The 49th

Rochester Mineralogical
Symposium

April 8-10, 2022

S. ROBINSON
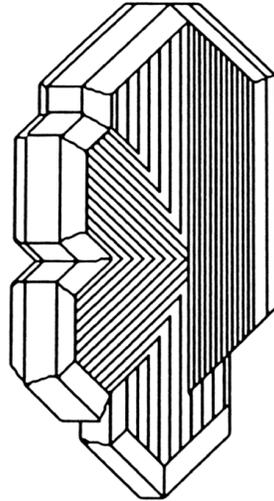
TABLE OF CONTENTS

Welcome to the e-RMS 2022!

Welcome to the 49th Rochester Mineralogical Symposium: the e-RMS 2022.

Once again, we were unable to be together in person, due to the global coronavirus pandemic. However, we are thrilled that the spirit of the Rochester Symposium is alive and well, such that we could gather online for a weekend of presentations.

If you missed the e-RMS 2022, the presentations set out in the Program are all included on the Rochester Mineralogical Symposium channel on YouTube. You can view them individually or the full symposium in a playlist at this link:

https://www.youtube.com/channel/UCaqK6Zq-eFG2hDUz1ouhUyA/playlists?app=desktop

For all of you who participated, we're so grateful – thank you all! The RMS remains our springtime reunion of mineral friends – we look forward to it each year and it would absolutely not be the same without you. Again this year, it was great to see Rochester's spirit at the e-RMS, complete with humour, laughs, a raised glass and mineral songs.

We'll see what the future has in store for us all over the next year. We are sure planning to hold the Rochester Mineralogical Symposium in Rochester, NY, in 2023. We also expect to host a portion of the RMS online. Our dates are April 20-23, 2023. Write it into your calendar!

We will communicate by email about future developments, so if we might not have your current email address, please let us know at contactrms@hotmail.com.

Please make sure you follow the Rochester Mineralogical Symposium on Facebook!

Stay well!

49th ROCHESTER MINERALOGICAL SYMPOSIUM: THE eRMS 2022!

FRIDAY, APRIL 8 – SUNDAY, APRIL 10, 2022

PROGRAM

Friday, April 8

8:00 pm   **Opening –** *Raymond McDougall*

8:10 pm   **The History and Minerals of the Rubtsovskoe Deposit, Altai, Russia –** *Inna Lykova*

9:15 pm -   VIRTUAL LOUNGE

Saturday, April 9

11:00 am   **World Premiere: The Crystals I Have Known (the video!) -** *David K. Joyce*

WHAT'S NEW IN MINERALS

11:05 am   **What's New in Minerals -** *Jeff Scovil*

12:05 pm   **What's New in Minerals II –** *John Betts, with Mark Jacobson, Raymond McDougall and Jim Nizamoff*

1:35 pm   --- LUNCH BREAK ---

2:00 pm   **Introduction to Mineral Deposits of Tajikistan and Afghanistan –** *Peter Lyckberg*

CONTRIBUTED PAPERS AND SHORT TALKS IN SPECIMEN MINERALOGY

3:00 pm   **Regenerative mineral replacement (RMR) of apatite from Grenville vein dikes at the Schickler Occurrence, Wilberforce Area, Ontario, Canada.** *S. E. Mounce,* *C. R. Emproto, and J. Rakovan.*

3:15 pm   **Fluorescence spectroscopy and zoning of apatite.** *M. Murchland* *and J. Rakovan.*

3:30 pm   **Raman study of minerals in phosphate nodules from Little Fish River, Inuvik Region, Northwest Territories, Canada.** *D.M. Doell* *and C. Robak.*

3:45 pm **Acicular Quartz from Kitwanga, British Columbia, Canada. *E. Grundel*** *and R. P. Richards*

4:00 pm **On the origin of quartz Japan Law twin oriented attachments. *Bob Morgan.***

4:15 pm **TotBlocks: Visualizing modular mineral structures with 3D-printed interlocking brick modules. *D. D. V. Leung*** *and P. E. dePolo.*

4:30 pm **Mineralogy of a Pegmatite in the pyroxene syenites of the Stettin Complex, Wausau Complex, Marathon County, Wisconsin. *T.W. Buchholz*,** *A.U. Falster, and W.B. Simmons.*

4:45 pm **Demantoid from the Belqeys Mountain- West Azerbaijan, Iran. *J. Ahmadi*,** *J. Rakovan, and B. Rahimzadeh.*

5:00 pm **Dangerous dust: the lungs and inhaled particulates, a representative display at the Maude Abbott Medical Museum. *D.M. Doell*** *and R. Fraser.*

5:15 pm - <u>VIRTUAL LOUNGE</u>

Raise a Glass and Sing! – *David K. Joyce*

Sunday, April 10

10:00 am **Minerals of the English Midlands - *Roy E. Starkey***

CONTRIBUTED PAPERS AND SHORT TALKS IN SPECIMEN MINERALOGY

11:00 am **Ryerson Hill Quarry, Maine: unusual rutile find. *L.W. Alexander*,** *A.U. Falster, and W.B. Simmons.*

11:15 am Coexisting kosnarite and zircon from the Emmons Pegmatite, Uncle Tom Mountain, Greenwood, Oxford Co., Maine: implications for the formation of kosnarite. *A.U. Falster, W.B. Simmons, and K.L. Webber.*

11:30 am **Arsenic minerals in the Emmons pegmatite, Uncle Tom Mountain, Greenwood, Oxford Co., Maine: genetic implications. *S.L. Hanson*,** *A.U. Falster, and W.B. Simmons.*

11:45 am **A Mineralogical and geochemical comparison of a granitic pegmatites and a miarolitic schlieren from Hart's Location, Carroll, Co, New Hampshire, USA. *L. Lovering*,** *A.U. Falster and W.B. Simmons.*

DEMANTOID FROM THE BELQEYS MOUNTAIN- WEST AZERBAIJAN, IRAN. *J. Ahmadi[1], J. Rakovan[1], and B. Rahimzadeh[2]*, [1]Department of Geology and Environmental Earth Science, Miami University, 118 Shideler Hall 250, S. Patterson Ave., Oxford, OH 45056, [2]Department of Geology, Shahid Beheshti University, Tehran, Iran.

The Belqeys Mountains are located in West Azerbaijan Province, northwest Iran. Skarn mineralization, formed during the late Alpine orogeny, includes fine demantoid specimens that have been exploited over the last 15 years. Demantoid is a green andradite variety of garnet admired for its color, brilliance and rarity. Variations in color of demantoid specimens result from substitutions in the octahedral Y site of the crystal structure by a variety of cations with similar size and charge. Traces of chromium (Cr^{3+}) commonly control the deep green color (Stockton & Manson 1983; Adamo et al. 2011). Additionally, Moore and White (1972) argue that Fe^{2+}-Ti^{4+} intervalence charge transfer as well as, Fe^{2+}-Fe^{3+} interactions can play a secondary role in the tint.

In the Belqeys Mountains, demantoid mineralization occurs in limestone layers within metamorphosed Paleozoic amphibolite and ophiolitic rocks (serpentinite, diabase, and basalts). An intrusion with granodiorite composition of Jurassic (questionable) age is believed to be the source of hydrothermal fluids that formed skarn mineralization. Demantoid mineralization occurs in both pockets and veinlets in limestone within pyrite, magnetite, quartz, calcite, and diopside. Matrix is mostly composed of limestone and marble covered by fine crystals of diopside (up to 10 mm) (fig. 1).

Large demantoid crystals (up to 8 cm) with well-developed morphology, dominated by trapezohedral (211) and dodecahedral (110) faces, with very good luster are found. Despite the exceptional crystals, gemmy demantoids have never been reported from the locality. Microfractures and an abundance of inclusions results in some crystals being dull, however, their deep green color is still exceptional.

Concentric zoning is one of the characteristics of the Belqeys demantoid. To investigate compositional aspects of concentric zoning and inclusions three samples were made into polished thin sections for Scanning Electron Microscope (SEM) imaging and XEDS analysis as well as for studying optical properties in polarized light. Among concentric zones of the demantoid, Fe concentration fluctuates slightly around 0.4 wt.% with a rise in bright regions. Cr, the dominant chromophore, shows a distinct concentration in various zones; near 0.1 wt.% in dark zones and around 0.8 wt.% in bright regions. Similarly, the concentration of Al is correlated with darker zones, exhibiting a difference of 7.00 wt.% from bright to dark regions. Following the growth history of the crystals, from core to rim, calcium content decreases gradually. Ti exhibits the same trend except for a rise in the first dark region. Mg behaves similar to Ca, with slight decreases in content as the crystal grows and tends to have higher concentrations in dark zones. The Si concentration from bright to dark regions undergoes a decrease of 4.0 wt.%. From core to rim Ti, Mg and Ca slightly decrease in concentration and Al, Si, and Cr fluctuations are most strongly correlated with the backscattered electron (BSE) contrast of concentric zones (fig. 2).

REFERENCES

Stockton, C. M., and D.V. Manson. 1985. A proposed new classification for gem-quality garnets. *Gems & Gemology*, 21(4):205-218.

Moore, R. K., and W.B. White. 1972. Electronic spectra of transition metal ions in silicate garnets. *Canadian Mineralogist*, 11(4):791-811.

Adamo, I., G.D. Gatta, N. Rotiroti, V. Diella, and A. Pavese. 2011. Green andradite stones: gemmological and mineralogical characterisation. *European Journal of Mineralogy*, 23(1):91-100.

Figure 1. Belqeys demantoid crystals associated with dioptase on marble matrix; covered with limonite. Concentric zoning is perceptible on the fractured crystal (specimen dimensions: 6×4 cm).
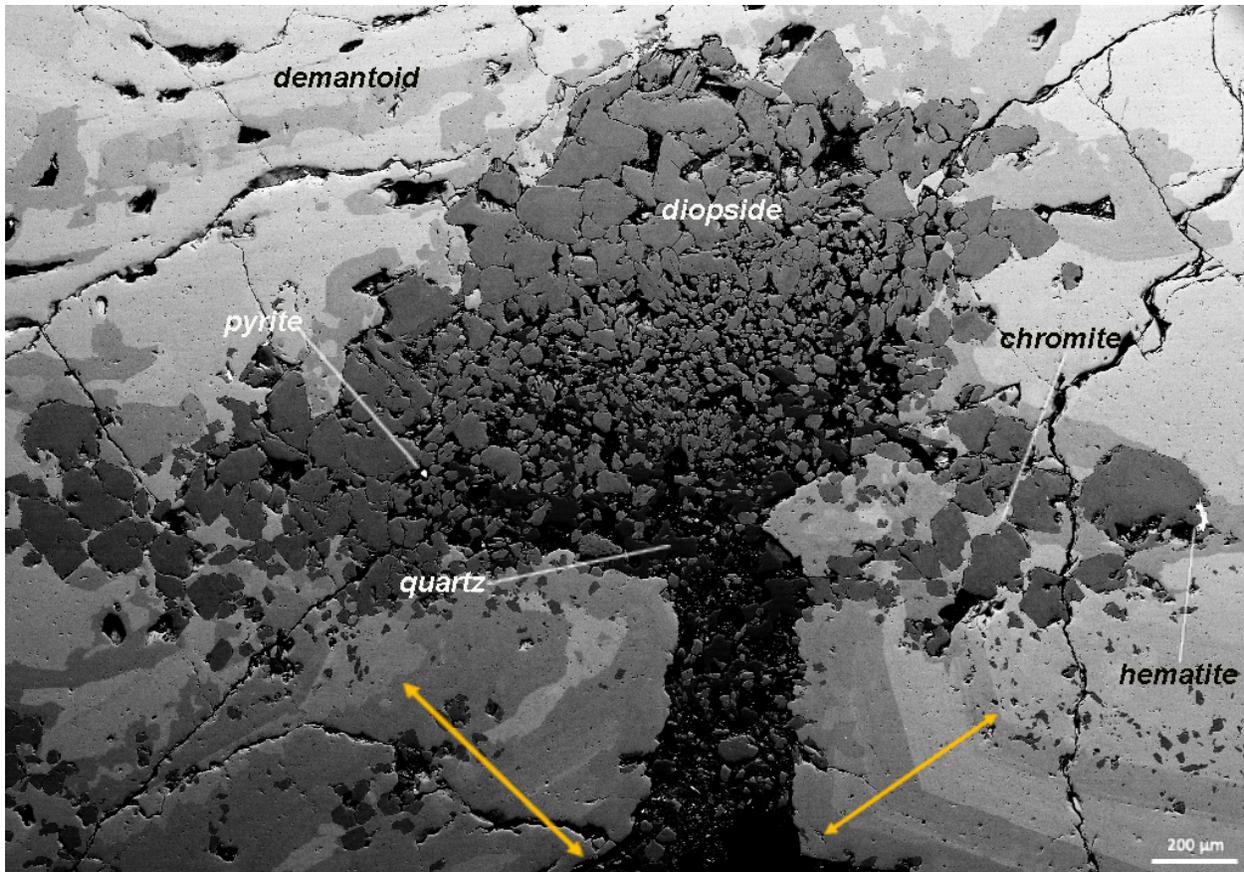
Figure 2. Backscattered electron photomicrograph of a thin section indicates inclusions in the demantoid crystals. Concentric zonings in the demantoid can be seen along the paths of the orange arrows. Working parameters include an acceleration voltage of 25KeV, 120 μm of aperture and 10mm working distance.

RYERSON HILL QUARRY, MAINE: UNUSUAL RUTILE FIND. L.W. Alexander[1], A.U. Falster[2] and W.B. Simmons[2], [1]265 Manchester Rd., Steep Falls, ME 04085, 207-518-0962, [2]MP[2] Research Lab, Maine Mineral and Gem Museum, 99 Main St., Bethel, ME, 04217.

The Ryerson Hill Quarry is in a complex pegmatite located in Paris, Oxford County, ME. It is surrounded by some of the most productive mines in Oxford County, including Mt. Mica, which is about a mile away. This report focuses on new finds in the core zone of the pegmatite between two previously excavated pits where smoky quartz and hydroxlherderite were found.

Triphylite pods occur throughout the whole quarry, with the largest concentration of pods from the edge of the eastern pit to the halfway point between the two pits, along a 3x4 m rectangular area. The largest pod to date was 1x 0.5x 0.2 meters. The pods show some replacement of triphylite by 0.5 to 1 mm vivianite crystals. Numerous secondary phosphates are known from the location but overall, most tend to be Fe-dominant since the primary triphylite is Fe-dominant. Elbaite is rare and occurs as mm long crystals. Clear, brown, blue, and green elbaite has been found in a rectangular area roughly 7-meters-long by 5-meters-wide. The pegmatite exhibits sharp contact with mica schist. The contact zone of the pegmatite is albitic.

Rutile occurs as straw-colored sagenite aggregates ranging from 1-3 mm (fig. 1) and is associated with clear to brownish gemmy micro tourmaline rods. The rutile is found near the

contact of the pegmatite with mica schist in an area that starts about 3 cm from the contact and extends out roughly 1 meter and in a line about 1 meter long. The rutile is Fe and Nb-poor. The presence of abundant chlorite suggests assimilation of biotite-bearing mica schist from which titanium was released that then formed the rutile crystals. Rutile and other titanium oxides are very uncommon in pegmatites of the Oxford pegmatite field. Only the Songo Pond pegmatite has been known to produce rutile and niobian rutile. However, the Songo Pond pegmatite may be related to the Songo pluton which is a granodiorite and does contain higher Ti. This pegmatite is an example of a contaminated pegmatite with a locally uncommon titanium signature in the early mineral association.

Figure 1. Rutile, 1-3 mm, in association with albite.

MINERALOGY OF A PEGMATITE IN THE PYROXENE SYENITES OF THE STETTIN COMPLEX, WAUSAU COMPLEX, MARATHON COUNTY, WISCONSIN.

T.W. Buchholz[1], A.U. Falster[2], and W.B. Simmons[2], [1]1140 12th Street North, Wisconsin Rapids, Wisconsin 54494, [2]MP[2] Research Group, Maine Mineral & Gem Museum, PO Box 500, 99 Main Street, Bethel, Maine 04217, USA.

The Stettin Complex is the oldest (1565 +3-5 Ma, Van Wyck 1994) and most alkalic of the four intrusions that comprise the Wausau Syenite Complex and is primarily composed of various syenite phases. Recently a short-lived opportunity arose to examine the mineralogy of a pegmatite in the pyroxene syenites of the Stettin Complex.

The pegmatite material is heavily fragmented and coated with Fe-oxide-stained clays. The irregular pegmatite(s?) appeared to be roughly horizontal, relatively thin (0.5-0.75 m) and of limited width (1-1.25 m). The dikes are zoned; intermediate zones include remnant hedenbergite, arfvedsonite with minor riebeckite, clear pink to orange zircons and other accessory phases. Core zone material is mostly anorthoclase with arfvedsonite, other accessory minerals and small miaroles

Per Medaris and Koellner (2010), pyroxenes in the Stettin complex range from Fe-rich diopside to hedenbergite and aegirine. Here, pegmatite minerals have been affected by late-stage oxidizing fluids, altering Fe^{2+}-rich pyroxenes to Fe^{3+}-rich smectite-group clays $\pm$ Fe^{3+}-rich arfvedsonite and riebeckite, with sparse remnants of hedenbergite, whereas aegirine is absent. Ca released by pyroxene alteration may have contributed to the formation of various late-stage Ca-rich species.

Accessory Mineralogy:
- **Aeschynite-(Ce):** Elongated, dark grey-black crystals in anorthoclase, locally common in pegmatite.
- **Synchysite/Parisite:** Small red to pinkish hexagonal crystals, tapering to each end, in small pockets with arfvedsonite or in anorthoclase. High Ca contents suggest they are either synchysite or parisite.
- **Bavenite(?):** Small white bladed crystals included in clear quartz; tentative ID based on their morphology.
- **Calcite:** White crusts and masses in vugs from lower portions of the excavation.
- **Chevkinite-group:** Dark grains with white borders in anorthoclase and arfvedsonite are often heavily altered to soft, chalky, fine-grained niobian Ti-oxides with minor Th, Ca, LREE $\pm$ Si and Al. This material likely reflects LREE & Ca mobility in late altering solutions.
- **Fayalite:** Uncommon gray radiating acicular crystals and glassy brown grains associated with arfvedsonite.
- **Fergusonite-(Y):** Abundant small yellowish to reddish-brown tapering crystals in anorthoclase, arfvedsonite and miaroles.
- **Ferro-anthophyllite:** Uncommon, patches of white acicular crystals in clay-rich altered pyroxenes.
- **Fluorapatite:** Small, sparse short hexagonal prisms in vugs with arfvedsonite.
- **Fluorite:** Late in vugs and isolated grains.
- **Ilmenite:** Common; thin black metallic plates with a pyrophanite component in anorthoclase and miaroles.

- **Fine-grained mixture of rutile and anatase:** Relatively soft whitish grains, generally with some Nb, probably an alteration of Nb-bearing ilmenite.
- **Magnetite:** Common as irregular masses, rarely as well-formed octahedral crystals.
- **Monazite-(Ce):** Uncommon, patches of small brick-red crystals in feldspar.
- **Niocalite?:** Yellow to pale yellow-brown elongated crystals in anorthoclase. Very sparse. Some compositions strongly suggest niocalite, others are yet-unidentified species.
- **Pyrochlore:** Rare yellow-brown octahedral crystals.
- **Quartz:** Common, generally as a late-stage mineral.
- **Rhabdophane?:** Elongated hexagonal prisms, generally soft/altered, with high Ca contents and low, variable LREE contents.
- **Titanite**: Uncommon, as brown to red-brown grains.
- **Zircon**: Abundant in intermediate zone, less so in core margin and core zones.
- **Potential Eakerite(?):** Sn-Ca-Fe-Si grain in heavy mineral separates, estimated about 6 μm in diameter: investigation continues.

As work continues, it is likely that additional phases will be identified. Thanks are due to Austin Gausmann and Bill Schoenfuss for access to pegmatite material.

REFERENCES

Medaris, L.G. Jr. and S.E. Koellner. 2010. Ferromagnesian minerals in the Stettin Syenite Complex, Marathon County, Wisconsin: compositions and contrasts with the Wolf River Batholith. In *Institute on Lake Superior Geology Proceedings, 56th Annual Meeting, International Falls, MN* 56(1):42-43.

Van Wyck, N. 1994. The Wolf River A-type magmatic event in Wisconsin: U/Pb and Sm/Nd constraints on timing and petrogenesis. *In Institute on Lake Superior Geology, 40th Annual Meeting, Part 1, Program and Abstracts* 40:81-82.

DANGEROUS DUST: THE LUNGS AND INHALED PARTICULATES, A REPRESENTATIVE DISPLAY AT THE MAUDE ABBOTT MEDICAL MUSEUM. *D.M. Doell and R. Fraser*, McGill University Health Centre, 1650 Cedar Avenue, Montreal, Quebec H3G 1A4.

The purpose of this new display at McGill's Maude Abbott Medical Museum is to introduce the visitor to the subject of lung disease caused by the inhalation of inorganic dust - pneumoconiosis. It features specimens, artifacts and photographs from the Museum's collection as well as minerals from the collection of one of the authors (figs. 1 and 2). Brief descriptions of the pathologic and clinical features of pneumoconiosis caused by dust from silica (quartz), asbestos (amphibole and chrysotile), coal, other minerals and inorganic substances are given. Examples of the means to diagnose the diseases and their occupational context and relevance to society are also included. Although space does not permit in depth discussion, the interested visitor will be able to acquire an appreciation of the importance of mineral and inorganic dusts as a cause of lung disease as well as an understanding of some of its manifestations.

Figure 1. Asbestos display. From left to right – 1A Chrysotile. Jeffrey Mine, Val-des-Sources, Les Sources RCM, Estrie, Québec, Canada. 1B Photograph, workers in asbestos mill. 1C Crocidolite (blue asbestos), a variety of riebeckite. Northern Cape Province, South Africa. 1D Industrial characterization of asbestos. 1E Lung showing asbestosis pathology.
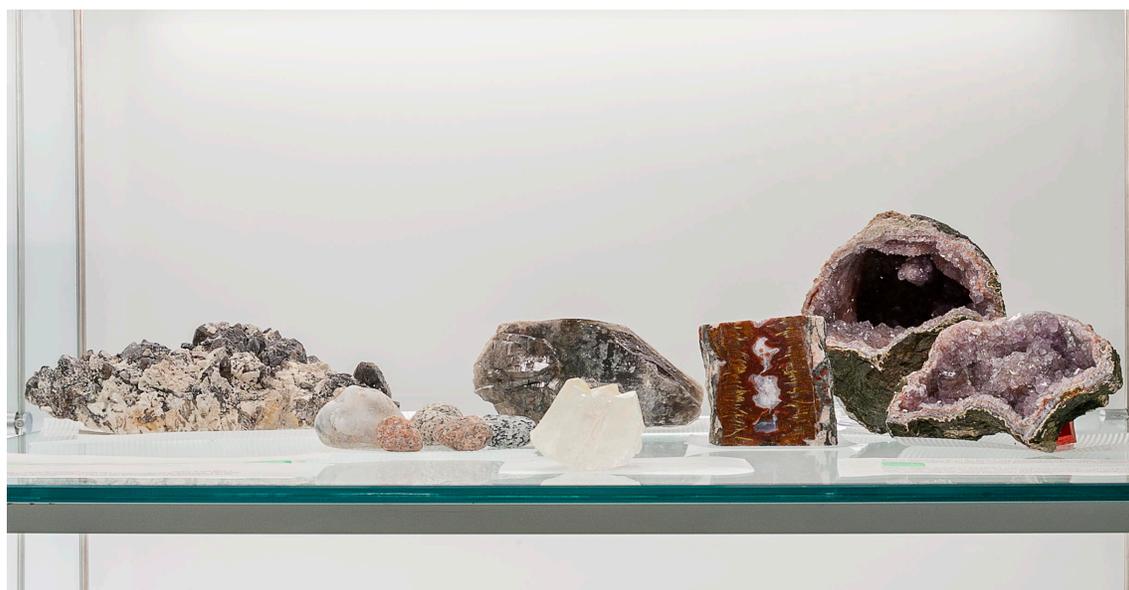
Figure 2. Various examples of quartz. From left to right - 2A Quartz crystals in granitic pegmatite. Bayer's Lake pegmatites, Halifax Co., Nova Scotia, Canada. 2B Glacial pebbles showing rocks containing quartz (Quartzite, Granite, Diorite, Gneiss). Lake Ontario Shoreline, Grafton, Northumberland Co., Ontario, Canada. 2C Quartz Crystal. Bayer's Lake pegmatites, Halifax Co., Nova Scotia, Canada. 2D Quartz crystal. Sainte-Hélène-de-Chester, Arthabaska RCM, Centre-du-Québec, Québec, Canada. 2E "Cherry Flame Agate". Cape Blomidon, Kings Co., Nova Scotia, Canada. 2F Amethyst geode. Sidi Rahal, El Kelaâ des Sraghna Province, Marrakesh-Safi Region, Morocco.

RAMAN STUDY OF MINERALS IN PHOSPHATE NODULES FROM LITTLE FISH RIVER, INUVIK REGION, NORTHWEST TERRITORIES, CANADA. <u>*D.M. Doell*</u>[1] *and* *C. Robak*[2], [1]Department of Geosciences, University of Arizona, 1040 E 4th, Tucson, AZ, USA, 85721-0077, [2]4656 61 Street, Red Deer, Alberta. T4N2R2.

The Rapid Creek and Big Fish River areas of the Yukon Territory, Canada, are famous for their rare phosphate minerals and together are the type localities for 12 mineral species. Recently, phosphate nodules have been discovered in a nearby Little Fish River, just across the provincial border in The Northwest Territories in a similar geological setting to that of Rapid Creek and Big Fish River. Several of these nodules were examined by Raman spectroscopy to help with preliminary identification of the minerals present. Raman spectroscopy on unoriented samples was performed using the Thermo Almega XR with 532 nm laser at The RRUFF project at The University of Arizona. The spectra were compared to Raman spectra in the RRUFF database and showed strong correlation with spectra for existing mineral species, all of which were also reported to occur at the nearby Rapid Creek and Big Fish River localities. Ludlamite, marićite, satterlyite, vivianite, wolfeite were the primary phosphate minerals identified in the nodules along with accessory pyrite (figs. 1 and 2). Further confirmation of these species using additional analytical methods is suggested.

Figure 1. Nodule composed of brown satterlyite with pyrite in anhedral greyish ludlamite and quartz. Broken in 4 pieces and together as the original 9.0x7.0x3.6 cm nodule.

Figure 2. Nodule composed of brown marićite sprays with anhedral platy ludlamite. 8.1x3.3 cm.

COEXISTING KOSNARITE AND ZIRCON FROM THE EMMONS PEGMATITE, UNCLE TOM MOUNTAIN, GREENWOOD, OXFORD CO. MAINE: IMPLICATIONS FOR THE FORMATION OF KOSNARITE. *A.U. Falster, W.B. Simmons, and K.L. Webber*, MP² Research Laboratory, Maine Mineral & Gem Museum, 99 Main St., Bethel, ME 04217.

The Emmons pegmatite is a highly evolved granitic pegmatite on Uncle Tom Mountain, Greenwood, Oxford Co., Maine. The pegmatite has the highest mineral species count, currently 183 (Falster et al. 2019), in the state of Maine. A recent find of several closely associated small lithiophilite masses up to 8 cm across revealed an unusual concentration of dark brown zircon crystals up to 5 mm in maximum dimension embedded within the lithiophilite and associated replacement products hureaulite and rhodochrosite. The zircon crystals show no evidence of alteration. A few light brown kosnarite [$KZr_2(PO_4)_3$] grains were found among the zircon crystals. In one zircon, a core of kosnarite was discovered which was completely encased by zircon (fig. 1). The kosnarite shows crystal forms that reach a maximum dimension of 1.5 mm. Thus, kosnarite formed almost simultaneously, but a little earlier than the zircon, and is therefore not a replacement product of zircon. It appears to have formed independently of the formation of zircon. This is the first reported occurrence of primary kosnarite. Chemically, both the zircon

and kosnarite contain elevated Hf. Given the proximity of etched cesium beryl and pollucite, mccrillisite may be another species that might exist in this pegmatite. Kosnarite was discovered at Mount Mica and Black Mountain (Brownfield et al. 1993) where it is associated with a complex mineral association of silicates, phosphates, and carbonates, like the Emmons pegmatite.

REFERENCES

Brownfield, M.E., E.E. Foord and S.J. Sutley. 1993. Kosnarite, $KZr_2(PO_4)_3$, a new mineral from Mount Mica and Black Mountain, Oxford Co., Maine. *American Mineralogist* 78:633-656.

Falster A.U., W.B. Simmons, K.L. Webber, D.A. Dallaire, J.W. Nizamoff, and R.A. Sprague. 2019. The Emmons pegmatite, Greenwood, Oxford County, Maine. *Rocks & Minerals*, 94:498-519.
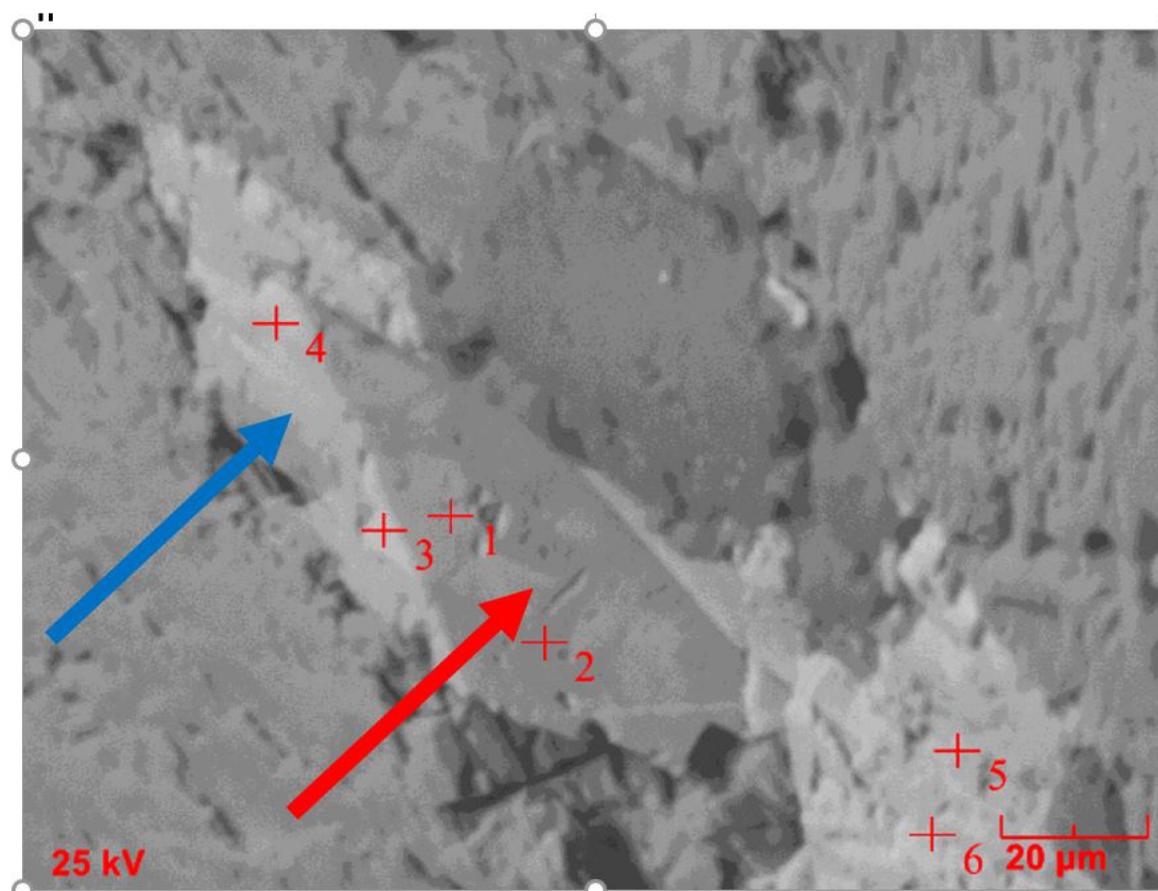
Figure 1. Backscattered electron image of kosnarite (red arrow) in zircon (blue arrow) from the Emmons pegmatite. Note that both species appear patchy due to variations in Hf-content.

ACICULAR QUARTZ FROM KITWANGA, BRITISH COLUMBIA, CANADA. *E. Grundel[1] and*

*R. P. Richards[2], * [1]77 Clinton Street Apt. T-1, New York Mills, NY, 13417, [2]Department of Geology, Oberlin College, Oberlin, OH, 44074.

Acicular quartz is a very rare habit for this most common of minerals (Frondel 1962). A web search turned up only two localities with truly acicular crystals, though the term acicular or needle quartz is often applied to crystals with a somewhat more elongated habit than usual. A roadcut near Kitwanga, British Columbia has produced excellent examples of these crystals, which are the subject of this paper.

The crystals occur in quartz veins cutting through a dark sandstone of Cretaceous age which is brecciated and extensively replaced by quartz. They are associated with prismatic quartz of normal proportions that are up to 8 mm; massive calcite and corroded calcite crystals; microcrystals of anatase; brookite; a clay mineral in the kaolinite group; pyrite; and spheres of a black manganese mineral. The acicular quartz was the first mineral to form, and crystals can be found protruding from quartz of normal morphology, which grew around them.

The acicular quartz crystals are 1-3 mm in length and as thin as 0.05 mm or perhaps less. The aspect ratio, the ratio between width and length (a:c axis), has been measured using photomicrographs of some of these crystals. Values as extreme as 1:50 have been observed. By comparison, a web site (visited 1/21/19) describes crystals from Val Bedretto, Valais, Switzerland, with aspect ratios as extreme as 1:100, with crystals often "thinner than a human hair" (~0.06 mm).

These slender crystals are easily bent, for example by pressure applied to the free end of a crystal with the point of a needle. This distortion is elastic - when the pressure is released, the crystal springs back to its original form. When the elastic limit is exceeded, the crystal breaks free with great energy, and disappears among the debris on the observer's desk!

Elasticity in quartz is familiar because of the vibrations of quartz oscillator plates, but it is a surprise to see what we think of as a rigid material bending so easily. This scale-dependent behavior is shown by acicular crystals of many minerals (e.g. cuprite, halite, natrolite), but not often observed.

REFERENCES

Frondel, C. 1962. Dana's System of Mineralogy, 7th Edition, V.III, Silica Minerals, New York, NY: John Wiley and Sons., p. 50.

Mineralienatlas – Fossilienatlas,
https://www.mineralienatlas.de/lexikon/index.php/MineralData?mineral=Nadelquarz

SEM HV: 30.0 kV | WD: 15.00 mm | 200 μm | VEGA3 TESCAN
View field: 1.24 mm | Det: BSE | |
SEM MAG: 335 x | Date(m/d/y): 11/17/18 | | OSNAP
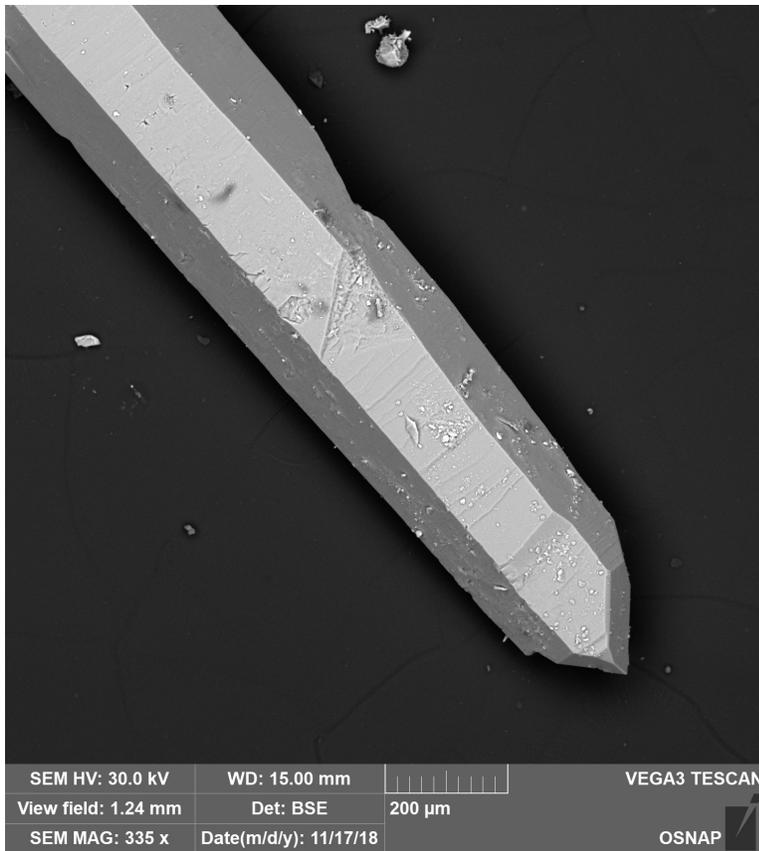
Figure 1. SEM image showing the termination of an acicular crystal, demonstrating that it is indeed quartz.

SEM HV: 30.0 kV | WD: 15.40 mm | 200 μm | VEGA3 TESCAN
View field: 1.20 mm | Det: BSE | |
SEM MAG: 346 x | Date(m/d/y): 11/17/18 | | OSNAP
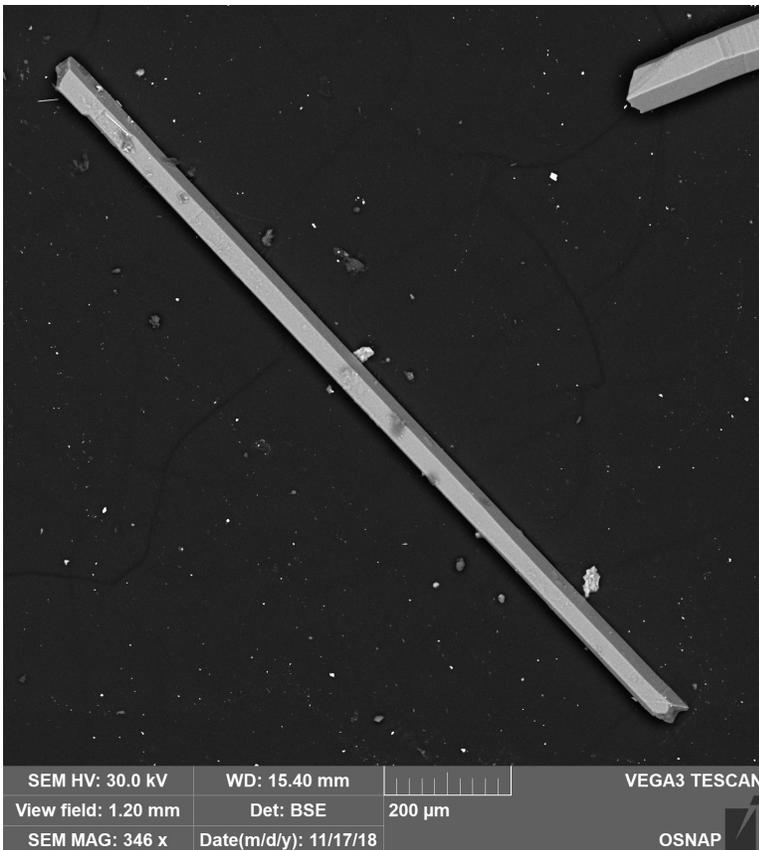
Figure 2. SEM image of an incomplete acicular crystal with an aspect ratio of 1:30.

16

ARSENIC MINERALS IN THE EMMONS PEGMATITE, UNCLE TOM MOUNTAIN, GREENWOOD, OXFORD CO., MAINE: GENETIC IMPLICATIONS. _S.L. Hanson[1], A.U. Falster[2], and Wm. B. Simmons[2]_, Geology Dept. [1]Geology Department, Adrian College, 110 S. Madison St., Adrian, MI 49221, [2]MP[2] Research group, Maine Mineral & Gem Museum, 99 Main Street, Bethel, Maine 04217.

The Emmons pegmatite, located on Uncle Tom Mountain, Greenwood, Oxford Co., Maine, is a complexly zoned LCT pegmatite that exhibits a wall zone, several intermediate zones, and a poorly exposed quartz-rich core. Replacement units along the core-intermediate zone boundary have undergone almost total alteration and replacement such that the only primary mineral remaining is muscovite. Arsenic mineral species are present in two distinct zones within the pegmatite. The first is located in the core of the pegmatite where löllingite [$FeAs_2$] is present in masses up to 8 cm. It is sometimes juxtaposed with lithiophilite ($LiMn^{2+}PO_4$) but no reaction between the two minerals is evident at the contact zone. The second occurrence is located in the footwall intermediate zone along a fracture zone that is parallel to, and in the middle, between two bands of schorl and almanditic garnet. At this location, arsenopyrite [$FeAsS$] is present but no löllingite has been found, thus arsenopyrite is the only sulfide group species present. Arsenopyrite occurs as small masses that are most commonly about 1 cm in diameter but can reach up to 4 cm in diameter. These masses are abundant and are closely spaced, within 2-3 cm of one another. Additionally, several secondary arsenic species are found at this location. Scorodite [$Fe^{3+}AsO_4 \cdot 2H_2O$] is present in nearly colorless drusy coatings and arseniosiderite [$Ca_2Fe^{3+}_3(AsO_4)_3O_2 \cdot 3H_2O$] occurs in brown crusts and radiating sprays of acicular crystals. It is interesting to note that closer to the wall zone contact, pyrite and pyrrhotite occur in mm-sized grains.

The fracture where the arsenopyrite is present must have occurred when at least this part of the pegmatite had solidified sufficiently for brittle behavior to occur. Thus, it is possible that the arsenic mineralization formed prior to löllingite in the core zone. If that were the case, the changes in mineralogy could be explained by a decrease in S activity as crystallization proceeded.   This would lead to the change from earlier crystallizing As-bearing sulfide minerals (arsenopyrite) to later forming arsenide minerals (löllingite) in the core zone as the sulfur anions became depleted. Subsequently, conditions became significantly more oxidizing as is evidenced by the formation of the secondary arsenate minerals. The timing of this late-stage event remains unclear as it could be related to either the formation of the arsenate assemblage as the pegmatite crystallized or a more recent oxidizing event.

TOTBLOCKS: VISUALIZING MODULAR MINERAL STRUCTURES WITH 3D-PRINTED INTERLOCKING BRICK MODULES. _D. D. V. Leung[1,2] and P. E. dePolo[1]_, [1]School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom, [2]Harquail School of Earth Sciences, Laurentian University, Sudbury, Ontario, Canada.

Minerals are the building blocks of the earth, and many minerals—such as pyroxenes, amphiboles, micas, and clay minerals—are constructed from shared chemical building blocks. These building blocks, or modules, consist of two opposing chains of vertex-sharing silica tetrahedra (*T*), which vertically sandwich a ribbon of edge-sharing metal-oxygen octahedra (*O*) in a *T-O-T* configuration.

The *T* and *O* modules are structurally and crystal-chemically versatile. They incorporate a multitude of common crustal elements, such as O, Si, Al, Fe, and Mg, and can be configured in many ways. Thus, minerals which are based on *T* and *O* modules are both abundant and diverse, having a modal abundance of 26% of the earth's crust and accounting for 23% of all silicate mineral species. However, the diversity of these modular rock-forming minerals results in complexity in terms of the crystal structures and crystal chemistries of this mineral family. For example, the amphiboles (~200 species) are sometimes nicknamed 'garbage can minerals' or 'black uglies' because of the wide variety of cations that can substitute into their structure. This complexity means that these modular minerals are difficult to understand.

Currently, traditional ball-and-stick models and computer visualization software are used to visualize the crystal structures of minerals, but both methods cannot show the modular relationships between these complex structures. Here, we apply 3D printing, modular mineralogy, and pedagogical theory to communicate these complicated structures in a widely accessible, interactive, and versatile manner.

The open-source TotBlocks project consists of a series of 3D-printed, *T-O-T* interlocking bricks, based on ideal polyhedral representations of *T* and *O* modules, which are linked by hexagonal pegs and slots (fig. 1). There are three different widths of the *T* and *O* modules (single-, double-, and triple-chain widths) and three different linking mechanisms by which they can be connected (2:1 phyllosilicate, pyribole, and palysepiole linkages). Using TotBlocks, we explore the relationships between modular minerals within the biopyribole (biotite-pyroxene-amphibole) and palysepiole (palygorskite-sepiolite) series, as well as other layered minerals (brucite, kaolinite-serpentine, and chlorite groups).

TotBlocks can be used in teaching and geoscience outreach settings to show the relationships between different mineral structures in a fun and interactive manner. TotBlocks also hold potential as dynamic displays in museums and mineral collections. The *T-O-T* modules within these minerals can be used to derive many mineral properties by first principles, e.g., habit, cleavage angles, and symmetry/polytypism (fig. 2). TotBlocks highlights the fractal relationship between atomic structures and the macroscopic properties of minerals. Additionally, distinct crystallographic sites within the structures can be highlighted for further understanding individual mineral species.

This project is positioned within the ethos of the maker movement, with open-sourced models that are easy to replicate on a 3D printer. These modules prove more versatile than traditional ball-and-stick models because a wide variety of different minerals can be constructed from the same building blocks. As physical manipulatives, they allow mineralogy enthusiasts to construct and directly interact with the modular structures they are interested in. Altogether, the TotBlocks project gives us a new way to glimpse the foundational structures of the earth.
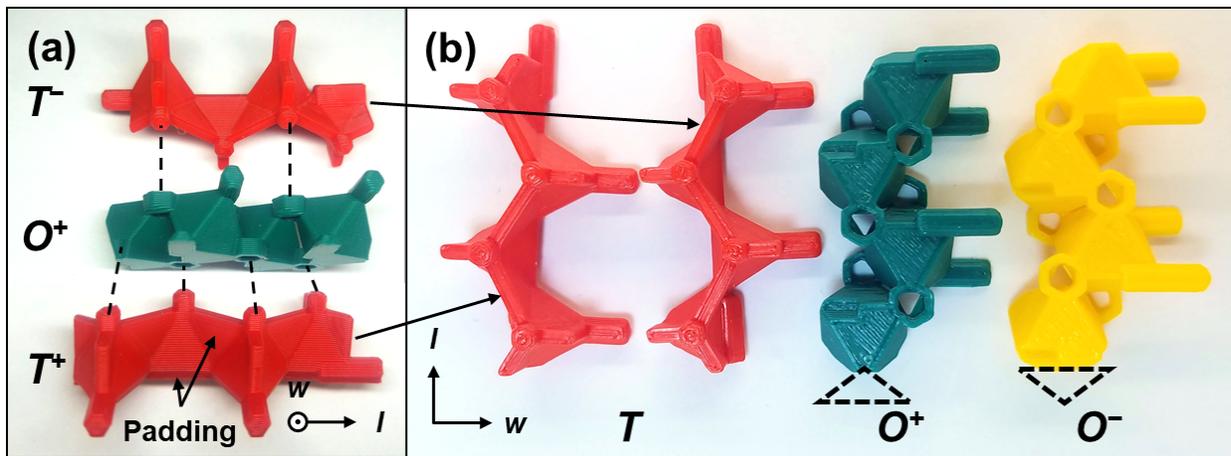
Figure 1. The individual modules that comprise TotBlocks, including (a) a disassembled single-chain *T-O-T* rod module, showing the component *T* and *O* modules and (b) the four types of *T* and *O* rod modules.
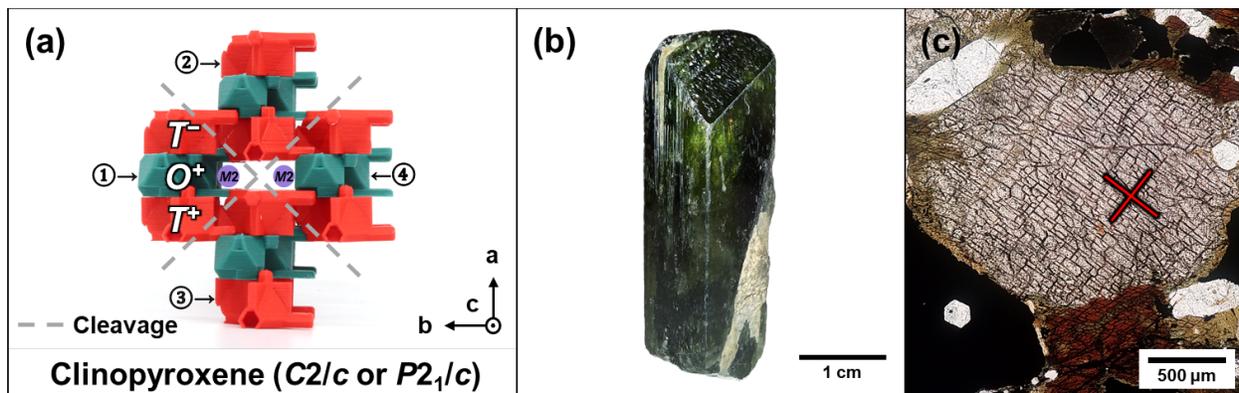
Figure 2. Relationship between (a) the crystal structure of clinopyroxene as constructed with TotBlocks, (b) its habit, and (c) its cleavage angles.

A MINERALOGICAL AND GEOCHEMICAL COMPARISON OF A GRANITIC PEGMATITE AND A MIAROLITIC SCHLIEREN FROM HART'S LOCATION, CARROLL CO., NEW HAMPSHIRE USA. *L. Lovering[1], A.U. Falster[2] and W.B. Simmons[2]*, [1]96 Spring Rd., Milan, NH, 03588, [2]MP[2] Research Laboratory, Maine Mineral & Gem Museum, 99 Main St., Bethel, ME 04217.

A miarolitic granitic pegmatite and a spatially associated miarolitic schlieren occur at an elevation of 670 m at Hart's Location in the White Mountains, Carroll Co., NH (Lovering et al. 2021). The pegmatite is approximately 1 m wide at the current exposure. A nearby (3 m) miarolitic schlieren had a large collapsed miarolitic cavity with a maximum dimension of 0.5 m. There is a contrasting mineral assemblage in the pegmatite and the miarolitic schlieren, even though both are in close proximity and related to the same intrusive event.

      Mineralogy of miarolitic cavities in the pegmatite: microcline (pink), transparent overgrowth on microcline (sodium-rich, unexsolved potassium feldspar, pressure quench

orthoclase likely), nearly endmember albite epitactic on microcline, quartz, bertrandite, danalite (both as inclusions and tiny free-standing crystals), phenakite, muscovite, feldspars and quartz, and siderite, replaced by hematite/goethite.

Mineralogy of the miarolitic schlieren: microcline (white) but without overgrowth of pressure quench feldspars, albite as exsolution lamellae in microcline but not epitaxial on microcline, quartz, large danalite (> 1 cm), astrophyllite, late hematite, goethite, and microlite.

The difference between the two modes of occurrence is the abundance of late albite, which was epitaxially deposited on microcline, possibly as the result of a pressure quench and a dramatic difference in the abundance and size of danalite. The K/Rb ratios in microcline are similar in both modes of occurrence and range from 60-140. The Fe/Mn ratios in Fe-Mn oxides replacing siderite range from 35-60 in the pegmatite and 10-40 in the schlieren.

For danalite to form and be stable, high sulfur activity is needed, coupled with low oxygen activity (Zito & Hanson 2017). Late-stage conditions in miarolitic cavities, especially in anorogenic pegmatites, typically have higher oxygen fugacity; this is indicated also by the replacement of siderite by goethite or hematite. It appears that the schlieren cavity had sufficiently high sulfur activity to initiate forming danalite but the oxygen fugacity was not high enough to alter danalite. Whereas in the miarolitic cavity in the pegmatite, most of the preserved danalite exists as inclusions in bertrandite.

Thus, even though the cavities were very close, there are distinct differences in crystallization and mineral assemblage in both occurrences, indicating that in the late stages of crystallization of these anorogenic pegmatites, small distinct environments play a role and follow their own routes in the late stages of formation.

REFERENCES

Lovering, L., A.U. Falster and W.B. Simmons, 2021. Mineralogy of the Field Pegmatite, an evolved REE-, Be-, and Ta-enriched anorogenic pegmatite from Hart's location, Carroll Co., New Hampshire. *Rocks & Minerals* 95:563-564.

Zito, G. and S.L. Hanson. 2017. Genthelvite overgrowths on danalite cores from a pegmatite miarolitic cavity in Cheyenne Canyon, El Paso Co., Colorado. *Canadian Mineralogist* 55:195-206.

ON THE ORIGIN OF QUARTZ JAPAN LAW TWIN ORIENTED ATTACHMENTS.
Bob Morgan, 2711 Mechanics Avenue, Savannah, GA 31404.

The source of Japan Law quartz twins is yet to be determined. The source of one group, the 'y' twins is proposed here.

These twins are the result of oriented attachment of a smaller crystal on a larger established crystal. They resemble a 'y' with the larger crystal being the long stroke of the 'y' and the attachment the shorter intersecting stroke.

Most Japan law oriented 'y' attachments developed on a prism face of the larger crystal generally designated the 'm' face, which is characteristically striated. Those striations cross the 'm' face perpendicular to the orientation of the crystal's c-axis. They are mostly composed of thin alternating faces, thin rhombohedral or 'r' faces and thin sections of 'm' faces. They generally step

down from a terminating 'r' face with the 'r' strips being risers and the in between 'm' faces being treads.

The site being proposed for an oriented attachment is where a lower 'm' face makes a trench like notch with a rising 'r' sliver. As a notch, it is more likely to attract and retain additions to the larger crystal. Yet most additions to the crystal align with the crystal structure and fail to attain a Japan law orientation.

The Japan law orientation might well happen if: 1) the deposition is of sufficient size not easily adjusted into alignment, and 2) if it has the shape of a simple rhombohedron. Such a rhombohedron, if one of its edges nested along the notch and its 'r' face joined to the 'r' face rise of the striation, would be in a nearly exact Japan law twin orientation - within a couple of degrees. The illustration has been drawn so that the c-axis of the rhombohedron attachment is in the plane of the page. The same is true of the other red line which is parallel to the c-axis of the host crystal. Their angle closely approximates the angle between crystals in a Japan Law twin relationship.

Further growth on this attachment would establish a larger crystal and produce the shorter intersecting arm of the 'y' twin.
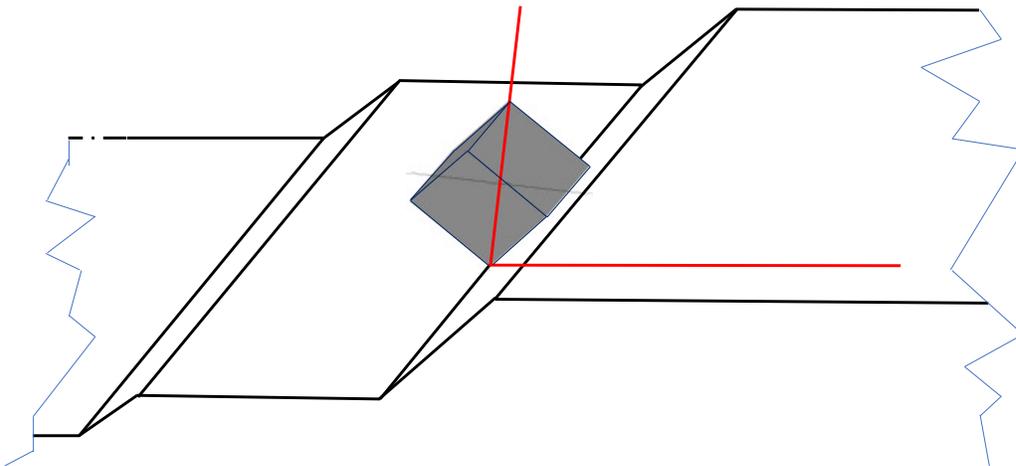
Figure 1. Japan law twinning in quartz.

REGENERATIVE MINERAL REPLACEMENT (RMR) OF APATITE FROM GRENVILLE VEIN DIKES AT THE SCHICKLER OCCURRENCE, WILBERFORCE AREA, ONTARIO, CANADA. *S. E. Mounce[1], C. R. Emproto[2], and J. Rakovan[1]*, [1]Department of Geology and Environmental Earth Science, Miami University, 250 South Patterson Avenue, Oxford, OH 45056, [2]Department of Earth and Environmental Sciences, University of Michigan 1100 North University Avenue, Ann Arbor, MI 48109.

The Schickler Occurrence is a fluorite-bearing Grenville vein dike locality situated near the town of Wilberforce in Ontario and is accessible to the public for collecting with permission from the municipal office. Other vein dikes of interest in this area (also fluorite-bearing) include the Dwyer Mine, Richardson Mine, and Cardiff Mine. Carbonatitic vein dikes of the Grenville province are well known to collectors for hosting exceptionally large crystals of common rock-forming minerals—the Schickler Occurrence is no exception. Among other minerals, striking red-brown apatite crystals, to 10+ centimeters in size, can be found hosted within the dissociated

calcite-fluorite carbonatite matrix. We prepared polished epoxy mounts of apatite crystals from the Schickler Occurrence in order to examine and characterize their internal textures and inclusions to better understand the formation of this fascinating mineral locality.

Investigation via scanning electron microscopy (SEM) backscattered electron (BSE) imaging and X-ray energy dispersive spectroscopy (EDS) mapping reveal that apatite crystals from the Schickler Occurrence exhibit textures indicative of post-growth alteration. This resulted in the formation of a multitude of secondary minerals that formed from elements freed from the primary apatite. In many cases, these zones of alteration form lamellae-like patterns within the apatite crystal (fig. 1A), visible in BSE imaging mode where the average atomic number (Z) correlates with brightness. Micromineral inclusions are primarily concentrated within lamellae exhibiting lower BSE intensity than areas of inclusion-free apatite (fig. 1A). EDS spot analysis reveals that apatite in lamellae of higher BSE intensity contains greater concentrations of rare earth elements (REE) than apatite in lamellae of lower BSE intensity. EDS maps in Fig. 1B-C also reveal phosphorus and calcium being concentrated in the inclusion-enriched lamellae.

We interpret these characteristics to be the result of regenerative mineral replacement (RMR) of Schickler Occurrence apatite, in which apatite was partially dissolved by fluids and reprecipitated as apatite of a different composition but structurally coherent with the remnant apatite. Trivalent REE cations (like Ce, Nd, and La) were distributed throughout the apatite structure before alteration (fig. 1D-F). When apatite dissolved and then reprecipitated, these REEs and other elements formed micromineral inclusions rather than being incorporated back into the apatite structure (fig. 1D-F). This resulted in the recrystallized apatite being relatively more pure in composition compared to its chemistry prior to alteration. This is evidenced by recrystallized apatite by higher concentrations of Ca and P and lower REEs (fig. 1B-C). Most of the micromineral inclusions generated by the RMR process in Schickler apatite appear to be REE minerals, an example EDS spectrum of a typical REE inclusion is shown Fig. 2. Further mineralogical identification of these inclusions is difficult through EDS, as determination of the dominant anion chemistry is challenging.

Apatite crystals from the Schickler Occurrence and nearby Dwyer Mine are also under investigation to characterize calcite- and fluorite-dominant globular inclusions interpreted to have crystallized from trapped melt (Mounce et al. 2021a,b). There are minerals found within polyphase examples of globular inclusions that are also present within RMR lamellae (most notably REE minerals). Continued investigation will help to determine whether any minerals found within polyphase globular inclusions could have resulted from RMR of Schickler apatite.

REFERENCES

Mounce, S.E., C.R. Emproto, M. Murchland, M. Rutherford, and J. Rakovan,. 2021a. Melt and Micromineral Inclusions in Fluorapatite, Calcite, Fluorite, Albite, and Augite from the Schickler Occurrence, ON, Canada. *Rocks and Mineral,* 96(2):180.

Mounce, S., C.J. Anderkin, C.R. Emproto, and J. Rakovan. 2021b. Fluorite and Calcite Melt Inclusions in Apatite from Carbonatitic Intrusions at the Schickler Occurrence and Dwyer Mine, Ontario, Canada. In *Geological Society of America Abstracts with Programs*. 53(3), 10.1130/abs/2021NC-362711.
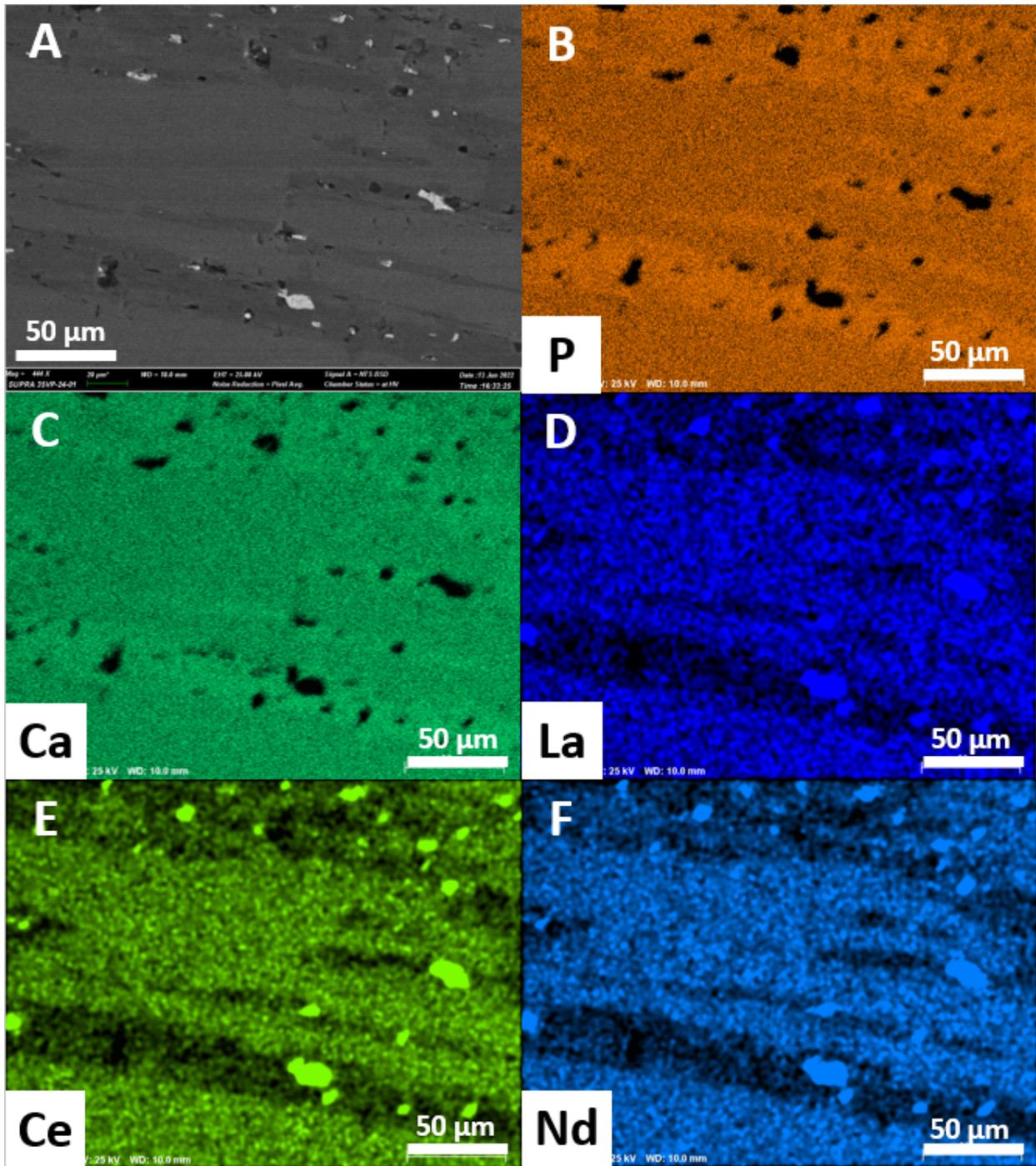
Figure 1. A SEM BSE image of RMR lamellae within a Schickler Occurrence apatite crystal. B-F EDS elemental distribution maps of phosphorus, calcium, lanthanum, cerium, and neodymium, respectively.
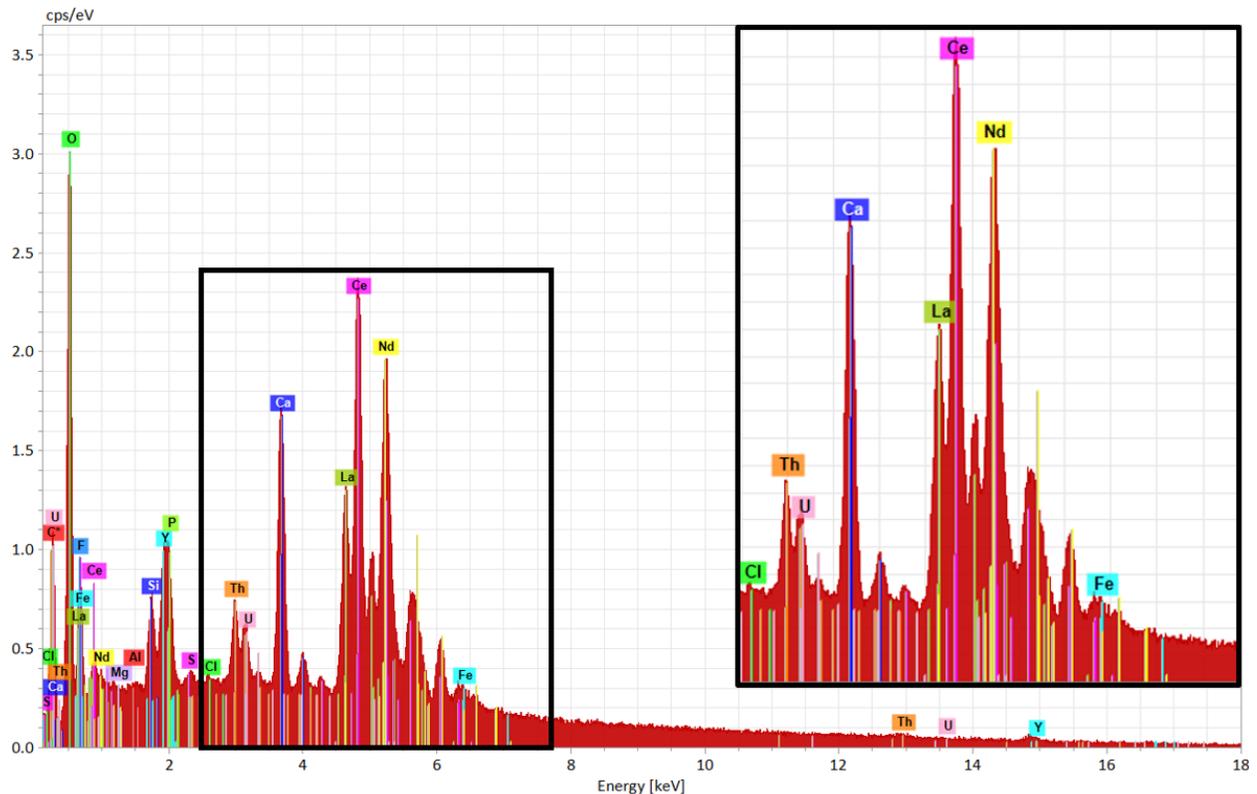
Figure 2. EDS spot analysis of an REE-bearing microinclusion found within the RMR lamellae of a Schickler Occurrence apatite crystal. The exact mineralogy of this inclusion has yet to be determined.

FLUORESCENCE SPECTROSCOPY AND ZONING OF APATITE. *M. Murchland* and *J. Rakovan*, Department of Geology and Environmental Earth Science**,** Miami University, Oxford OH, 45056.

Luminescence in minerals is most often the result of specific elements substituting in the structures of crystals. The complex interactions between these activators, coactivators, and quenchers of luminescence within the crystal fields of the three cation sites in apatite ($^{[IX]}$M1, $^{[VII]}$M2, $^{[IV]}$T) lead to a wide range of colors and intensities of emission. Apatite, a mineral with the general chemistry $Ca_{10}(PO_4)_6(F, Cl, OH)_2$, is commonly luminescent under ultraviolet (UV) light. This is in part due to the mineral's structure, which includes multiple cation sites that are incredibly accommodating to substitutions. Luminescence in apatite is most commonly caused by Mn^{2+}, Eu^{2+}, Eu^{3+}, Ce^{3+}, Dy^{3+}, Nd^{3+}, Sm^{3+}, and Sm^{2+} acting as activators, and occasionally Pb and Sb acting as coactivators to Mn^{2+} (Waychunas 2002). Quenching of fluorescence can also occur with the incorporation of elements like Fe^{3+}. Combinations of these ions along with other substitutions will distort the structure and cause shifts in the crystal field around the sites that they occupy. Adding to the complexity of fluorescence in apatite is zoning (Rakovan 2022), a phenomenon where subtle differences in activators cause observable color differences within the same crystal (fig. 1).

  Activators of luminescence can be broadly determined by fluorescence emission spectra, as differences in energy, relative intensities, and peak shape are characteristic to specific

elements in the apatite structure (fig. 2). This is particularly useful in determining the differences in activators of crystals that emit the same color of fluorescence. For example, bright yellow fluorescence under longwave and midwave UV light can be caused by either Mn^{2+} or Sm^{3+}, however, the spectra for each are distinctly different. Furthermore, this method has allowed us to make broad correlations between emission color and type of geological occurrence. Apatite specimens from granitic pegmatites are often yellow, be it caused by REEs or Mn, while crystals from polymetallic hydrothermal ore deposits often show pink-violet to blue emissions caused by Sm or Eu.

REFERENCES

Rakovan, J. 2022. Fluorescence Zoning: Examples in Apatite. *Rocks & Minerals* 97: 36-47.

Waychunas, G. 2002. Apatite Luminescence. In *Phosphates: Geochemical, geobiological and materials importance*, ed. M. Kohn, J. Rakovan, and J. M. Hughes, 701–42. Reviews in mineralogy and geochemistry 48. Washington, DC: Mineralogical Society of America.
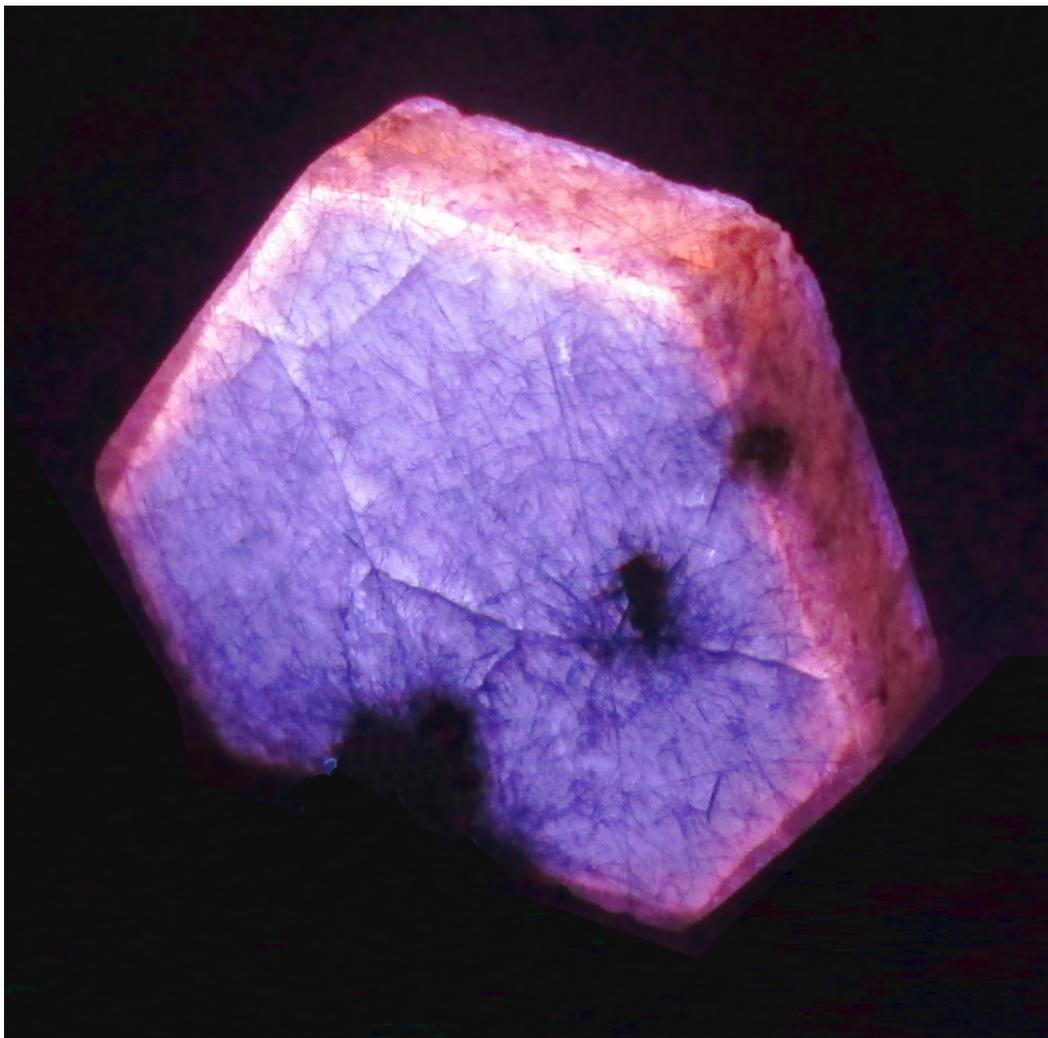
Figure 1. Fluorescent sector zoned fluorapatite (MWUV) from the Siglo XX Mine, Llallagua, Rafael Bustillo Province, Potosí, Bolivia. Prism (100) faces fluoresce pink and pinacoid (001) faces fluoresce violet.
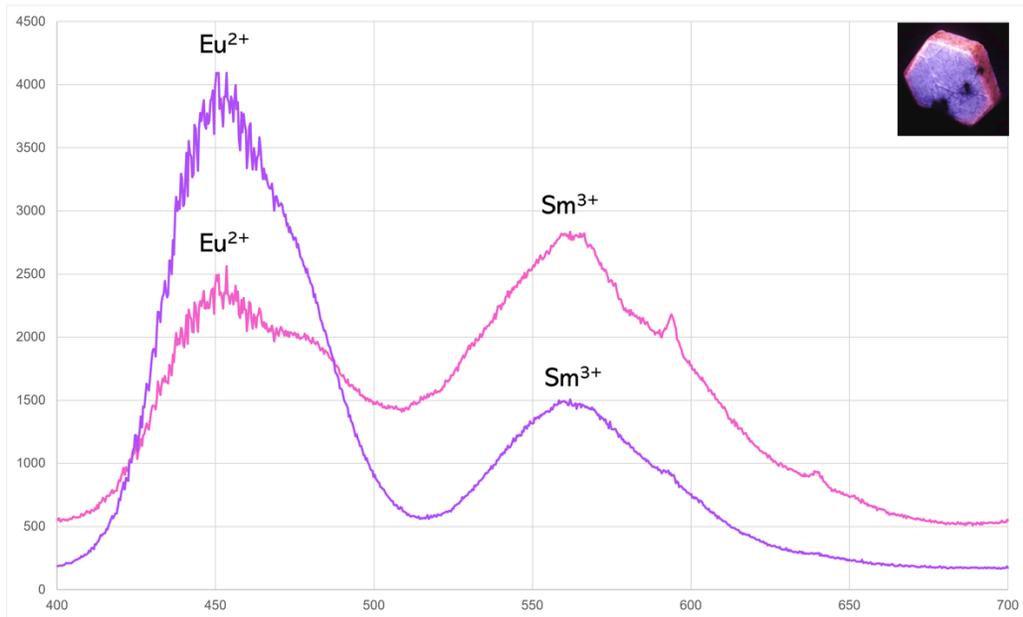
Figure 2. Emission spectra from the (001) pinacoid, violet, and (100) prism, pink, of a sector zoned fluorapatite from Llallagua, Bolivia, in fig. 1.