WORLD GEM FOUNDATION

Gemmology Today

December 2019
Quarterly Publication

Testing Times

JEAN-MARIE ARLABOSSE is a chemist and gemologist. He is the owner of an independent gemological laboratory-free-structure (Gem Solid-Phase GemLab) located on the French Riviera in France. He was the creator and for fifteen years the animator - webmaster of www.geminterest.com"

Blue Gahnospinel Crystals from Nigeria

Introduction

While surfing the Internet and several social networks, a posting showing deep blue, octahedron-shaped crystals reportedly from Nigeria caught our attention. We subsequently purchased four reference samples from the supplier.

The following gemmological and laboratory data is reported here in order to determine the exact nature of these spinel-shaped crystals and the origin of their deep-blue color.

Material and Method:

Samples:

Four crystals, each weighing 2.02 carats, 0.63 carats, 0.46 carats and a twinned crystal of triangular shape weighing 1.00 carats (4.11 carats in total) (Figure 1).

Figure 1 - Four crystals in incident D65 daylight equivalent

Visible-NIR spectrometry using an Ocean Optic USB 4000 spectrometer equipped with a homemade setting involving an integration sphere.

Fourier Transform InfraRed (FTIR) spectrometry using a Bruker Alpha spectrometer using a low noise DLaTGS detector, equipped with a diffuse (or specular in this case) reflectance type (DRIFT) signal capture module and was run at 4 cm^{-1} resolution.

X-Ray Powder Diffraction (XRPD) using a 2nd generation Bruker D2-Phaser diffractometer.

Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometry collected with a homemade spectrometer involving a silver-anode X-Ray tube running under 10 to 40 kV and 5 to 200 µA and a silicon CCD detector. This setting was chosen to detect elements that were heavier than sulphur.

Specific gravity determined with a homemade set up involving a Dendritic Gem Scale.

Reactions to ultraviolet radiation (shortwave and longwave) evaluated in a dark box lit with 6W UV tubes.

Results and Related Comments:

When observing these four crystals, we immediately thought of the 'Spinel' mineral group since octahedrons and triangular twinned crystals are strongly indicative of minerals belonging to this group. As the blue color is most often encountered in the spinel mineral species, one could guess that these crystals could be spinel.

Under the polariscope, the reaction was one consistent with isotropic material with the tabby extinction (anomalous birefringence) expected for a mineral belonging the spinel group (Figure 2).

Although spinel will often fluoresce under SW & LW ultraviolet light, the four crystals did not exhibit any fluorescence.

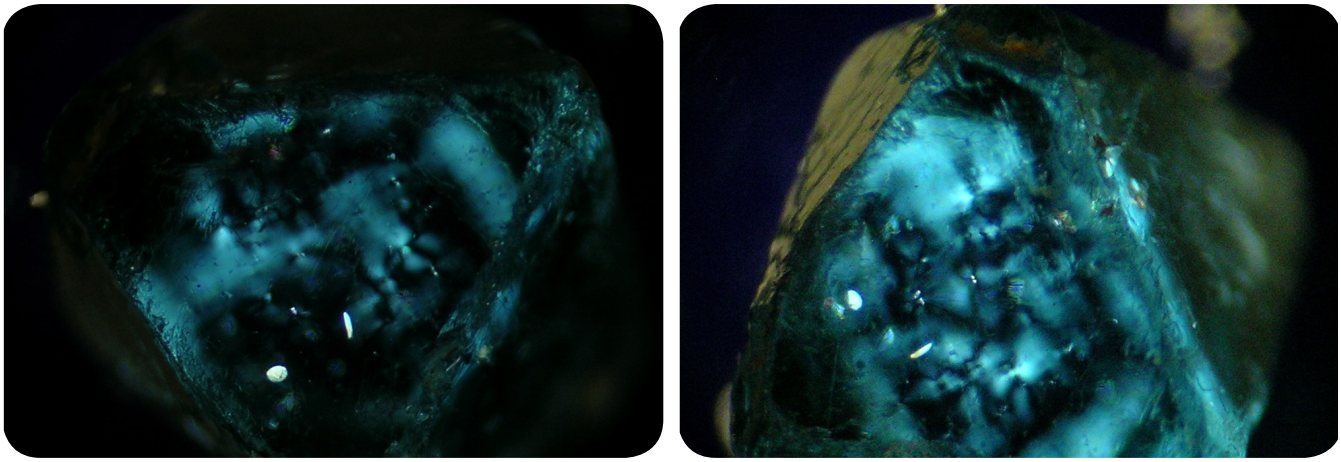

Figure 2 - Between crossed polarizing filters (polariscope), dark shadows were seen. These shadows changed shape and position when the stone was rotated indicating 'tabby extinction' or 'anomalous birefringence'. However, as the stone was rotated, it did not change from light to dark (typical of anisotropic gemstones), indicating that it was isotropic.

Under magnification and crossed polarizing filters, anisotropic inclusions could be seen (Figures 3 a, b and c, d) and after referencing 'The Photoatlas of Inclusions in Gemstones Volumes 1 & 3), it appeared, in all probability, that they were apatite inclusions.

The specific gravity (conducted on each stone separately and collectively for greater accuracy) was 4.50. The refractive index, taken on a polished face and on a smooth enough natural face, was over the limit of the contact liquid (R.I. of the contact liquid was 1.788). According to GIA, spinel has an S.G. of 3.06 and an R.I. of 1.718, while gahnite has an S.G. of 4.55 and an R.I. of 1.800. As a combination of the two, gahnospinel's S.G. can fall anywhere in between. The values for S.G. and R.I. were consistent with these observations.

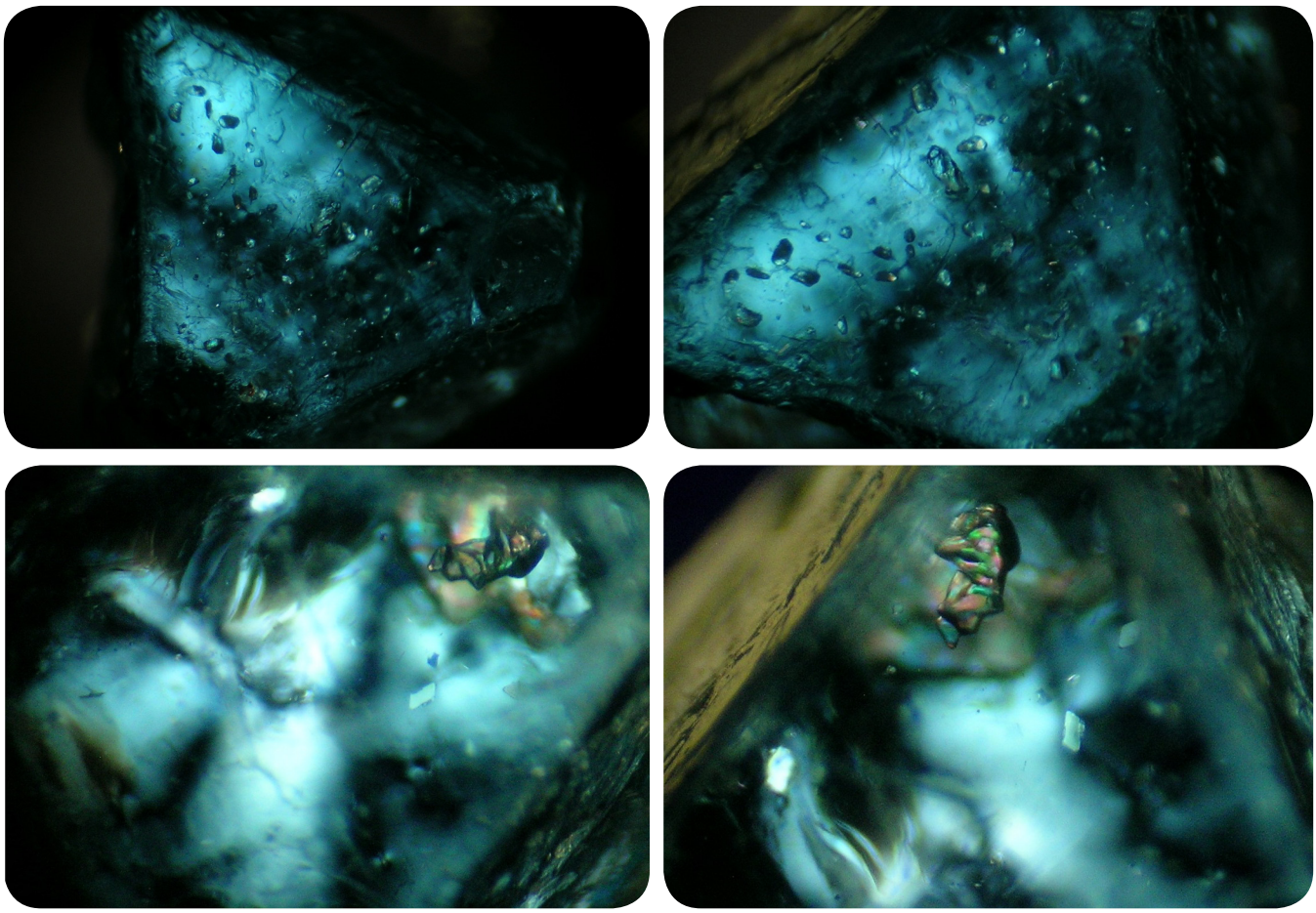

Figure 3 - Under magnification between crossed polarizing filters several anisotropic inclusions could be seen (light polarization wasn't the same in the inclusions when the stone was rotated at ~45°). These inclusions could be apatite crystals.

Figure 4 - Spectrum observed using a prism spectroscope

An observable spectrum using a prism spectroscope showed absorption bands in the red, orange to yellow, light blue, blue and a cut-off in the indigo to violet part (Figure 4). These are indicative of a coloration from iron and presumably from cobalt.

At the laboratory, visible near infrared (Vis-NIR) spectroscopy indicated iron and cobalt related bands (Figure 5). The bands at 460, 475, 560, 585, 665, 725 and 925 nm are due to iron (Fe^{2+},Fe^{3+}; D'Ippolito et al. 2015). The bands at 550, 575, and 622 nm are due to cobalt (Co^{2+} ; D'Ippolito et al. 2015). Note that although cobalt is a powerful coloring agent, the deep-blue color of these gahnospinel is predominantly due to iron.

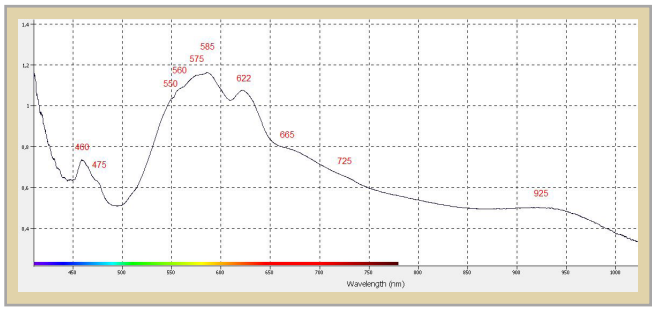

Figure 5 - Typical Vis-NIR spectrum

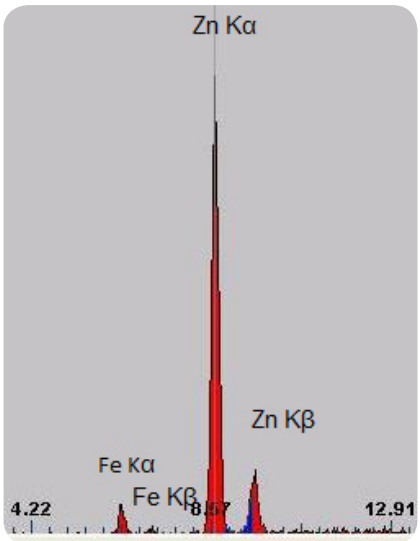

Figure 6 - Typical EDXRF spectrum (8.64 Cursor). The expected zinc content for Gahnospinel was obvious (Zn Kα 8.64 KeV, Zn Kβ 9.57 KeV). Iron was detectable too (Fe Kα 6.40 KeV, Fe Kβ 7.06 KeV) but not cobalt (too low concentration). Note this equipment allows for the detection of elements heavier than sulphur.

Energy Dispersive X-Ray Fluorescence spectroscopy showed, as expected for gahnospinel, a strong zinc content (Figure 6 Zn Kα and Zn Kβ). Iron was detectable (Figure 6 Fe Kα and Fe Kβ). Cobalt, although it could be seen in the Vis-NIR spectroscopy, was not detectable in EDXRF due to the low concentrations.

In order to definitively and structurally identify this mineral phase, some fragments were broken from the smallest crystal. Resulting shards were then powdered for an X-Ray Powder Diffraction analysis (Figure 7). The resulting powder diffraction pattern matched perfectly with the Gahnite-Spinel mineral phase.

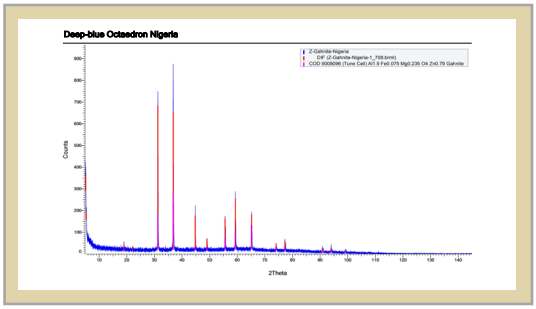

Figure 7 - X-Ray Powder Diffraction (XRPD) pattern (blue trace with red assignments-sticks) of the material studied. A perfect match with Gahnite-Spinel mineral phase was found (pink assignment-sticks).

As specular reflectance Fourier Transform InfraRed (Specular-FTIR) spectroscopy is a powerful non-destructive spectroscopy method for further gem identification (cut or rough) the four spectrums of the crystals were recorded (Figure 8), then referenced in our identification database. It was interesting to note, within this technique, the differences that exists between iron rich spinel (Spinel-Hercynite Figure 8 pink trace) and gahnospinel.

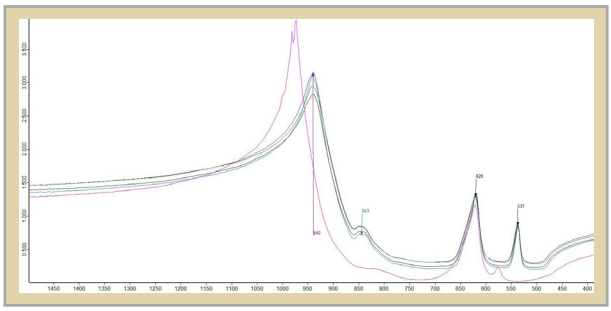

Figure 8 - Specular reflectance FTIR spectrums for the four crystals with peaks at 940, 843, 620 and 537 cm^{-1}, compared to a Spinel-Hercynite reference (pink trace). This non-destructive method can be used in the separation of spinel and gahnospinel even when the specimens are rough.

Figure 9 - Crystals in transmitted Light

Conclusions:

These four crystals, reported from Nigeria, have been identified as natural gahnospinel (close to the end member Gahnite of the Gahnite-Spinel series) and are colored by iron and cobalt traces.

As this blue color is attractive and gemmy quality gahnospinel especially in well-formed crystals with a very clear crystal habit, are uncommon, one suspects that this material will become an appreciated 'collection' or 'jewelry' item.

Acknowledgements:

Thanks to Mr Sternis E. for his contribution in reference sample (Spinel-Hercynite) and samples preparations.

Bibliography:

Chauviré B., Rondeau B., Fritsch E., Ressigeac P., Devidal J-L, 2015, Blue Spinel from the Luc Yen District of Vietnam, Gems & Gemology, Volume 51, No.1

D'Ippolito V, Andreozzi G.B, Hålenius U, Skogby H, Hametner K, Günther D, 2015, Color Mechanisms in Spinel: Cobalt and iron interplay for the blue color, Phys Chem Minerals, 42, 431–439

Gubelin & Koivula, Photoatlas of Inclusions in Gemstones Volume 1

Gubelin & Koivula, Photoatlas of Inclusions in Gemstones Volume 3

Rizzio J. 2019 Large Faceted Gahnospinel Gems & Gemology Vol. 55, No. 1 – Lab Notes

Shigley L. E. and Sloclzton C. M., 1984, 'Cobalt-blue' Gem Spinels, Gems & Gemology, Spring 1984. Notes news techniques.

Gemmology Today Quiz #13

- Fifteen questions
- No time limit
- No pressure!

This quiz is a little different to the previous ones. Let's see how you do!

Click here to start

Australian Opal Centre

The Australian Opal Centre (AOC) is a not-for-profit facility dedicated to opal-related scientific research, education, training, heritage, arts, travel, cultural and economic development. Based in the classic opal mining locality of Lightning Ridge, Australia, the AOC has developed its public collection and programs since 2004, while working towards construction of an innovative building that will be an international hub for opal-related knowledge and activity.

Please Support

www.australianopalcentre.com