Spinel: A Gemstone on the Rise

Dr. Michael S. Krzemnicki
Swiss Gemmological Institute SSEF
Switzerland

Spinel of 110 ct from Tajikistan
What is Spinel?

Spinel as a gemstone is mainly magnesium-aluminium-oxide

\[ \text{MgAl}_2\text{O}_4 \]

More general: the spinel group

\[ (\text{Me}^{2+}) (\text{Me}^{3+})_2 \text{O}_4 \]

Me\(^{2+}\) tetrahedral coordination
Me\(^{3+}\) octahedral coordination

Cubic

Colours of Spinel

Pure MgAl\(_2\)O\(_4\) is colourless.

Trace elements such as chromium, vanadium, iron, cobalt produce many different shades of colours such as red, pink, orange, purple, blue, black...
Most spinel crystals are octahedral, but also other cubic forms exist such as rhombic dodecahedra...

But remind: Rubies may also have a pseudo-octahedral “shape”
Crystal Shape of Spinel

Spinel crystals are often twinned.

Formation of spinel

Many gemquality spinels are formed in marbles, similar to rubies.
- Spinel in dolomite marble (Mg-Ca-carbonate)
- Ruby in calcite marble (Ca-carbonate)
**Formation of spinel**

Often occurring together with magnesium minerals such as clinohumite and chondrodite (Mg-Fe-silicates), phlogopite (K-Mg mica), pargasite (Na-Ca-Mg-Fe amphibole).

**History of spinel**

In ancient times, spinel was not known as a mineral and many of the large historic „balass rubies“ from Central Asia and Persia were later identified mineralogically as spinels.

One of the finest examples of a Badakhshan spinel is the Black Prince “ruby” (~ 140 ct) which is mounted in the front of the Imperial State Crown of Great Britain.

These large and often just slightly polished and engraved spinels went through the hands of the kings and shas of central Asia, Persia and India and were only described by a few adventurous European travellers such as Jean-Baptiste Tavernier and others at that time.
Exceptional historic spinel necklace certified at SSEF
Properties of Spinel

Spinel is cubic,

RI for natural gem quality spinels usually approx. 1.718

SG 3.60

Lustre: High vitreous

Hardness: 8 (Mohs scale)

Clarity: Often clean stones, no cleavage

Colour: by trace elements in many shades from red, pink, orange, purple, to blue and black no pleochroism, usually no colour zoning red spinels often with Cr-luminescence, resulting in bright red colour

Most spinel crystals are octahedral, but also other cubic forms exist such as rhombic dodecahedra...

Octahedral shape perfect fitting for cutting proportions

Faceted red spinel (2.24 ct) with spinel crystal (15 ct), both from Burma.

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Properties of Spinel

Spinels are generally rather pure gemstones without distinct colour zones, in contrast to rubies, which are often quite included and fractured and colour zoned!

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Heating experiments on spinels show no or only limited enhancement, apart from clarifying some turbidity in spinel. Heated spinels are detected by microscopy and Raman-microspectrometry (Photoluminescence) at SSEF.

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**Synthetic spinel**

Most are produced by a flame-fusion process (Verneuil).

Visit at Djevahirdian SA, Monthey, Switzerland

Large quantities are produced for technical purposes (e.g. scratch resistant glasses for watches).

Usually these synthetic spinels are highly pure, and often show a colour range from blue, light blue, green, and colourless.

Experiences gemmologists generally can separate them easily from natural spinels based on microscopy, UV fluorescent reactions and slightly increased values for RI (1.725 instead of 1.718) and SG (3.65 instead of 3.60).

The difference in these physical properties is due to a non-stoichiometric chemical composition of these Verneuil synthetic spinels, i.e. they contain too much aluminium.

As a consequence, there crystal structure is slightly deformed, resulting in strain double refraction under the polariscope and in broadening of the peaks in the Raman spectrum.
Flux-melt synthetic Spinel

Flux-melt synthetic spinels are known since the 90ies, but quite rare. As a consequence of the increased interest and value of red and intense blue spinels, the SSEF has tested recently a number of such synthetic spinels from the market.

Flux residue in synthetic spinel

Flux-melt synthetic spinel form as nice octahedral crystals, mostly in saturated red and blue colours. These stones are not easy to separate from natural spinel.

Raman spectra of flux-melt synthetic spinel
Luminescence spectra of flux-melt synthetic spinel

Sources of spinel

As for ruby and sapphire, spinel of fine quality is often certified. The clients often require an origin determination of the spinel, especially for stones from Burma, Tajikistan (Pamir), Vietnam and Tanzania.

At SSEF, origin determination is based on microscopy (inclusions), trace element distributions and UV-Vis and Raman spectroscopy. The origin of spinels cannot be determined in all cases due to overlapping properties of spinels from different sources.
Major sources of spinel

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Madagascar
Tajikistan
Burma (Myanmar)
Ceylon (Sri Lanka)
Vietnam
Tian (Thailand)
Siam (Thailand)
Tanzania
Afghanistan
Ceylon (Sri Lanka)

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Tajikistan is a classical source for large spinels since ancient times. They usually show a pinkish red to pink colour.

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Pierre Lefèvre, gemmologist at SSEF with a superb spinel of 110 cts from Tajikistan.

Spinel from Burma is highly appreciated in the market especially for its outstanding saturated red colour.
But Burma is also the source of spinels in many pastel colours.

Colour changing spinel (84 ct) from Madagascar
Vietnam

Apart from red and pink spinels, Vietnam has recently produced fine spinels in light purple, light blue and saturated cobalt blue.

Characteristic crossed inclusions in spinel from Vietnam.
Main sources for spinel in Tanzania are Matombo, Mahenge and Tunduru in the south.
Oriented planes of fine „dust“ precipitates in spinel from Tanzania

Figure 1a. Lithological units in the study area compiled from 50 available 1:50,000 degree sheets (QDR) from the Tanzania Geological Survey.
Tanzania, Mahenge

Geological map of the Mahenge fold nappe. Indicated in blue are the marble rocks. The spinels (and rubies) are found at different spots in these marbles or near-by eluvial and aluvial gravels.

Spinel from Mahenge (3.4 ct), showing a characteristic attractive bright red colour.
In 2007, a 52 kg (260'000 cts) spinel was discovered in Mahenge. Although only partly of gem quality, this resulted in a sudden supply of large (up to 50 cts) and many small vibrant pinkish red spinels (totally several thousand carats) in the market.
Going to the mine: Epangko, south of Mahenge

Epangko, Spinel mines

Gemmologist Walter Balmer at the Epangko spinel mines.
Epangko, Spinel mines
Epangko, Spinel mines
Epangko, Spinel mines
Thank you for your attention...

High Noon in Mahenge...