JEREMEJEVITE

A description of a 400 crystal collection from Namibia and a preliminary study of five color types

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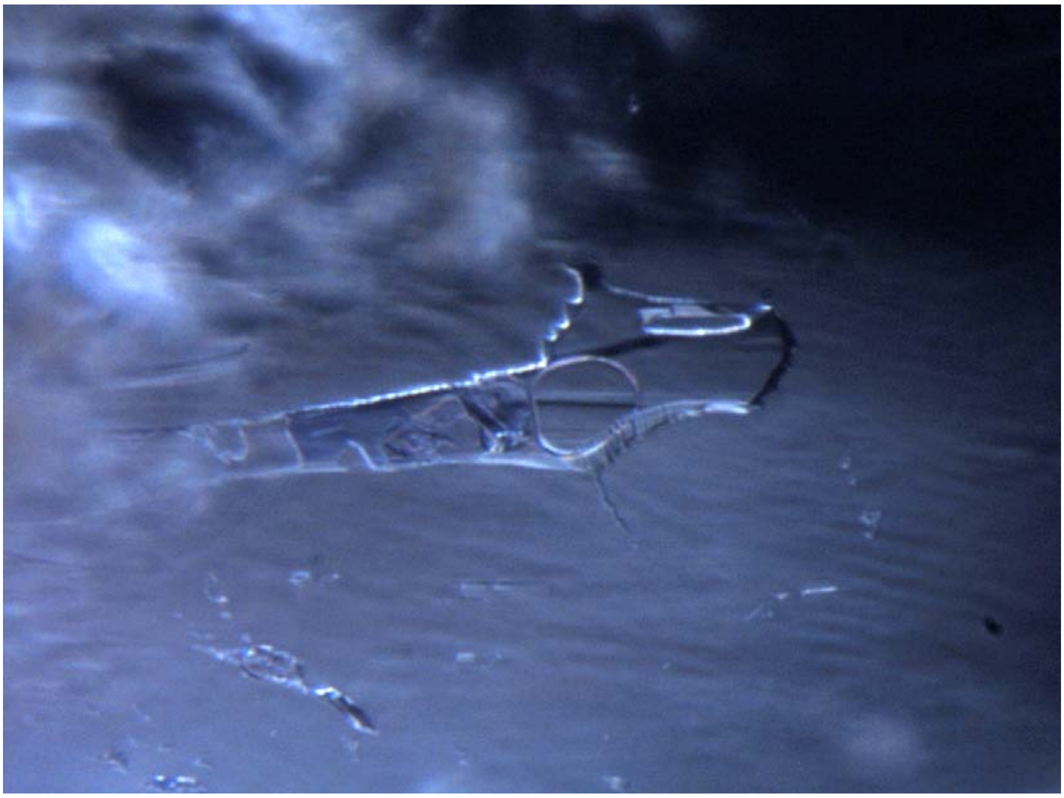


Figure 1: A clear multi-phase inclusion in jeremejevite. Magnified 128x. *Photo ©GIA*

Abstract

Jeremejevite is considered a gemological rarity and is therefore hardly ever encountered by the public in the market. Reports issued in the gemological literature to date have focused more on faceted examples, with only brief accounts of rough material being available to collectors and gemologists. Mr. Randy Price of www.jeremejevite.net recently acquired a unique collection of 400 crystals and brought them into GIA Laboratory, Bangkok. He then allowed them to remain in the laboratory for research purposes. This report gives an overview of the collection and reports on an initial five selected samples. The project is on-going with data being recorded and eventually reported on for further specimens in the collection (Figure 2 and page 13).

Figure 2: One of several boxes containing Randy Prices's jeremejevite collection. *Photo ©GIA*

Introduction

Jeremejevite (*The name honors the mineralogist and crystallographer Pavel Vladimirovich Eremeev (Jeremejev in German) (1830–1899) who first recognized this species*) is a borate mineral with the reported chemical composition $Al_6[(F, OH)_3(BO_3)_5]$ (mindat.org). It has been described in the gemological literature on previous occasions, e.g., (Scarratt, 2001). The color of specimens reported previously tend to be blue in varying tones and saturations, although they mostly appear to be light to mid tones and of moderate saturation. Colorless and yellow material have also been encountered (Scarratt, 2001). Crystals are often euhedral and usually form in small sizes which mean that large faceted examples are rare.

The likely source of the crystals was reported as being Namibia. The project at Mile 72 (72 miles north of the coastal city of Swakopmund in Namibia) produced many 'straw' yellow specimens (Johnstone, 2002), however most of the crystals in the loaned group were blue.

For this initial study five crystals were selected from the group of 400; the selection being made to encompass the observed color range, which spanned near-colorless to blue through to a more violet hue (Figure 3). Such a diverse color range being most likely to provide a representative set of results. Since the samples were crystals (unfashioned) the refractometer was limited in its use to obtain accurate refractive indices or indications of optical character. Other gemological tests such as examination with a hand-held spectroscope, use of a balance with a hydrostatic weighing accessory, exposure to long-wave (LW) and short-wave (SW) ultra-violet light and observation with a dichroscope were all conducted. However, the main focus of the examination is on the data obtained from analyses using ultra-violet visible and near-infrared *(UV-Vis-NIR*), energy dispersive x-ray fluorescence *(EDXRF)*, fourier-transform infrared (*FTIR)* and Raman spectroscopy.

The crystals

Jeremejevite belongs to the hexagonal crystal system and all the five selected crystals (Figure 3) exhibited good acicular-like forms with hexagonal cross-sections and prism faces clearly visible. Two of the five crystals exhibited clear single pyramidal terminations and the colorless specimen exhibited a very irregular 'mountain-peak' termination reminiscent of many spodumene crystals. The basal pinacoids showed fractured surfaces and no indications of any cleavage plane perpendicular to the C-axis. Elongated irregular etch pits and marks were evident on at least two of the prism faces of each crystal, and iron staining was also evident in many of the surface reaching inclusions and/or surface features, especially those around the area of the basal pinacoid of sample number 63. Two of the crystals also possessed smaller crystals in parallel growth. The largest crystal weighed 3.69 carats (No. 56) and the smallest 1.85 carats (No. 55) (Figure 3).

Figure 3: Five crystals selected for examination in this preliminary study. From left to right samples 39, 56, 55, 63 and 145: *Photo ©GIA*

Routine gemological properties

The refractive index readings obtained were not accurate given the unfashioned nature of the samples, approximated RI's (direct when possible and distant vision) all fell within the 1.63 to 1.65 region and all appeared to be uniaxial and negative in sign. The results obtained using standard gemological equipment are shown in Table 1.

An interesting aspect of jeremejevite is that it may be anomalously biaxial in sector-zoned crystals. Given the size of this collection, the opportunity to examine this phenomenon is realized and planned.

Table 1: Basic gemological data recorded for each sample

Sample #	39	55	56	63	145
SG	3.28	3.25	3.28	3.26	3.26
Spectroscope	Nothing diagnostic	Nothing diagnostic	Nothing diagnostic	Nothing diagnostic	Nothing diagnostic
Dichroscope	Very strong violet and colorless	Very strong blue and colorless	Weak blue and colorless (basal area)	Very strong blue and colorless	None observed
LW & SW	Inert	Inert	Inert	Inert	Inert
CCF[1]	Moderate pink	Moderate pink	Weak pink	Moderate pink	No reaction
Inclusions - (Figure 10 Figure 17)	Fingerprints, multi-phase, fissure, some surface etch pits & striations, growth features.	Fingerprints, fluid-filled planes and fingerprints, multi-phase, internal growth zones, surface etch pits and iron staining.	Quite clean, a few fingerprints, fine needles. Fluid fingerprints running in the junction plane of the main crystal and parallel crystal.	Fingerprints, fluid-filled fingerprints, fine acicular inclusions (needles), distinct color zoning/growth zoning. Surface etch marks/features and heavy iron staining within surface reaching features were very evident.	Minor fingerprints, very few small needles, etch marks and other surface growth features. Also present are some external associated crystals identified as tourmaline.

UV-Vis Spectroscopy

All the samples were analyzed using a Perkin-Elmer Lambda 950 UV/Vis/NIR Spectrometer with a polarizing filters accessory to separate the ordinary and extraordinary rays. Spectra obtained perpendicular to the optic axis (C-axis) provided the greatest range of variance as can be seen in Figure 4, with the colorless sample (purple trace) producing a flat spectrum in the visible region, as would be expected for a colorless material, before absorbing in the UV region which is also a recurring feature of all the other four samples. The blue and pink traces on the other hand each show that the sample absorbs in the green spectral region, with a center of absorption around (600 nm) and hence the color of these specimens appears blue. However, the dark blue trace shows a slightly different absorption band with the center (566 nm) offset to the two previous traces and this shift towards the blue together with a stronger absorption in the UV region contribute towards the stones more violet hue. The spectra obtained parallel to the optic axis show little in the way of any spectral features (Figure 5). Since the latter direction appears distinctly near-

[1] Chelsea Colour Filter

colorless to colorless when the crystals are viewed down their length this is entirely consistent with the results expected.

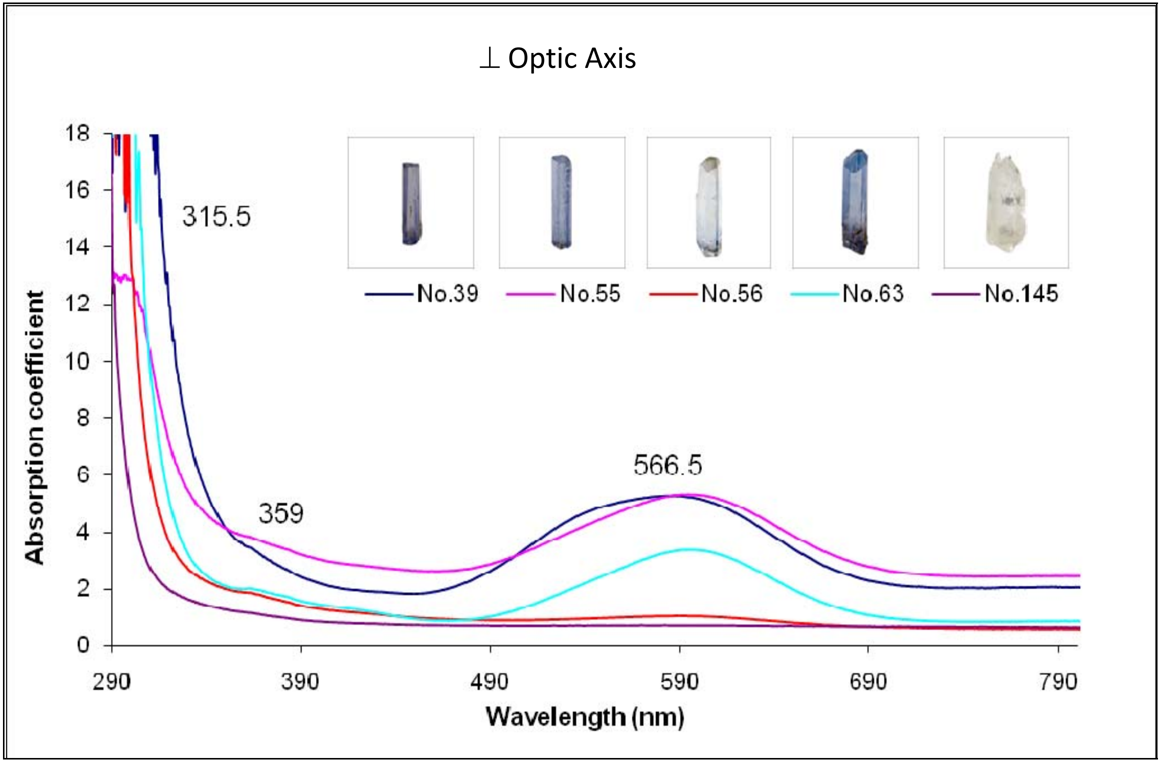


Figure 4: The UV-Visible spectra, of five jeremejevite samples, perpendicular to the C-axis.

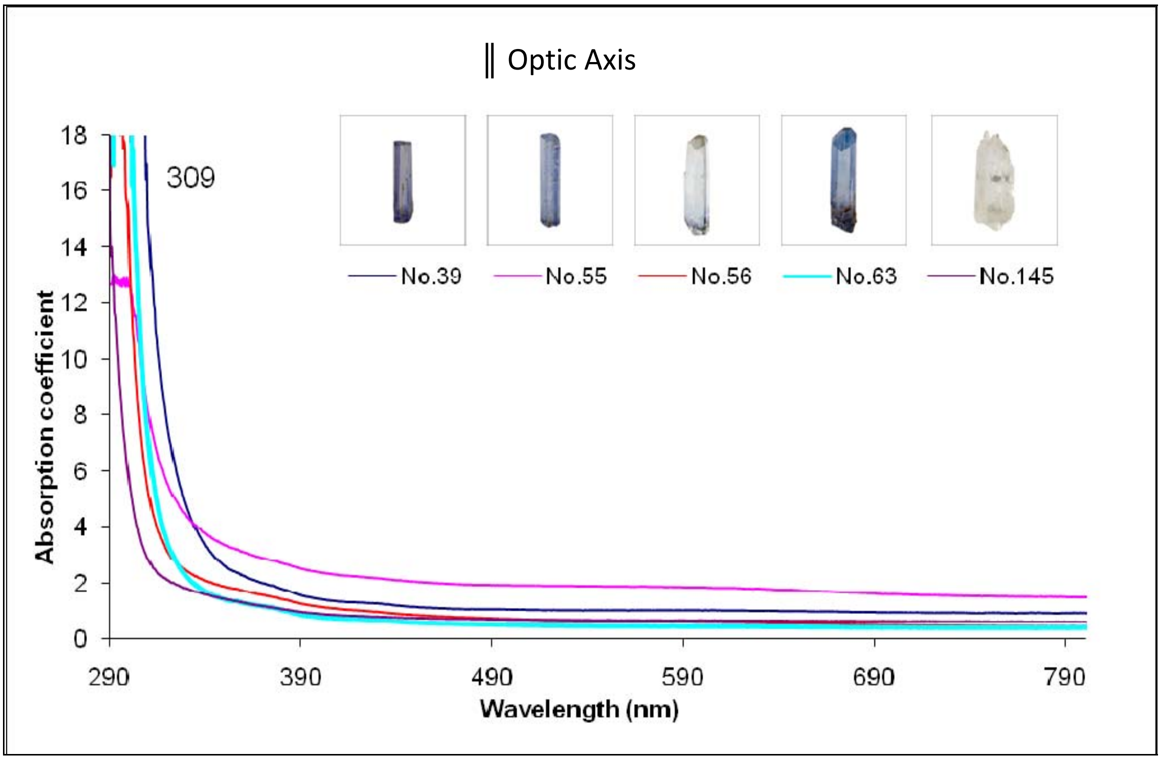


Figure 5: UV-Visible spectra of five jeremejevite samples taken parallel to the C-axis.

Infra-red spectroscopy

The infra-red spectra (Figure 6) recorded for the five samples were obtained using a Thermo Scientific Nicolet 6700 Spectrometer with a 6x Beam Condenser accessory. Basic parameters were 500 scans at 4 cm-1 resolution in absorbance mode within the range 3000 – 5500 $^{cm-1}$. The beam condenser accessory was chosen because the samples were transparent and had parallel faces that allowed clear signals to be acquired by the spectrometer's detector. All the samples exhibited near identical spectra with prominent peaks in the 3600 $^{cm-1}$ area and smaller features in the area of ~ 3200, 4400 and 4650 $^{cm-1}$(Figure 6).

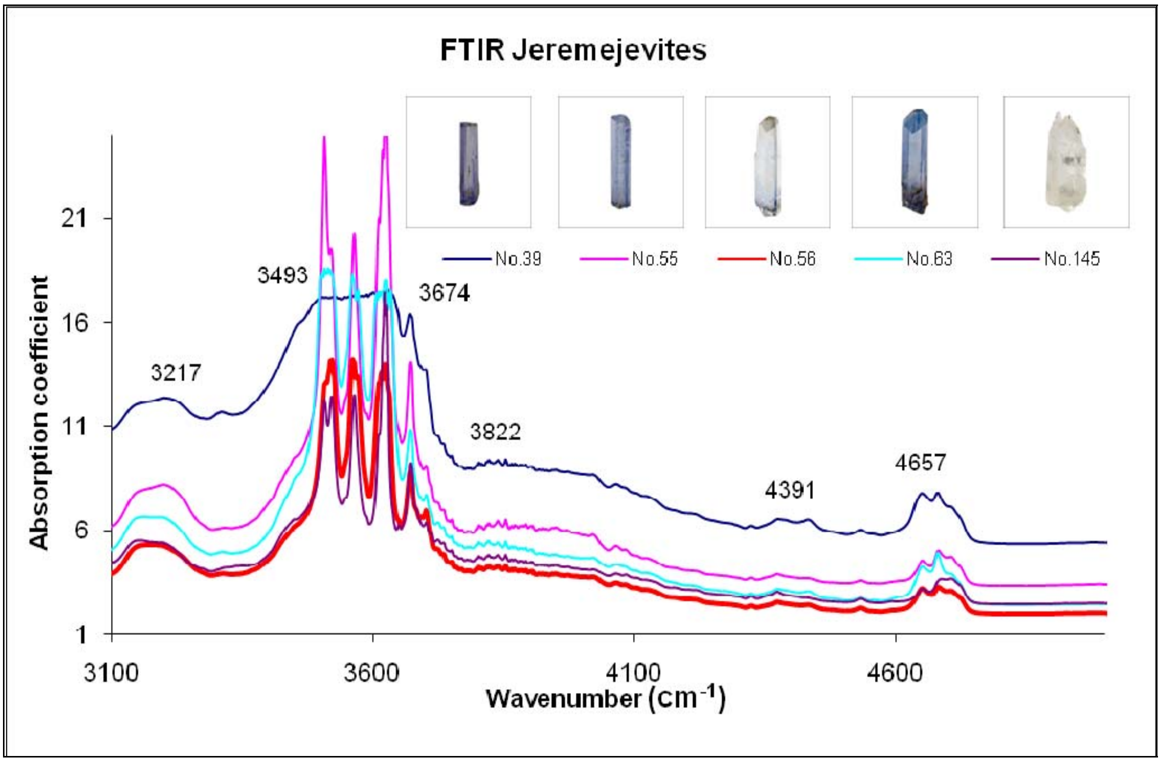


Figure 6: Consistent infrared absorbance spectra were obtained from all five samples of jeremejevite.

Chemistry

In order to record the chemistry of each sample an ARL QUANT'X Energy Dispersive X-ray Fluorescence (EDXRF) Spectrometer manufactured by Thermo Fisher Scientific was used. Since the chemical composition of jeremejevite is recorded as $Al_6[(F, OH)_3(BO_3)_5]$ (mindat.org), it was no surprise to find that all the samples revealed high levels of Al. In addition, major trace elements of Fe, Si and Ga were also detected and minor trace levels of Cr and Zn were also noted, but the levels were not consistent. Of all the samples, it was sample number 39 with the more violet component that showed the highest Fe content. Since the light elements in the periodic table cannot be detected by the EDXRF method no measurements could be recorded for these elements. To detect the presence of lighter elements Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) would have to be applied; the need for this analysis is recognized and planned.

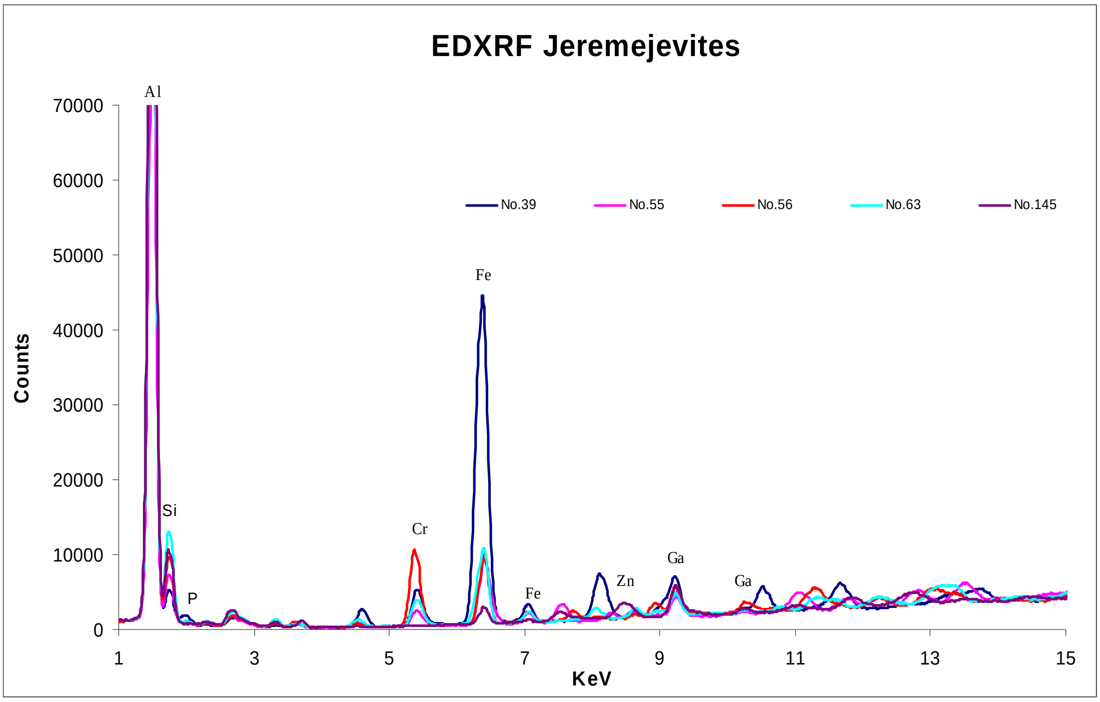


Figure 7: The main trace elements in the jeremejevite specimens examined thus far are; Al, Si, Fe, Ga, and the minor elements are Cr and Zn.

RAMAN

Using a Renishaw InVia Raman Microscope fitted with a 514 nm argon-ion laser the Raman spectra of the five samples were obtained. These matched the jeremejevite spectra in the various Raman libraries available to GIA laboratories. Each crystal was also analyzed in two orientations (on the basal pinacoid or opposite termination, and 90° to this direction on one of the prism faces), to see if there were any directional differences in the spectra obtained. On the whole the results showed that there was little difference in the spectra, with only slight variations in the peak intensities becoming apparent (Figure 8 and Figure 9). The stable position of peaks and subsequent differences in peak intensities on changing orientations of a sample is a common feature of Raman microscopy spectra.

The colorless crystal (No. 145) was unique amongst the samples examined because it possessed a group of small surface guest crystals with a slightly bluish-green tint to them. These crystals were subsequently identified as tourmaline by Raman spectroscopy.

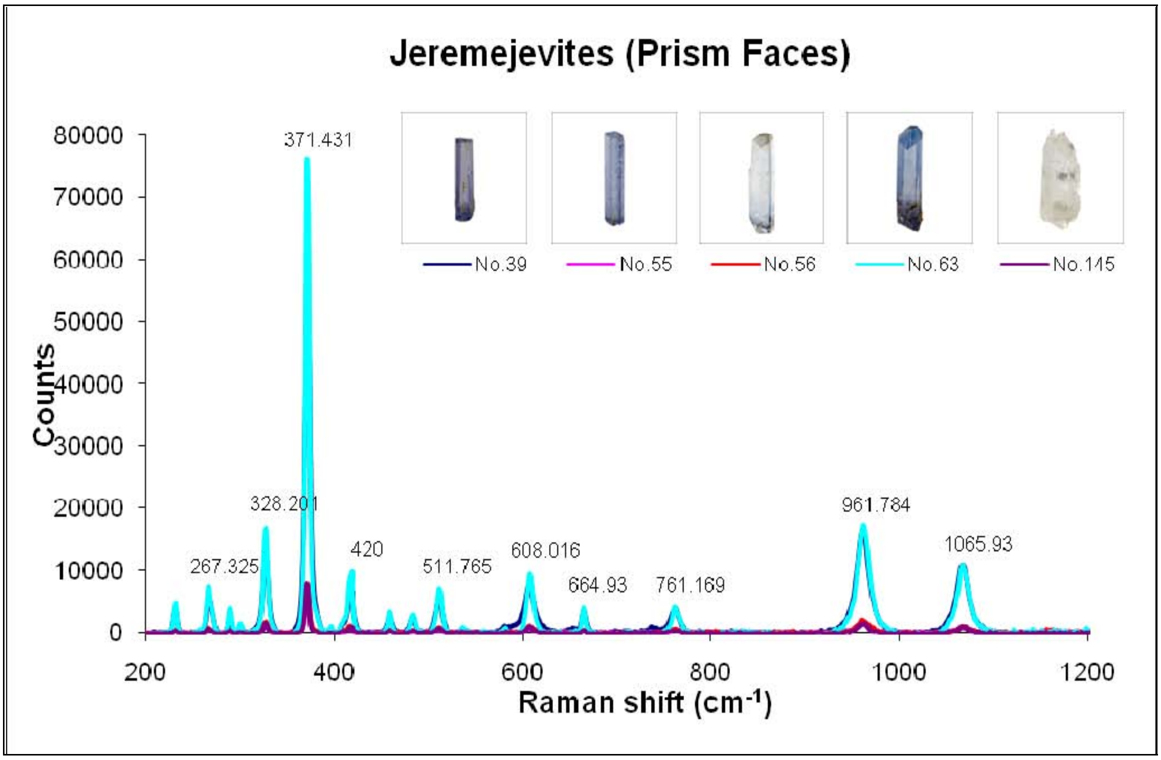


Figure 8: A diagnostic Raman spectrum for jeremejevite was obtained for all the crystals.

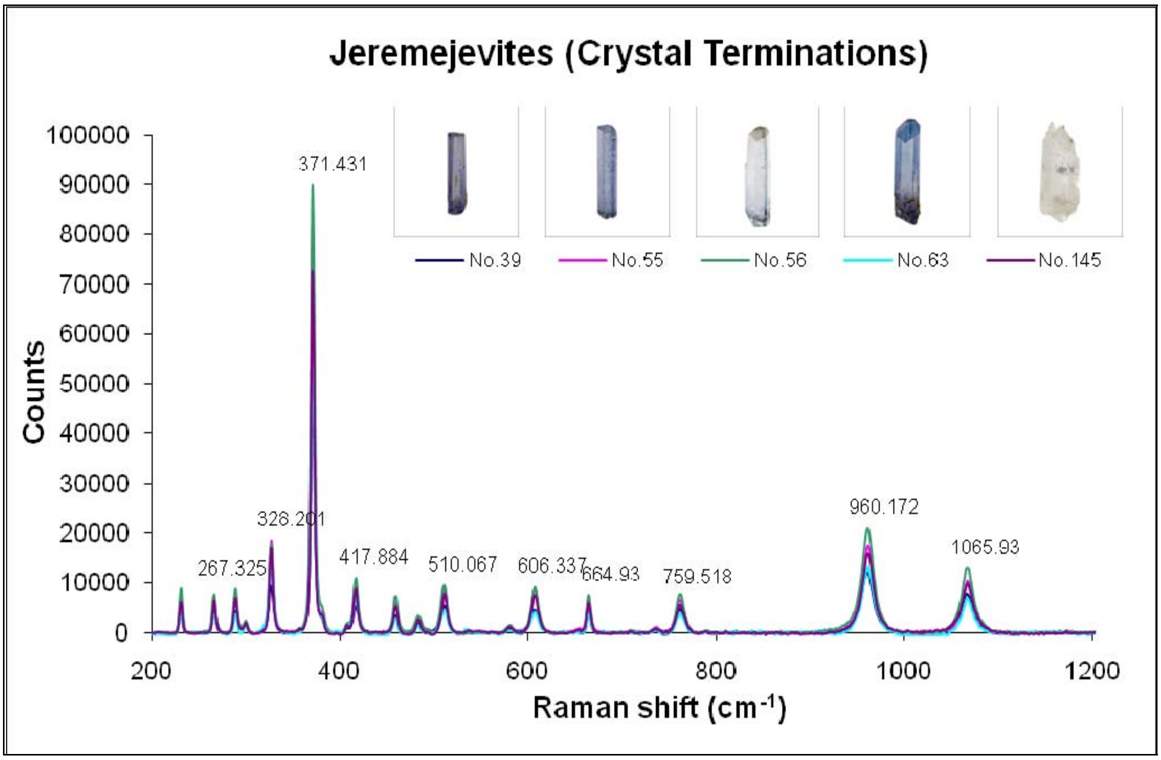


Figure 9: Little variation in the jeremejevite spectra was seen when the samples were examined in different orientations.

Inclusion Scene

As can be seen from the inclusion field for each stone in Table 1, the samples displayed a wide range of interesting internal features. These included "fingerprint" (healed fractures) inclusions in various forms that wound their way through the crystals creating a network of fine patterns. A close examination of the fingerprints revealed that they consisted of fluid-filled channels (Figure 13) or fine pinpoints that produced wonderfully artistic patterns (Figure 14) resembling the "zebra-stripes" sometimes seen in and associated with amethyst.

Many of the samples showed clear surface etch patterns and internal growth lines/zones. Crystal number 63 in particular exhibited some very clear colorless and light blue color zoning that resulted in interesting patterns. This was especially clear when using a diffused transmitted lighting.

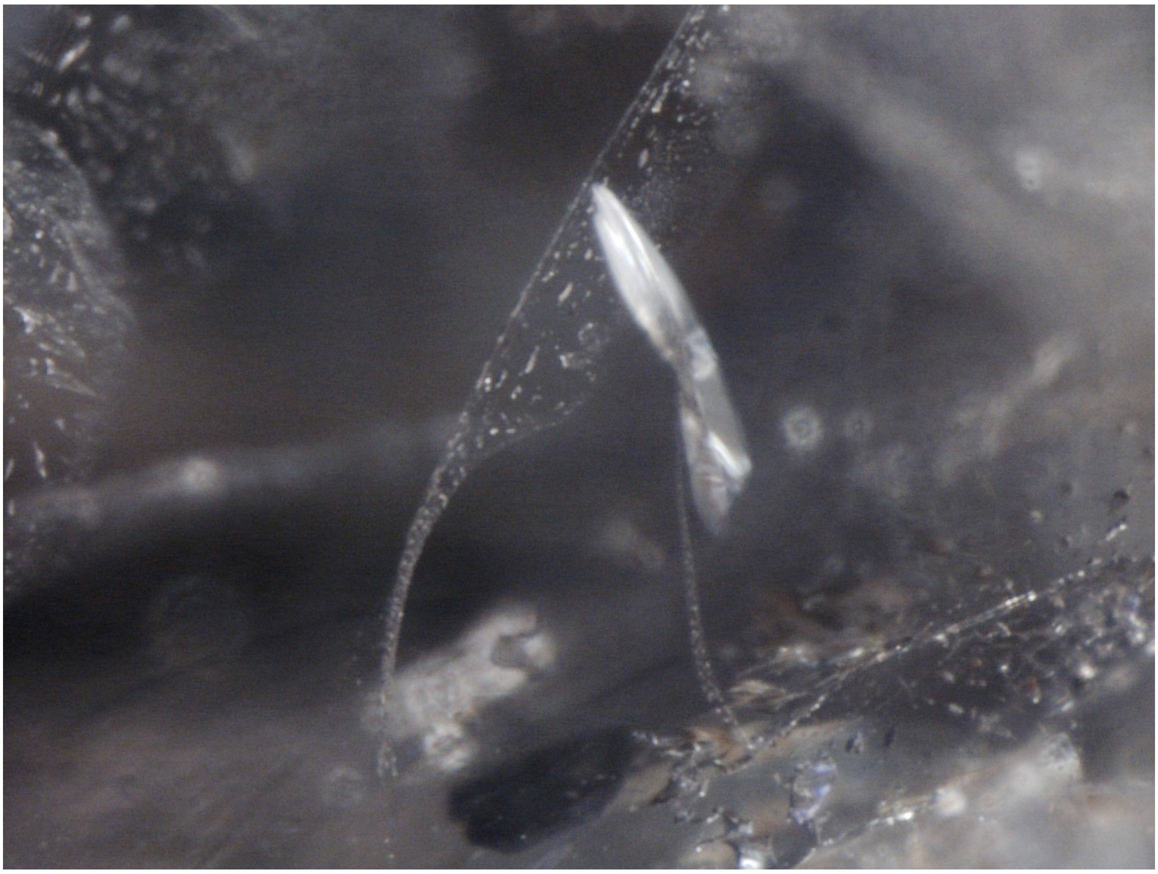


Figure 10: A fine fingerprint with a slightly curved outline in jeremejevite. Magnified 80x. *Photo ©GIA.*

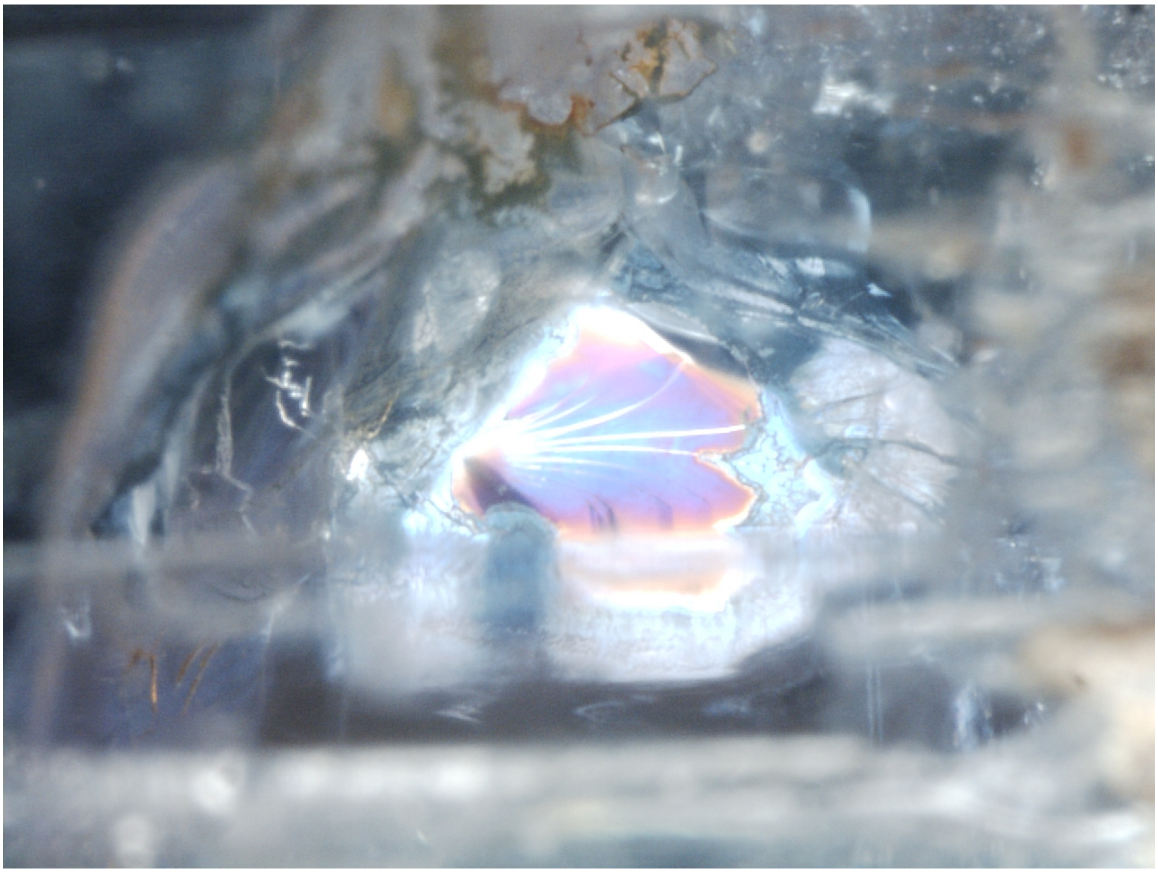


Figure 11: A highly iridescent fracture observed in jeremejevite using fiber-optic lighting. Magnified 60x. *Photo ©GIA.*

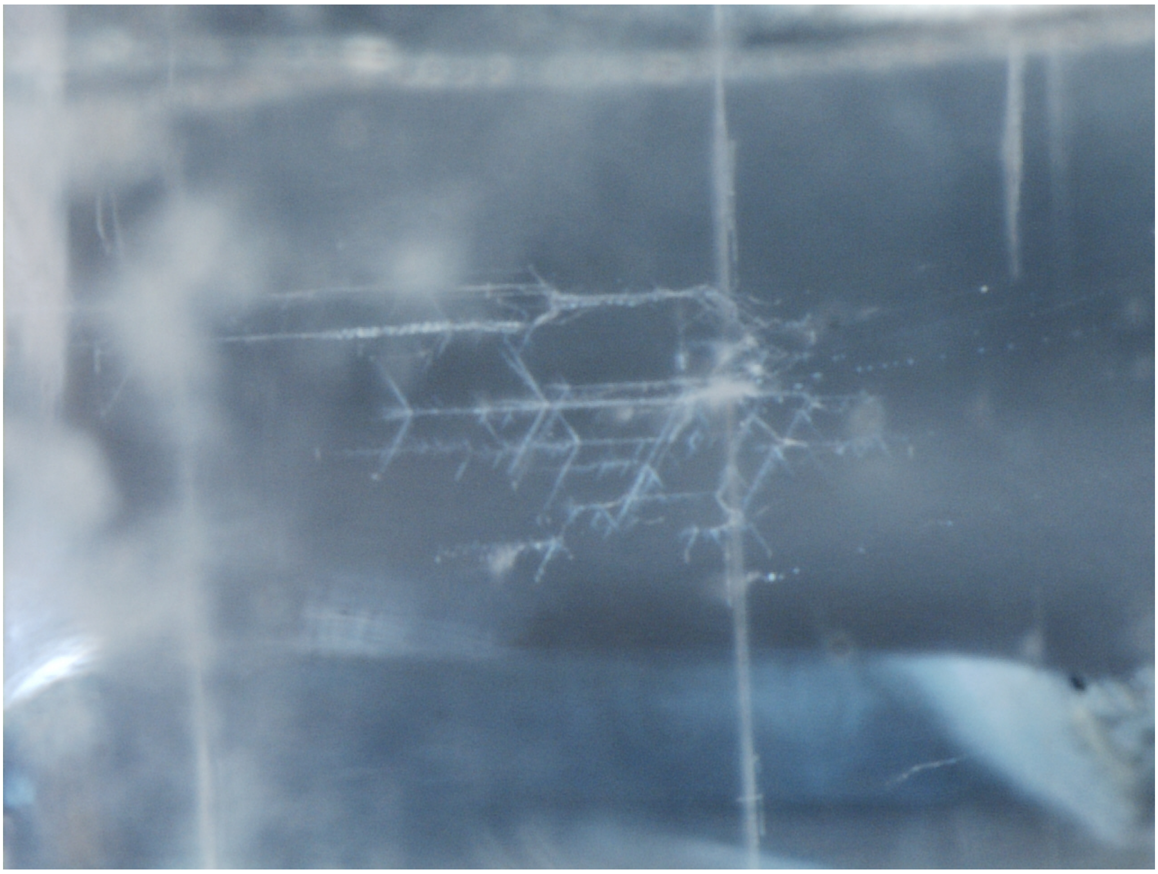


Figure 12: A network of fine needle-like inclusions forming a matrix-like pattern in jeremejevite. Magnified 110x. *Photo ©GIA.*

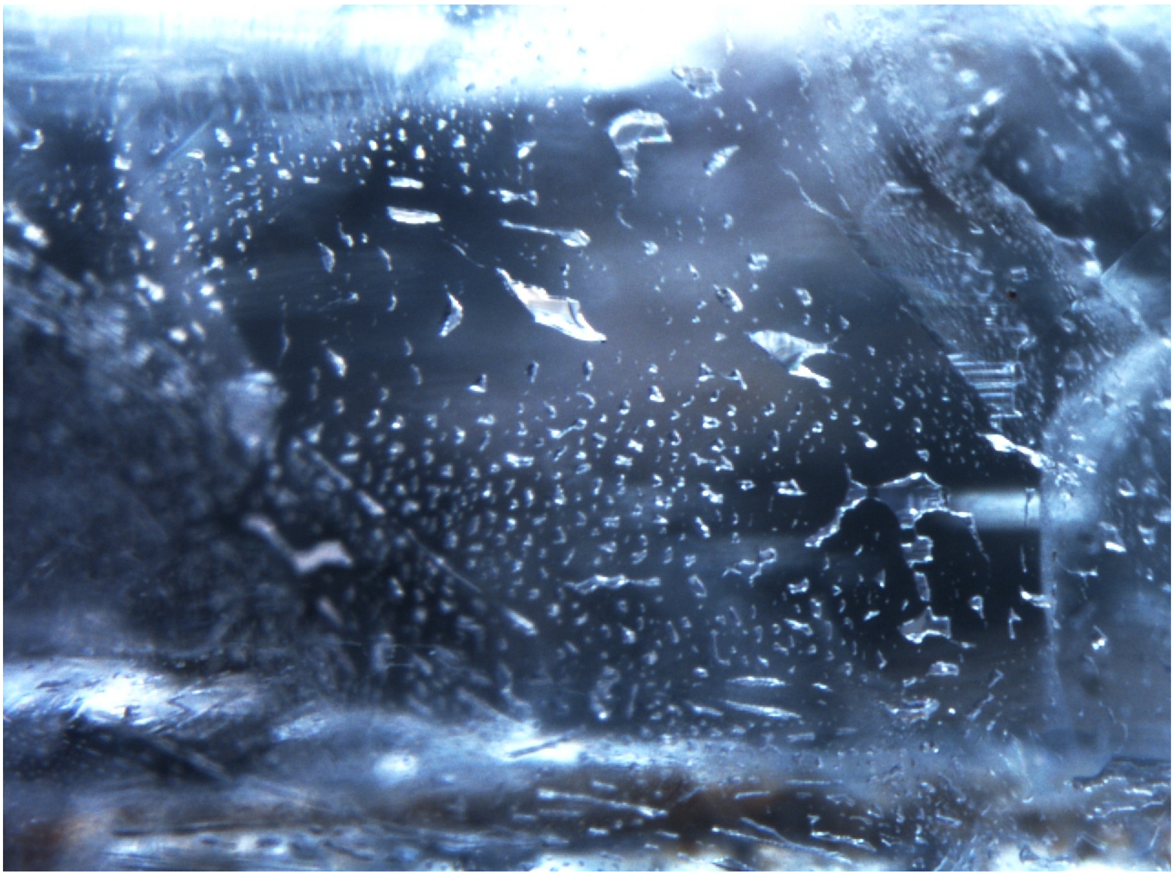


Figure 13: A fingerprint showing the fluid channels within its form in jeremejevite. Magnified 64x. *Photo ©GIA.*

Figure 14: Another fingerprint exhibiting a wonderful zebra-stripe pattern in jeremejevite. Magnified 90x. *Photo ©GIA.*

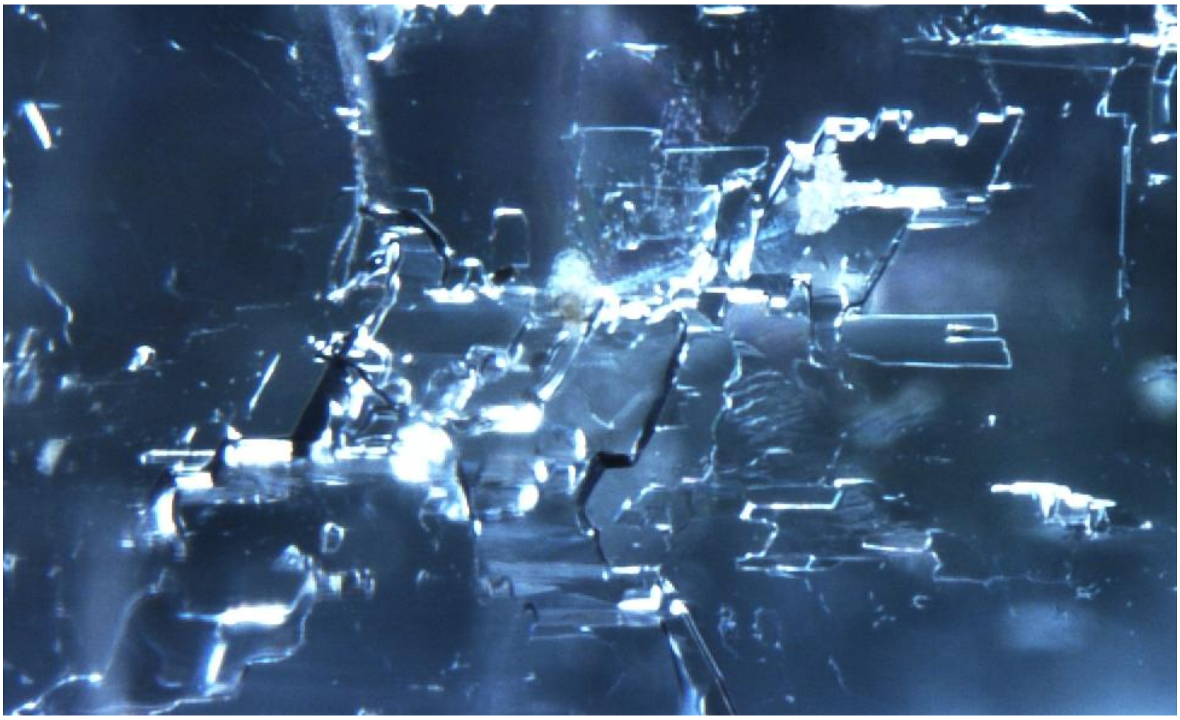


Figure 15: Fluid inclusions producing an interesting pattern in jeremejevite. Magnified 60x. *Photo ©GIA.*

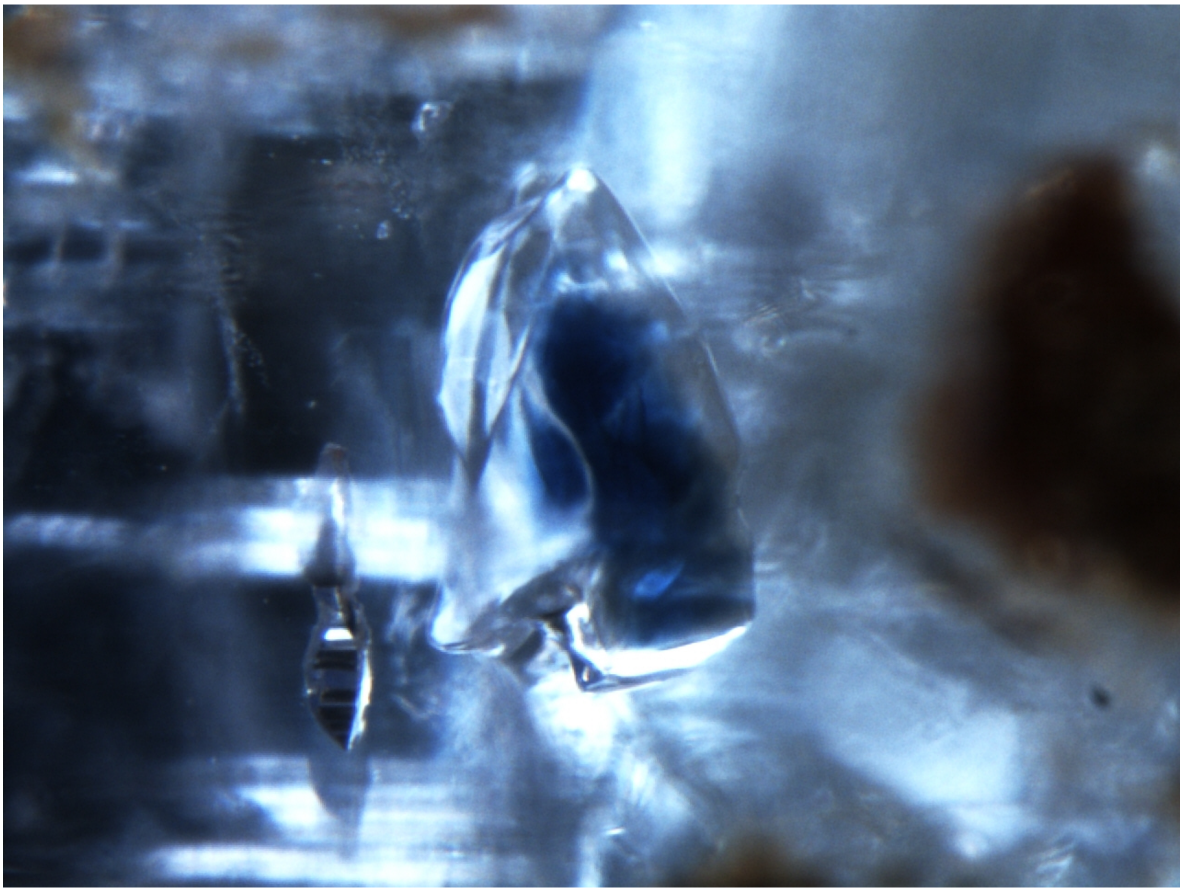


Figure 16: The blue internal coloration of this inclusion in jeremejevite stands out from its surroundings. Magnified 128x. *Photo ©GIA.*

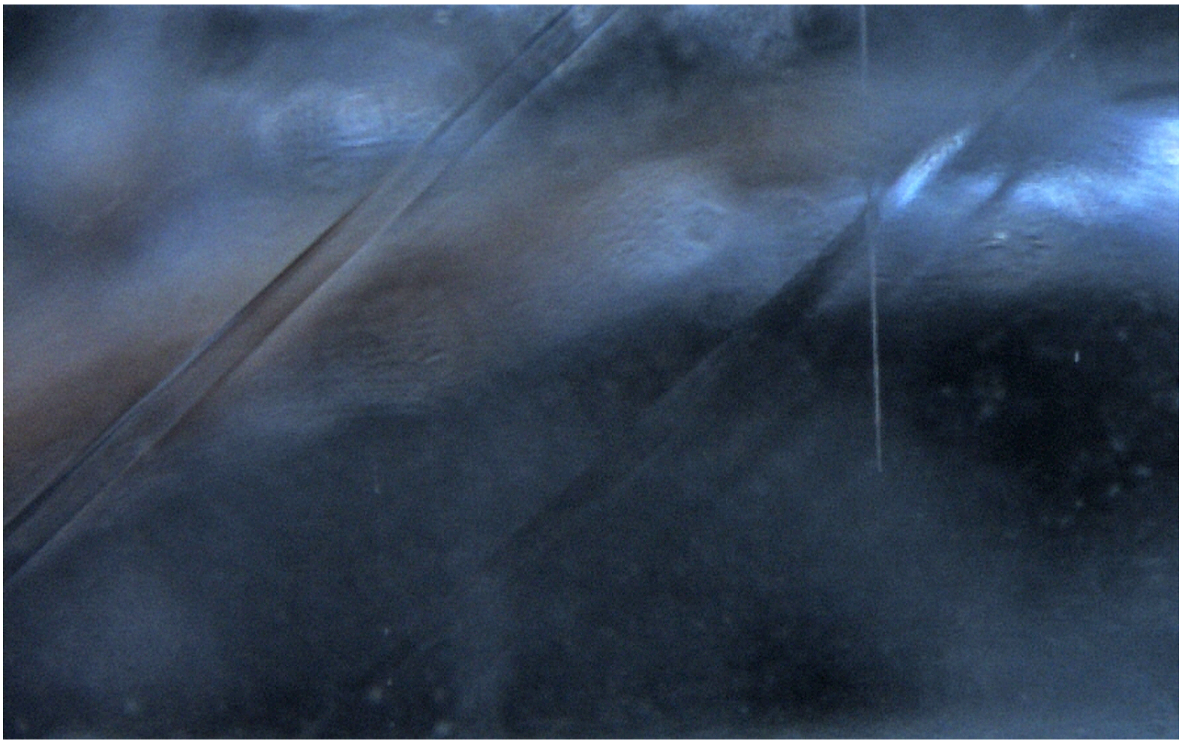
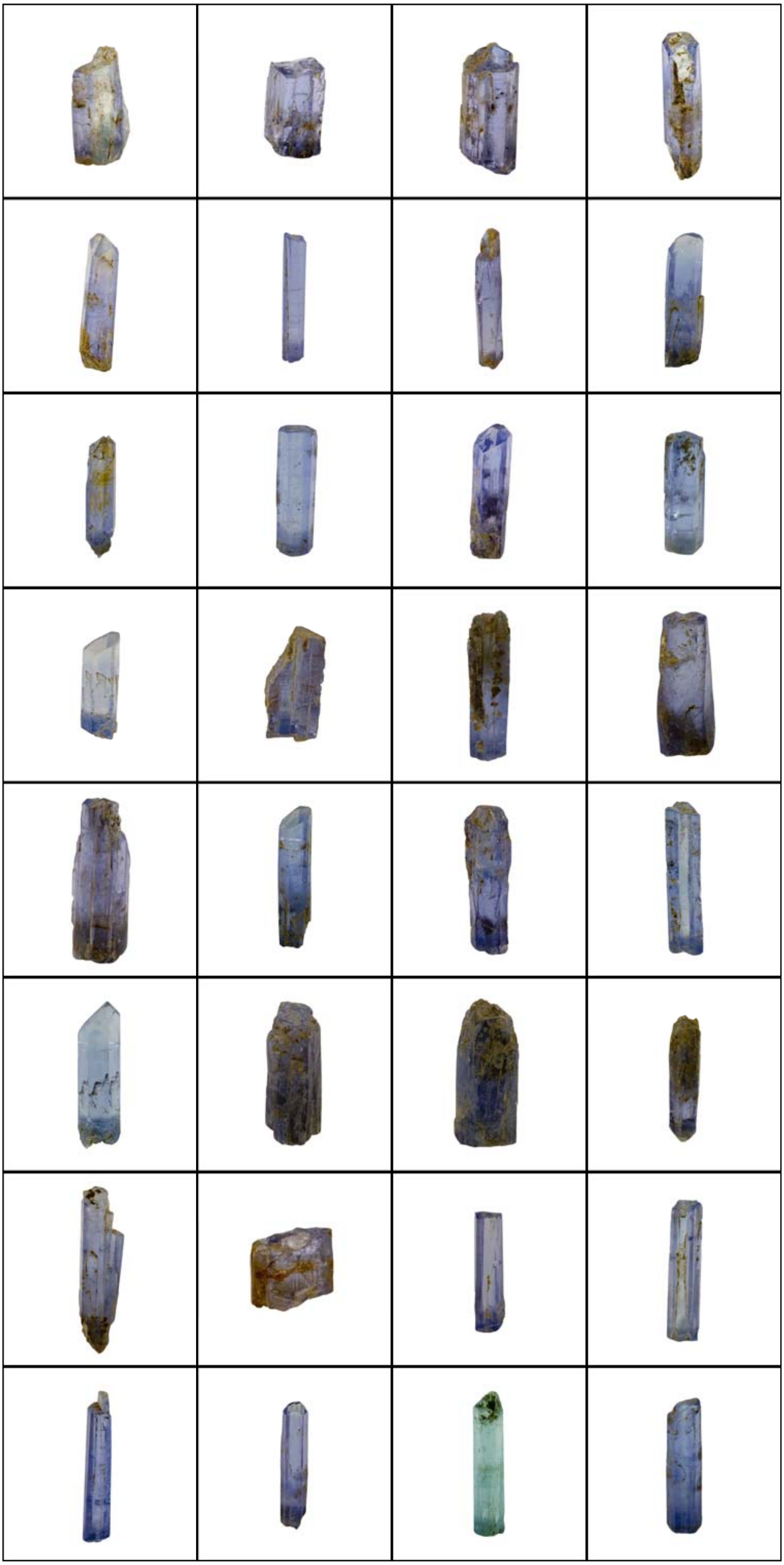
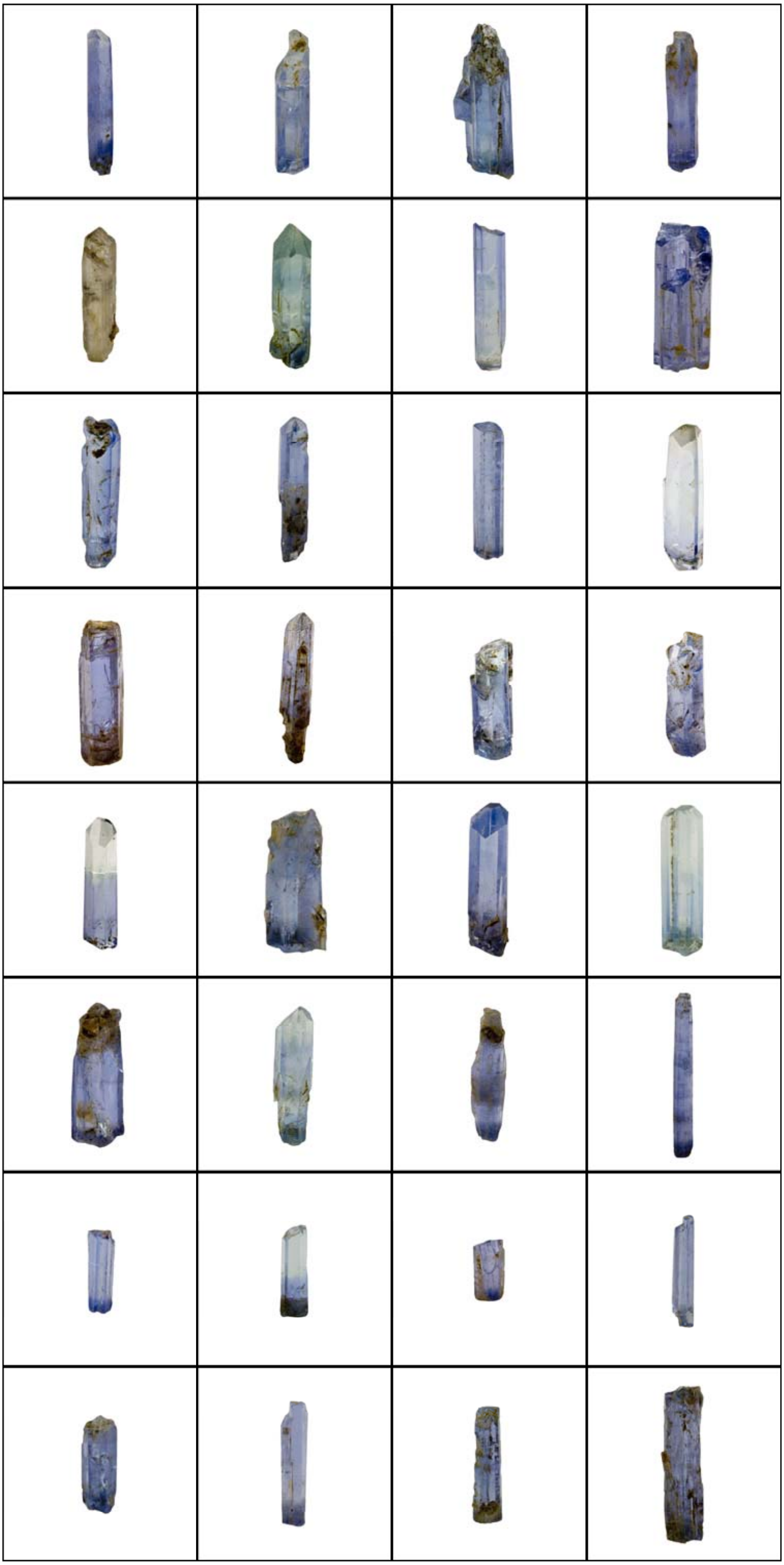


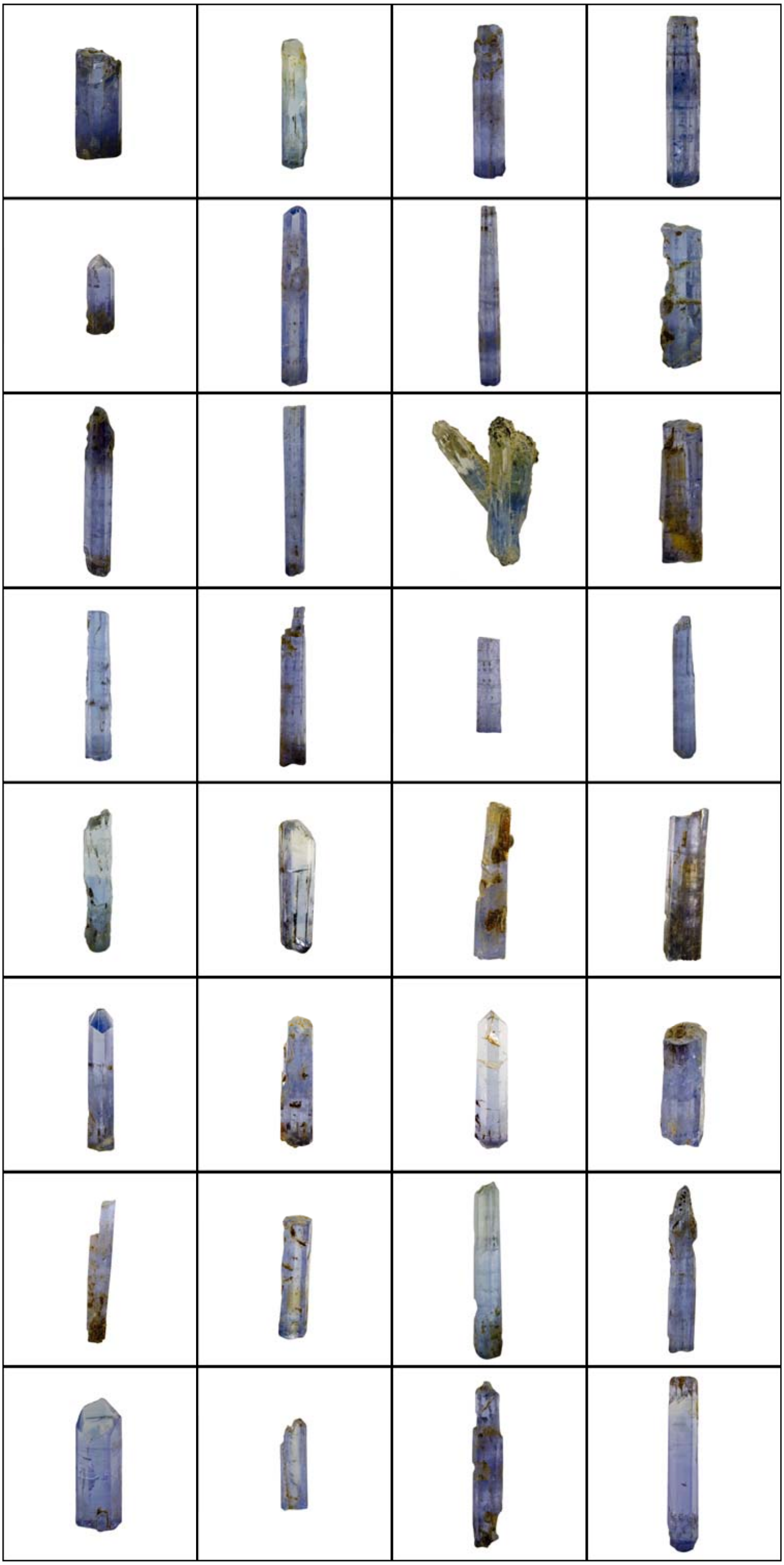
Figure 17: Growth lines/zones such as this were quite a common feature of the jeremejevite samples. Magnified 104x. *Photo ©GIA.*

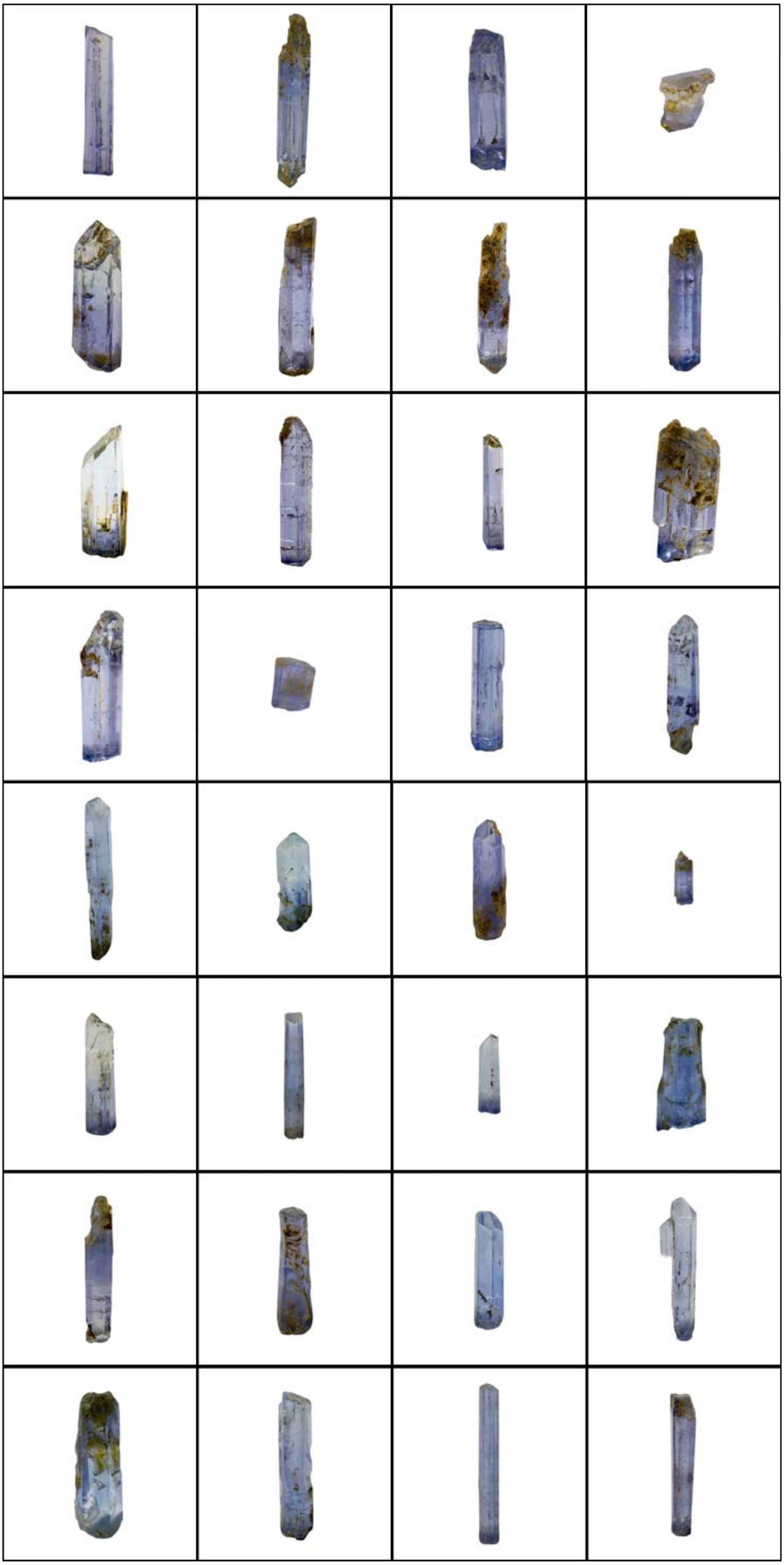
The collection

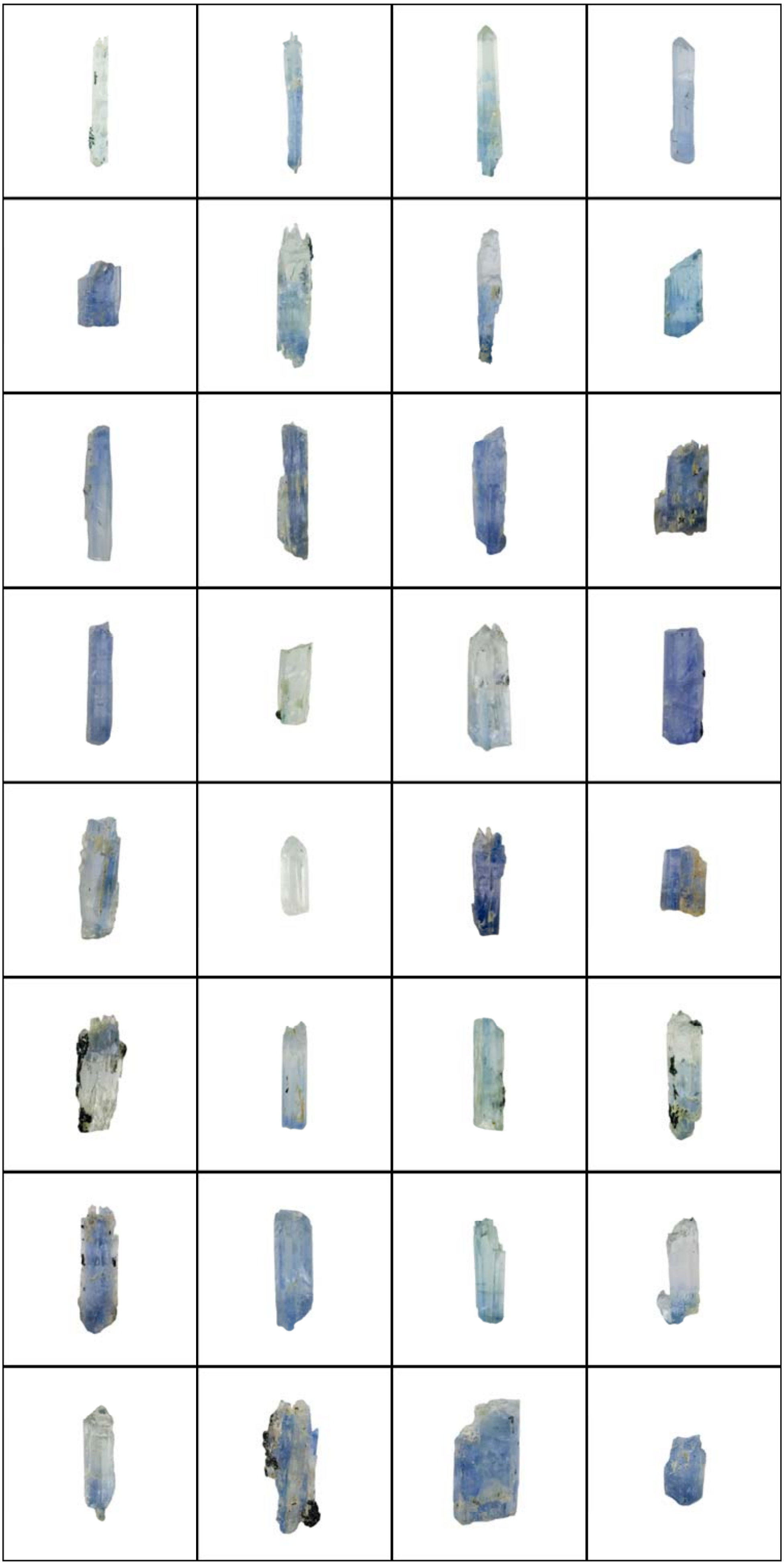
Images of each crystal in this collection of 400 jeremejevite are appended below. These images reveal a diverse range of forms and color distribution. Data on other selected crystals will be forthcoming.

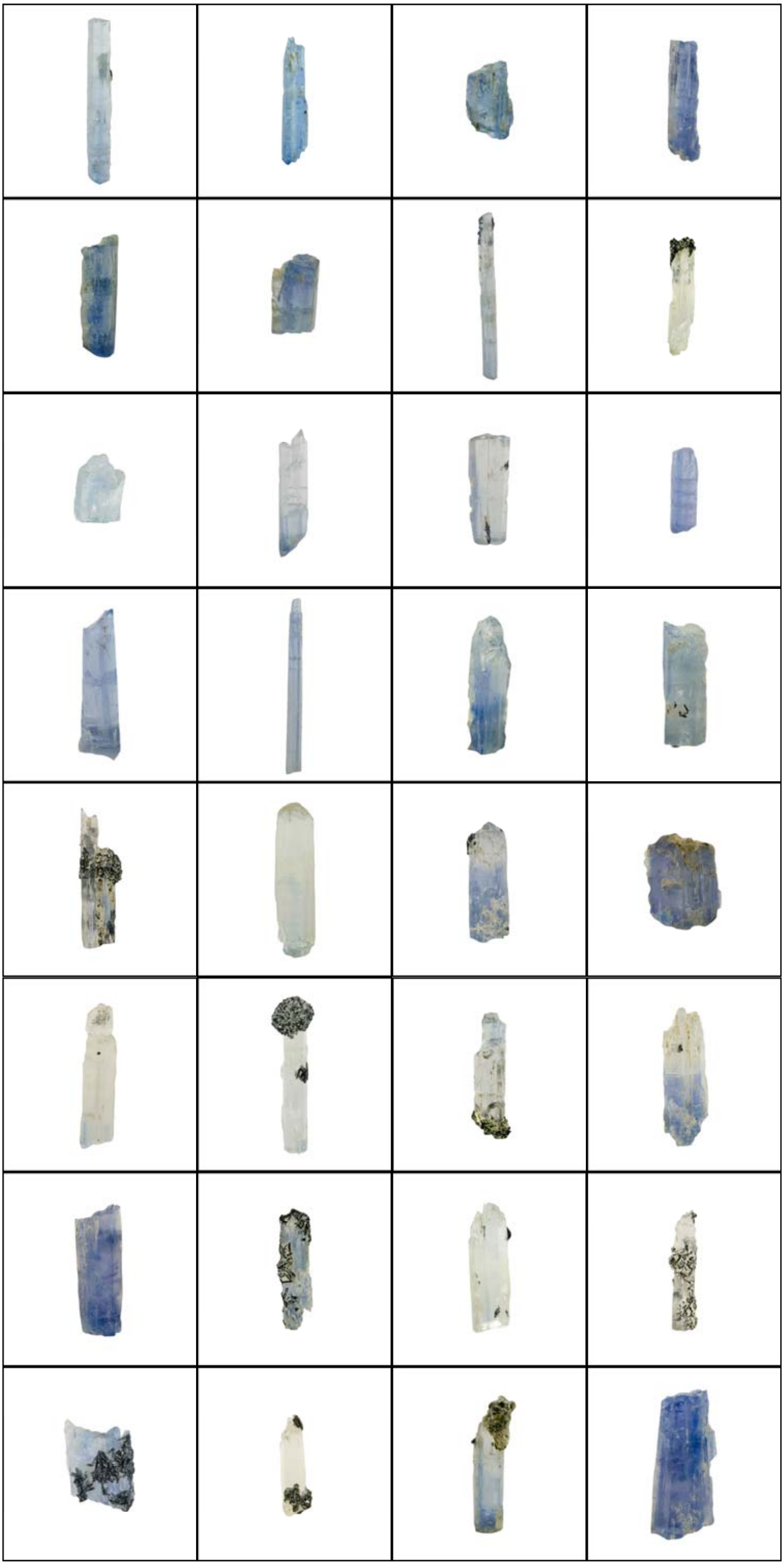


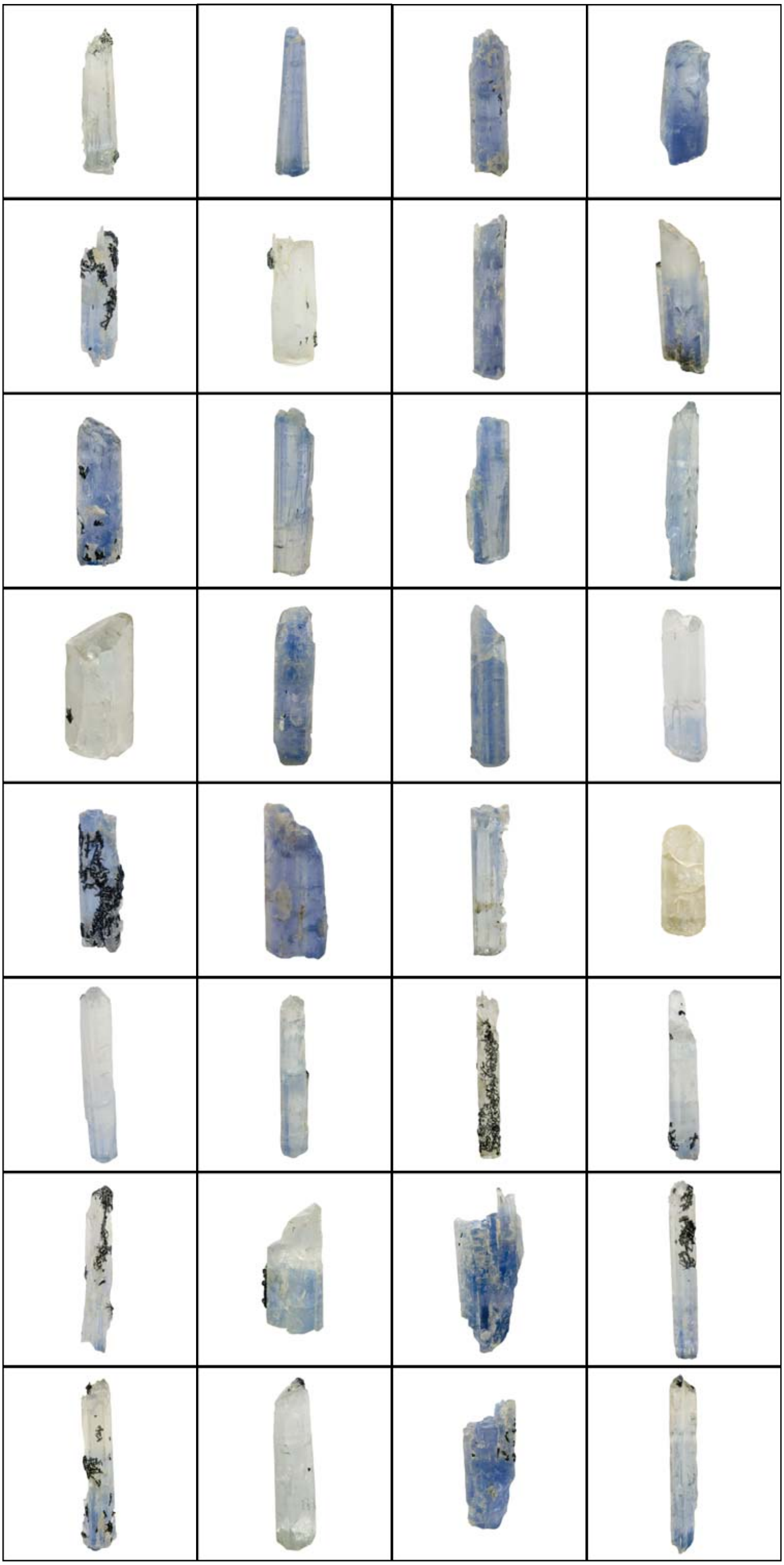


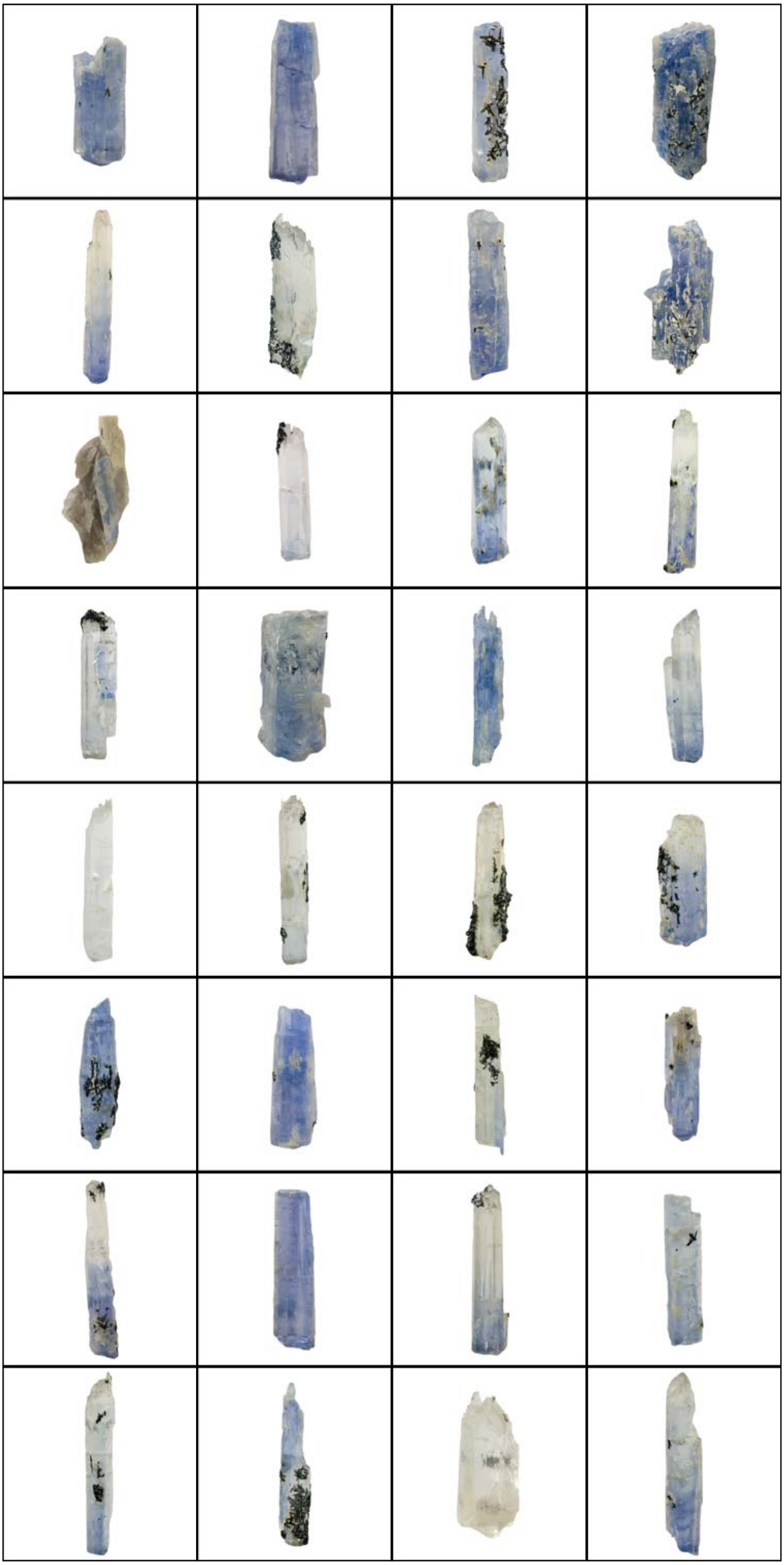


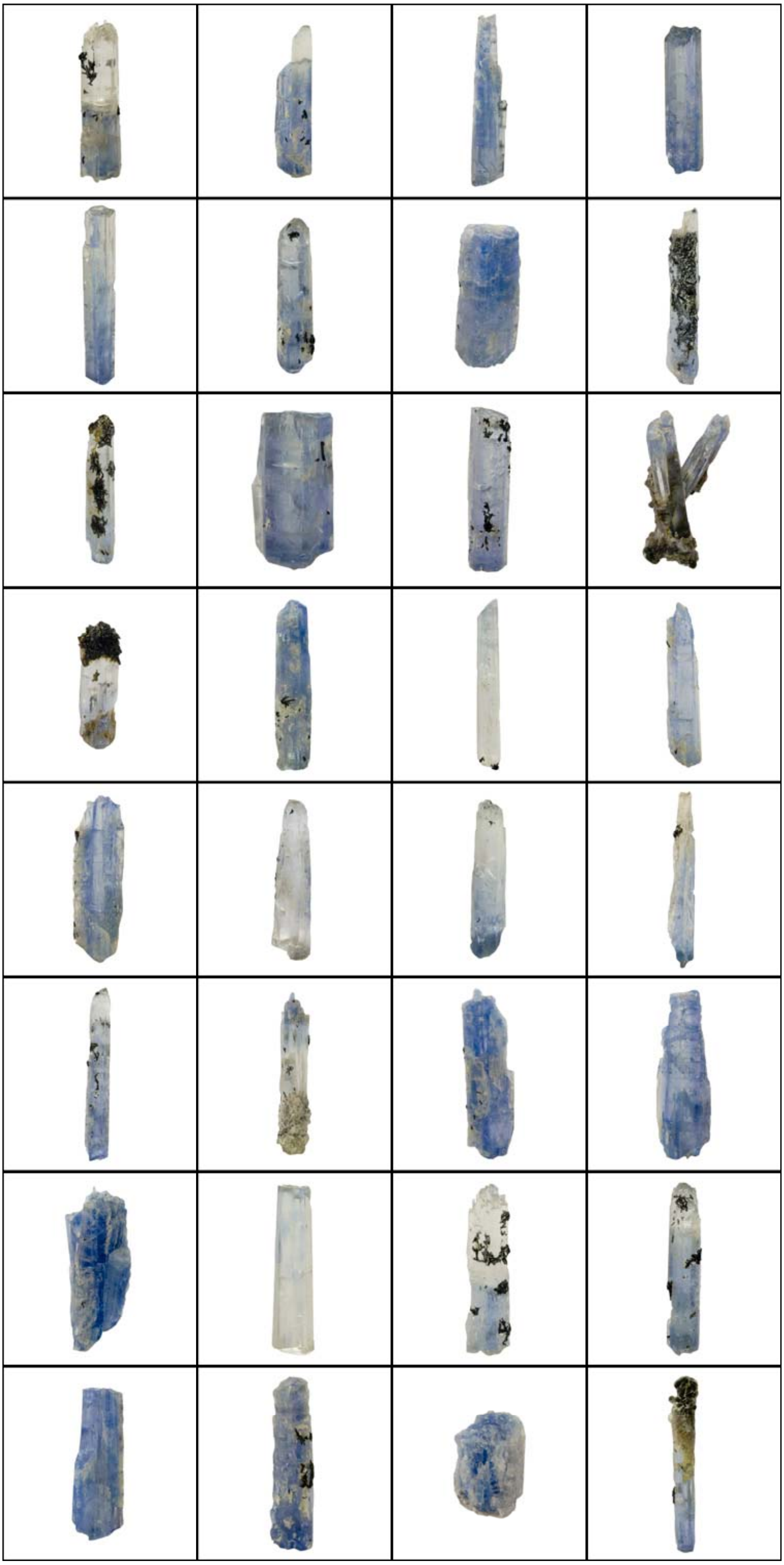


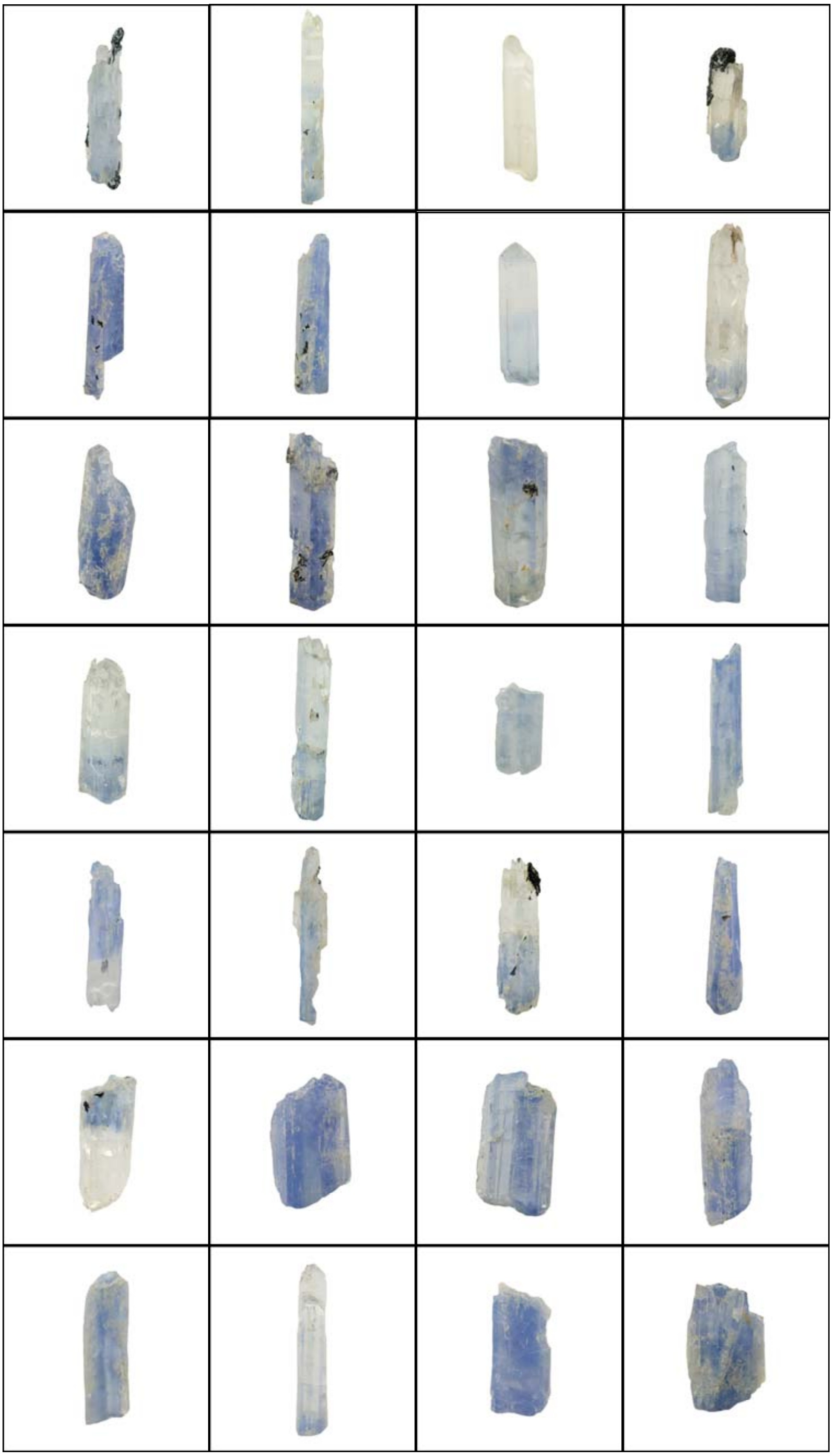












Discussion and further plans

Jeremejevite is a collector's stone that often occurs in euhedral crystals of varying colors. The gemological properties obtained from the five samples so far examined in this report corresponded favorably with previously acquired data produced by other researchers. All the crystals examined showed no indications of any form of treatment, such as heating, and the inclusions all indicated that nothing untoward had taken place.

Further inclusion photomicrographs and more comprehensive data will be published as research continues.

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