Väyrynenite of Exceptional Quality and Size, Reportedly from Nigeria

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ABSTRACT: Väyrynenite is an attractive and rare phosphate mineral that—until recently—has been known in gem quality mostly as small, often included stones from northern Pakistan (and less commonly, Afghanistan). Since early 2025, väyrynenite gemstones of exceptional quality and size have entered the market, reportedly from a new source in central Nigeria. The standard gemmological properties, polarised UV-Vis-NIR spectra and Raman spectra of the Nigerian material are consistent with data for väyrynenite previously reported in the literature. Based on the samples analysed for this report, väyrynenite from Nigeria could be separated from our Pakistani samples by distinct differences in the amounts of Fe, Zn, Sc, Y and REE.

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Väyrynenite, ideally $Mn^{2+}Be(PO_4)(OH,F)$, is a rare phosphate mineral that was first discovered in 1935 in a granitic pegmatite near Orivesi in southern Finland, and named after the Finnish mineralogist Prof. Heikki A. Väyrynen (Volborth 1954). Since then, this rare phosphate has been found in a few other localities in Europe, the USA, China and along the Himalayan mountain range, but only in very limited sizes and quantities (Falster *et al*. 2012; Wang *et al*. 2022). Gem-quality väyrynenite has been described only from northern Pakistan (Shigar and Gilgit areas; Bank & Schmetzer 1979; Laurs & Fritz 2006b; Zwaan 2016) and from Afghanistan (Laurs & Fritz 2006a), but generally in small sizes (usually <1 ct) and often quite included. However, these stones are highly appreciated by gem collectors due to their attractive padparadscha-like orangey pink colour and their rarity.

In early 2025, we were surprised to receive for testing two faceted väyrynenites of excellent quality and exceptional size, weighing 12.0 and 16.0 ct (Figure 1). The 12.0 ct stone was encountered in Bangkok in January 2025, and the 16.0 ct gem was

Figure 1: Fine-quality väyrynenite, reportedly from a new find in central Nigeria, recently entered the gem trade, as shown by these 16 ct (left) and 12 ct (right) faceted stones. Also seen here is a prismatic crystal weighing 2.2 g. These three samples were included in this study as samples 448_A, 768 and 448_B, respectively. Composite photo by L. Phan, SSEF; digitally arranged by M. S. Krzemnicki.

submitted together with a crystal (about 28 mm long and weighing 2.2 g; again, see Figure 1) during the 2025 Tucson gem and mineral shows. According to information from the supplier of the rough and cut specimens, as well as reliable members of the gem trade (Farooq Hashmi and Mark Smith, pers. comm. March 2025; see also Anonymous 2025), this new material originates from Nigeria, specifically from a pegmatite known for producing fine tourmaline, near the town of Keffi in Nasarawa State, central Nigeria (see, e.g., Akoh & Ogunleye 2014; Olobaniyi *et al.* 2019). Tao (2025) recently described two large faceted väyrynenites (5.00 and 5.07 ct) from an unspecified locality, and based on their similar appearance to the samples documented by the present authors, including their excellent clarity and exceptional size, we believe that they could also originate from Nigeria.

The sudden appearance of faceted väyrynenite of such size and quality is exciting news to the trade and to gem collectors, and it motivated us to collect and characterise additional samples, and to compare them with specimens from the 'classic' locality for gem-quality väyrynenite in northern Pakistan (Figure 2).

Figure 2: In addition to the samples in Figure 1, we analysed these five faceted väyrynenites reportedly from Nigeria (0.41–1.00 ct) and five crystal fragments from Pakistan (1.03 g total). Composite photo by L. Phan, SSEF; digitally arranged by M. S. Krzemnicki.

MATERIALS AND METHODS

For this study, we analysed a total of 13 stones: eight samples (seven faceted and one rough) reportedly from Nigeria and five crystal fragments from northern Pakistan (Table I). Five of the faceted stones (0.41–1.00 ct) were sold to us by gem dealer Mark Smith as Nigerian väyrynenite, and two specimens (16.0 ct faceted and 2.2 g crystal) were submitted by a client as Nigerian väyrynenite, as mentioned above. A 12.0 ct faceted stone was submitted by a different client with no origin information, but we believe it is also from Nigeria based on its similarity to the other Nigerian samples (see the Results and Discussion section below). The five crystal fragments from northern Pakistan (1.03 g total) came from the SSEF collection, and were originally purchased from Shakir Hussain, Pakistan.

Gemmological testing was performed on all faceted samples with a refractometer, hydrostatic balance

Table I: : Väyrynenite samples analysed for this study.

Sample no.	Origin	Weight	Shape	Faceted/crystal
789_A	Nigeria	0.50 ct	Octagonal	Faceted
789_B	Nigeria	0.48 ct	Oval	Faceted
789_C	Nigeria	0.41 ct	Oval	Faceted
790	Nigeria	0.98 ct	Pear	Faceted
791	Nigeria	1.00 ct	Oval	Faceted
448_A	Nigeria	16.0 ct	Cushion	Faceted
448_B	Nigeria	2.2 g	Prismatic	Crystal
768	Nigeria*	12.0 ct	Pear	Faceted
750_A	Pakistan	1.03 g (total)	Flat prismatic	Crystal
750_B	Pakistan		Flat prismatic	Crystal
750_C	Pakistan		Flat prismatic	Crystal
750_D	Pakistan		Flat prismatic	Crystal
750_E	Pakistan		Flat prismatic	Crystal

* Sample no. 768 was submitted by a client with no origin information, but we believe it is from Nigeria based on its similarity to the other Nigerian samples.

(Mettler Toledo JE503C), polariscope, dichroscope, UV lamp (Vilber Lourmat VL-6.LC) and a gemmological microscope (Gemmaster from System Eickhorst) coupled with a Nikon camera. For the rough specimens, all tests were carried out except for RI and SG measurements. Polarised ultraviolet-visible-near infrared (UV-Vis-NIR) absorption spectroscopy was performed on all samples except the 2.2 g crystal using an Agilent Cary 5000 spectrophotometer.

Raman spectroscopy of the väyrynenite was done on all samples except the ones tested in Bangkok and Tucson using a Renishaw inVia spectrometer coupled with a Leica DM2500 M microscope and an argon-ion laser (514.5 nm excitation). The analyses were carried out in confocal mode using a 50× objective to focus on the samples' surface. Two orientations ($E\|c$ and $E\perp c$) relative to the electric vector of the laser beam were analysed.

Chemical analysis was carried out on all samples by energy-dispersive X-ray fluorescence (EDXRF) spectroscopy using a Thermo Scientific ARL Quant'X spectrometer in vacuum mode. In addition, the SSEF-owned samples were analysed by laser ablation inductively coupled plasma time-of-flight mass spectrometry (LA-ICP-TOF-MS) using SSEF's GemTOF system. This instrumentation includes a 193 nm ArF excimer laser coupled with a commercial ICP-TOF-MS unit (*icp*TOF from Tofwerk AG). We analysed three spots (100 µm in diameter) on visually inclusion-free areas of each sample. All spots were ablated at 20 Hz with a fluence of 5.6 J/cm^2. Helium was used as the carrier gas (0.8–0.9 L/min). Since we had no matrix-matched phosphate standard, we used NIST SRM 612 glass as the external standard and normalised the data internally on the sum of Mn and Fe (40.21 wt.%, based on ideal stoichiometry). Further details about instrumental parameters, analytical conditions, data processing and plotting can be found in Wang *et al.* (2016) and Wang and Krzemnicki (2021).

RESULTS AND DISCUSSION

Visual Appearance and Inclusions

The samples from Nigeria were characterised by saturated orangey pink to orange colours (Figures 1 and 2). The colouration of the two large client stones (12.0 and 16.0 ct) was effectively supported by well-proportioned cutting styles that resulted in multiple internal reflections. The sizes of those samples indicate the occurrence of rather large and thick crystals. By contrast, väyrynenite from Himalayan sources has typically been found as relatively small and flat crystal fragments, with only rare reports of faceted orangey pink stones of around 2 ct (Kammerling 1994; Laurs 2011; Bradshaw 2020).

Figure 3: A partially healed fissure composed of thready fluid inclusions is seen in this väyrynenite reportedly from Nigeria. The doubling effect is a result of the distinct birefringence of this mineral. Photomicrograph by M. S. Krzemnicki; magnified 50×.

The Nigerian samples investigated for this study were mostly of excellent clarity, with only a few partially healed fissures occurring as partly irregular, thready, fluid-filled tubes resembling so-called trichites in tourmaline (Figure 3). By contrast, the samples we examined from Pakistan contained numerous partially healed fissures ('fingerprints') and hollow channels parallel to the *c*-axis, as described previously (Laurs & Fritz 2006a, b; Zwaan 2016).

Gemmological Properties and Spectroscopic Analyses

The gemmological properties of the Nigerian samples were consistent with previously reported data for väyrynenite (Mrose & von Knorring 1959; Meixner & Paar 1976; Kammerling 1994; Anthony *et al.* 2005), with RIs = 1.640–1.663, a distinct birefringence of 0.023 (biaxial negative) and SG = 3.23–3.25. The RI and SG values of the Pakistani material we tested (and from the literature) overlapped with the data obtained from the Nigerian samples in this study. All investigated specimens (Nigeria and Pakistan) remained inert when exposed to long- and short-wave UV radiation. Distinct trichroism was seen as pink, pinkish orange and yellowish orange pleochroic colours, especially for the larger Nigerian stones (e.g. Figure 4).

This pleochroism was also evident as differences in polarised UV-Vis-NIR absorption spectra (Figure 5), which were dominated by sharp Mn-related peaks and bands in the UV-to-visible range of the spectrum, along with complex, possibly combined Mn- and Fe-related bands mainly in the 400–600 nm range, as inferred from various references describing Mn- and/

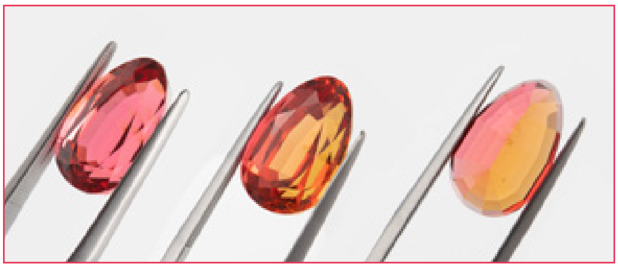

Figure 4: Distinct pleochroism typical of väyrynenite is visible in the 12.0 ct sample upon rotation of the stone in plane-polarised light. Composite photo by L. Phan, SSEF; digitally arranged by M. S. Krzemnicki.

or Fe-related absorption bands in väyrynenite and other minerals, or in solution (Jørgensen *et al*. 1954; Manning 1967; Taran *et al*. 2023; Xu *et al*. 2025). The sharp bands at 308, 319 and 328 nm mentioned by Tao (2025) were also found in our samples from Nigeria and Pakistan.

Raman spectra taken in two perpendicular orientations (E||c and E⊥c) showed distinct anisotropy of the vibrational peaks (Figure 6a). This anisotropy effect was also evident in the intensity of the peak at 3214 cm^{-1} (related to OH; Frost *et al*. 2014), which was much stronger in the spectrum obtained with the laser polarisation parallel to the *c*-axis than perpendicular to it (Figure 6b).

Chemical Analyses

EDXRF spectroscopy yielded the same Fe/Mn trend as the GemTOF analyses (see below), but since we used a general EDXRF analytical routine (we do not have one for phosphates), the data were semi-quantitative at best, and therefore are not included in this article.

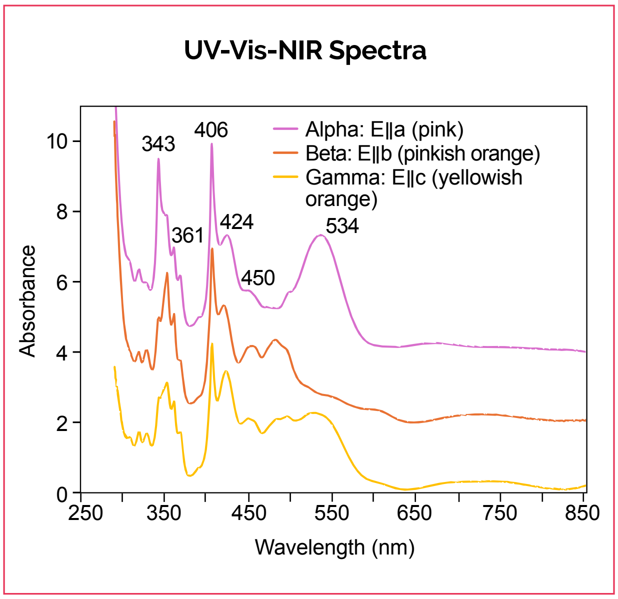

Figure 5: Polarised UV-Vis-NIR spectra of väyrynenite reportedly from Nigeria illustrate the effects of the pleochroic colours: pink, pinkish orange and yellowish orange. Positions are labelled for the peaks and bands attributed to Mn^{2+}. The complex bands between 400 and 600 nm mainly visible in the beta and gamma orientations may be related to a combination of Fe and Mn absorption bands. The spectra have been offset vertically for clarity.

In addition to their main constituents (Mn, P and Be), all the väyrynenite samples contained significant amounts of Fe and various trace elements (Table II). Interestingly, the Nigerian samples proved to be very homogeneous, even in their trace-element content, while our samples from Pakistan revealed greater variability, especially in their REE and Y concentrations.

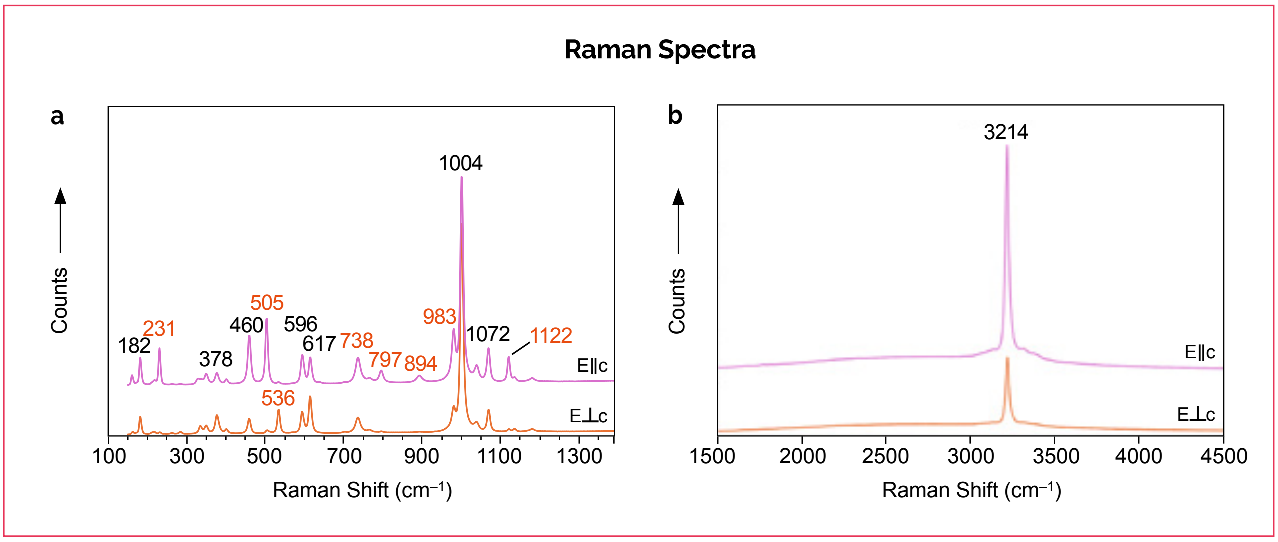

Figure 6: Raman spectra of väyrynenite reportedly from Nigeria obtained in two perpendicular directions (E||c and E⊥c) show distinct differences in peak intensity. (**a**) In the 100–1400 cm^{-1} range, the peaks labelled in red are related to the anisotropy effect. (**b**) The OH-related peak at 3214 cm^{-1} also displays strong differences in intensity (normalised to the 1004 cm^{-1} peak) due to the anisotropy of väyrynenite. The spectra have been offset vertically for clarity.

Table II: Chemical composition of the väyrynenite samples from Nigeria and Pakistan measured by LA-ICP-TOF-MS.[a]

Locality	Nigeria					Pakistan				
Sample no.	789_A	789_B	789_C	790	791	750_A	750_B	750_C	750_D	750_E
Oxides (wt.%)										
BeO[b]	17.72	17.73	18.29	18.22	18.15	16.97	16.97	16.98	17.17	17.08
P_2O_5[b]	35.02	34.57	34.05	33.83	34.57	38.85	36.83	38.78	38.33	36.48
MnO	34.63	35.29	35.16	35.45	35.95	38.00	37.32	37.53	37.62	37.73
FeO	5.58	4.92	5.05	4.76	4.26	2.21	2.89	2.68	2.59	2.48
Trace elements (ppmw)										
Mg	90.97	84.14	92.55	197.2	125.0	48.20	102.9	57.27	55.42	57.39
Ca	572.5	457.3	399.2	229.8	565.3	415.6	248.8	314.4	217.1	428.9
Sc	bdl	0.13	bdl	2.84	0.25	12.25	6.74	17.84	6.88	10.57
Ti	30.40	31.59	30.73	29.57	31.05	32.30	31.56	32.45	32.41	30.91
Zn	24.20	26.46	28.62	23.16	66.47	0.28	0.62	0.16	0.14	bdl
Ge	8.20	6.93	6.14	9.92	7.04	17.36	10.22	9.78	9.01	22.71
Sr	0.42	0.35	0.29	0.48	0.36	0.87	0.55	0.48	0.46	1.08
Y	bdl	bdl	bdl	0.01	bdl	13.92	0.96	40.68	0.68	2.20
Mo	0.79	0.79	0.72	0.75	0.77	0.95	0.87	0.86	0.87	0.82
Cd	2.01	2.27	2.27	2.19	10.52	bdl	0.05	bdl	bdl	bdl
REE	bdl	bdl	bdl	bdl	bdl	5.36	0.56	15.26	0.21	0.46

[a] The data consist of average values of three analyses per sample. Abbreviation: bdl = below detection limit.

[b] Be and P deviate about 5–20% from the ideal formula due to the non-matrix-matched standard (NIST SRM 612 glass) used for the GemTOF analyses.

The samples from Nigeria showed distinct chemical differences from our Pakistani material. Notably, the Nigerian specimens contained significantly more Fe (4.26–5.58 wt.% FeO) compared to our Pakistani samples (2.21–2.89 wt.% FeO). The lower Fe content of the latter is consistent with what has been reported in the literature for väyrynenite from the Chitral region of Pakistan (Anthony *et al.* 2005; Frost *et al.* 2014). Also of note was a distinct difference in Zn content in our samples from the two localities. Those from Nigeria had 23.16–66.47 ppm Zn, while in our Pakistani material Zn ranged from below the detection limit to only 0.62 ppm. A plot of Fe vs Zn contents shows a clear separation for the two localities (Figure 7).

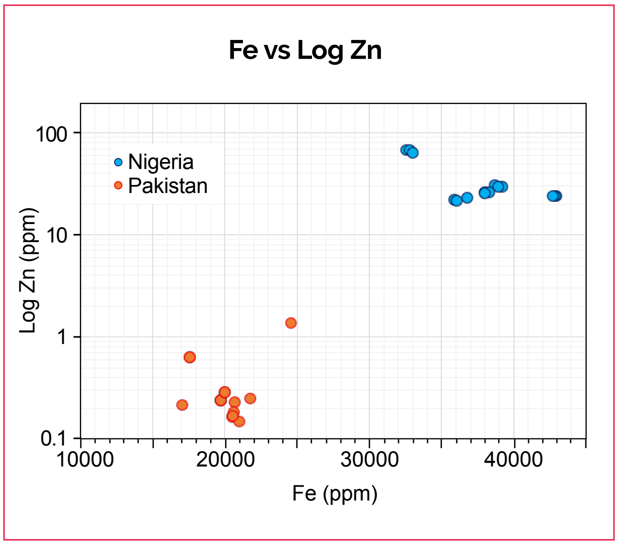

Figure 7: A bivariate scatterplot of Fe vs log Zn in our väyrynenite samples reveals a clear separation into two groups related to their geographic provenance.

Our väyrynenite samples from Nigeria and Pakistan can also be distinguished by their Sc, Y and REE contents (see Table II), with elevated traces in our Pakistani stones and amounts that were mostly below the detection limits in the Nigerian samples (about 0.8 ppmw for Sc, and about 0.05 ppmw for Y and REE).

CONCLUSIONS

The recent discovery of väyrynenite of exceptional quality (e.g. Figure 8) from Nigeria has created interest within the gem trade and among rare-stone collectors. A comparison of this väyrynenite with material from

Figure 8: These väyrynenite gemstones reportedly from Nigeria weigh (**a**) 1.25 ct and (**b**) 3.42 ct. Courtesy of Mark Smith, Thai Lanka Trading.

Pakistan showed overlapping gemmological properties (except for the generally more-included nature of the Pakistani material), and UV-Vis-NIR and Raman spectroscopy of our Nigerian samples recorded features consistent with those reported for väyrynenite in the literature. Chemical data revealed distinct differences between the Nigerian and Pakistani samples analysed for this study, particularly in their Fe, Zn, Sc, Y and REE contents, making it possible to separate our specimens originating from either source.

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