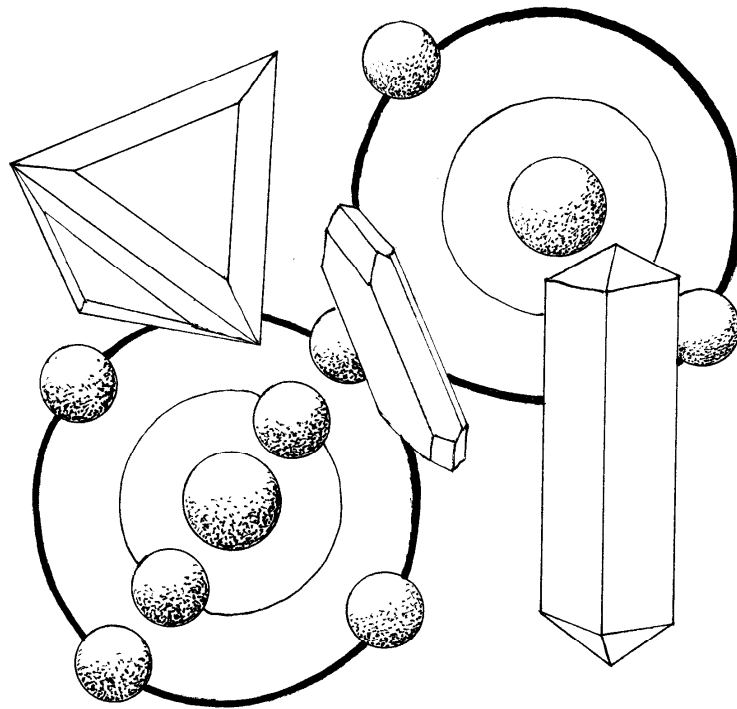# The 44th

Rochester Mineralogical

Symposium

April 20 – 23, 2017

S. ROBINSON

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44th Rochester Mineralogical Symposium

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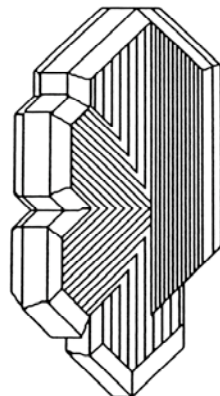
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Our warmest welcome to the 44th Rochester Mineralogical Symposium. We continue this year with our program designed to provide excellent speakers, new information, camaraderie, displays of extraordinary specimens, opportunities to acquire desired objects—all in a familiar and comfortable environment. Our speakers for this year include several who have never lectured here before and others who are familiar faces. Most of their topics will be quite new to our collective experience. This year's Technical Session is very large and very diverse! We welcome numerous new attendees and hope you enjoy our meeting. We appreciate the continuing support of returning attendees. The Program Notes are again electronically printed with a mix of color and black and white. As usual, everything is different, yet everything is the same.

In Memoriam

William Wallace Pinch
(1940 – 2017)

Bill Pinch passed away on April 1, 2017 from complications of earlier surgery. A reception will be held this year in Rochester, NY, to celebrate his life.   Next February, there will be a memorial service in Tucson, Arizona. We will celebrate his many achievements next April at the 45th Rochester Mineralogical Symposium.

Bill was an elemental force in specimen mineralogy. One of his most significant achievements was the initiation of the Rochester Mineralogical Symposium. The First Annual Mineral Workshop was held 20-21 April 1974 at the Sheraton Inn in Canandaigua. Under the auspices of Mineral Section President, Kay Jensen, Bill and Dave Jensen served as co-chairmen this first year. The second workshop, now the Rochester Mineralogical Symposium, was held 17-20 April 1975 in the downtown Holiday Inn and was again co-chaired by Bill and Dave Jensen.

For the next ten years, Pinch served as convening co-chairman and helped build the Symposium into an internationally recognized annual event, setting the highest standards for speakers, exhibits, and congeniality. He initiated the annual What's New in Minerals—still a popular Saturday morning part of the event. He also began the annual production of Program Notes. With the 13th RMS formal leadership of the Symposium passed to others, but Bill continued to serve as an advisor. With his support, the Technical Session was added to the Friday afternoon program and important mineralogical works were reprinted, including Goldschmidt's *Atlas der Krystalformen*, and Beck's *Mineralogy of New-York State*, to name just a few.

At the 25th Symposium, Bill gave a keynote address, "50 years of mineral collecting; 25 years of the symposium". The preceding year, the Symposium had donated the proceeds of its annual auction to the successful funding effort for the Canadian Museum of Nature to purchase the W. W. Pinch mineral collection, establishing another legacy

Slowly, over the next decades, Bill drifted away from direct participation in the Symposium. We were delighted by his attendance at the 43rd RMS on the occasion of Michael Bainbridge's talk, "The William W. Pinch Collection at the Canadian Museum of Nature". The coming book of the same title will be a fitting memorial to Bill's success in assembling a world-class mineral collection. Here we acknowledge our debt to Bill for his successful efforts in beginning and growing the Rochester Mineralogical Symposium. Godspeed.

PROGRAM
Thursday Evening, April 20, 2017

PM   4:00-6:00   Cocktails and Snacks – Hospitality Suite, Room 400 (4th Floor)

      6:00-7:45   Dinner – Baxter's

      8:00-9:15   **King of Tides—Nova Scotia's Bay of Fundy** – *Raymond McDougall*

                Raymond McDougall was born in Montreal, grew up in Toronto, and studied mineralogy and geology while completing a B.A. at McGill University in 1992. He went on to become a corporate/securities lawyer in Toronto for 18 years, where he was an internationally-known partner of the firm Stikeman, Elliott LLP, working with clients in the Canadian mining industry. He retired from law in 2013 to become a full-time mineral dealer (McDougall Minerals - www.mcdougallminerals.com). His website includes articles and reports, including an annual report about this Symposium.

                Ray has been an avid mineral collector since childhood and has enjoyed field collecting across Canada and around the world. Living in the woods near Bancroft Ontario, he burrows in holes in the woods and travels internationally, all in pursuit of fine mineral specimens - and he spends a lot of time in a dark room taking mineral photographs.

                Tonight he will tell us about the minerals from the basalts that rim the Bay of Fundy in Nova Scotia. We warmly welcome Ray back to the RMS speakers' podium.

      9:15   Cocktails and snacks in the Hospitality Suite on the 4th floor will be available throughout the rest of the evening. Dealers' rooms will be open at this time. All of the dealers are located on the 4th floor.

Friday Morning, April 21, 2017

AM   9:00   Announcements

      9:15-10:15   **Overview of Silicate Structures** – *Dr. Frank Hawthorne*

                Frank Hawthorne was born in Bristol, England, in 1946, and educated at the Royal School of Mines, Imperial College, London, and McMaster University, Hamilton, Ontario. He is Distinguished Professor in the Department of Geological Sciences, University of Manitoba. He is an Officer of the Order of Canada (2005), a Fellow of the Royal Society of Canada (1990), a Foreign Member of the Russian Academy of Sciences (2006), a Distinguished Fellow of the Geological Association of Canada, an Honorary Fellow of the Russian Mineralogical Society and the Societá Italia Mineralogia Petrologia, a Life-Fellow of the Mineralogical Association of Canada and the Mineralogical Society of America, and a Fellow of the Geochemical Society, the Geological Association of Canada, the Geological Society of America, European Association for Geochemistry. According to Thomson Scientific, Hawthorne was the most cited geoscientist in the world for the decade 1997-2007, and held a Kilam Fellowship 1989-1991.

                He has been awarded the Hawley Medal (1984, 1994, 1998) and the Peacock Medal (1999) of the Mineralogical Association of Canada, the Past-Presidents' Medal (1991) and the Logan Medal (1996) of the Geological Association of Canada, the Willet G.

Miller gold medal (1993) and the Bancroft Award (2010) of the RSC, the Schlumberger Medal (1995) of the Mineralogical Society of Great Britain and Ireland, the Brock Award (1992) of the Canadian Museum of Nature, the Carnegie Medal (2009) of the Carnegie Museum and the Hillman Foundation, the IMA Medal (2010) of the International Mineralogical Association, the Queen's Diamond Jubilee Medal (2012) from the Government of Canada, the Roebling Medal (2013) of the Mineralogical Society of America, and the Killam Prize in Natural Sciences (2008) from the Canada Council and the Killam Foundation.

His academic interests include topological, electronic and complexity aspects of crystal structures, graph-theoretic and combinatorial approaches to crystal structure, the crystal chemistry of rock-forming minerals, short-range order in minerals, diffraction and spectroscopic methods, microbeam analysis, and solution of unknown mineral structures. His personal interests include English poetry, biography, painting and sculpture, Byzantine mosaics, the history of Europe and Central Asia, the history of Science, detective novels, chocolate and coffee.

This morning we are delighted to have Frank take the podium to discuss silicate structures.

10:15   Coffee Break

10:30-11:30 **Orthosilicates**- *Dr. Robert Lauf*
Dr. Robert J. Lauf earned a Ph.D. in metallurgical engineering from the University of Illinois. For more than twenty years he served as a scientist at the Oak Ridge National Laboratory. He is now a registered patent agent and technology consultant. He is also a prolific author of books on specimen mineralogy. He has published more than a dozen well-received books in Schiffer Book's "Collector's Guide" series and serves as the external editor for Schiffer's earth science series. Last year he spoke about radioactive minerals on the occasion of the publication of his book *Introduction to Radioactive Minerals.*

We welcome Bob Lauf back to the speakers' podium to talk in some detail about orthosilicates, the topic of his coming book.

11:30-1:00   Lunch and Shopping Break

Friday Afternoon, April 21, 2017

PM   1:00 **Contributed Papers in Specimen Mineralogy** - *Dr. Carl A. Francis* - Moderator

1:00 Reuniting the Canadian national mineral collection. **Anderson, E.,** and Coyne, M.

1:15 Crystallinity and texture of natural and synthetic wire silver. **Anderson, C. J.**, Rakovan, J., Böllinghaus, T., and Lüders, V.

1:30 Mineralogical characterization of phosphate accessory minerals throughout the Llallagua Tin Porphry, Bolivia. **Betkowski, W. B.,** and Rakovan, J.

1:45 Discovery of an alumotantalate mineral from the Nine Mile Pluton, Wausau Complex, Marathon County, WI. **Buchholz, T. W.,** Falster, A. U., and Simmons, W. B.

2:00 Gash veins near Bigelow, St. Lawrence County, NY. **Chamberlain, S. C.**, Bailey, D. G., and Carlin, D. M., Jr.

2:15 Tetrahexahedral fluorite crystals from the Nine Mine Pluton, Wausau Complex, Marathon County, WI. **Falster, A. U.**, Buchholz, T. W., and Simmons, W. B.

2:30 Genthelvite overgrowths on danalite cores from a pegmatite in Cheyenne Canyon, Stove Mountain Area, Colorado. **Hanson, S. L.**, and Zito, G.

2:45 Internal examination and imaging of a sperrylite-bearing sulphide. **Joyce, D. K.**, Doell, D. D., Tampieri, D., and Hatem, A.

3:00 Fluorescent twinned calcite crystals and lustrous drusy quartz from a newly discovered gash vein in the Town of Gouverneur, St. Lawrence County, New York. **Lalonde, D. A.**

3:15 A potentially new mineral of the palygorskite group from Wind Mountain. **Leung, D.**, and McDonald, A. M.

3:30 Two fluorite twin morphologies. **Morgan, B.**

3:45 New results and methods in the neutron analysis of large gold specimens from Venezuela. **Rakovan, J.**, Tremsin, A. S., Vogel, S. C., and Nakotte, H.

4:00 Anorthoclase spherulites: A rare and lost occurrence—alkali feldspar in a volcanic glass matrix. **Reynard, C. C.**

4:15 Morphology and genesis of unusual calcite from the Lakeshore Lavas (Middle Proterozoic) north of Duluth, Minnesota. **Richards, R. P.**, and Hedtke, M.

4:30 Structure and chemical complexities of hydroxylapatite from the Sapo mine, Brazil. **Richards, H.**, Kelly, S., and Rakovan, J.

4:45 Garnet line replacement of almanditic garnet by löllingite from the Havey Pegmatite, Poland, Androscoggin Co., Maine. **Simmons, W. B.**, and Falster, A. U.

5:00 Intergrowth texture of Fe-Si intermetallic compounds in a fulgurite from Central Lower Michigan. **Stefano, C. J.**

5:15 Tracing the conflict mineral wolframite through crystal chemistry, structure, and spectra. **Ziga, D.**, Accorsi, G., Hughes, J., and Rakovan, J.

5:30 End of Technical Session

5:30-6:30 Shopping Break

Friday Evening, April 21, 2017

6:30-8:00   Dinner – Baxter's

8:15-9:15   **The Monteponi Mine, Sardinia, Italy** – *Dr. Renato Pagano*
     In 1950, the honorary curator of the Museum of Natural History in Genoa first introduced Dr. Renato Pagano to mineral collecting as a Boy Scout. He has never looked back.
     Renato earned a doctorate in electrical engineering, a masters of power systems engineering at the Rennselear Polytechnic Institute, and had a distinguished career in Italian industry.

His passion for minerals has produced a collection of more than 13,000 specimens, with both systematic and aesthetic subcollections, mineralogical instruments and a large library including important antique books.

His wife Adriana shares his passion for minerals and is his partner in collecting and curating. In 2013 they were awarded the Pinch Medal by the Mineralogical Association of Canada. An excellent profile of Renato, Adriana, and their many collections appeared in the *Mineralogical Record* (**42**:41-52).

Tonight Dr. Pagano will talk about a famous specimen producer, the Monteponi Mine in Sardinia, Italy. We warmly welcome Dr. Renato Pagano back to the speakers' podium.

9:15-???   Continuation of "Shop'til You Drop", spirits, and fellowship – 4th Floor

Saturday Morning, April 22, 2017

AM   9:00-10:00   **What's New in Minerals and Localities, Part I** – *Jeffrey A. Scovil*
Each year Jeff Scovil shares his excellent photographs of minerals that have appeared on the market since the previous Symposium. Again this year, we welcome Jeff to the speakers' podium for What's New in Minerals and Localities.

10:00-11:00   **What's New in Minerals and Localities, Part II** – *Contributions from the audience*.

11:15-12:15   **mindat.org—Sixteen years on: How mindat is Driving New Scientific Discoveries** – *Jolyon Ralph*
Jolyon Ralph still has the first mineral specimen he collected. It is a pebble from Tintagel in Cornwall, which he collected when he was 6 years old in the summer of 1976. A more recent examination of this specimen revealed many tiny, perfect anatase crystals.

It was on Christmas day in 1993, however, when he embarked on a project that was to have a massive impact on specimen mineralogy—that day he started writing from scratch a personal PC mineral database. This effort went live in September 2000 and the rest is history. mindat.org has grown to be an absolutely essential tool for serious mineral collectors world-wide.

Today, we are delighted to welcome Jolyon to the RMS speakers' platform to tell us about the future of mindat.org!

Saturday Afternoon, April 22, 2017

PM   1:30-2:30   **Upside Down and In the Future, Mining Tasmania's Adelaide Mine** – *John Cornish*
John Cornish was born in Washington state in 1961. At age 29, he was first exposed to collected treasures at a friend's home. Soon thereafter he found local sites for collecting marine fossils. In fact, a decapod crab, *Asthenognathus cornishorum*, and a new species of whale, *Sitsqwayk cornishorum*, have been named after him. Since then he has been on a 20+ year career of professional collecting.

John owns and operates John Cornish Minerals and is a much desired speaker at mineral symposia and shows. Today, we are delighted to have John make his debut at the RMS speakers' podium to talk about his experiences mining crocoite at the famous

Adelaide mine in Tasmania.

2:30	Coffee Break	

2:45-3:45 **Red Cloud Mine—The World's Greatest Wulfenite Locality** – *Les Presmyk*

Les Presmyk is the principal mining engineer for SRP, dealing with coal mines in Arizona, New Mexico, and Colorado. He and his wife of 40+ years, Paula, are Arizona natives and are both graduates of the University of Arizona.

Les started collecting at the age of 10 and just attended his 55th straight Tucson Show. Their displays have received AFMS Regional and National Trophies, along with the Prospectors and Pearl Trophies in Denver and the Desautels, Lidstrom, and Bideaux Trophies at the Tucson Show.

Les has been president of the Mineralogical Society of Arizona, board member and chairman of the Arizona Mineral and Mining Museum Foundation (now the Flagg Mineral Foundation), a founding member of the University of Arizona Mineral Museum Advisory board, and a member of the Tucson Show Committee (for 32 years).

He has explored and collected at a number of localities in Arizona, Missouri, and Mexico and provided engineering expertise at the San Francisco mine in Sonora, Mexico, the Brushy Creek mine in Missorui, and the Red Cloud mine in Arizona. Les has written several articles and co-authored the recently published *Collecting Arizona*. He has spoken at the Dallas, Northwest Friends of Mineralogy, Arizona and New Mexico Symposia as well as at numerous mineral shows and mineral clubs throughout the United States

We warmly welcome Les Presmyk to his debut at the RMS speaker's podium.

Saturday Evening, April 22, 2017

5:15-6:30 SILENT AUCTION

7:00-8:30 Forty-first Annual Symposium Auction Dinner – Main Ballroom

8:30 FORTY-FIRST ANNUAL SYMPOSIUM AUCTION

Sunday Morning, April 23, 2017

AM 9:00-10:00 **Meet an Important Unknown Mineralogist** – *Herwig Pelkmans*

Herwig Pelckmans was born in the summer of 1962 and grew up on the outskirts of Antwerp (not Antwerp, New York, but Antwerp in Belgium)! When he was 10, his parents gave him a comic book on the evolution of life on earth. One section dealt with paleontologists finding dinosaur remains in Mongolia. It did not take long for Herwig to find large bones and teeth himself. The fact that they later turned out to be whale bones and shark teeth instead of dinosaur fossils did not really ever disappoint him; the collecting bug had already taken over.

Ever since, his travels and collecting trips have brought him all over Europe and the United States, and even some countries in Africa and Asia. Besides, he loves to write mineralogical articles and give talks for mineral clubs. Recently he became the president of the MKA (the Mineralogical Society of Antwerp; one of the most vivid mineral clubs in the world). Herwig is also promoting the use of the polarizing microscope and the spindle stage as an inexpensive and reliable aid for mineral collectors who want to identify their unknown minerals

He retired from his job as an officer and a database administrator for the

Belgian Army in 2013 and soon realized life is even more hectic when you're retired. He lives with his loving wife and three kids in the small town of Hasselt, Belgium.

We warmly welcome Herwig back to the RMS speakers' podium!

10:00-11:00   **The Pioneer District, Pinal County, Arizona—The Silver King and Magma Mines** – *Les Presymk*

Les returns to the speakers' podium to talk about two famous mines and mineral localities in the Pioneer District—the Silver King mine and the Magma mine.

11:00   End of the Symposium

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See you next year for the
45th RMS:
April 19-22, 2018

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Contributed Papers in Specimen Mineralogy

This year submitted abstracts were reviewed by a committee consisting of Dr. Carl Francis, Dr. Marian Lupulescu, Dr. George Robinson, Dr. Sarah Hanson, and Dr. Steve Chamberlain. Eighteen abstracts were submitted, accepted and scheduled for platform presentations on Friday afternoon. The accepted abstracts follow.

REUNITING THE CANADIAN NATIONAL MINERAL COLLECTION.

Anderson, E.[1] and Coyne, M.[2] [1]Canadian Museum of Nature, PO Box 3443, Station D, Ottawa, ON, K1P 6P4, Canada; [2]Geological Survey of Canada, 601 Booth St, Ottawa, ON, K1A 0E8, Canada.

In 2014, the Geological Survey of Canada (GSC) approached the Canadian Museum of Nature (CMN) to assist in the re-housing of the extensive National Geological Reference Collections in Ottawa. The CMN responded with enthusiasm, and a working group formed in 2015 chose two smaller collections to move in 2016 as a test. The result is a partnership that will see the move of the Systematic Reference Series of the National Mineral Collection, the National Invertebrate and Plant Type Fossil Collection and the National Meteorite and Tektite Collections from Ottawa to the CMN's Natural Heritage Campus in Aylmer. The transfer promises to be an enormous undertaking that will result in the reunification of the National Mineral Collection.

Since its inception in 1842, the GSC has been collecting rocks, minerals, fossils, and other natural samples from around Canada for scientific research and public interest (Zaslow, 1975). In 1927, the National Museum of Canada was partitioned into what has become the Museum of History and the CMN (Zaslow, 1975). When the GSC moved to a purpose built space in the 1950s, the National Mineral Collection was physically separated and in 1961 the National Mineral Collection agreement was drafted (Zaslow, 1975; Harrison, 1961). The agreement stated "there be one National Mineral Collection" (Harrison, 1961). The GSC retained the "Systematic Reference Series" for research, analysis and consultation, while "the Display Series" remained with the museum (Harrison, 1961). The GSC still retained some very fine and historic specimens like molybdenite (Figure 1) from the Ross Mine, Quebec, Canada (P. Belley, personal communication November 22, 2016; M. Picard, personal communication December 1st, 2016). Over the next 50 years, each part of the National Mineral Collection grew independently. The CMN focused on display quality material as well as research material and representative samples from around the world, while the GSC was dedicated to acquisition and discoveries aligned with the Survey's geoscience programmes and priorities, including a recent focus on meteorites and tektites.

The GSC part of the National Mineral Collection is composed of more than 22,000 specimens including more than 350 type minerals, radioactive minerals, and valuable historic minerals, many of which were displayed in London and Paris in the 1800's. A gold sample collected in 1931 from Mistake Bay, Nunavut, will be featured in the CMN's new Arctic Gallery opening to commemorate Canada's 150th anniversary in 2017 (Figure 2). The National Meteorite and Tektite Collection with over 3000 samples was moved in 2015/2016 as part of a pilot project and has already been put to use at the CMN's Natural Heritage Campus' annual Open House. The collection contains representative samples from over 1000 international falls or finds and more than 50 Canadian meteorites, including the main mass of the Madoc Meteorite. The National Plant Type Fossil Collection was moved to CMN in 2016 as another successful pilot project.

It is important to note that although the GSC Collections will be closed during the transition, samples will be made available for loans and research once the move is completed. The same procedures as any regular loan or visit to the CMN will apply to GSC material. Once the collections

are moved, the GSC minerals will remain on long term loan until 2026, when they will then be added permanently to the CMN's Mineral Collection, officially reuniting Canada's National Mineral Collection.

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Zaslow, M. Reading the Rocks : the story of the Geological Survey of Canada, 1842-1972, Toronto : Macmillan Company of Canada ; Ottawa : Department of Energy, Mines and Resources ; Ottawa : Information Canada, 1975, p. 599.

Harrison, J.M. Letter from the Director of the GSC to Deputy Minister, Dr. Marc Boyer on the Co-operation between the National Museum and the Geological Survey of Canada, June 12, 1961.

Figure 1: Geological Survey of Canada molybdenite sample from the Ross Mine, Quebec, Canada (NMC 5114). Photograph by Jodie Francis, GSC.

Figure 2: Geological Survey of Canada gold specimen from Mistake Bay, Nunavut, Canada, (NMC 10363) to be put on display in the new Canada Goose Arctic Gallery at the Canadian Museum of Nature. Photograph by Michelle Coyne, GSC.

CRYSTALLINITY AND TEXTURE OF NATURAL AND SYNTHETIC WIRE SILVER.

C. J. Anderson[1], J. Rakovan[1], T. Böellinghaus[2], and V. Lüders[3]: [1]Dept. of Geology and Environmental Earth Science, 250 S. Patterson Ave., Miami University, Oxford, OH, 45056; [2]Bundesanstalt fuer Materialforschung und pruefung (BAM) Unter den Eichen 87 D-12205 Berlin, Germany. [3]Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum, Section 3.2 Telegrafenberg, 14473 Potsdam, Germany.

It may be surprising that while excellent and numerous specimens of wire silver have been collected for centuries, no data about their crystallinity and texture has been published. As a part of a larger study on the nature of wire silver, we have been investigating the crystalline texture of both natural and synthetic samples using crystal sections, x-ray diffraction, scanning electron microscopy (SEM), and energy resolved neutron imaging.

Wire silver is an unusual crystal habit of native silver. It exhibits no crystal faces, but rather possesses longitudinally parallel striations that resemble strands in a lock of hair (hence the German name "haarsilber"). We had initially speculated whether silver wires might be single crystals, or perhaps bundles of individual whiskers. Much to our surprise, our results indicate that not only are these elongate wires polycrystalline, but that the striations are merely superimposed on an equigranular grain texture.

Natural samples from Freiberg and Schneeberg, Germany were acquired for analysis, and one wire from Kazakhstan was prepared as a crystal section. Synthetic samples were produced both by flame-induced decomposition of acanthite (Ag_2S), and by hydrothermal synthesis from silver sulfate solutions on acanthite and other sulfide mineral substrates (see Jenson 1939).

The crystal section of a wire silver from Kazakhstan clearly exhibits a polycrystalline texture (fig. 1). The crystallites, though highly variable in size, are roughly equant as opposed to those of whiskers, which are extremely elongate in one direction. While some domains may have preferred grain

orientation, the crystallites appear randomly oriented overall. These observations are consistent with x-ray diffraction data from synthetic samples, which yielded a distinctly polycrystalline pattern.

SEM analysis reveals that silver crystallite boundaries are expressed at the surface of natural, flame-grown, and hydrothermal wires (fig. 2). While the boundaries of some crystallites coincide with striations, many span across several striations, and sometimes the entire wire. It appears that the arrangement of crystallites does not depend on striation direction, while the relationship between crystallite size and striation width is proportional across a wide range of scales.

Although crystal sections can reveal internal features, it is a destructive technique and provides a limited picture, and since native silver is highly absorbing of x-rays, traditional diffraction techniques only provide near-surface information, as does SEM. Energy-resolved neutron imaging is a novel, non-destructive technique capable of probing internal bulk crystallinity and elemental composition simultaneously (Tremsin et al. 2017). Preliminary results confirm the heterogeneous texture of natural wire silver and may help to discover a link between crystallite orientation and local composition, if such a relationship exists.

While it remains unclear why or how such an irregular texture consistently constructs coherent wires, this trait is characteristic of silver wires, irrespective of the formation conditions or substrate. Perhaps the most surprising aspect of this phenomenon is the expression and persistence of striations despite cross-cutting crystallites. While whiskers would be expected to posses long, parallel crystallites, wire silver's internal texture is roughly equigranular, and the surficial striations are independent of the underlying crystal fabric. Thus, it appears that silver wires may be more texturally analogous to granite than to whiskers.

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Jensen, E. 1939. Sølvet på Kongsberg, om de kjemiske prosesser ved dets utfelling og om trådsølvdannelsen [The silver of Kongsberg, about the chemical processes of its precipitation and about wire silver formation]. University of Oslo Department of Chemistry, dissertation, p. 69-94. [English summary on pages 94-99.]

Tremsin, A.S, J. Rakovan, T. Shinohara, W. Kockelmann, A.S. Losko, and S.C Vogel. 2017. Non-destructive study of bulk crystallinity and elemental composition of natural gold single crystal samples by energy-resolved neutron imaging. *Scientific Reports* 7:1-9.
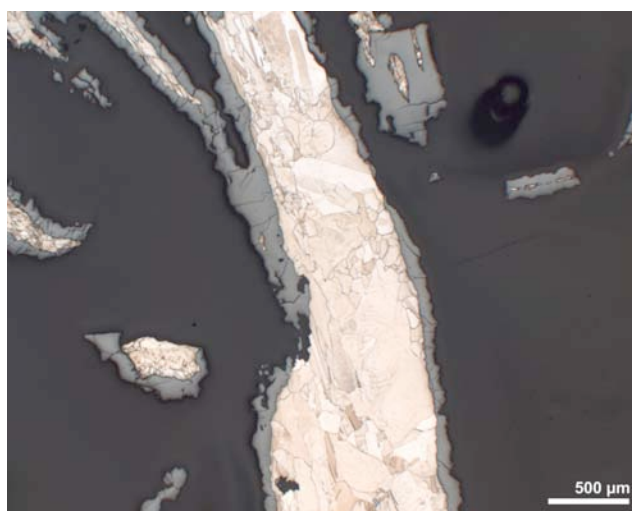
Figure 1: Crystal section of wire silver from Kazakhstan shows roughly equigranular texture as opposed to a bundle of whiskers.

Figure 2: SEM image of a synthetic wire silver shows striations superimposed on a roughly equigranular texture.

MINERALOGICAL CHARACTERIZATION OF PHOSPHATE ACCESSORY MINERALS THROUGHOUT THE LLALLAGUA TIN PORPHYRY, BOLIVIA.

W. B. Betkowski, and J. Rakovan, Department of Geology and Environmental Earth Science, Miami University, Oxford, OH, 45056.

Careful characterization of accessory minerals including their identification, geochemistry and geochronology represent a powerful tool in understanding the history of one of the world's biggest tin deposits, the Sigo XX mine, Llallgua, Bolivia (Betkowski, Rakovan and Harlov 2017). The Llallagua tin deposit is a hydrothermally altered porphyry stock that hosts disseminated and vein mineral assemblages, and is part of the subduction-related Bolivian tin belt. Llallagua is also known for producing World class specimens of hydrothermal fluorapatite and hydrous phosphates including among others vauxite, paravauxite and wavellite. Despite multiple studies, there is still a debate about the timing and characteristics of mineralization related to post-magmatic metasomatism and hydrothermal vein formation. A well-documented ~20Ma inconsistency exists among ages determined from the zircon in the least altered porphyry (U-Pb 42.4 ± 4Ma), reportedly coeval (by paragenetic relationships) vein minerals, fluorapatite (Sm-Nd 43.8 ± 4.7Ma) and monazite (U-Pb 19 ± 1.6Ma), and altered porphyry minerals (K-Ar c. 20Ma).

Insight into the history of Llallagua is given by a study of phosphate minerals and their paragenesis. Apatite, monazite and xenotime were carefully investigated for fluid alteration, development and preservation of primary and secondary growth and alteration textures (fig. 1), and for U-Pb geochronology. Minerals studied were evaluated using a petrographic microscope, a scanning electron microscope and electron microprobe analysis of the mineral assemblages. U-Pb ages were determined by Laser Ablation Inductively Coupled Plasma Mass Spectrometry. The results show mineralization and alteration products in relation to the various alteration styles (sericitization, silicification and tourmalinization). The disseminated primary phosphate minerals, which can be found within metasomatically altered porphyry, were partially dissolved, remobilized and concentrated within hydrothermal veins as gangue minerals including fluorapatite and monazite associated with cassiterite tin mineraliztion. The timing of vein formation was determined as 19.98 ± 0.5Ma and 19.69 ± 4.6Ma from monazite+xenotime and apatite geochronology, respectively. The equilibrium coexistence of

monazite and xenotime was used to constrain temperature changes during precipitation of hydrothermal veins and shows that significant portion of vein cassiterite precipitated around 300 °C. The mineralization was followed by hydrothermal alteration and recrystallization of monazite but not fluorapatite and xenotime. The primary mechanism of monazite alteration was identified as dissolution-reprecipitation which led to HREE exchange by LREE. This is evident by the presence of micro-porosity and the formation of secondary, reaction induced xenotime within the altered grains, and is proposed to be a function of mineral-fluid disequilibrium resulting from temperature drop, and changes in fluid chemistry.

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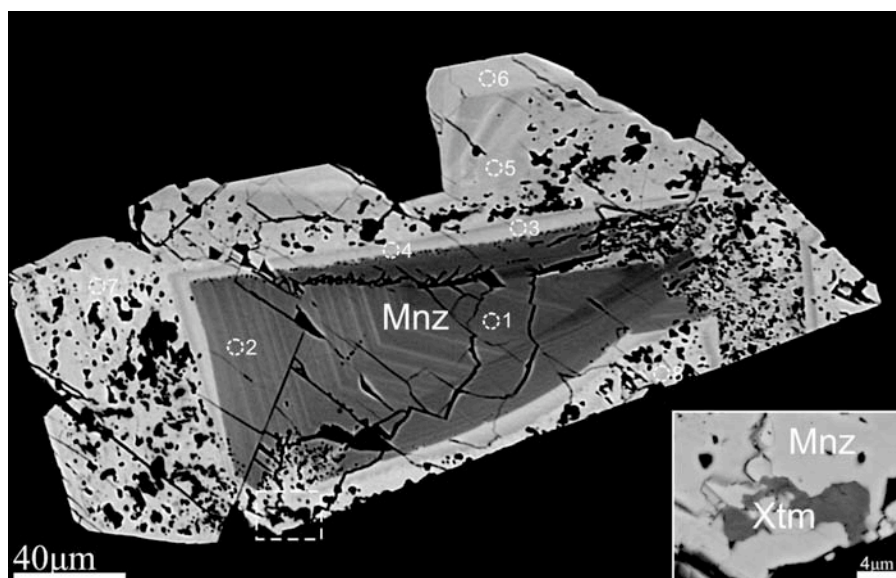
Figure 1. SEM backscattered image of a slice through a euhedral vein monazite that exhibits primary growth partial replacement reaction textures. The lower dashed box is magnified in the inset of this figure. Note secondary xenotime (Xtm) inclusions in the voids created by the alteration.

Figure 2. Close-up of twinned monazite crystals on quartz from the vein assemblage, Llallagua. Note the translucent and lustrous surfaces of the monazite.

DISCOVERY OF AN ALUMOTANTALATE MINERAL FROM THE NINE MILE PLUTON, WAUSAU COMPLEX, MARATHON COUNTY, WI.

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

The Nine Mile Pluton is the youngest (≈1505 Ma, Dewane & Van Schmus, 2007) and most silicic of the four intrusions comprising the Wausau Syenite Complex, and is primarily composed of granite and quartz monzonite. The Red Rock Granite northeast gravel pit is located in the south-western portion of the Nine Mile Pluton in altered granite or episyenite.

   Pegmatites and aplites are rare in this portion of the Nine Mile Granite, but in 2015 a small arching aplite-pegmatite was exposed in the western working face of the northern portion of the pit. The dike was approximately 20 cm thick, with a thin pegmatitic zone measuring approximately 5-6 cm thick near the upper margin of the dike. The center of the pegmatite has a thin (<0.5 cm) discontinuous band of fine-grained albite. Occurring adjacent to and within the albite band are small zircons, small crystals of columbite-group minerals, and very small (300-400μm) brownish grains of an unusual non-fluorescent niobium-bearing alumotantalate mineral. Associated minor minerals include: almandine-spessartine, columbite-(Fe), tapiolite-(Fe), zircon, hafnian zircon, zoned microlite-pyrochlore and U-rich pyrochlore, betafite, xenotime-(Y), ilmenite, monazite-(Ce), and thorite.

   Chemical analysis of this alumotantalate yields a formula of
$Al_{0.986}Fe^{2+}_{0.021}Mn^{2+}_{0.001})_{\Sigma 1.008}(Ta_{0.803}Nb_{0.147}Ti_{0.062})_{\Sigma.012}$ which is essentially identical to : alumotantite $(AlTaO_4)$, the stoichiometry of simpsonite, $Al_4Ta_3O_{18}$ (OH), rules this species out.   X-ray diffractometry is needed to further confirm the presence of alumotantite. Pegmatites of the Nine Mile Pluton are anorogenic in origin; and typically, NYF pegmatites contain a paucity of Ta-dominant phases. However, as we have previously reported, Nine Mile pluton pegmatites contain late-stage Ta-enrichment, resulting in the formation of various Ta-dominant phases, including tantalite-(Mn), tapiolite-(Fe), and microlite. The occurrence of 'alumotantite' is noteworthy considering the metaluminous nature of the NYF pluton. It seems likely this occurrence also results from a process of very late-stage fractionation similar to the processes that produced the high-Ta species in other

pegmatites in the pluton.   Considering the lack of dark mica (annite or siderophyllite) in the dike, availability of Fe was likely limited, and the small amount of Fe available for interaction with late-stage fluids was likely consumed in the formation of columbite-(Fe), tapiolite-(Fe), almandine-spessartine and ilmenite. Pyrochlore, microlite, monazite and albite crystallization reduced concentrations of Ca, Na, U and other elements. Thus, Al was available to combine with residual Ta and Nb to form probable alumotantite. The result of this fractionation was the crystallization of small amounts of probable alumotantite. Another possibility for increased Al availability may be a greisenization trend such as has been observed in one location where abundant topaz was found.

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GASH VEINS NEAR BIGELOW, ST. LAWRENCE COUNTY, NY.

S. C. Chamberlain[1], D. G. Bailey[2], and D. M. Carlin, Jr.[3] [1]3140 CEC, Center for Mineralogy, New York State Museum, Albany, NY 12230; [2]Geosciences Department, Hamilton College, Clinton, NY 13323; [3]18 Country Club Road, Gouverneur, NY 13242.

As part of our ongoing study of so-called "gash veins" in St. Lawrence County, NY, we have discovered a cluster of these veins just southeast of Bigelow at about 44°25'18" N ,75°21'44"W. These veins are south of the tourmaline road cut (Lupulescu et al., 2010) on the Hermon-Richville Road, in the woods on the opposite of side the road. Thus far three gash veins have been discovered and characterized. All are nearly vertical in a matrix of Grenville Marble. We have numbered them in the order in which they were discovered.

The mineralization of GV1 consists mainly of gray to white calcite crystals to 3.7 cm with clusters to 5.5 cm. Most are rhombohedral and often show Rossie twinning; a few are scalenohedral. Most faces are frosted, but some are glassy. Fluorite cubes to 4 cm occur sparingly and range from pale green to gray (Chamberlain, 2015). These are transparent to translucent and have frosted crystal faces. Late-stage colorless quartz crystals to 4 mm and mm-sized graphite flakes and rosettes are common in the lining of the vein.

The mineralization of GV2 consists of colorless to gray rhombohedral calcite crystals in parallel growths to 13 cm. Rossie twinning is common. Fluorite is relatively common in pale blue cubes to 5 cm, but are often shattered. Fluorite also occurs as pale green and colorless crystals.

The mineralization of GV3 consists of creamy-white clusters of rhombohedral calcite crystals to 7.3 cm. Blocky white barite cleavages and crystals are a common accessory. Cleavage blocks are common to 5 cm and crystals with tapered, deeply-striated terminations occur to 8 cm. Most notable, however, are fluorite cubes of a dark blue color to 14 cm. Other fluorite in this vein is pale blue or pale green.

The presence of fluorite in gash veins in this part of St. Lawrence County correlates with elevated concentrations of fluoride in drinking water (Shawe, 1976) but the cause and effect is unclear. What *is* now clear is that noteworthy fluorite specimens can come from these gash veins.

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overgrown dravite , Bigelow, St. Lawrence County, New York. *Rocks & Minerals* **85**:250-259.
Shawe, D. R. (ed). (1976) Geology and resources of fluorine in the United States. *U.S.G.S. Professional Paper 993*.

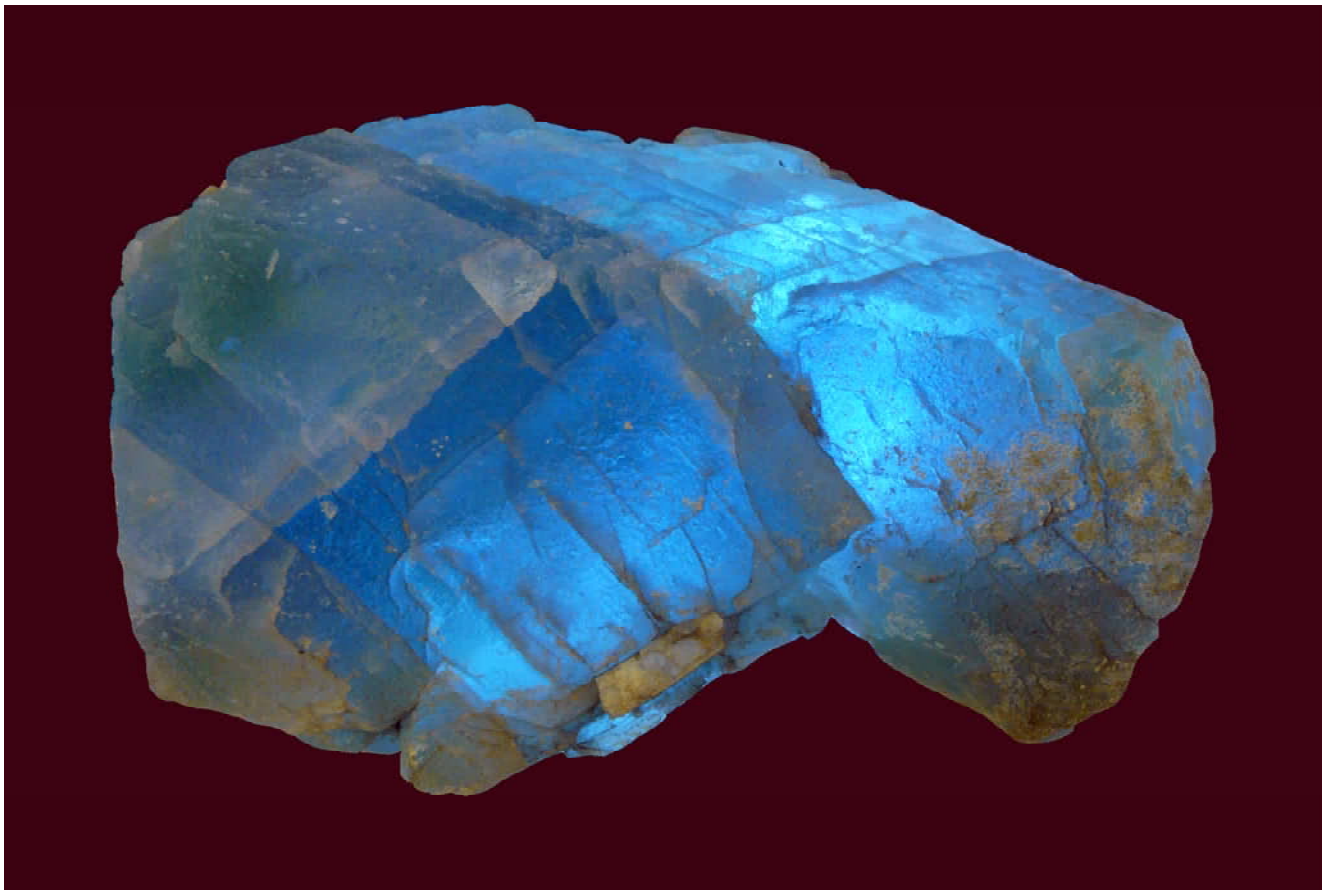Fig. 1. Calcite with Rossie twinning. Bigelow Gash Vein #2. 4.6 cm. Collected, 9/16.

Fig. 2. "Bigelow Blue" fluorite. Bigelow Gash Vein #3. 14 cm. Collected 9/16.

TETRAHEDRAL FLUORITE CRYSTALS FROM THE NINE MILE PLUTON, WAUSAU COMPLEX, MARATHON COUNTY, WI.

Falster, A. U. [1,] Buchholz, Thomas W.[2], and Simmons[1], Wm. B., [1]Maine Mineral and Gem Museum, PO Box 500, 99 Main Street, Bethel, Maine 04217; [2]1140 12th Street North, Wisconsin Rapids, Wisconsin 54494.

The Red Rock Southwest gravel pit is located in the south-western portion of the Nine Mile Pluton in altered granite or episyenite consisting of quartz, chloritized remnants of biotite (probably originally annite) and extensively albitized K-feldspar. Episyenite bodies are abundant in portions of the Nine Mile Pluton, and although many are barren, some were subsequently mineralized. This unusually large body has been quarried away over the years; the currently exposed pit measures approximately 160 by 70 meters.

Excavations in 2015 exposed a small portion of the episyenite body mineralized with quartz, fluorite and calcite. All three phases completely or partially fill the vugs, in some instances, with well-formed crystals. Quartz crystals are colorless to white and of simple morphology with prism and the two rhombohedra. Calcite (high Mg content) crystals are creamy white and form simple rhombohedra. Deep purple fluorite crystals appear to have formed in two generations; an older generation consisting of stepped octahedrons up to 3 mm across and a later generation of well-formed tetrahexahedrons with smaller cube faces, both as terminations on points of fluorite octahedrons, and as single isolated crystals. Rare hexoctahedral faces also occur. Compositionally, the calcite is light rare earth element-bearing (LREE) and the fluorite is rich in heavy rare earth elements (HREE), notably Y and Yb. The fluorite is color-zoned with deep purple rims and paler to almost colorless or white cores. HREE are present in over 1 wt. % in the core whereas the rim is notably poorer in HREE. Yb is the second most abundant HREE after Y.

There is little information in the literature pertaining to the question of fluorite morphology versus temperature of formation, but there are a few studies concerning episyenite formation. Hecht et al (1999) suggest that quartz dissolution in episyenite formation in Königshain granites may have taken place between 300 and 450°C under conditions of low pressure and moderate salinity. Nishimoto et al (2014) suggest episyenite formation at 300-430°C under conditions of moderate salinity and 100MPa in the Toki granite based on fluid inclusion studies in quartz. It should be noted that conditions of episyenite formation may have been different from conditions of mineralization, but it seems reasonable that conditions may have been comparable in the Nine Mile pluton.

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GENTHELVITE OVERGROWTHS ON DANALITE CORES FROM A PEGMATITE IN CHEYENNE CANYON, STOVE MOUNTAIN AREA, COLORADO.

S. L. Hanson[1] and G. Zito[2], [1]Adrian College, Geology Department, 110 S. Madison St., Adrian, MI 49221. [2]Colorado School of Mines, Metallurgical and Materials Engineering Department, 1500 Illinois St., Golden, CO 80401.

In 2012, small (1 – 50 mm) genthelvite crystals that sometimes occur as epitaxial overgrowths on danalite were recovered from a pegmatite pocket in Cheyenne Canyon, El Paso County, Colorado. The pegmatite dike is small (1.5 – 3 m thick) and composed primarily of quartz and feldspar with a surface alteration to an orange/red color due to the presence of "limonite," a mixture of trivalent iron oxide minerals, predominantly goethite. The genthelvite / danalite crystals were present in a small miarolitic cavity that was lined with 0.1 to 4 cm white microcline crystals, some with epitaxial clear albite overgrowths. Microcline crystals are sometimes covered with 1-5 mm white monoclinic prisms of prosopite [$CaAl_2(F,OH)_8$]. Quartz crystals (0.1 – 5 cm) are clear to lightly smoky. Some exhibit a smoky core that is overgrown by up to three distinct zones of milky quartz. The largest crystals in the pocket (up to 10 cm) are white octahedral fluorite with light green cores. Mica minerals are notably absent as they have been altered to sericite that is stained yellow with late-stage "limonite." Accessory minerals include black/brown ilmenite (1-3 mm), rare 1-3 mm black columbite-(Fe), and 0.5 to 1 cm root beer colored bastnäsite-(Ce) crystals that are elongate parallel to the c-axis. Late-stage iron minerals, generally "limonite," coat the feldspar, quartz, and sericite. Rare highly altered "limonite" after siderite and hematite are also present (Zito and Hanson, 2017). Helvine-group minerals include light-rose colored genthelvite crystals that occur as distorted octahedrons although some exhibit rhombic dodecahedron faces. A few of these crystals occur as partial to complete epitaxial overgrowths on tetrahedral danalite cores. If the overgrowth is incomplete, danalite is exposed as a red triangular face within a genthelvite crystal face (Fig. 1). Late-stage beige genthelvite coatings are present on exposed danalite faces.

   Helvine-group minerals are represented by the general formula $M_8Be_6(SiO_4)_6S_2$ where the species is determined by M-site occupancy; genthelvite is Zn dominant, danalite is Fe dominant, and helvine is Mn dominant. For samples from Cheyenne Canyon, the genthelvite overgrowths are near end-member composition as there is little substitution of Fe and Mn for Zn and the ternary mol % of genthelvite is 96% (Figure 2). In contrast, danalite cores exhibit significant substitution of Zn and Mn for Fe with Zn ranging from 2.179 – 2.216 apfu and Mn from 1.474 – 1.528 apfu. Ternary mole compositions show danalite is the dominant component (52.82 – 53.04%) with substantial genthelvite (27.80 – 28.15%) and helvine (19.04 – 19.16%) components.

   This mineral assemblage is, in part, the result of the alkaline nature of the melt that leads to the formation of helvine-group minerals rather than beryl. Decreasing sulfur activity from early to late pocket forming stage resulted in the change from crystallization of danalite to genthelvite. Increasing oxygen activity resulted in both the cessation of danalite crystallization and a change in crystallizing oxide phases, from siderite to hematite to "limonite." Changes in the late-stage fluid composition are indicated by the shift from earlier formed red genthelvite overgrowths with Fe > Mn to the more Fe-depleted late-stage beige genthelvite coatings. During the final stages of mineralization, an extremely late-stage fluid may have altered the final mineral assemblage to produce an outer trace element enriched genthelvite rind. The mineral assemblage in this small pegmatite pocket in Cheyenne Canyon illustrates that variability in fluid composition in small pegmatite systems can be as complex as those in larger pegmatite systems (Zito and Hanson 2017).

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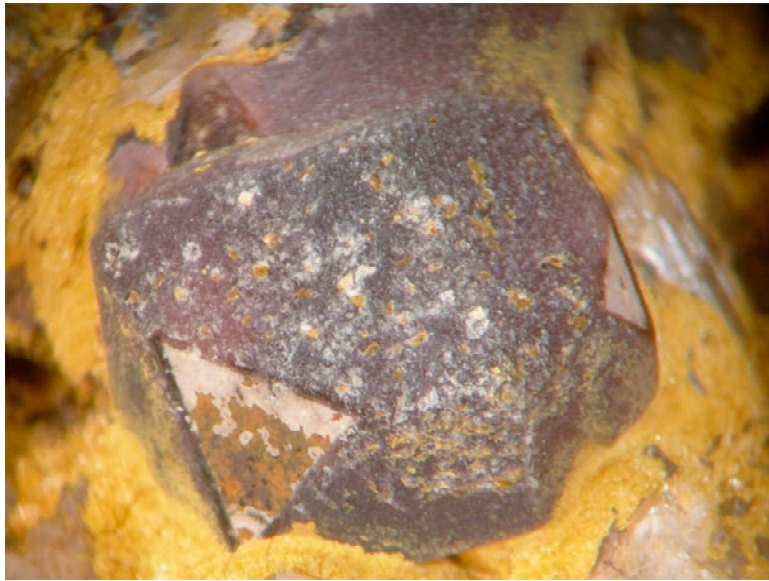
Figure 1. Genthelvite overgrowth on an exposed danalite core (FOV = 9 mm)
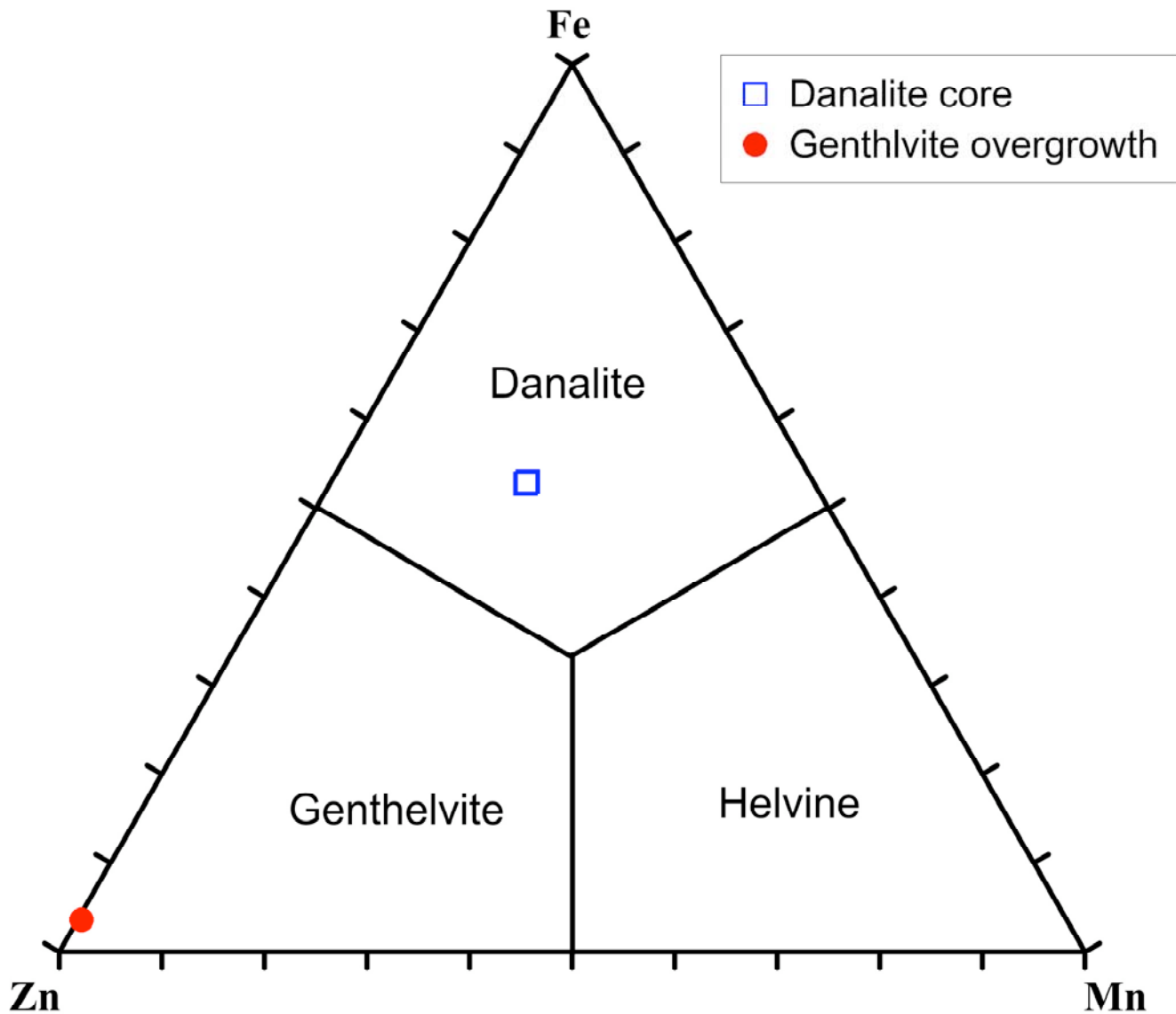
Figure 2. Composition of Cheyenne Canyon helvine-group minerals.

INTERNAL EXAMINATION AND IMAGING OF A SPERRYLITE_BEARING SULPHIDE.
D.K.Joyce, D.D.Doell, D.Tampieri, A. Hatem, Box 95551, Newmarket, Ontario, Canada, L3Y 8J8

One of the authors (D.K. Joyce) recently came into possession of several large pieces of chalcopyrite, from the Broken Hammer Deposit, Sudbury, Ontario. From external examination of exposed partial sperrylite crystals, it was thought that the chalcopyrite pieces could contain additional sperrylite crystals. The original plan was to break the specimens, to expose any hidden crystals. Of course, that approach would be, done"blind", would be completely arbitrary and could result in the damage of potential specimens. One of the authors (Dr. D. D. Doell) hypothesized that CT scanning technology could be used to examine the internal contents of the sulfide fragments. He arranged with the Montreal

Neurological Hospital and Institute (MNHI), Montreal, Quebec, to try an imaging session to test that hypothesis. The densities of the materials were of much higher density than the humans that are usually examined and imaged using this equipment but MNHI staff felt that by adjusting equipment parameters, such imaging could be successful. Using a Toshiba Aquilon ONE CT Scanner, the chalcopyrite samples were examined, sperrylite crystals noted internally and then were successfully revealed by trimming based on information obtained during the scans. This presentation will provide a review of the procedure and results.
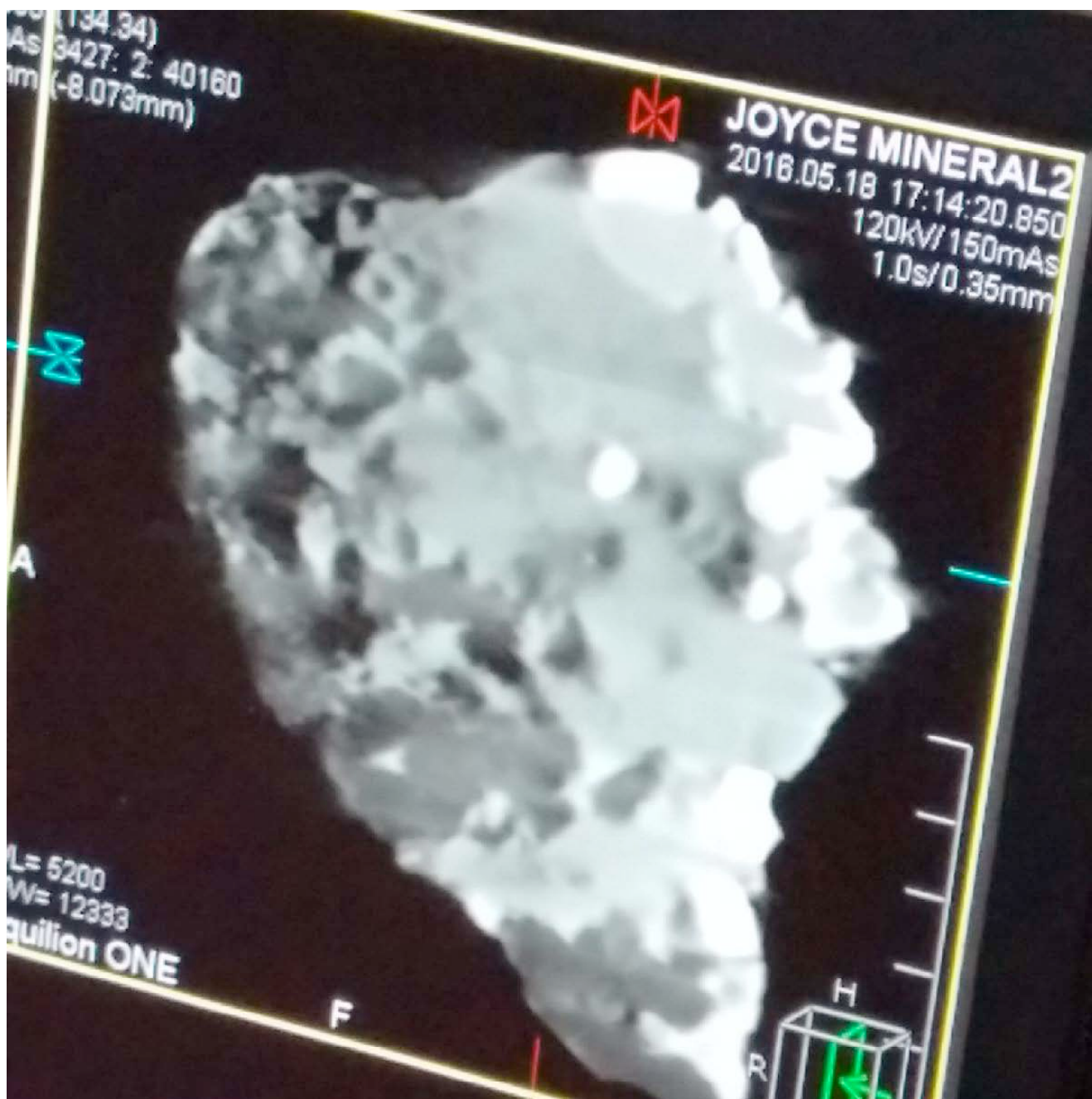

Figure 1. CT scan image of a fragment showing sperrylite crystals as lighter colored areas. Specimen-15 cm.

Figure 2) Toshiba Aquilon ONE CT Scanner, Montreal Neurological Hospital and Institute.

FLUORESCENT TWINNED CALCITE CRYSTALS AND LUSTROUS DRUSY QUARTZ FROM A NEWLY DISCOVERED GASH VEIN IN THE TOWN OF GOUVERNEUR, ST. LAWRENCE COUNTY, NEW YORK.

D. A. T. Lalonde, 5 Lead Mine Road, Gouverneur, NY 13642.

In the spring of 2016, exploratory reconnaissance on farmland neighboring the Beaver Creek State Forest in western St. Lawrence County led to the discovery of an outcrop rich in interesting mineralogy. In particular, a gash vein in Precambrian marble (44°24'48''N 75°29'59''W) contained

fluorescent calcite crystals and drusy quartz crystals with minute enclosed flakes and rosettes of graphite. The calcite crystals are principally rhombohedral in habit with p{101} modified by secondary scalenohedral faces, mostly N{532}. Some are classic Rossie-habit twins on (001) to 4 cm. Some calcite crystals are principally scalenohedral in habit and are largely untwinned. The quartz occurs as transparent and colorless equant crystals with positive and negative rhombohedral faces and only minor prism faces. The minerals in the gash vein appear to have been deposited by descending meteoric waters carrying weathering products from overlying marble. The vein is partially filled with clay. The marble host rock contains amphibole, mica, and other silicates as small inclusions. The setting and mineralization are similar to other gash veins in the area such as those at Bigelow, Edwards, and Yellow Lake, but especially resemble those at the Oxbow road cut (Walter and Chamberlain, 2009).

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Figure 1. Twinned calcite crystal on drusy quartz. Collected by David A. T. Lalonde, 2016. 4 cm. S. C. Chamberlain collection and photo.

Figure 2. Syncroscopy image of graphite. S. C. Chamberlain photo.

A POTENTIALLY NEW MINERAL OF THE PALYGORSKITE GROUP FROM WIND MOUNTAIN, NM.

D. Leung and A. M. McDonald, Harquail School of Earth Sciences, Laurentian University, Sudbury, Ontario P3E 2C6, Canada.

The Wind Mountain Laccolith, located 12 km north of the border between New Mexico and Texas, is an alkaline pluton associated with the Cornudas Mountains and Trans-Pecos magmatic province. It is dominated by nepheline syenite locally containing pegmatitic segregations enriched in REE and HFSE. The intrusion is also cross-cut by a vesicular phonolite dike, the cavities of which are occupied by colourless plagioclase, a clinopyroxene (aegirine?) and an unidentified mineral related to palygorskite.

The unidentified mineral occurs in divergent, radial aggregates (average 1 x 2 mm; up to 4 x 6 mm) that commonly span the entire vesicle they occur in. Individual crystals are acicular to fibrous (average length 0.4 mm; average length:width ratio 25:1). They are typically orange-brown in colour, some with reddish-brown tips; altered versions are purplish-brown in colour.

Studies of associated mineralogy, mineral chemistry and both powder and single-crystal X-ray diffraction studies suggest the mineral is an Fe^{3+}-rich, alkali-deficient member of the palygorskite group. The crystal structure of the mineral has been solved and refined (1158 unique reflections, R = 4.01%, wR2 = 10.70%). The mineral is monoclinic, crystallizing in the space group $C2/m$ with $Z = 4$, $a = 13.759(3)$, $b = 17.911(4)$, $c = 5.274(1)$ Å and $\beta = 106.44(3)°$. Combined electron-microprobe and results from the refined crystal structure yields a structural formula of $(\square_{0.44}Mn^{2+}_{0.31}Ca_{0.15}K_{0.08}Na_{0.03})_{\Sigma=1.01}(Fe^{3+}_{2.46}Mg_{0.84}Mn^{2+}_{0.44}Al_{0.22}Ti_{0.04})_{\Sigma=4.00}Si_8O_{20}[(OH,O)Cl_{0.02}]_2(H_2O, OH)_4 \cdot 4H_2O$, with an ideal chemical formula of $(\square,Mn^{2+},Ca,K,Na)(Fe^{3+},Mg,Mn^{2+})_4Si_8O_{20}(OH,O)_2(H_2O,OH)_4 \cdot 4H_2O$, and a potential end-member formula of $\square Fe^{3+}_4Si_8O_{20}(OH,O)_2(H_2O,OH)_4 \cdot 4H_2O$. The mineral belongs to the palygorskite group, which includes yofortierite $((Mn^{2+},Mg,Fe^{3+},\square)_5Si_8O_{20}(OH,H_2O)_2 \cdot 7H_2O)$ and windhoekite $(Ca_2Fe^{3+}_{(3-x)}[(Si,Al)_8O_{20}](OH)_4 \cdot 10H_2O)$, many of which are found as late-stage minerals in alkaline environments.

The mineral is paragenetically late, overgrowing clear, colourless plagioclase (albite?) that typically lines the vesicles and a clinopyroxene (aegirine?). The predominance of Fe^{3+} being present in the mineral is based on its colour, observed bond distances and association with presumed aegirine. The mineral is considered to have developed as a late-stage product of hydrated, oxidized, SiO_2-bearing fluids that were rich in Fe^{3+}.

TWO FLUORITE TWIN MORPHOLOGIES.

Bob Morgan, 2711Mechanics Avenue, Savannah, GA 31404.

Fluorite twins on the (111) plane. From a similar origin two different morphologies develop. They are commonly designated the penetration twin and the spinel twin.

Fluorite penetration twins are composed of cubes as seen notably on specimens from Weardale, England. The cube habit is an indicator of low temperature formation (Kostov & Kostov, 1999).

Senechal (1976)showed how a growing isometric (111) twin could develop into a penetration morphology. As the cube form emerges on both crystals, they eventually grow around each other. Thus, the development is not one of penetration but encompassing overgrowths.

Seager (1953) photographed a cube face of one of these twins showing growth layers centered around a reentrant edge of the other twinning crystal. New layers were initiated faster than older ones could spread to outer edges of the face.

This appears on both crystals, wherever a corner of one crystal is protruding out of the other's cube face. They have a mutual effect on each other maintaining relative equal size.

Fluorite spinel twins have relatively large faces of dodecahedral and octahedral forms as on twins from Naica, Mexico and Erongo, Namibia. These other forms are indicative of growth in higher temperatures (Kostov).

Spinel twins of spinel and galena have large, wide (111) contact planes with flattened crystals on either side. Twins of fluorite are not like that. The pattern of their final morphology will be described and some preliminary questions explored concerning the processes of growth that produce the fluorite 'spinel twin' morphology.

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NEW RESULTS AND METHODS IN THE NEUTRON ANALYSIS OF LARGE GOLD SPECIMENS FROM VENEZUELA.

J. Rakovan[1], A.S. Tremsin[2], S.C. Vogel[3], H. Nakotte[3&4]:
[1]Dept. of Geology and Environmental Earth Science, 250 S. Patterson Ave., Miami University, Oxford, OH, 45056; [2]Space Sciences Laboratory, University of California at Berkeley, 7 Gauss Way, Berkeley, CA 94720; [3]Los Alamos Neutron Science Center, Los Alamos National Laboratory, Los Alamos, New Mexico 87545; [4]Department of Physics, New Mexico State University, Las Cruces, New Mexico 88003.

Rakovan et al. (2009) first reported on the use of neutrons as a noninvasive way to study the interiors of large gold samples. In that paper they applied neutron diffraction to evaluation of the crystallinity of large apparent gold crystals. All of the samples studied at that time were shown to be true single

crystals, consistent with their external morphologies. This same technique was then used to study the structure of some of the finest crystals (fig. 1) ever found in Venezuela if not the world (Rakovan 2014). The external morphologies of these specimens suggest that they are single crystals. Diffraction measurements of all three samples were made on two different instruments at the Lujan Center, Los Alamos Neutron Scattering Center, Los Alamos National Laboratory. These were the single crystal diffraction instrument (SCD) and the high-pressure-preferred orientation instrument (HIPPO).

For sample 1, both SCD and HIPPO data are composed of sharp, well defined diffraction spots that can all be indexed given a single crystal orientation. This indicates that sample #1 is structurally a single crystal, consistent with its morphology. This is also the case for data from sample 3, however, the data cannot be indexed with a single crystal orientation. It appears that they can be described as two crystals. This indicates that sample #3 is structurally a twin crystal or is composed of two crystals in a non-twinned orientation. In the case of sample 2 both datasets collected are consistent and indicate that the sample is polycrystalline with numerous (probably hundreds or more) grains of very different orientation. The external morphology, however, is that of an exceptionally sharp and perfectly formed single crystal. Thus, the diffraction data are inconsistent with that morphology. Our interpretation of this result is that the external morphology is not natural but was created by some process such as casting.

In addition to recent diffraction experiments, a newly developed technique, energy-resolved neutron imaging (ERNI), has been employed in the study of other Venezuelan gold specimens (fig. 2). This technique enables non-destructive analyses, with high spatial resolution (~100 μm), of both bulk crystallinity (i.e. single crystal vs polycrystalline) and elemental composition. Through the analysis of neutron absorption resonances compositional data are not only element specific but also isotope specific. For example, different isotopes of palladium that are alloyed with gold can be detected and their concentrations quantified. To test the capabilities of this technique four gold samples were chosen for analysis, two that showed possible alloying with palladium, one that was suspected to have grown authigenicly in lateritic sediments, and a 1 cm single hopper octahedral crystal used in the study of Rakovan et al. (2009). Spatial heterogeneities (zoning) of palladium were mapped in the two alloyed specimens. One was found to be single crystal while the other is polycrystalline. The suspected authigenic sample showed no detectable impurities (e.g. very pure gold) and a polycrystalline structure. Surprisingly the single octahedral crystal was also pure within detection limits of the technique (e.g. <0.3 atom % for Pd), suggesting that it two may be authigenic.

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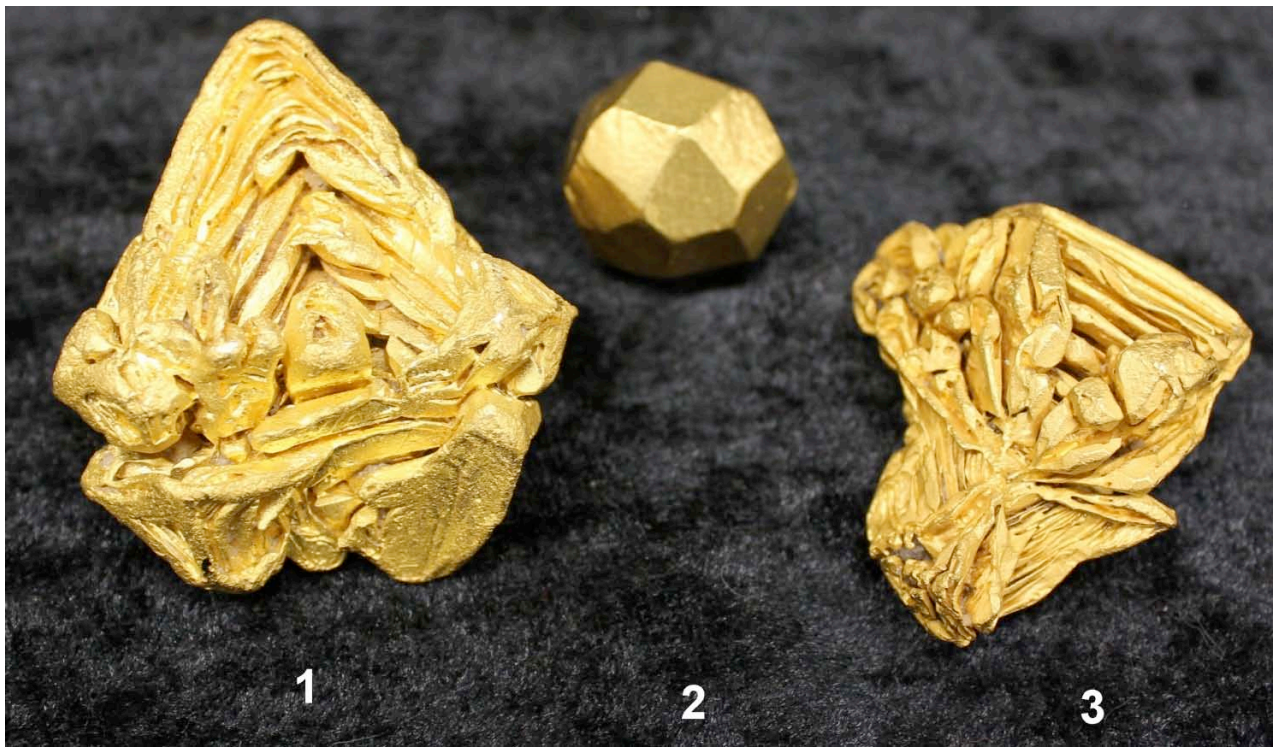
Figure 1. Gold specimens from the Roraima Shield District, Bolivar, Venezuela studied by neutron diffraction. Sample 1: a 4.44 x 4.27 x 2.06 (217.78 g) hoppered octahedron; sample 2: a 2.16 x 2.11 x 2.06 (73.2 g) trapezohedron; a 3.5 x 3.2 x 2 cm (89.9 g) complex hoppered crystal.
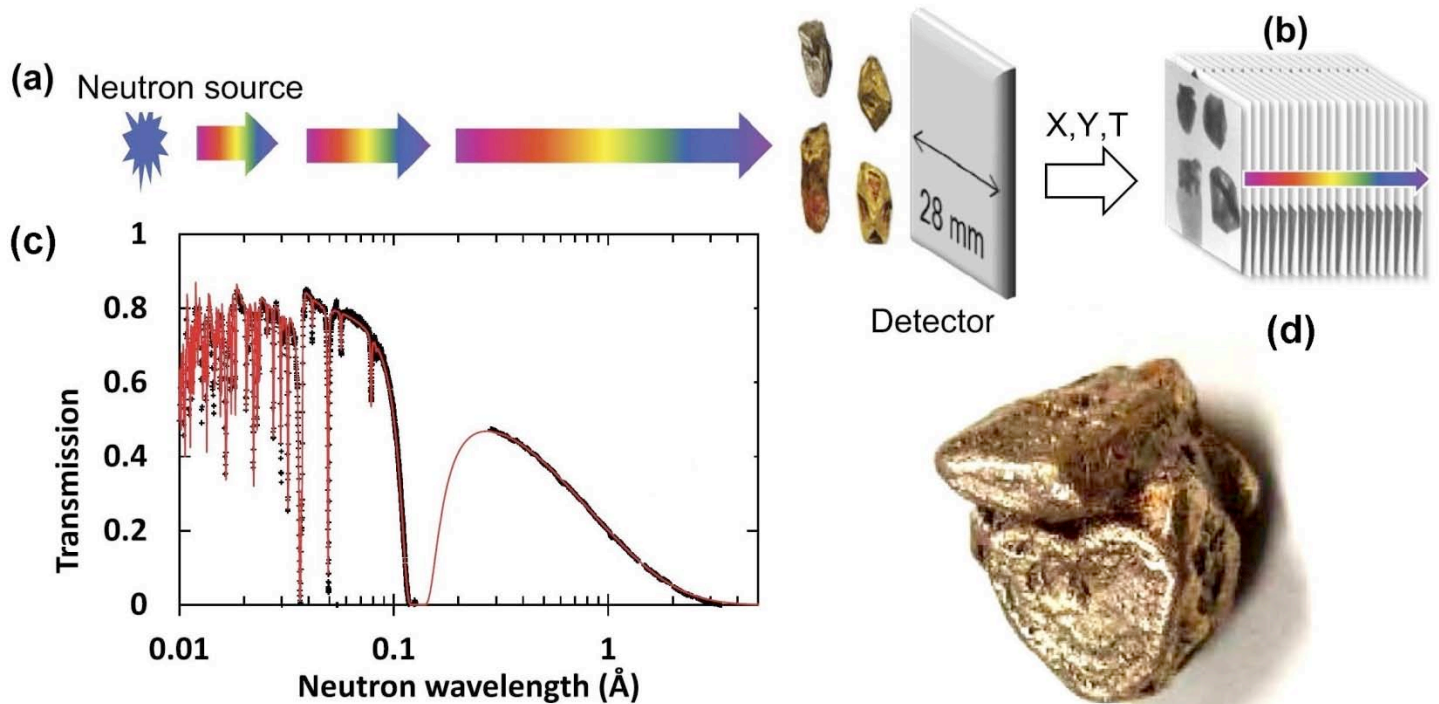

Figure 2: a) Schematic of the experimental setup for energy resolved neutron imaging: neutron pulses travel from the source through the sample and to the detector, which measures position X,Y and time T (which is related to the energy of the neutron) for each detected neutron. (b) The measurement results in a set of neutron transmission images, each corresponding to a specific neutron energy. (c) Neutron transmission spectra measured for one of the Venezuelan gold/palladium samples, extracted from the set of neutron transmission images; the solid red dline is the transmission calculated from the tabulated cross sections of Au and Pd.

ANORTHOCLASE SPHERULITES: A RARE AND LOST OCCURRENCE –ALKALI FELDSPAR IN A VOLCANIC GLASS MATRIX.

Reynard, C. C. 110 College Avenue, Poughkeepsie, NY 12603.

Unknown dark red-brown spherulites in volcanic glass were found in the Dugway Geode Beds of Juab County, Utah more than a decade ago. Dugway Pass is well known site for geodes in weathered rhyolite of Tertiary age. The site is now abandoned and backfilled.

Recently, collector R. Werner sent samples of these unknown spherulites in volcanic glass to Tony Nikischer of Excalibur Mineral Corporation for identification. The testing with XRD[1] suggested anorthoclase; further testing by SEM/EDS[2] supported the XRD analysis. The unknown spherulites are now confirmed alkali to be feldspar anorthoclase. The anorthoclase spherulites are dark orange-red-brown, have a radial symmetry and are 2mm to 4mm in size. Some are singular and others are in groups aligned parallel to the flow structure of the darker perlite volcanic glass.

The spherulites are hosted by volcanic glass called perlite. Microscopic study of this glass reveals a pattern of silvery-white spheres, hence the name perlite. When broken, a specimen of perlite reveals concentric fractures that look like small onions cut in half and closely packed together. These perlitic fractures result from contraction during cooling and solidification. The chemistry of perlite is 70-75% SiO_2; 12-15% Al_2O_3; 3-4 % Na_2O; 3-5% K_2O with minor amounts of iron, magnesium, and calcium oxides (Reference - Samar & Saxena).   Perlite has 3-5% structural and absorbed water. Rhyolitic magmas that are cooled extremely rapidly form volcanic glass containing less than 1 percent are called obsidian. Hydration of this obsidian forms perlite. The greater percentage of water in perlite is the primary difference between the two volcanic glasses. Perlite is also identified by its perlitic fracturing.

The spherulites of triclinic anorthoclase, $(Na, K)AlSi_3O_8$ lie compositionally between sanidine and albite in a solid solution series. Anorthoclase is usually found massive; crystals are rare and not found in many collections. The best known are dingy gray flattened rhomb-shaped crystals from Antarctica. Other members of the feldspar group have more color, complex twinning and form and are more common. Now, mineralogists, in addition to the massive and the crystal form have another occurrence of anorthoclase to study-- as spherulites in the volcanic glass perlite from Utah.

Further information can be found in the September 2016 issue of Mineral News, the Mineral Collector's Newsletter. Published by Excalibur Mineral Corporation.

1**. XRD** - X-ray powder diffraction is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The analyzed material is finely ground, homogenized, and average bulk composition is determined.

2. **SEM** - A Scanning Electron Microscope. Produces images of high resolution and detailed depth of field unlike those attainable using normal optical microscopy. **EDS** Energy Dispersive X-Ray Spectroscopy can be used to obtain semi-quantitative elemental results about very specific locations within the area of interest.

REFERENCE

Samar, M and Saxena, S. (2016) Study of chemical and physical properties of perlite and its application in India. International Journal of Science Technology and Management. V.5. p 70-80.

Figure 1. Photograph - Specimen of anorthoclase in perlite. T. Seideman photo.
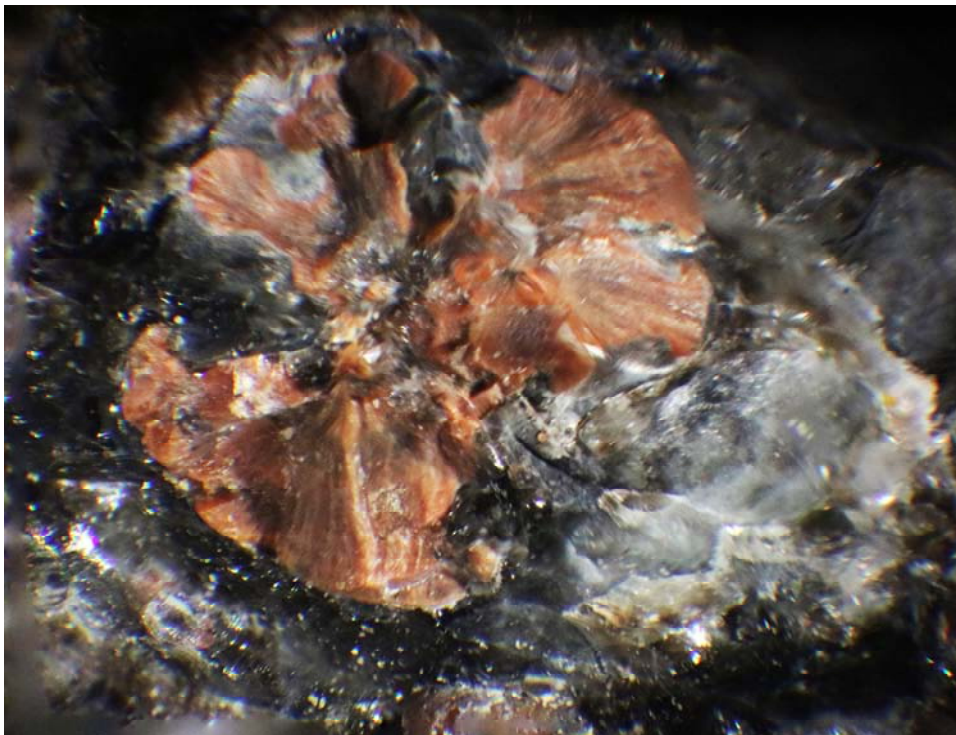

Figure 2. Photograph – Detail of anorthoclase spherulite in perlite. C. Reynard photo.

MORPHOLOGY AND GENESIS OF UNUSUAL CALCITE FROM THE LAKESHORE LAVAS (MIDDLE PROTEROZOIC) NORTH OF DULUTH, MINNESOTA.

R. P. Richards and M. Hedtke, Department of Geology, Oberlin College, Oberlin, Ohio 44074, and P.O. Box 258, Clearbrook, MN 56634.

Veins and vugs in the Lakeshore Lavas north of Duluth, Minnesota contain a mineral sequence dominated by two phases of calcite deposition; other species are of minor importance. The senior author's interest in this material was piqued by a crystal fragment included in samples provided by the junior author. This fragment, with no crystal faces, shows calcite's typical rhombohedral cleavage plus an additional "cleavage" parallel to the basal pinacoid (0001).

The first phase of calcite deposition is characterized by thin tabular crystals consisting almost entirely of the basal pinacoid, often with a peculiar pearly luster. Many of these crystals are composed of parallel to sub-parallel paper-thin lamellae, a habit referred to in the German literature as *papierspat*, or paper spar. These lamellae are often separated by thin voids, which are incompletely filled by intergrowths of second generation calcite.

Second generation crystals are combinations of rhombohedra and scalenohedra, often with prominent pinacoidal terminations. These overgrowths struggled to grow on the (0001) faces of the *papierspat*, but grew much more readily on the edges of these tabular crystals. The resulting assemblage contains squat crystals from sub-mm size to tens of centimeters, typically incompletely encrusting one side of a *papierspat* crystal, and rarely growing over onto the opposite surface. Considerable distortion of normal crystal habits results.

Second generation crystals are often fairly strongly etched, yet the papierspat surfaces on which they grew are usually mirror-like and pristine, at least at magnifications of 30x or lower. The apparent pinacoidal cleavage is instead a parting along one of many planes of weakness left during compromised growth on the pinacoidal faces of the *papierspat* and the second generation calcite.

The pinacoid (0001) is not an uncommon face for calcite, being among the 19 forms ranked "very common" in Palache's (1945) list of some 700 forms for calcite. Yet it is rarely a major form, is generally regarded by collectors as rare, and when present is often pitted and irregular. What then can account for the high perfection and inert chemical nature of the faces of this *papierspat* – inert in resistance both to etching and to overgrowth by later calcite generations? The typical crystallographic cop-out is to appeal to "poisoning of the surface by unknown materials", and it may be true in this case, but not very informative.

Experimental studies have shown that as calcite is synthesized at increasing pH, it develops a minor pinacoid face, which becomes larger and larger with increasing pH, until at some point a new mineral, portlandite $Ca(OH)_2$ begins to precipitate, and eventually at pH>11 only portlandite is produced. Portlandite has the same crystal symmetry as calcite, and a similar structure. It forms platy crystals with (0001) cleavage. Ikornikova (1973) suggested that portlandite epitactically coats the pinacoid of calcite at high pH, slowing its growth so that it becomes the dominant face, and eventually supplanting calcite growth altogether.

One can envision a chemical model of oscillating precipitation of calcite and portlandite, in which each precipitation event enriches the solution in the other component (CO_3 or OH), ensuring the continuation of the oscillatory process. As with any good mystery, not all the clues are provided – in particular, portlandite is water-soluble and alters to calcite in damp environments, guaranteeing that important evidence about this hypothesis will not be found by enquiring mineralogical sleuths.

One line of investigation that would be fruitful is geochemical modeling of the likely composition of fluids associated with the host rocks, to determine if the high pH conditions assumed by this preliminary model are reasonable. High resolution studies of the geometry of the (0001) surface might also be fruitful.

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Ikornikova, N. Yu. 1973. Growth characteristics of calcite crystals in aqueous solutions of carbonic acid. Pp. 93-112 in *Crystallization Processes under Hydrothermal Conditions*, A.N. Lobachev, Editor. Consultants Bureau, New York (translation from the Russian).

Palache, C. 1945. Calcite – An angle table and critical list. Contribution from the Department of Mineralogy and Petrography, Harvard University, No. 259.

Figure 1. Calcite from the Lakeshore Lavas, Duluth, MN.

STRUCTURAL AND CHEMICAL COMPLEXITIES OF HYDROXYLAPATITE FROM THE SAPO MINE, BRAZIL

H. Richards, S. Kelly, J. Rakovan, Department of Geology and Environmental Earth Science, Miami University, Oxford, OH, 45056

The Sapo pegmatite mine, located in the eastern portion of Minas Gerais, Brazil, in the municipality of Conselheiro Pena has produced many significant specimens of apatite group minerals including what are arguably the best of species for hydroxylapatite; from a pocket found in June 2005 (Menezes, 2009). Structural and chemical analyses were conducted on shallow bipyramidal crystals (fig. 1) found in 2005 using optical mineralogy, single crystal X-ray diffraction (SCXRD) and electron microprobe analysis (EMPA). Thick sections of (001) and (100) orientation were made from single crystals. An EMPA traverse was made across one of the (100) sections, indicating compositional concentric zoning. Optical microscopy in crossed polars was conducted on a second, (001), section. In a third, (001), section, fragments of different concentric layers were removed and ground to spheres of approximately 150 microns for SCXRD analysis. The structures of these spherical fragments were solved and refined, including column anion site occupancies, from the SCXRD data using the Bruker APEX3 software package.

   All of the crystals show distinct color zoning (e.g. fig. 1) with a yellow to grey core that is mantled by a thick green overgrowth. In some cases the core is exposed at the surface of the crystal, while in others it is buried to the point of obscurity. The green mantle shows subtle concentric zones of different color intensity. In crossed polars three major concentric zones are observed, each with

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distinct optical characteristics (fig. 2). Zone 1, which correlates to the yellow core, is extinct in all orientations, consistent with hexagonal symmetry when looking down the optic axis. Zone 2 exhibits weak birefringence and undulatory extinction, which may be strain induced similar to what is commonly observed in metamorphic quartz. This zone also exhibits strained uniaxial interference figures in which incipient separation of the isogyres occurs with sample rotation. Zone 3 shows distinct birefringent domains of different optical orientation that exhibit biaxial interference figures with variable 2V up to about 30°; indicating non-hexagonal symmetry.

The structure of the yellow-grey core was refined in the hexagonal space group $P6_3/m$ (R_1=1.5) with a dominance of F in the column anion sites (i.e. fluorapatite). The structures of fragments from zone 2 were also refined in $P6_3/m$, but with slightly higher R_1 values, and with a dominance of OH in the column anion sites (i.e. hydroxylapatite). Attempts to refine the structure of fragments from zone 3 in the same space group lead to problematically high R_1 values (e.g. >5). Further refinement of one zone 3 fragment indicates four "twin" components with lower than hexagonal symmetry; consistent with the optical characteristics of zone 3. Final structure determination of these components, including column anion site occupancy is in progress.

These results show that the Sapo hydroxylapatites are complexly zoned in both structure and chemistry. Researchers using this material as a hydroxylapatite reference may need to consider this complexity, depending on the nature of their studies.

REFERENCE

Menezes, L. 2009. Famous Mineral Localities: The Sapo Mine, Ferruginha District, Conselheiro Pena, Minas Gerais, Brazil. *Mineralogical Record* 40:273-292.

Figure 1. A 1 cm bipyramidal crystal of zoned hydroxylapatite (green) and fluorapatite (grey core) on albite from the Sapo mine.
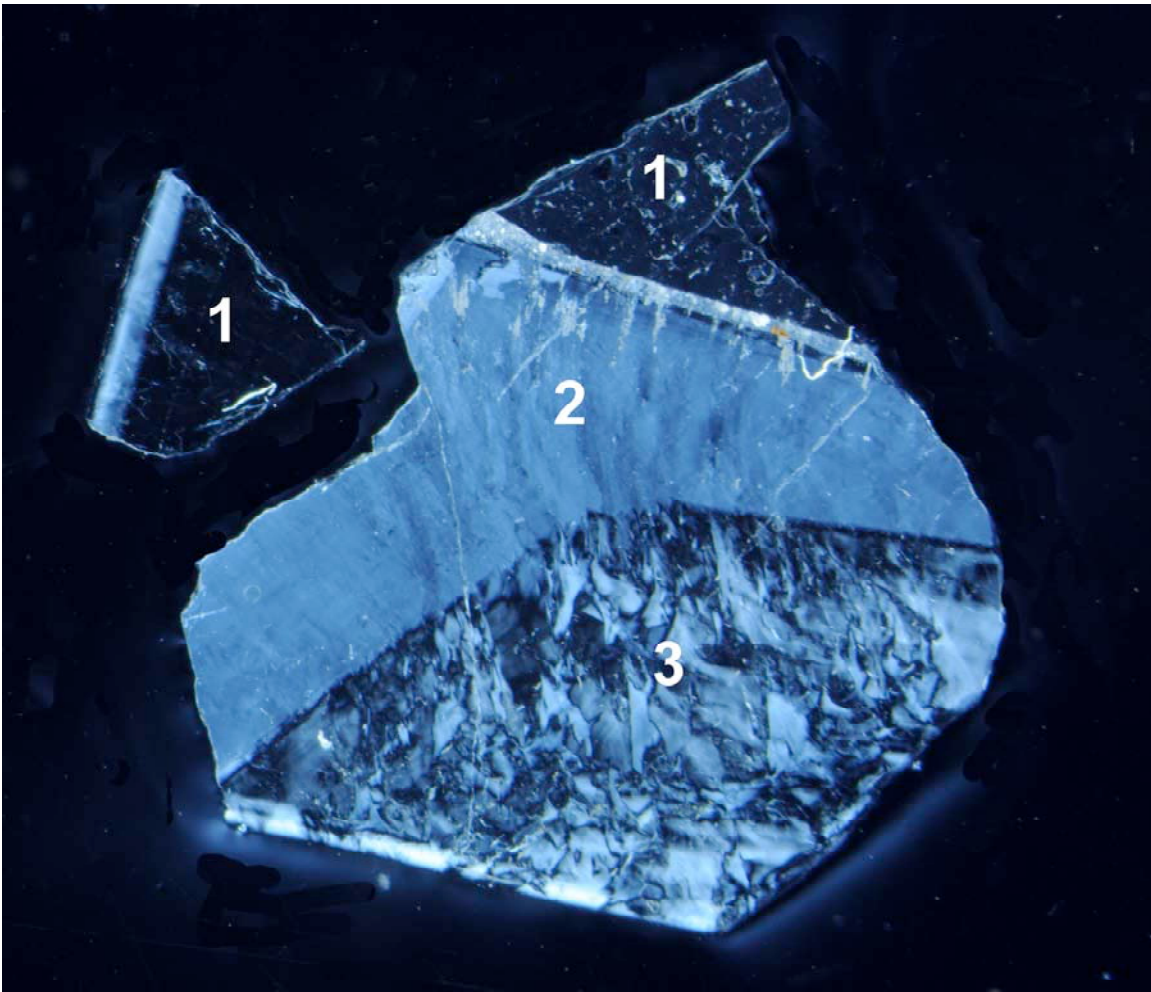
Figure 2. Photomicrograph of a 1 cm zoned hydroxylapatite/fluorapatite crystal (001) section taken in crossed polars. Optically distinct zones are labeled 1-3.

GARNET LINE REPLACEMENT OF ALMANDITIC GARNET BY LÖLLINGITE FROM THE HAVEY PEGMATITE, POLAND, ANDROSCOGGIN CO., MAINE.

Simmons, W. B., and FALSTER, A. U. Maine Mineral and Gem Museum, PO Box 500, 99 Main Street, Bethel, Maine 04217.

The Havey pegmatite in Poland, Androscoggin Co., Maine, is part of the Oxford county pegmatite field which occurs in the Sebago migmatite terrain. It is an evolved Li-B-rich pegmatite being mined mainly for gem tourmaline and occasional pocket beryl as well as mineral specimens. As is common to many Oxford County pegmatites, the Havey pegmatite has a well-formed garnet layer (or line) in the footwall portion of the pegmatite. As we have previously reported, in other pegmatites in the field, garnets in the garnet line adjacent to pockets are commonly altered and replaced or rimmed by blue elbaite tourmaline. In some cases, the interiors of the garnets have been replaced by siderite-rhodochrosite and quartz. In the summer of 2016, unusual replacements of the garnets in the garnet line of the Havey pegmatite were discovered: the garnets were completely replaced by löllingite. In some cases, in small voids in the massive löllingite, well-formed crystals of löllingite were found. These crystals were all less than 1 mm in maximum dimension and showed {110}, {101} and {011} forms rather than being prismatic. This is a very rare replacement reaction that attests to an unusual

As-rich composition of the late-stage fluids that were present at the time of replacement. We propose that the source of the arsenic was remobilized As from löllingite masses elsewhere in the pegmatite.

INTERGROWTH TEXTURE OF FE-SI INTERMETALLIC COMPOUNDS IN A FULGURITE FROM CENTRAL LOWER MICHIGAN.

Stefano, C. J. A.E. Seaman Mineral Museum, Michigan Technological University, Houghton, MI.

A fulgurite is a natural glass that is formed when lighting strikes sand, soil, or rock. During the formation process it is estimated that temperatures can exceed 2000 K. Extreme temperature combined with organic matter in the soil may result in highly reducing conditions. These extreme conditions effectively smelt the soil, producing native silicon, iron silicides and other compounds. A 14 cm diameter fulgurite was formed in sandy glacial till in 2014 near Houghton Lake, MI. Spherical grains of iron silicides found in the natural glass were studied using the Scanning Electron Microscope. Back-Scattered Electron images of these spheres showed a unique texture showing intergrowth of two iron silicides. The observed texture may shed light on the processes that occur during fulgurite formation.

TRACING THE CONFLICT MINERAL WOLFRAMITE THROUGH CRYSTAL CHEMISTRY, STRUCTURE & SPECTRA.

D. Ziga[1], G. Accorsi[2], J. Hughes[2], J. Rakovan[1]. [1]Department of Geology and Environmental Earth Science, Miami University, Oxford, OH, 45056
[2]Department of Geology, University of Vermont, Burlington, VT, 05405

In 2010, former president Barak Obama signed Dodd-Frank into Federal Law, a wall street reform and consumer protection act designed to improve accountability and transparency within American companies financial systems. Title XV, Section 1502 of Dodd-Frank focuses on the use of conflict minerals from the Democratic Republic of Congo (DRC) and any neighboring countries. Gold and other conflict minerals like cassiterite, wolframite, and "coltan" (columbite-tantalite) are mined for their tin, tungsten, and tantalum, respectively. This is done unethically in certain regions within and surrounding the DRC. Dodd-Frank requires that companies using these materials in their products report the steps they take to identify their provenance and an independent private sector company must audit the report. Since enacted, few companies, if any, have been able to comply with these rules (Kester & Murphy 2014). This may likely be due to companies' inability to ensure the sources of mineral shipments rather than a lack of effort. To trace the origin of these ore minerals would require someone to verify the supply chains by physically traveling with the shipments from where the minerals are mined, to the smelting/refinement location. This process is not cost effective, and in many cases, is not possible to follow.

One other potential way to identify the provenance of these minerals is to analytically fingerprint the ore minerals, based on unique characteristics that might be found in their chemical, structural, or spectroscopic data. Companies attempting to comply with these rules have not yet explored this tactic for tracing ore minerals, possibly because an effective procedure has not yet been established. This project is the most comprehensive study yet analyzing the ferberite-hubnerite ($FeWO_4 - MnWO_4$) solid solution series. Wolframite is an iron, manganese tungstate and while it is the world's primary source of tungsten, a means of analytically fingerprinting wolframite has not yet been discovered and standardized.

This study focuses on a suite of 15 samples from around the world, all falling along the ferberite-hubnerite solid solution series, and examines the crystal structures, chemistries, powder x-ray diffraction, and Raman spectra of each sample to determine if any of these data can provide a method of analytically distinguishing ore from different localities, thus providing a tool to comply with Dodd-Frank without directly following the complete chain of supply.

Although numerous statistical analyses were done with the data it appears as though there are no obvious tracers to distinguish the origin of wolframite from our chemical, structural, and spectral data. The XRD single crystal & powder patterns provide no accessible link to identify provenance. Similarly, after compiling plots of spectroscopic data no characteristic patterns are apparent in the spectra either. This research does provide data that may be useful in future studies, and makes way for similar projects to be conducted on conflict ore minerals like cassiterite and the columbite-tantalite solid solution series. Still, 7 years after Dodd-Frank has been signed, there is more to be done to exercise due diligence on the source and chain of custody for these conflict minerals, and to reassure consumers that their mineral resources are ethically sourced.

REFERENCE

Kester, J. & Murphy, M. (2014): Companies Detail Use of 'Conflict' Metals- First Reports Filed to SEC on Potential Use of Minerals from a Region of War-Torn   Africa. *Wall Street Journal*, online June 2nd.

The King of Tides: Nova Scotia's Bay of Fundy
by Raymond McDougall

Nova Scotia's Bay of Fundy has been famous among mineral collectors for a long time. The shoreline and island occurrences are among the earliest of Canadian mineral localities, and have been producing superb specimens of many mineral species since the mid-19th century. Fine mineral specimens are found in the northeastern area of the Bay of Fundy, including particularly the Minas Basin. From Cape D'Or on the north shoreline, to the Morden area on the south shore, the linear length of shoreline to travel to the various mineral occurrences is over 400 km.

The Bay of Fundy is known for the highest tides in the world, with a difference of over 50 ft. from low to high tide. These daily surges of huge volumes of water scour the cliff bases of the shorelines and the islands. Together with the annual destruction caused by freeze-thaw, the phenomenal tides cause significant erosion and change, constantly exposing mineralized areas.

Several minerals occur in world-class specimens from the Bay of Fundy localities: analcime, chabazite and gmelinite are the classics. Excellent specimens of natrolite, native copper and thomsonite are also found. Even certain more common minerals, known in spectacular specimens from other world localities, occur in rather unique specimens from the Bay of Fundy. For example, stilbite colours range into distinctive and beautiful golden yellow and orange hues. The type locality for mordenite is Morden, Nova Scotia, on the south shore of the Bay of Fundy.

This presentation focuses on five classic localities: (1) Wasson's Bluff; (2) Blomidon Peninsula/Amethyst Cove; (3) Cape D'Or; (4) Two Islands and (5)Five Islands. The emphasis is on the beautiful minerals from this region, highlighting specimens that have been collected over the last 25 years, and with insights into the nature of the collecting, localities and the scenery along Nova Scotia's Bay of Fundy.

Figure 1. Cliffs at Cape D'Or, Bay of Fundy, Nova Scotia

Figure 2. Gmelinite pseudomorph after chabazite, Five Islands, Nova Scotia - 4.8 cm

Figure 3. Twinned gmelinite, Two Islands, Nova Scotia - 1.8 cm

Figure 4. Natrolite, Wasson's Bluff, Nova Scotia - 2.0 cm ball

Figure 5. Analcime, Amethyst Cove, Blomidon Peninsula, Nova Scotia - 5.8 cm

STRUCTURE HIERARCHY IN SILICATE MINERALS
By F. C. Hawthorne

Geological Sciences, University of Manitoba, Winnipeg, MB R3T 2N2, Canada

Silicate minerals are of particular interest because of their importance in large-scale Earth processes. In his seminal work, Bowen (1928) proposed his *reaction series* which describes the sequence in which silicate minerals crystallize from a parent basaltic liquid: olivine → pyroxene → amphibole → mica → feldspar → quartz. At the same time, Matchatski (1928) and Bragg (1930) proposed classifying silicate minerals according to the types of linkage of their constituent silicate and aluminosilicate groups, the still-familiar *neso* (ortho-), *soro-* (pyro-), *cyclo-* (ring-), *ino-* (chain-), *phyllo-* (sheet-), *tecto-* (framework) silicate classification that we teach today. Belov (1961) introduced the "Second Chapter" of silicate crystal chemistry that organizes silicates of large alkali and alkaline-earth cations (e.g., Ca, Ba, Sr), and other classification criteria for silicate minerals, based on the topological and geometrical characteristics of the silicate and aluminosilicate linkages, were introduced by Liebau (1985). In the 1990s, structure hierachies started to be developed for borates, sulfates, phosphates etc. What are hierarchies? A mathematical hierarchy is an ordered set of elements where the ordering reflects a natural hierarchical relation between (or arrangement of) the elements. A structure hierarchy is one where the structures ordered according to the polymerization of coordination polyhedra of higher bond-valence. Such hierarchies have two functions: [1] They serve to organize our knowledge of minerals in a coherent manner. [2] If the basis of the classification involves factors that are related to the mechanistic details of the stability and behaviour of minerals, then the physical, chemical and paragenetic characteristics of minerals should arise as natural consequences of their crystal structures and the interaction of those structures with the environment in which they occur. We may justify the structure hierarchy hypothesis by considering a hypothetical structure-building process whereby higher bond-valence polyhedra polymerize to form to form the structural unit. The clusters constituting the FBBs (fundamental building blocks) may polymerize to form the following types of structural unit: (1) isolated polyhedra; (2) clusters; (3) chains and ribbons; (4) sheets; and (5) frameworks. A major advantage to such a structure hierarchy is the fact that the hypothetical structure-building process outlined above resembles (our ideas of) crystallization from aqueous solution, whereby complexes in aqueous and hydrothermal solutions condense to form crystal structures, or fragments of linked polyhedra in a magma condense to form a crystal. Although our knowledge of these processes is rather vague from a mechanistic perspective, the foundations of the structure hypothesis give us a framework within which to think about the processes of crystallization and dissolution. To deal with the large number of silicate minerals, a factor that has inhibited the development of a modern structure hierarchy, I will divide them into **Clusters** (neso-, soro-, cyclo-), **Chains** (chains, ribbons and tubes), **Sheets** and **Frameworks**, and ititially I will deal with them separately. I am just finishing Sheets and my student Maxwell Day and I are about halfway through Chains. The overall hierarchy is organized in terms of increasing linkage between ($T\varphi_4$) (T = Si^{4+}, Al^{3+}, B^{3+}, Be^{2+}, Mg^{2+}, P^{5+}, As^{5+}, V^{5+}, S^{6+}; $\varphi = O^{2-}$, $(OH)^-$, F^-) tetrahedra; this increasing linkage correlates with decreasing x where [$T\varphi_x$] is the stoichiometry of the linkage of tetrahedra. Here, I will give a brief description of the sheet-silicate hierarchy and also discuss the idea of complexity of crystal structures based on information content, and show how complexity is related to the degree of rarity of a mineral.

Meet an Important Unknown Mineralogist
by Herwig Pelckmans

Throughout history, many mineral species have been named after a person. Some of these individuals are hardly known to science, even today. On the other hand, the mineralogists who described new species are fairly well known in most cases.

One 20th century mineralogist however, who described many new minerals, remained a complete mystery. Besides his name and the minerals he described, hardly anything else was known about him. No biography was ever written about him, no photos of him were ever published, and even his nationality was an open question.

So join us on a hunt for his scientific and civil traces, discover with us the many beautiful new minerals he described, and get to see, for the first time in history, some photos of the mineralogist in question.

44th RMS Exhibits

Barbara Sky – Calcite Miniatures
Bob Morgan – The Faces and Forms of Calcite
Bob Morgan – Twins
Canadian Museum of Nature – TBA
Carl Francis – Hematites and Goethites
Dale Russell – Collect Big or Stay Home - Ontario
David & Karen DeBruin – New Acquisitions from Tucson
David Joyce – Minerals of the Grenville Geological Province
Don Lapham – Minerals Collected Last Year
Elise Skalwold – The Fabled Viking Sunstone
Elise Skalwold – Diamond Anvil Cell
Eric Grundel – Two Centuries of Nova Scotia's Mineralogy
George Loud – The Homestake Mine Collection of Dr. Robert Jenkins
George Thompson – TBA
John Betts – Recent Acquisitions
John Medici – Midwest Minerals
Jonathan Levinger – CATAPLEIITE
Maine Mineral & Gem Museum (Carl Francis) – Quartz from the
        Palermo #1 Mine, Groton, New Hampshire
Mike Walter – Father/Son Collecting
New York State Museum (Marian Lupulescu) – Minerals of the Rich
        & Famous
Raymond Hall – Fabulous Gemstones
Technical Session – Specimens from the Technical Session
Terry Huizing – New Stuff
Woody Thompson – Specimens from the Bakewell Rock Exchange,
                Derbyshire

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