zoning and the optical path through the gem also influence its appearance. [4]

Three phenomena to distinguish

Feature	Interpretation
Teal hue	Blue accompanied by green: a colour description that does not automatically imply colour change.
Pleochroism	Colour varies with viewing direction and polarisation under constant lighting.
Colour change / colour shift	A change in perceived colour when the illumination spectrum changes, with geometry kept as constant as possible.

From blue to violet: the influence of lighting

Some sapphires show two transmission windows whose relative contributions change between light rich in short wavelengths and warm light. Vanadium may contribute, sometimes alongside chromium and iron. These possibilities are documented in analysed sapphires; they do not identify the chemistry of the specimen photographed here. [5]

The diptych shows the 0.935 ct octagonal sapphire under 6000 kelvin on the left and 2700 kelvin on the right. Ultra Rare observes a transition from blue to violet, described here as colour shift . Colour temperature does not describe a lamp's entire spectrum: two LEDs at 6000 kelvin may differ. The photographic comparison documents an observation.

Octagonal sapphire · 0.935 ct · VS · 6.7 × 4.1 × 3 mm · Ultra Rare photographs.

Fluorescence: emitted light, distinct from transmitted light

Fluorescence is light emission under excitation. In corundum, Cr^{3+} can produce red emission, with lines near 694 nm. Iron may suppress this emission through non-radiative relaxation pathways. Weak fluorescence therefore does not necessarily mean an absence of chromium; nor is red fluorescence alone sufficient to distinguish natural from synthetic corundum. Excitation wavelength, filters and exposure strongly influence the image. [6]

The diptych below shows the pale blue sapphire weighing 1.24 ct in visible light, followed by its strong orangey red fluorescence under 365 nm UV , observed by Ultra Rare. The origin of this emission has not been identified for this specimen. Image colour alone cannot establish a specific luminescent centre. For the 1.287 ct teal sapphire, the Bellerophon report separately states ‘Fluorescence: None’.

The same 1.24 ct pale blue sapphire · visible light and 365 nm UV · Ultra Rare photographs.

Discover this fluorescent blue sapphire

See the colour change in the 0.967 ct sapphire



Cool light · 6000 K



Visible light · 1.24 ct

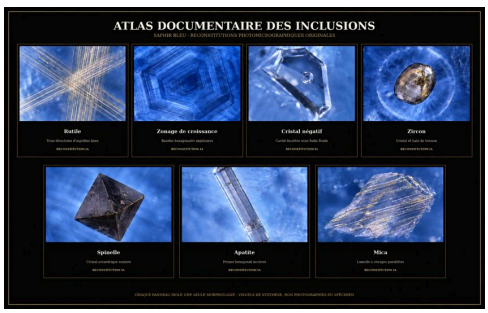
Inclusions

Inclusions record growth and subsequent transformations. They may include rutile needles or silk, solid crystals, particle clouds, negative crystals and healed-fracture fingerprints. Their distribution, orientation and relationship to zoning are often more informative than an isolated feature. Needles aligned in three directions can produce asterism when their density and a cabochon cut are suitable; silk does not always produce a visible star. [7]

Assemblages depend on the formation environment. Basalt-related sapphires may contain feldspars, oxides and silicate melt inclusions. Metamorphic sapphires may contain fluid inclusions or different mineral associations. None of these examples should be attributed to the teal specimen without appropriate observation. Where conditions permit, Raman microscopy can test the identity of an included crystal without extracting it. [3] [7]

Photomicrographs of Ultra Rare specimens

On the left, the photomicrograph shows the 1.287 ct teal sapphire at high magnification. It reveals a blue-green field, small bright features and sharply bounded dark areas. Their interpretation depends on the focal plane, lighting and reflections between facets. On the right, the photomicrograph shows the 1.24 ct pale blue oval sapphire: the visible lines and details are photographic observations, with no included mineral identified solely by appearance. The term eye clean describes examination with the unaided eye: it does not imply the absence of structures visible under a microscope.



Rutile Computer-generated illustration



Teal sapphire · 1.287 ct Original Ultra Rare photomicrograph.

Deposits – Atlas

Blue sapphire occurrences span several continents and different geological histories. Reference sources include Sri Lanka, Myanmar, Kashmir and Madagascar for sapphire populations associated with metamorphic or metasomatic settings. Australia, Thailand, Cambodia, Nigeria and Ethiopia provide basalt-related examples. Montana and Tanzania illustrate other settings that cannot be reduced to a simple binary distinction. [2] [3]

A country may contain several deposit types. Colour alone cannot establish origin: the chemical ranges and inclusions of some populations overlap. An occurrence map provides geographical context for the literature; it replaces neither purchase traceability nor laboratory origin determination. Administrative boundaries are used for orientation and do not represent geological boundaries. [3]

A geological and chromatic mosaic

Madagascar is not a uniform petrological block. Its Precambrian shield is divided into six major domains — Bemarivo, Antongil–Masora, Antananarivo, Ikalamavony, Androyan–Anosyan and Vohibory — juxtaposed and reworked through a polycyclic history, notably during the Pan-African orogeny. Mesozoic sedimentary cover predominates in the west; Neogene to Quaternary alkaline volcanic fields occur chiefly in the north and in parts of the central and southern regions. [17]

In the south, granulites of the Androyan–Anosyan domain record high-grade conditions, commonly around 700–800 °C and 4–5 kbar, during Pan-African events approximately between 565 and 490 Ma. Mafic–ultramafic rocks in the Vohibory domain locally record higher pressures, around 9–11.5 kbar at 750–800 °C. These are regional orders of magnitude: each district has its own P–T–t history. [20]

Ilakaka–Sakaraha. The south-western district, developed from 1998, exploits Triassic detrital horizons of the Isalo, interpreted as extensive palaeoplacers locally reworked by present-day erosion. It yields blue, pink, violet, yellow, orange, padparadscha and colour-change sapphires. The wide spread of inclusion, trace-element and oxygen-isotope signatures — published $\delta^{18}O$ values extend approximately from –0.3 to 16.5 ‰ for corundum from Malagasy secondary deposits — reflects a mixture of primary sources. [2] [3]

Andranondambo and the south-east. The classic primary deposit is a metasomatic skarn formed at the contact between Anosyan granites and Proterozoic marbles and calc-silicate rocks of the Tranomaro group. Rock–fluid reactions, desilication and component transfer produced corundum-bearing assemblages; subsequent weathering supplied nearby secondary concentrations. Zircons contemporaneous with the sapphires date this episode to approximately 523–510 Ma. [2]

Ambondromifehy and the north. Neogene–Quaternary alkaline basalt fields transported sapphire-bearing xenocrysts and xenoliths. Gems are mainly recovered from alluvium, residual soils and palaeokarst breccias developed in Jurassic limestones; directly observed primary occurrences remain rare. Basalt should therefore not automatically be described as corundum's parental melt. [16]

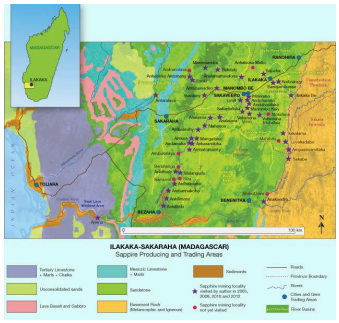
Didy, Andilamena and Bemainty. Didy produces rubies and sapphires, including pink sapphires, chiefly from secondary deposits whose sources remain unevenly characterised. Andilamena is best known for alluvial ruby. Bemainty yields predominantly blue metamorphic sapphires and some pink to orangey stones; it lies within the protected Ankeniheny–Zahamena forest corridor. Bekily remains a regional reference point in the south, within granulitic and metasomatic terrains, rather than a single district devoted exclusively to pink sapphire. [9]

Oxygen isotopes and provenance

Oxygen-isotope ratios complement petrography and trace-element chemistry. Published Malagasy primary corundum spans approximately $\delta^{18}O$ = 1.3 to 15.6 ‰. Groups around 4.7–9.0 ‰ are consistent with pyroxenite or feldspathic gneiss settings, while high values of 10.7–15.6 ‰ notably characterise the marble-related skarns of Andranondambo. Overlap between deposits nevertheless requires isotopes, inclusions, spectra and trace elements to be considered together. [15]

Basalt-related sapphires: clues to provenance

Sapphires associated with alkaline basalts are documented in the Ambondromifehy district, near the Montagne d'Ambre massif, and in the Vatomandry region. Basalt may carry crystals formed earlier at depth, with weathering subsequently supplying secondary deposits. The volcanic formations of Ankaizina, near Bealanana, also form part of the northern volcanic landscape; their presence alone does not establish a sapphire deposit without local documentation. The collection's 1.29 carat unheated, eye clean teal sapphire , from Madagascar, has an affinity described by Bellerophon as 'Basaltic Related Deposit'. An origin in one of Madagascar's basalt-related sapphire districts is therefore plausible; no particular district can be favoured on teal colour alone. [16] [18]



Regional reference points, without assigning a mine to the specimen. Sector map: Vincent Pardieu, GIA, 2013 . The date refers to the document, not the current activity of each working.

Treatments

Heating can change charge states, element distribution and certain inclusions. Its effects vary with initial composition, temperature, duration and atmosphere. It may lighten or strengthen a blue component, transform silk or alter transparency. These changes do not follow a universal recipe applicable to every sapphire. [8] [12]

Experiments by Hughes and Perkins on Malagasy sapphires show that relatively low-temperature heating

can leave subtle evidence. Interpretation combines microscopy and spectroscopy; an apparently intact included crystal does not rule out heating. FTIR criteria must be interpreted according to sapphire type: a band that occurs naturally in some basalt-related sapphires does not automatically indicate treatment. [8] [10]

Feature	Interpretation
Heating	Thermal modification of existing material; effects depend on chemistry and atmosphere.
Ti or Be diffusion	Introduction of elements during heat treatment; chemical analysis and colour distribution require examination.
Filling / impregnation	Material introduced into fissures; possible effects on clarity assessment and care.
Synthesis	Artificial growth of corundum: a category distinct from treatment of a natural stone.

Heated 1.118 ct specimen shown for illustration. This is not a before-and-after treatment comparison.



Deep blue · 1.118 ct · heated

Rarity and occurrence

Occurrence

The existence of many corundum deposits does not imply an equivalent abundance of gem-quality stones. A rock may contain opaque, fractured or undersized crystals unsuitable for cutting. Several selection stages separate a mineral occurrence, cuttable rough and a finished gem: recovery, sorting, orientation and material loss. A figure established for one deposit or parcel cannot be extrapolated to the whole market without a sound method. [11]

Rarity within rarity

An appealing gem combines desirable colour, suitable transparency, balanced cutting and good structural integrity. Within an unheated selection, meeting all these criteria becomes more demanding. Teal adds a particular requirement of hue: blue should remain perceptible while green complements it without making the colour heavy. This is a gemmological and aesthetic judgement, not a statistical frequency. [11]

Assessment

Blue sapphire: 10 times rarer geologically than diamond.

Eye-clean blue sapphire above 1 carat: 50 to 100 times rarer than an eye-clean diamond of the same weight.

Unheated eye-clean teal above 1 carat: 100 to 150 times rarer than a diamond of the same clarity and weight.

Identification

Identification begins with measurements consistent with corundum: refractive indices, birefringence, optic character, specific gravity and microscopic examination. Agreement between several results is more robust than a single indicator. A synthetic stone also has the formula Al_2O_3 and similar physical properties: mineral identity does not establish natural origin. [10]

Feature	Interpretation
Refractometer / polariscope	Refractive indices and anisotropy; observation is limited by facet condition, orientation and measurement conditions.
Microscopy	Zoning, growth structures, inclusions and evidence of heating; examination under several lighting conditions.
Raman	Identification of the material and, where accessible, solid inclusions.
FTIR	Vibrations, defects notably involving hydrogen, and useful information on certain thermal histories.
UV-Vis-NIR and trace-element chemistry	Absorption and composition; comparison with reference populations to assess geological setting and origin.

Geographical origin is established through considered comparison with reference samples, not a test that directly produces a country name. A conclusion may remain undetermined where signatures overlap. A deposit-type description can then provide useful information without amounting to a national origin determination. Eye clean clarity requires an unaided-eye observation protocol; it cannot be inferred from transparency alone as stated on a report. [3] [10]

Spectroscopy

Interpreting absorption and transmission

UV-Vis-NIR links colour to wavelength-dependent absorption. Under controlled geometry, absorbance is $A = -\log_{10}(T)$, where T is corrected relative transmission; the absorption coefficient is $\alpha = 2.303\ A / l$, with l in centimetres. A faceted stone produces multiple light paths and reflections: a photographic curve or decorative profile is not a quantitative spectrum. [4] [10]

Published reference features include Fe^{3+} absorptions near 380–390 and 450 nm, and a broad Fe–Ti contribution around 580 nm in many blue sapphires. A band near 880 nm, outside the visible range shown below, contributes to the study of basalt-related populations. Its interpretation must remain grounded in the literature and the full analytical evidence. Amplitudes, widths and polarisations vary; none of these features has been measured here on the teal specimen. [4]

Luminescence: chromium and other emitting centres

Transmission is incident light passing through the crystal. Luminescence is emission following excitation of a luminescent centre: they are distinct physical contributions. In Cr^{3+}-bearing corundum, the red R_2 and R_1 lines occur near 692.9 and 694.3 nm respectively at room temperature. Their widths and intensities depend

notably on temperature, concentration, ion interactions and quenching by iron. The diagram marks their positions; it does not predict the teal specimen's fluorescence. [6]

Ultra Rare's bright blue, colour-change and fluorescent 0.935 carat sapphire shows a distinct red emission line when examined with a spectroscope, consistent with the presence of chromium. Low iron content may favour this fluorescence, but fluorescence alone cannot establish that content.

Rare-earth elements are well-known activators in several mineral families. Their possible presence in a sapphire, sometimes associated with microscopic inclusions, does not demonstrate that they control its luminescence. Without elemental identification and an emission spectrum attributable to a specific centre in corundum, adding generic Eu^{3+}, Sm^{3+} or Dy^{3+} lines to this diagram would be incorrect. Other published corundum emissions include contributions associated with titanium and lattice defects under suitable excitation. [6]

Complementary methods, not interchangeable terms

Raman spectroscopy examines inelastic scattering and lattice vibrations; FTIR measures infrared absorption; photoluminescence measures emission under excitation. Their horizontal axes, signals and purposes differ. Photoluminescence can detect weak emitting centres without their light dominating the gem's colour. Red emission under UV therefore does not fully explain its colour in white light. [3] [6] [10]

Interpreting the collection specimens

The 1.287 ct teal cushion

This natural sapphire is presented as 1.29 ct, rounded from the 1.287 ct weight printed on Bellerophon report A31949 dated 7 January 2026. It measures 6.43 × 6.39 × 3.81 mm. The laboratory records the shape as Cushion, the colour as Greenish Blue, colour stability and no indications of treatment. The report's trade note allows the term teal. Fluorescence is recorded as None.

Ultra Rare describes this stone as eye clean and states Madagascar as its origin. The Bellerophon macro photograph illustrates light return and the blue-green hue; it should not be interpreted as a spectral map. Neither colour change between two illuminants nor red fluorescence is claimed for this cushion.

Discover this teal sapphire

The 0.935 ct octagonal sapphire

Ultra Rare grades this second specimen VS; it measures 6.7 × 4.1 × 3 mm. It illustrates the photographed transition from blue to violet under 6000 kelvin and 2700 kelvin, followed by red fluorescence under 365 nm long-wave UV. It will soon be available in the collection.

The 1.24 ct pale blue sapphire

An oval measuring 6.8 × 5.6 × 3.4 mm, Eye clean VS, from Madagascar. The Bellerophon GemLab test confirms no heating. Its strong orangey red response under 365 nm UV complements the assessment of its colour in visible light; the origin of the fluorescence remains unidentified.

The 1.118 ct deep blue sapphire

An octagon measuring 5.8 × 5.5 × 3.3 mm, VS and heated, according to the supplied documentation. This photograph illustrates a deeper blue. Ultra Rare uses it as an example of sapphire heated by Ultra Rare; it is not offered for sale.

A 0.967 ct sapphire from Madagascar — from violet to magenta pink

Under a 6,000 K LED, this sapphire appears intense violet. Under 2,800 K incandescent light, the same stone turns vivid magenta pink. The paired images on the specimen page show the two hues side by side. Under 365 nm UV light, the stone shows a separate effect: strong orange fluorescence.

This cushion-cut sapphire measures 6.1 × 5 × 3 mm. It has excellent transparency and is graded eye clean on the Ultra Rare clarity scale. Bellerophon GemLab test T8549, dated 6 January 2026, identifies it as a natural sapphire with no indications of heating.

View the 0.967 ct colour-change sapphire



Teal blue-green · 1.29 ct



Under 365 nm UV · 1.24 ct

Method, conclusion and sources

Interpretive method

This study distinguishes four levels of evidence: published general sapphire properties; data from original report A31949; observations and provenance supplied by Ultra Rare; and educational diagrams and models. The photographs preserve the gems' colours, clarity and details. Jewellery renderings are creative visualisations, not photographs of finished jewellery.

The atomic models use the coordinates of the corundum master; the six crystal habits use its geometries. Computer-generated textures follow the faces. The world background is a terrestrial raster combined with Natural Earth boundaries; points mark districts or countries, not mine coordinates. The Madagascar map follows the Ultra Rare documentary reference. Spectral bands are published reference features, with schematic profiles explicitly distinguished from specimen measurements. No new chemical, FTIR, Raman or UV-Vis-NIR measurements were performed on the specimens for this article.

Conclusion

Blue sapphire combines a remarkably stable crystal lattice with subtle sensitivity to trace elements. Understanding its colour requires absorption, emission, optical direction and lighting to be distinguished; understanding its origin requires laboratory evidence, field observations and deposit history to be connected.

Teal is one expression of this diversity. Assessment becomes more precise when every photograph, figure and conclusion remains tied to its actual source.

Main sources and further reading

Mineral Data Publishing (2001–2005). Corundum — Handbook of Mineralogy. ↩

Giuliani, G. & Groat, L. A. (2019). Geology of Corundum and Emerald Gem Deposits: A Review. ↩

Palke, A. C. et al. (2019). Geographic Origin Determination of Blue Sapphire. ↩

Emmett, J. L. et al. (2020). A Quantitative Description of the Causes of Color in Corundum. ↩

GIA (2019). Low-Fe, High-V Color-Change Burmese Sapphire. ↩

D'Haenens-Johansson, U. F. S. et al. (2024). Glowing Gems: Fluorescence and Phosphorescence of Diamonds, Colored Stones, and Pearls. ↩

Renfro, N. D. et al. (2017). Chart: Inclusions in Natural, Synthetic, and Treated Sapphire. ↩

Hughes, E. B. & Perkins, R. (2019). Madagascar Sapphire: Low-Temperature Heat Treatment Experiments. ↩

Pardieu, V. et al. (2017). Sapphires from the Gem Rush Bemainty Area, Ambatondrazaka (Madagascar). ↩

Groat, L. A. et al. (2019). A Review of Analytical Methods Used in Geographic Origin Determination of Gemstones. ↩

GIA (Accessed 8 October 2026). Sapphire Quality Factors. ↩

GIA (Accessed 8 October 2026). Sapphire Care and Cleaning Guide. ↩

GIA (Accessed 8 October 2026). September Birthstone — History and Location.

Maslen, E. N. et al. (1993 · structural reference cited in [1]). Synchrotron X-ray study of the electron density in α-Al_2O_3, Acta Crystallographica B49, 973–980. ↩

Giuliani et al. (2007), Oxygen isotope systematics of gem corundum deposits in Madagascar, Mineralium Deposita 42, 251–270. ↩

Rakotosamizanany et al. (2014), Chemical and oxygen isotopic compositions, age and origin of gem corundums in Madagascar alkali basalts. ↩

USGS, A geological synthesis of the Precambrian shield in Madagascar. ↩

Mottet (1982), Tectonique et volcanisme dans le massif du Tsaratanana–Ankaizina. ↩

GIA (2024), Shining a Light on Gemstone Properties: An Exploration of Photoluminescence Spectroscopy.

Rakotondrazafy, A. F. M. et al. (2008). Gem corundum deposits of Madagascar: a review. Ore Geology Reviews, 34(1–2), 134–154. DOI : 10.1016/j.oregeorev.2007.05.001. ↩

Sources for this study: Bellerophon GemLab report A31949 and media supplied by Ultra Rare; owner's instructions dated 8 October 2026; V82 charter and Blue Garnet article master. Cartographic source: Natural Earth, public domain; terrestrial background distributed by Three.js (NASA). Bibliography accessed 8 October 2026.

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