

# Minerals of Hurricane Mtn. Conway, NH

Tom Mortimer, Bob Wilken

With specimen photos from the collections of

Don Dallaire

Gordon Jackson

Bob Janules

Don Swenson

Harvard Mineral Museum via Kevin Czaja

EDS analysis sponsored by the Micromounters of New England at the Boston College labs

Additional EDS support from the MMGM laboratory courtesy of Al Falster .

Raman spectroscopy efforts by George Adleman, Arlington, MA are acknowledged.



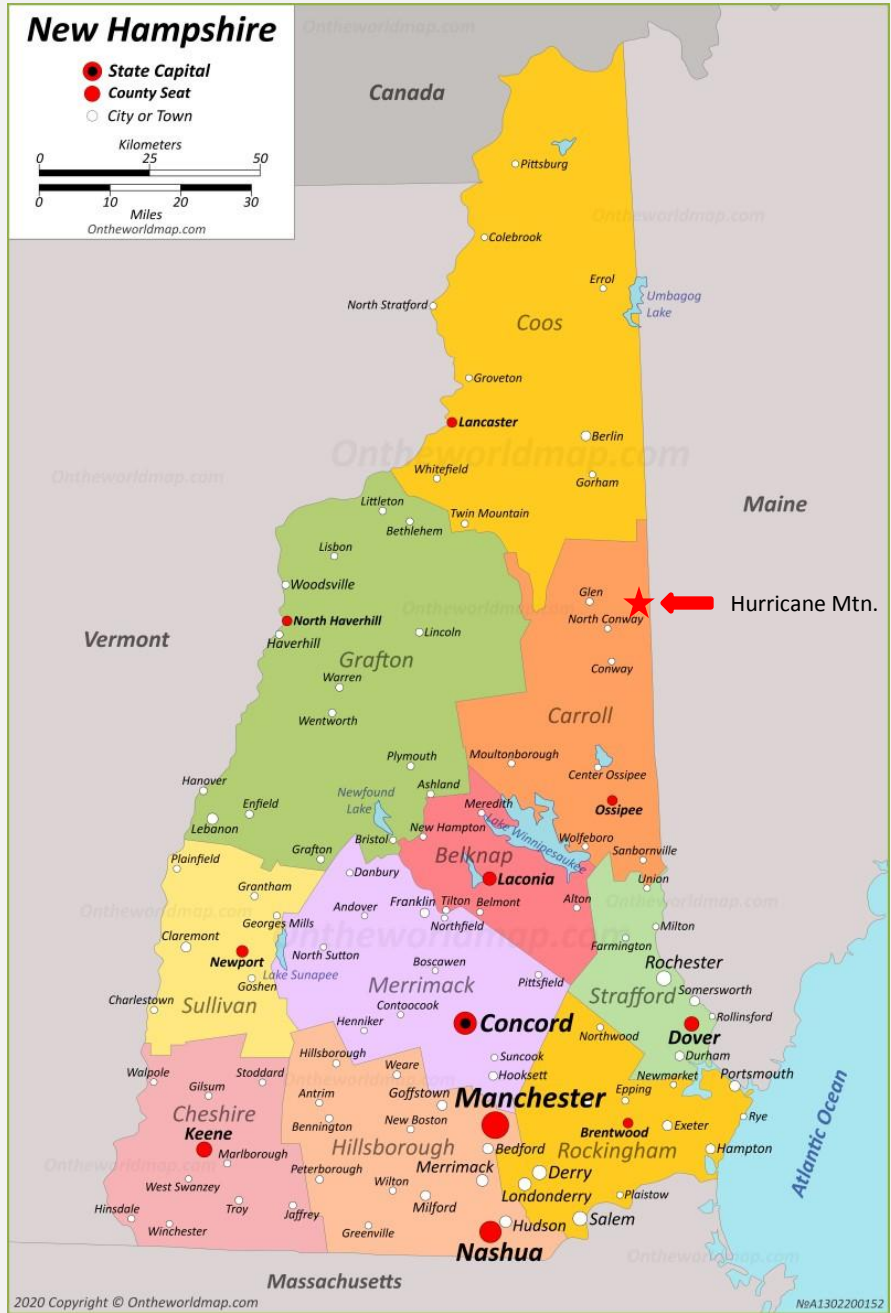
# New Hampshire

● State Capital  
● County Seat  
○ City or Town

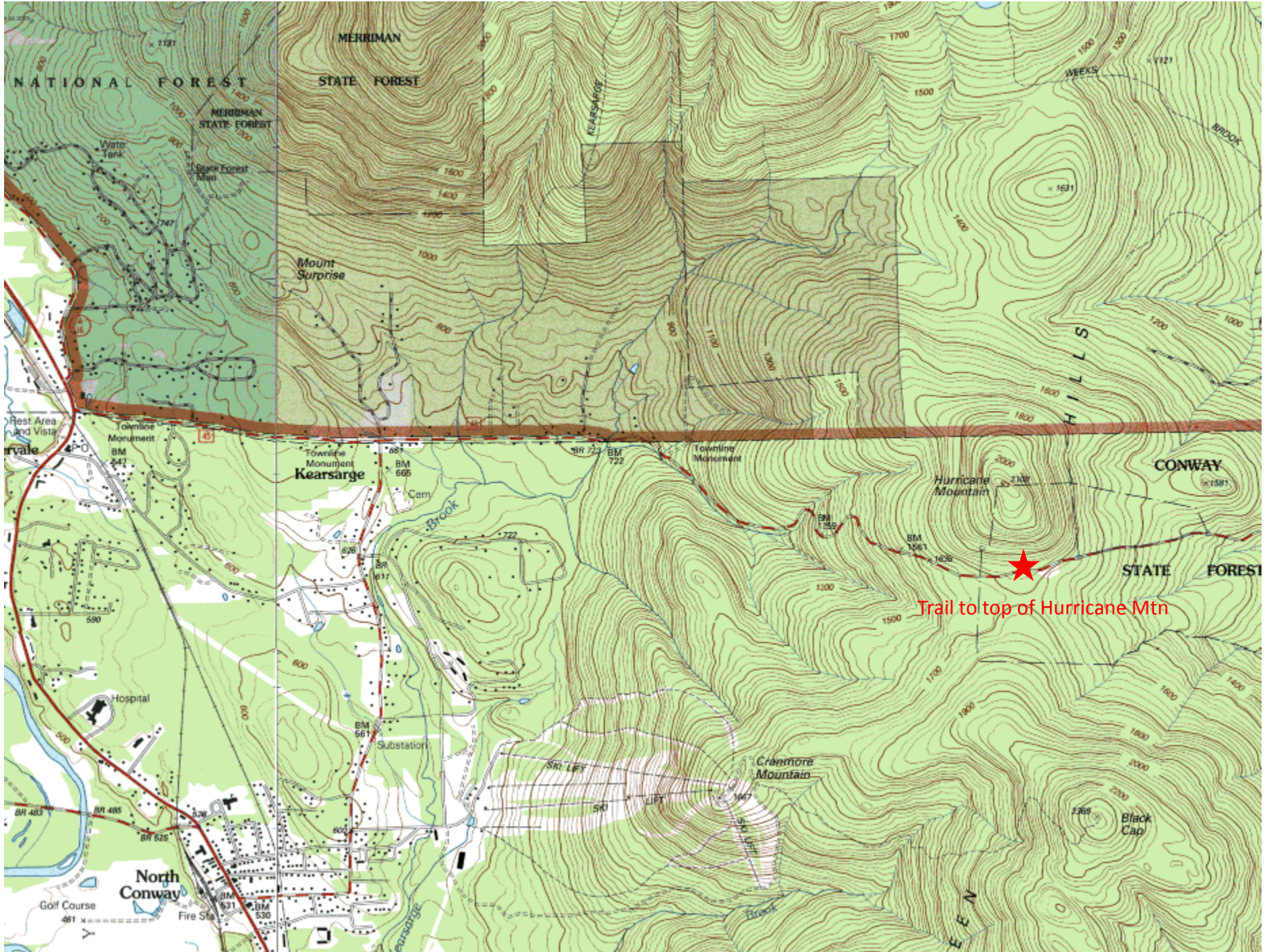
Kilometers  
0 25 50

Miles  
0 10 20 30

Ontheworldmap.com



35 miles SSE of  
Bethel, ME



NATIONAL FOREST

MERRIMAN STATE FOREST

MERRIMAN STATE FOREST

Mount Surprise

Kearsarge

HILLS

CONWAY

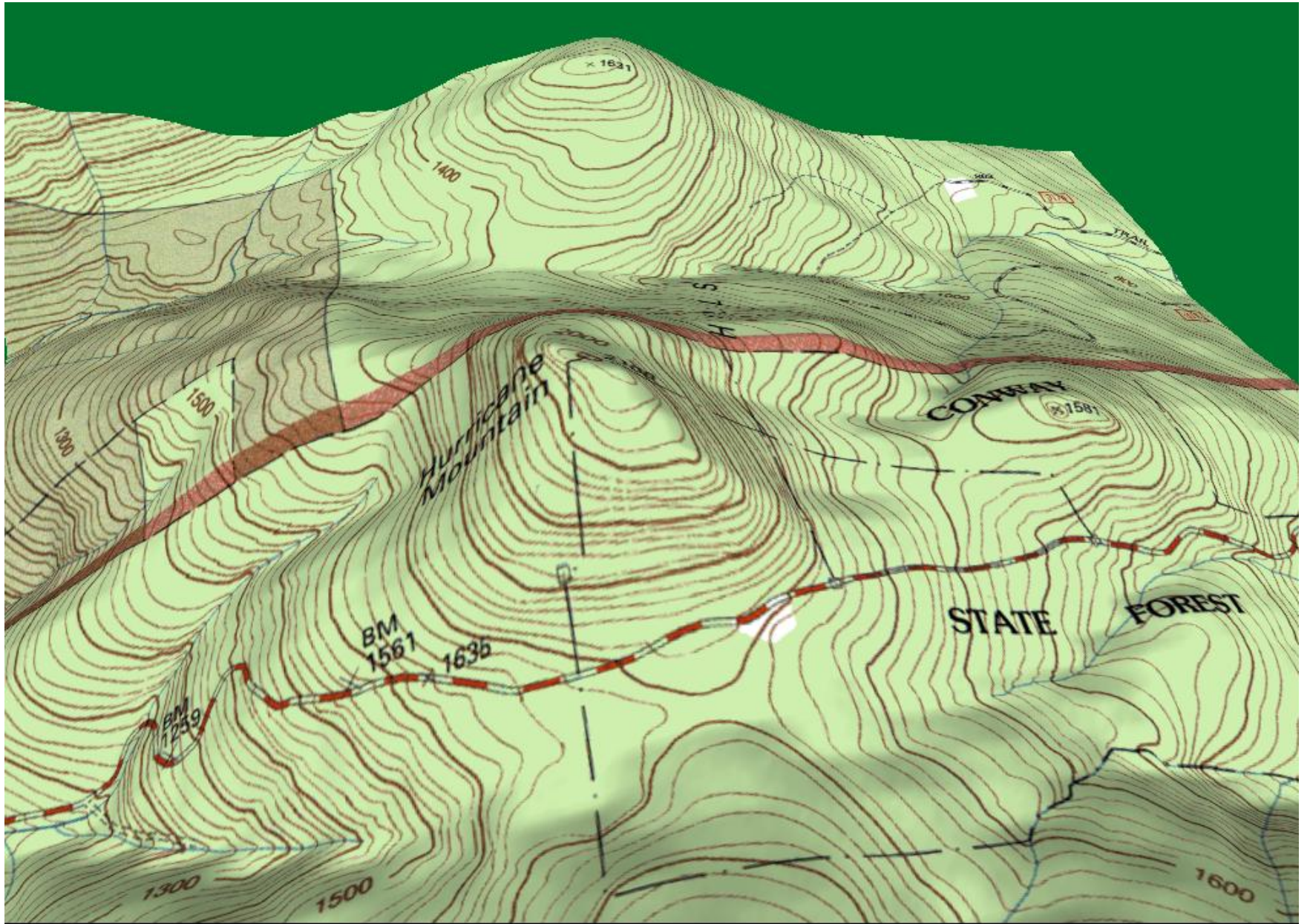
STATE FOREST

Trail to top of Hurricane Mtn

North Conway

Greenmore Mountain

Black Cap



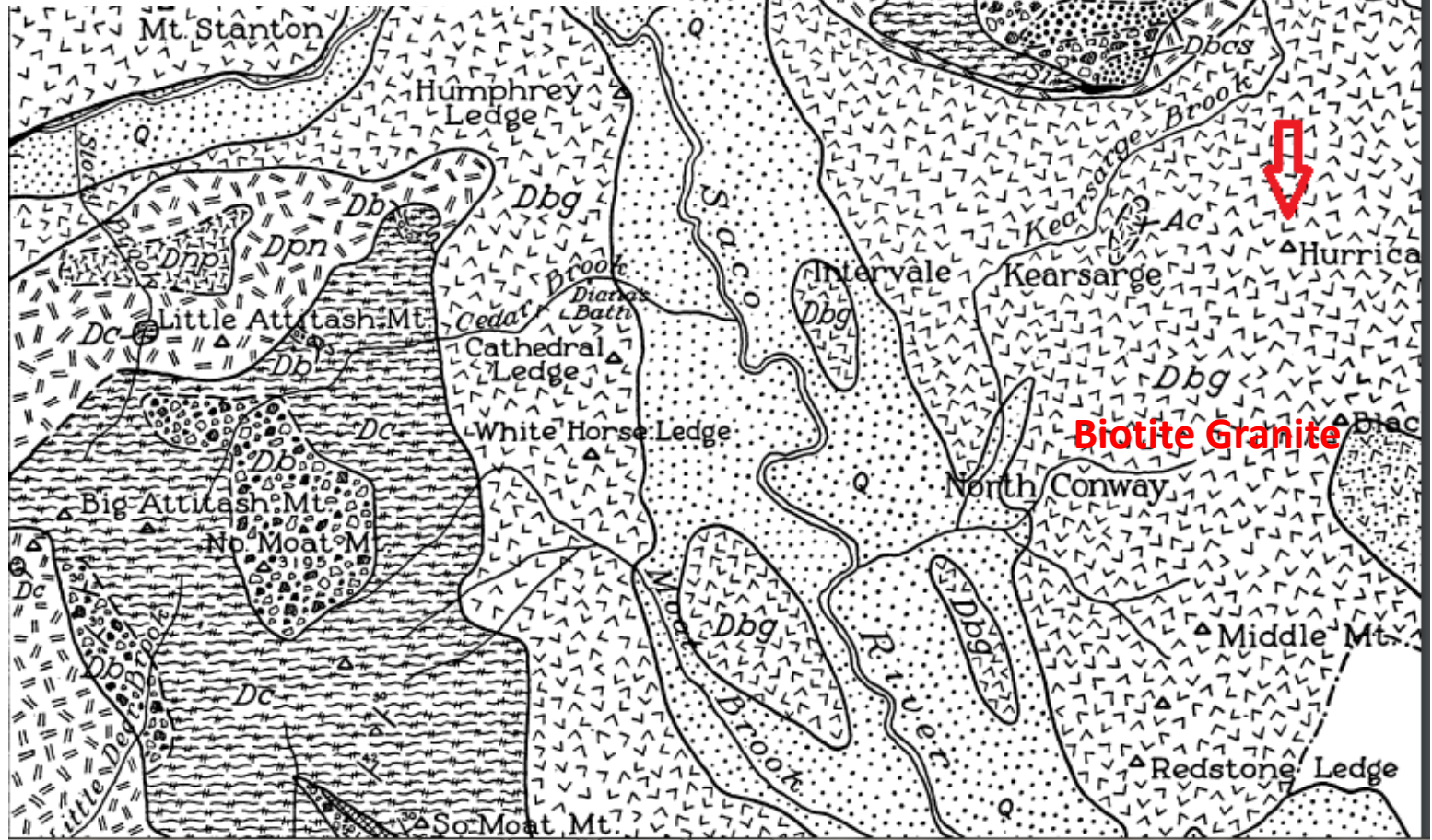
THE PETROLOGY OF THE NORTH CONWAY QUADRANGLE  
IN THE WHITE MOUNTAINS OF NEW HAMPSHIRE

BY MARLAND BILLINGS.  
Harvard University, Cambridge, Massachusetts.

Presented by Esper S. Larsen.

Received April 11, 1928.

Presented by title, April 11, 1928.







Hurricane Mtn. prospecting sites . Photos from 2002 and 2008

# Hurricane Mountain Minerals

## Mindat.org listed species (2023)

Albite  
Arfvedsonite  
Arsenopyrite  
Astrophyllite  
Bavenite  
Calcite  
Fluorite  
'Glaucosite'  
Hematite  
Microcline  
Muscovite  
Quartz  
Riebeckite  
Zircon

## Species – this study (new Red)

Aegirine  
Albite  
Arfvedsonite  
Astrophyllite  
Bastnasite  
Fluorite  
'Glaucosite'  
Hematite  
Microcline  
Opal  
Quartz  
Riebeckite  
Siderite  
Topaz  
Stilpnomelane ?  
Thorite  
Zircon



## Hurricane Mountain Minerals

### Three closely related species

Arfvedsonite	$\text{Na}_3\text{Fe}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$
Riebeckite	$\text{Na}_2\text{Fe}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$
Aegirine	$\text{NaFeSi}_2\text{O}_6$

Our search and inquiries failed to locate confirming analysis for Hurricane arfvedsonite and riebeckite.

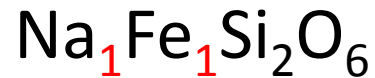
Arfvedsonite



Riebeckite



Aegirine



Ideal chemistry indicates different Na:Fe ratios

Analytic tools:

EDS

XRD

Raman



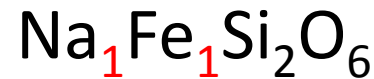
Arfvedsonite



Riebeckite

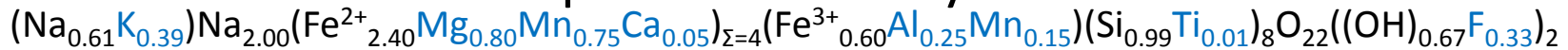


Aegirine

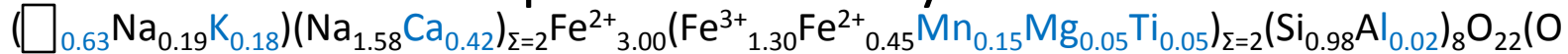


Measured chemistry is much more complicated

RUFF **Arfvedsonite** empirical chemistry:



RUFF **Riebeckite** empirical chemistry:



RUFF **Aegirine** empirical chemistry:



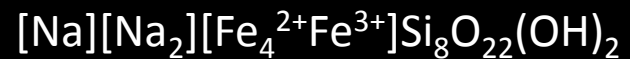


**ARFVEDSONITE** 1.2 cm arfvedsonite crystal on microcline  $[\text{Na}][\text{Na}_2][\text{Fe}_4^{2+\text{Fe}^{3+}}]\text{Si}_8\text{O}_{22}(\text{OH})_2$   
A Don Dallaire specimen and photo



**ARFVEDSONITE** 11 cm arfvedsonite crystal

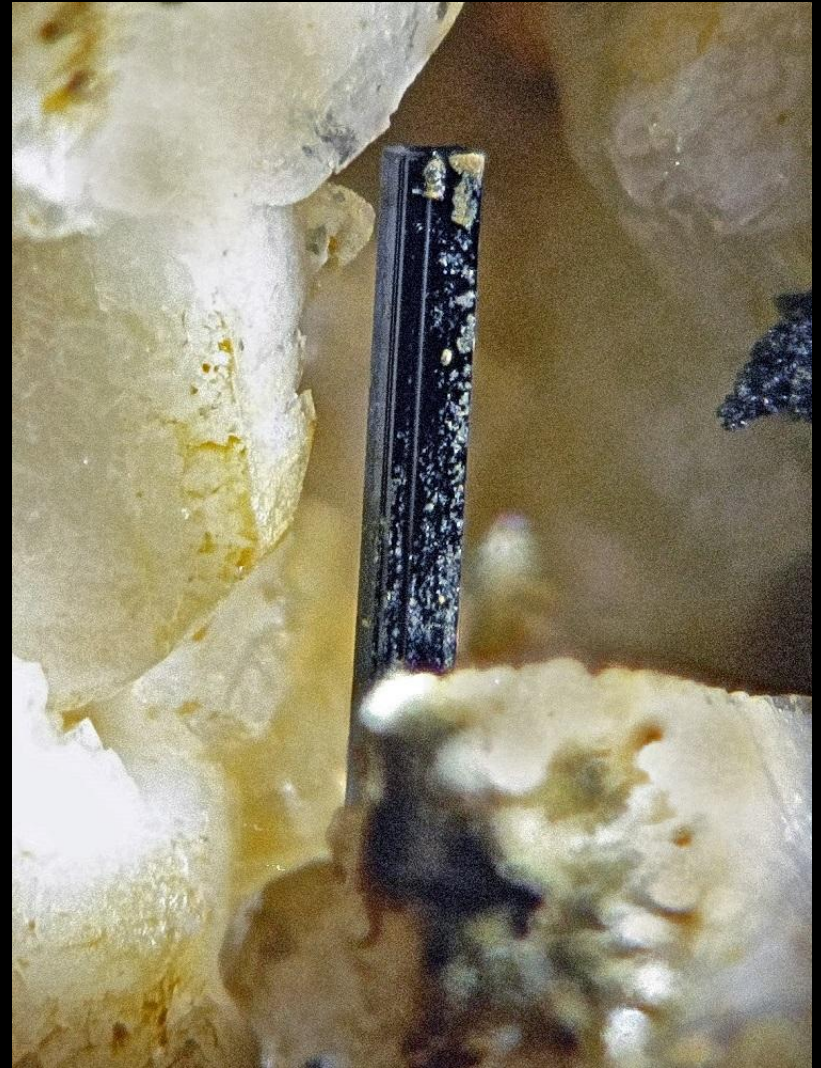
Harvard Mineral Museum #119209. A gift from M. Chandler.



A K Czaja photo



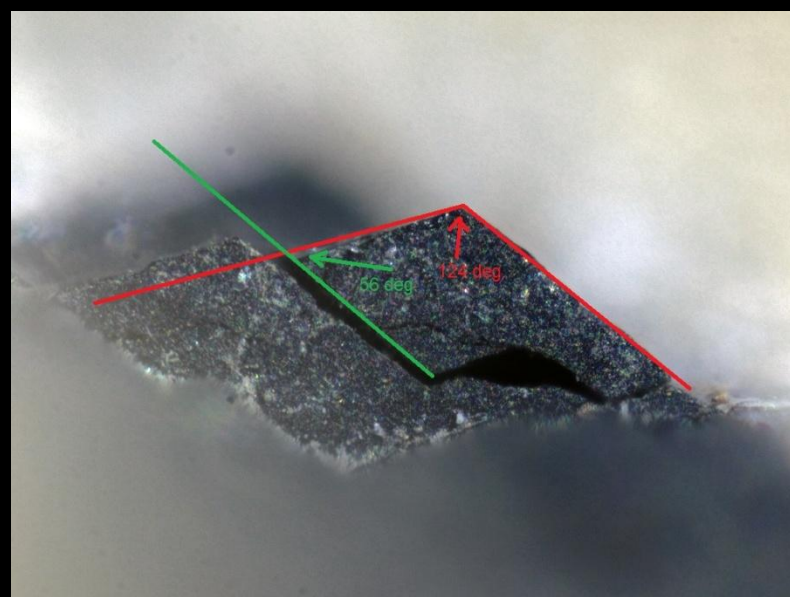
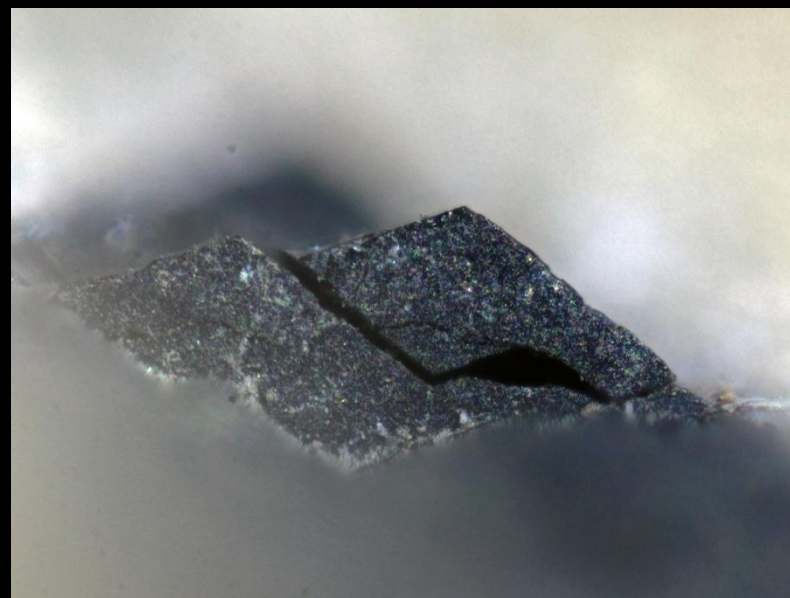
**ARFVEDSONITE** 3.8 cm crystal  
A Don Dallaire specimen and photo



**ARFVEDSONITE** 2 mm crystal  
Finding a cm + crystal is difficult today



**ARFVEDSONITE** 4.2 cm arfvedsonite crystal in matrix



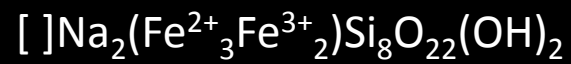
Amphibole cleavage **124** and **56** degrees





**RIECKITE** var Crocidolite

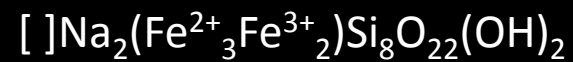
4 cm specimen





**RIECKITE** var Crocidolite

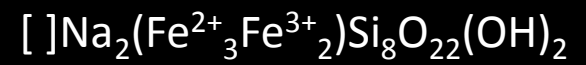
2 cm specimen





**RIEBECKITE**

12 mm field of view





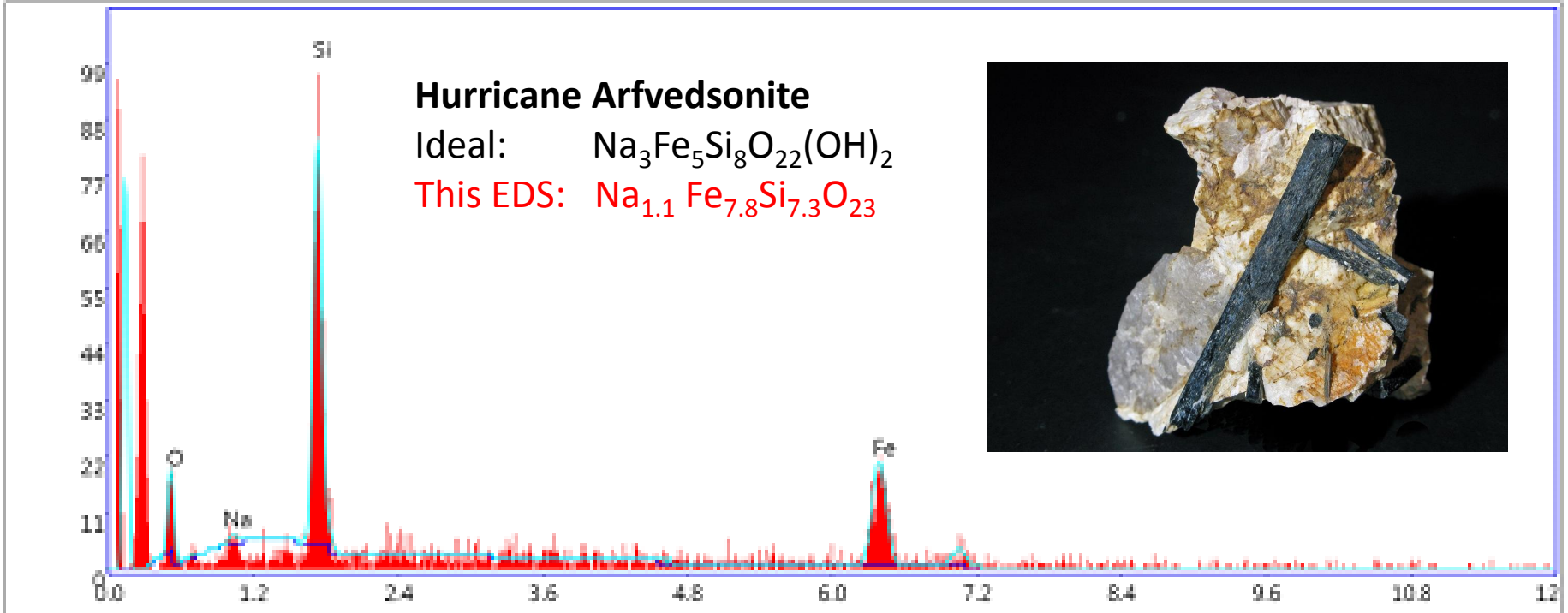
**RIEBECKITE** Hairs in quartz crystal and microcline 8 mm field of view

## EDS Spot 3 - Det 1

### Hurricane Arfvedsonite

Ideal:  $\text{Na}_3\text{Fe}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$

This EDS:  $\text{Na}_{1.1}\text{Fe}_{7.8}\text{Si}_{7.3}\text{O}_{23}$

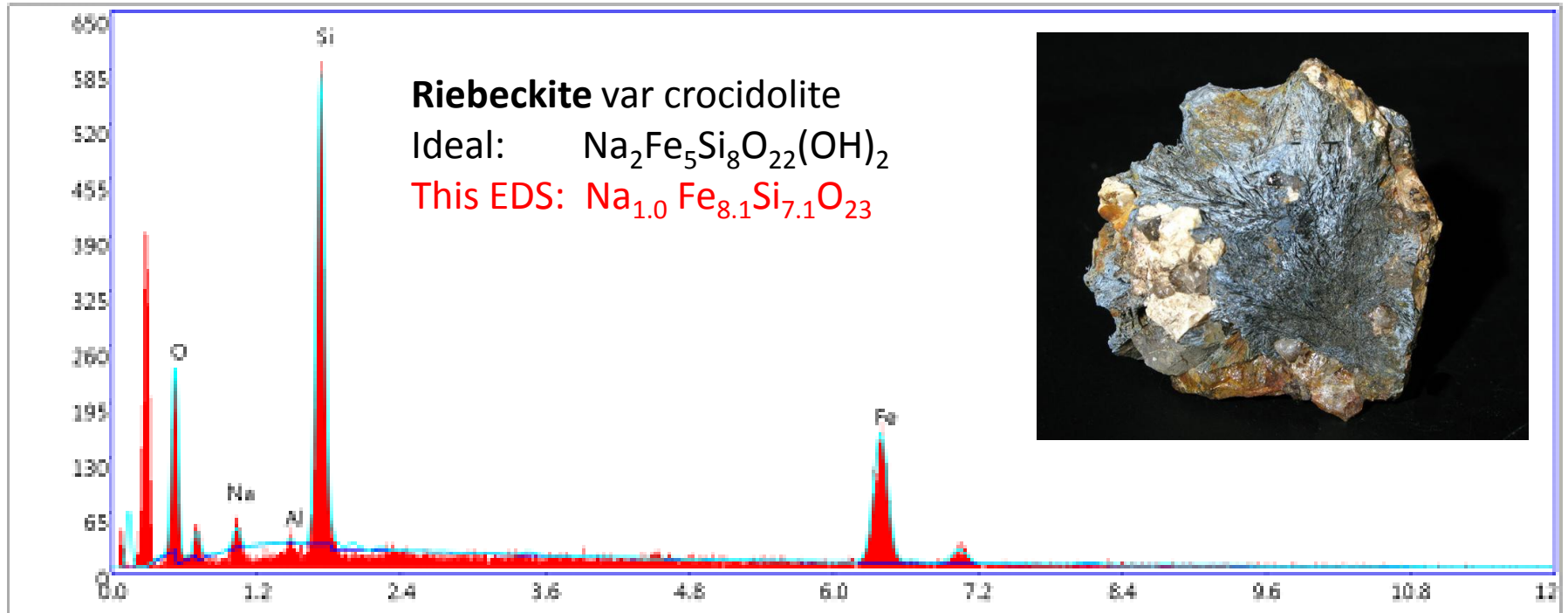


Use: 0.1    6 Cnts    7.090 keV    Det: Octane Plus

### eZAF Smart Quant Results with Oxides

Element	Weight %	Atomic %	Net Int	Error %	Kratio	Z	A	F
Na 2O	3.21	3.42	310.67	79.78	0.0106	1.0267	0.3197	1.0007
Si O2	42.68	46.87	6538.23	10.36	0.1960	1.0268	0.7142	1.0021
Fe O	54.12	49.71	2815.85	15.34	0.4871	0.8546	1.0030	1.0093

## EDS Spot 1 - Det 1

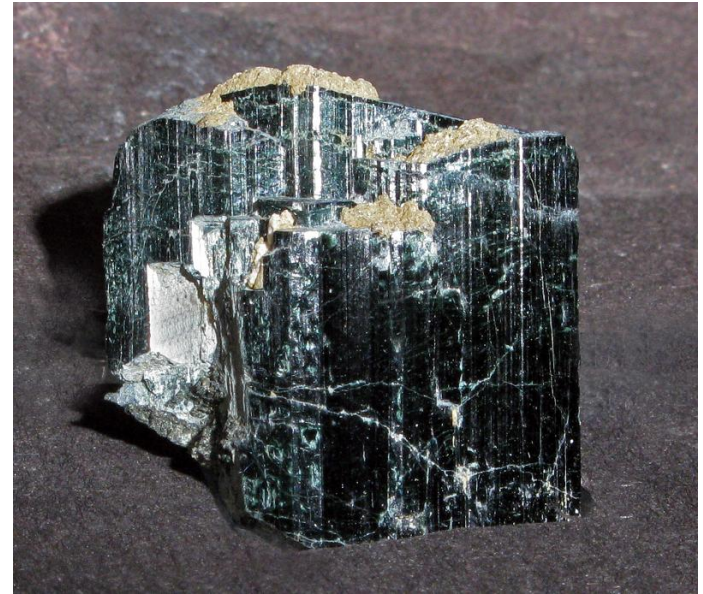


Lsec: 3.3 31 Cnts 7.070 keV Det: Octane Plus

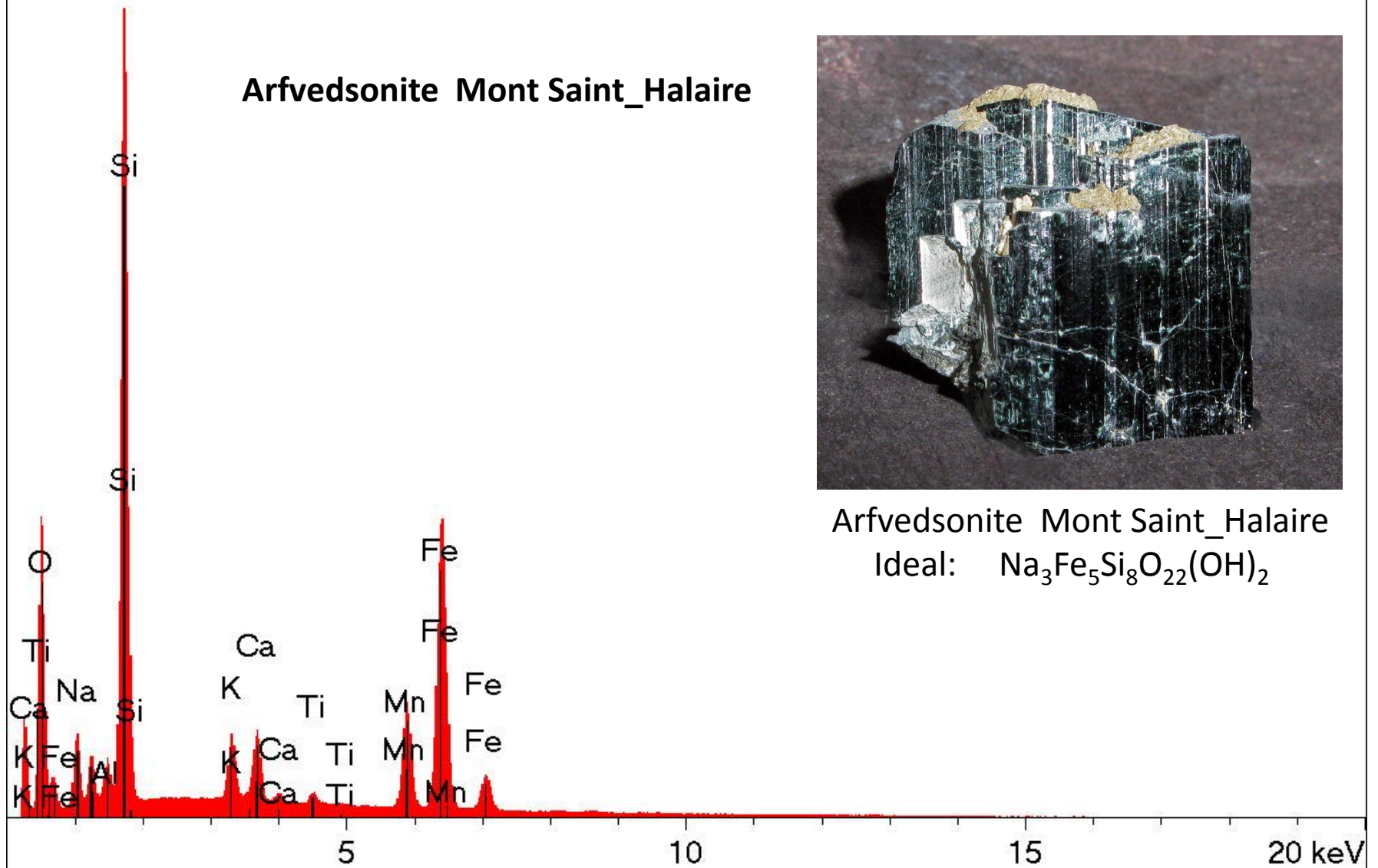
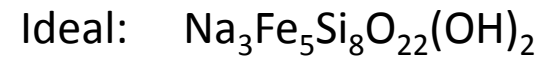
### eZAF Smart Quant Results with Oxides

Element	Weight %	Atomic %	Net Int	Error %	Kratio	Z	A	F
Na 2O	2.98	3.18	67.78	27.75	0.0092	1.0293	0.3155	1.0007
Al 2O3	0.36	0.23	12.32	78.37	0.0014	1.0070	0.6898	1.0026
Si O2	40.91	45.13	1484.69	6.38	0.1788	1.0285	0.7095	1.0021
Fe O	55.77	51.45	691.75	6.08	0.4809	0.8571	1.0030	1.0089

Arfvedsonite Mont Saint\_Halaise



Arfvedsonite Mont Saint\_Halaise

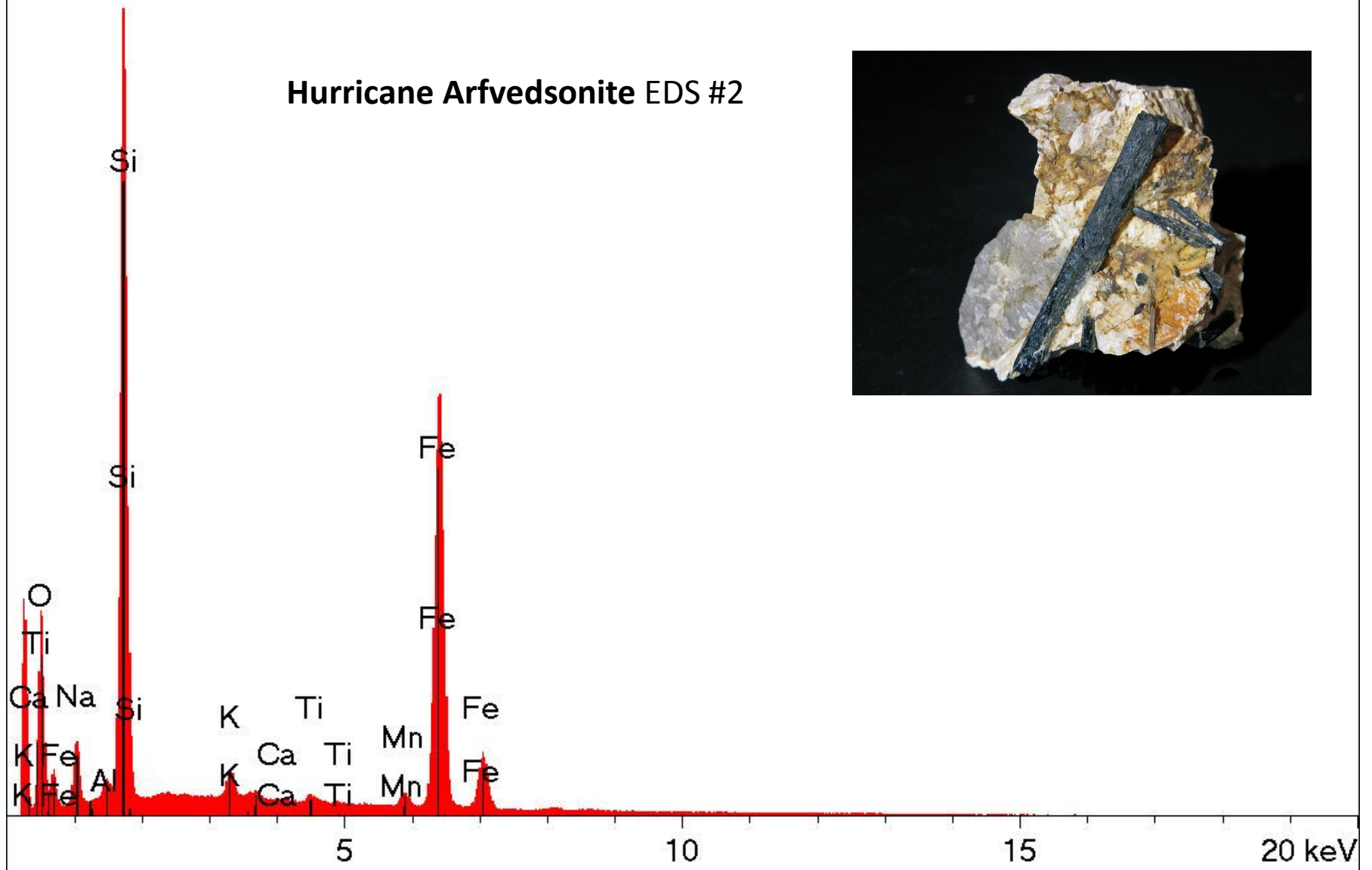


Cursor=  
Vert=21414

Window 0.005 - 40.955= 1,010,265 cnt

BC531-1

### Hurricane Arfvedsonite EDS #2

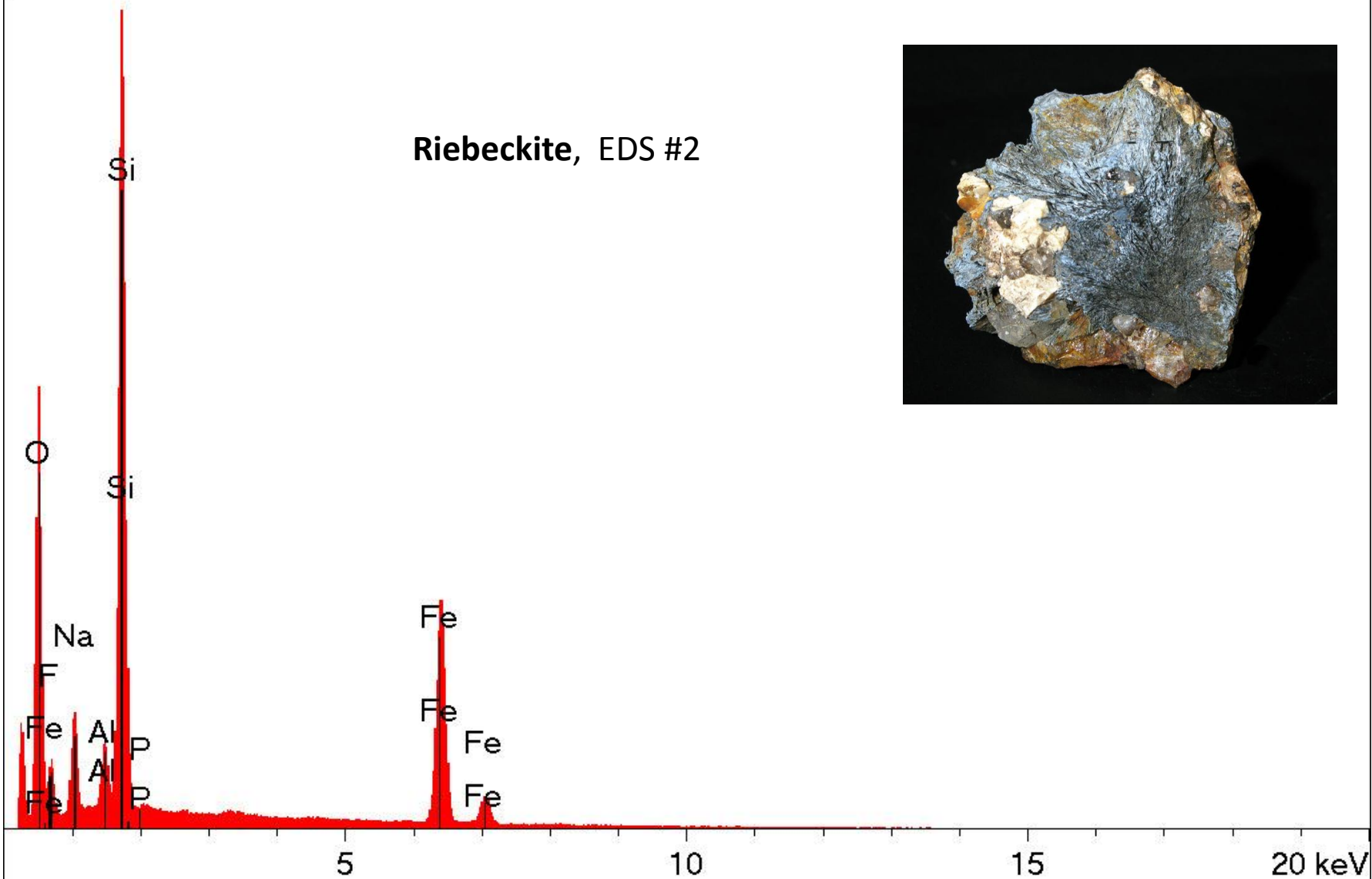


Cursor=  
Vert=13477

Window 0.005 - 40.955= 616,656 cnt



Riebeckite, EDS #2



Cursor=  
Vert=8605

Window 0.005 - 40.955= 348,178 cnt



## Mindat.org analyses for arfvedsonite and riebeckite

	Arfvedsonite	Riebeckite
SiO <sub>2</sub>	49.33 %	49.74 %
TiO <sub>2</sub>	0.40 %	0.63 %
Al <sub>2</sub> O <sub>3</sub>	0.72 %	2.04 %
Fe <sub>2</sub> O <sub>3</sub>	1.55 %	0.0 %
FeO	30.95 %	33.36 %
MnO	2.15 %	1.36 %
MgO	0.74 %	0.99 %
CaO	1.01 %	0.80 %
Na <sub>2</sub> O	7.07 %	6.56 %
K <sub>2</sub> O	1.81 %	1.50 %
ZrO <sub>2</sub>	0.20 %	0.0 %
<b>Total:</b>	<b>95.93 %</b>	<b>96.98 %</b>

APFU from both had  $1.90 < \text{Na} < 1.99$ ..... Essentially identical !

# Amphibole Summary

## **Our study:**

- Failed to find in published literature a confirming analysis for Hurricane arfvedsonite or riebeckite.

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- Our limited quantitative analyses could not chemically differentiate classic Hurricane arfvedsonite from riebeckite.

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- The Hurricane arfvedsonite-riebeckite appear to be very iron rich.

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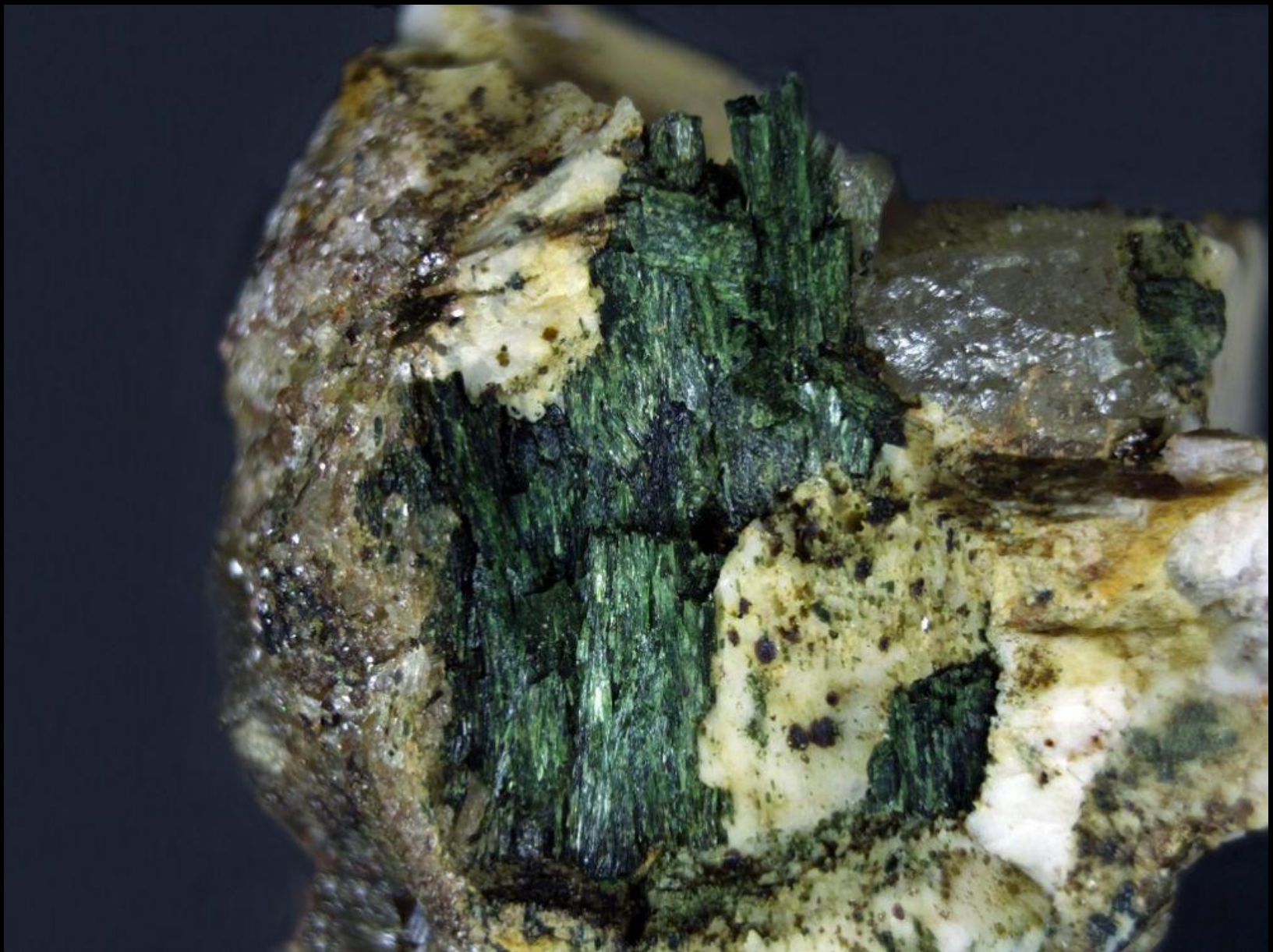
- Failed to find in published literature confirming analysis for Hurricane arfvedsonite or riebeckite
- Our limited quantitative analyses could not chemically differentiate classic Hurricane arfvedsonite from riebeckite.
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- A PXRD analysis of a Hurricane arfvedsonite correlated equally well with reference arfvedsonite AND riebeckite data.

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## **Our study:**

- Failed to find in published literature confirming analysis for Hurricane arfvedsonite or riebeckite
- Our limited quantitative analyses could not chemically differentiate classic Hurricane arfvedsonite from riebeckite.
- The Hurricane arfvedsonite-riebeckite appear to be very iron rich.
- A PXRD analysis of a Hurricane arfvedsonite correlated equally well with reference arfvedsonite AND riebeckite data.
- The mindat.org analyses of arfvedsonite and riebeckite are very compositionally close. In particular, the Na<sub>2</sub>O values were not diagnostic of the 3 Na atoms in arfvedsonite vs. the 2 Na atoms in riebeckite.





**AEGIRINE** 1.8 mm tall mass.

EDS confirmed

$\text{NaFe}^{3+}\text{Si}_2\text{O}_6$

kV: 15

Mag: 50000

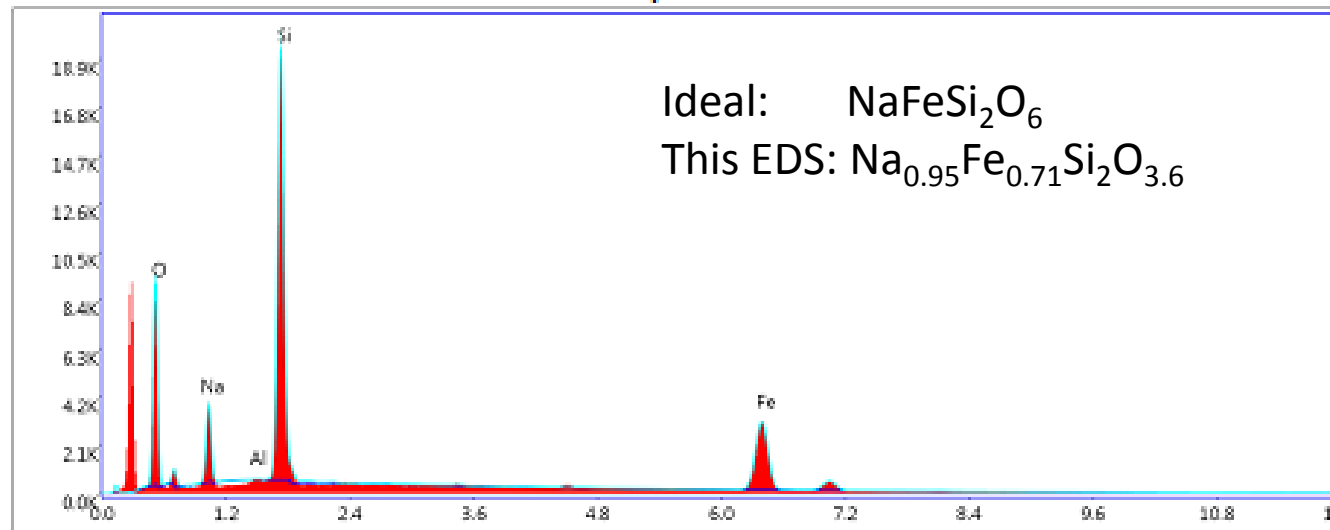
Takeoff: 35.2

Live Time (s): 24.4

Amp Time (μs): 7.68

Resolution (eV)

## EDS Spot 4 - Det 1



Lives: 24.4 1.359K Cnts 6.530 keV Det: Octane Plus

## eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int	Error %	Kratio	Z	A	F
O K	17.57	32.70	1866.14	7.13	0.0951	1.1571	0.4681	1.0000
Na K	9.65	12.49	877.45	8.75	0.0365	1.0489	0.3614	1.0008
Al K	0.01	0.01	2.17	98.62	0.0001	1.0262	0.5985	1.0030
Si K	30.35	32.17	6132.99	4.49	0.2282	1.0482	0.7163	1.0017
Fe K	42.42	22.62	1738.34	3.01	0.3743	0.8743	0.9997	1.0097

AEGIRINE 1.8 mm tall mass.

EDS confirmed

 $\text{NaFe}^{3+}\text{Si}_2\text{O}_6$



**AEGIRINE** 1.3 mm splintery mass.

$\text{NaFe}^{3+}\text{Si}_2\text{O}_6$

Mindat.org: Aegirine and arfvedsonite are frequent associates.



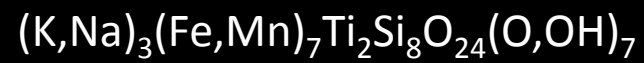
**ALBITE** 7 mm field of view.





**ASTROPHYLLITE**

4.2 cm crystal





**ASTROPHYLLITE** Golden astrophyllite hairs in 9 mm quartz crystal



**ASTROPHYLLITE** Golden astrophyllite hairs in quartz crystal. 15 mm field of view



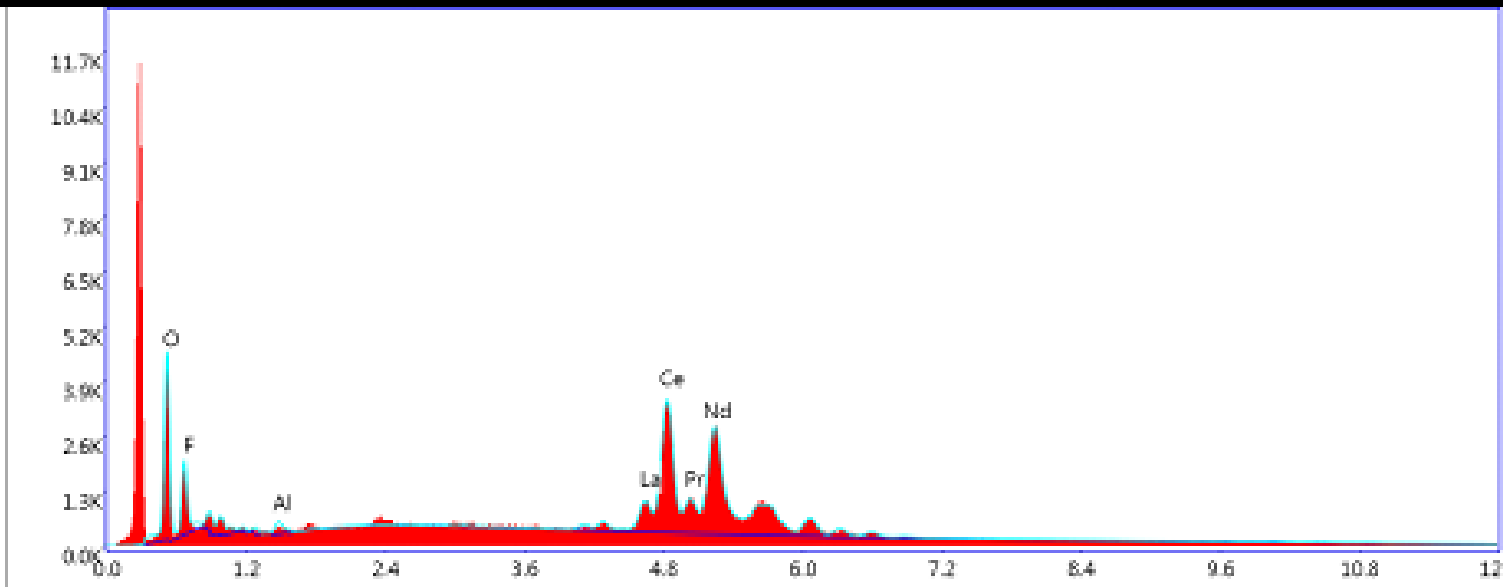
**ASTROPHYLLITE** Golden astrophyllite hairs in quartz crystal. 15 mm field of view





**BASTNASITE-Ce** 0.5 mm crystal





Live: 24.0 379 Cnts 6.530 keV Det: Octane Plus

### eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int	Error %	Kratio	Z	A	F
O K	7.36	37.87	962.24	7.78	0.0636	1.6222	0.4779	1.0000
F K	1.71	7.43	276.78	10.36	0.0117	1.4147	0.4838	1.0000
Al K	0.67	2.03	77.36	13.97	0.0030	1.3677	0.3316	1.0033
La L	9.99	6.92	370.34	8.74	0.0966	0.9384	1.0061	1.0137
Ce L	60.60	29.67	1741.36	3.14	0.4811	0.9433	1.0073	1.0026
Pr L	6.22	3.64	201.46	17.06	0.0693	0.9608	1.0006	1.0016
Nd L	23.66	13.44	697.37	6.31	0.2209	0.9410	0.9992	0.9977

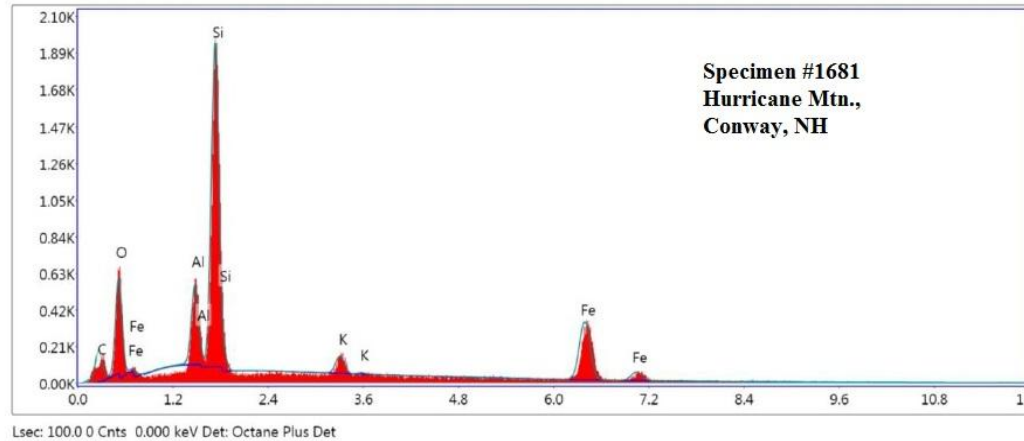
BASTNASITE-Ce 0.5 mm crystal

(Ce/Y/REE)(CO<sub>3</sub>)F



**'GLAUCONITE' - Celadonite Group** 3.5 cm specimens  $(K,Na)(Fe^{+3},Al,Mg)_2((Si,Al)_4O_{10})(OH)_2$

EDS Spot 4

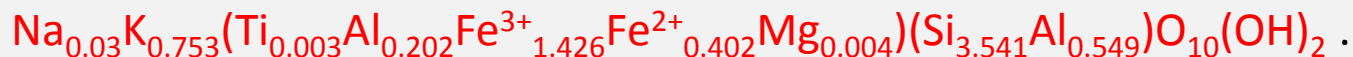


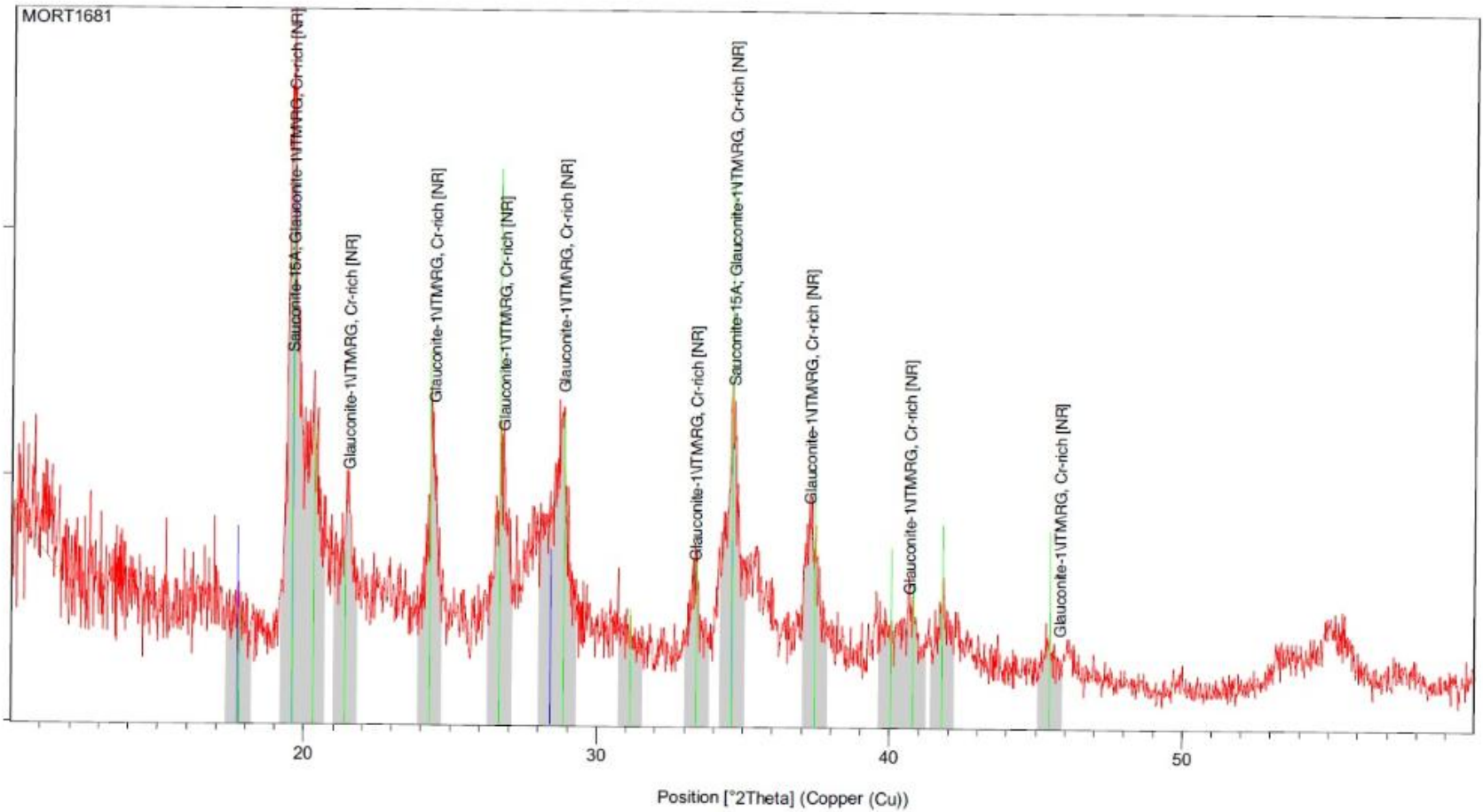
**eZAF Smart Quant Results with Carbon Coat 18nm**

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	R	A	F
O K	19.47	36.07	62.12	10.30	0.09	1.15	0.93	0.41	1
AlK	7.76	8.53	51.46	7.56	0.05	1.02	0.97	0.64	1.01
SiK	30.71	32.41	214.52	5.18	0.22	1.04	0.98	0.71	1
K K	2.92	2.22	13.26	13.39	0.03	0.97	1.01	0.91	1.02
FeK	39.14	20.78	54.16	4.74	0.33	0.87	1.04	1	1

**Mindat.org discussions:**

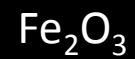
- "Glaucosite is essentially the K-deficient equivalent of celadonite."
- "for practical purposes, if the mineral occurred in a sedimentary rock it was called "glaucosite" and if in a volcanic rock it was called "celadonite"."
- Bishop et. al. in their 2008 article in *Clay Minerals* (3/ 2008) include an analysis of a Hurricane Mtn. glaucosite with a formula:

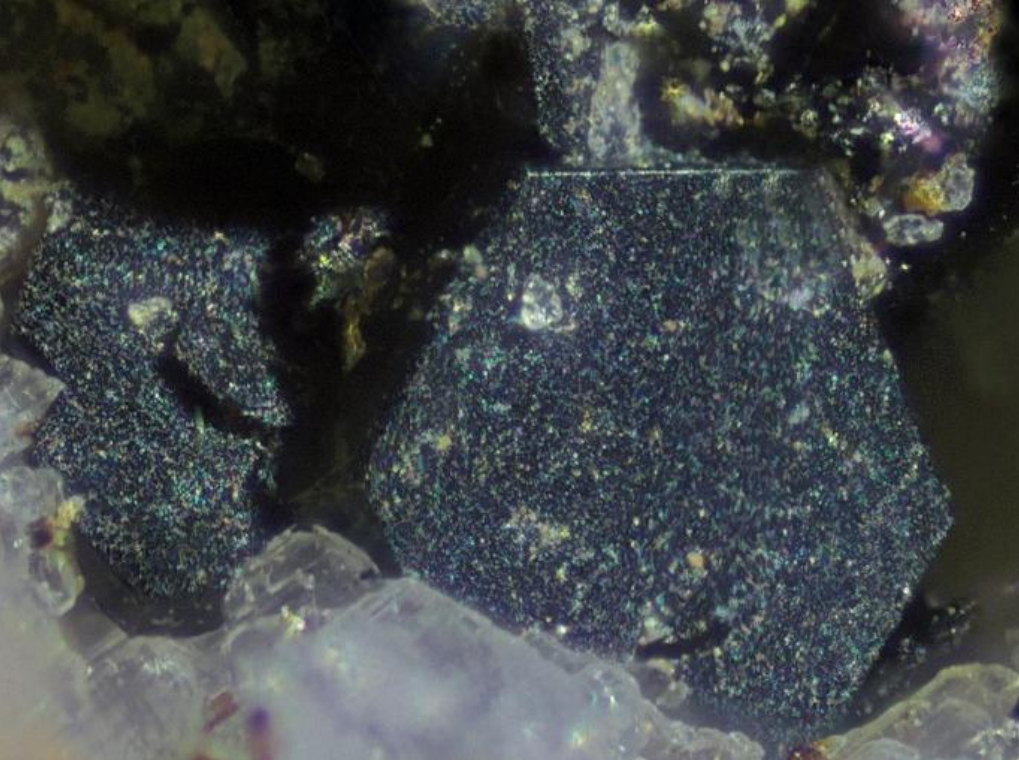




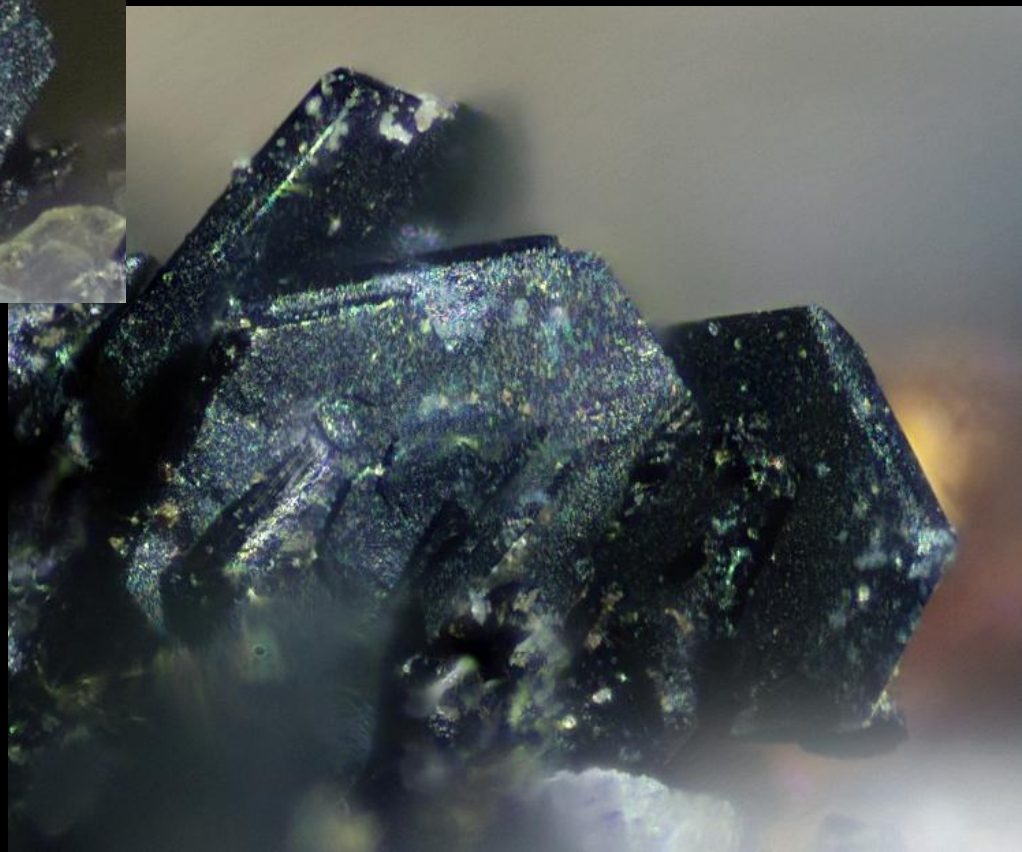


**HEMATITE** 7 mm field of view on left - EDS confirmed

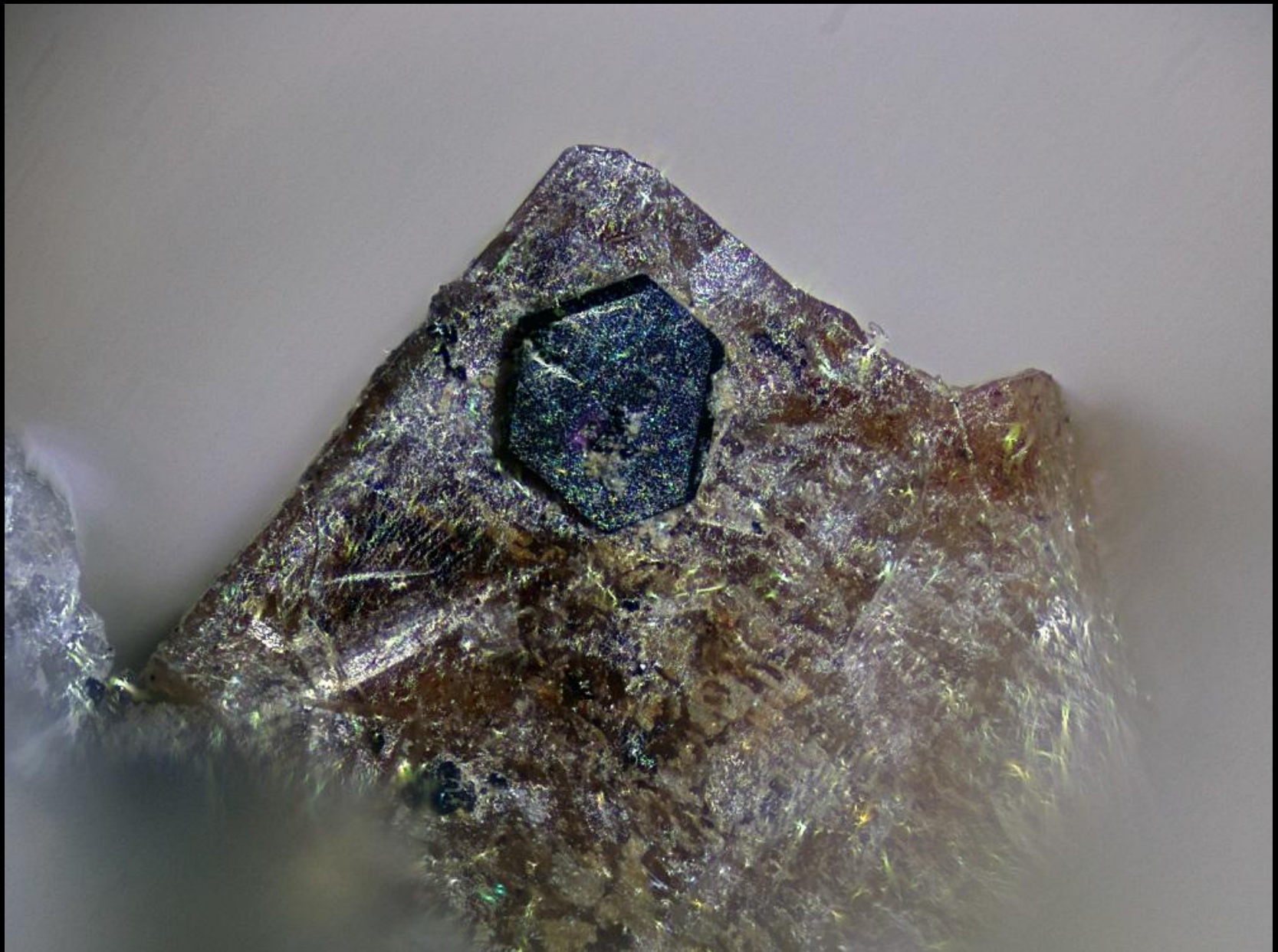




**HEMATITE** 0.5 mm crystals



$\text{Fe}_2\text{O}_3$



**HEMATITE** 0.3 mm hematite crystal on zircon crystal



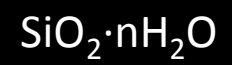


**MICROCLINE** 4 cm specimen



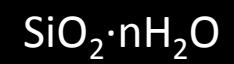


**OPAL var. Hyalite** 8 mm field of view





**OPAL var. Hyalite** 4 mm field of view





**QUARTZ** 2.4 mm field of view





**QUARTZ** 9.5 cm smoky crystal  
Harvard Mineral Museum #124880. Col. by R. Bohmar 1972.

$\text{SiO}_2$   
A K Czaja photo



**QUARTZ** var. Jasper      10.5 cm specimen

Harvard Mineral Museum #110214.      Source W. Ross, 1980.

$\text{SiO}_2$

A K Czaja photo



**QUARTZ** var. Jasper 91.9 ct. oval  
Harvard Mineral Museum Gem #1404.

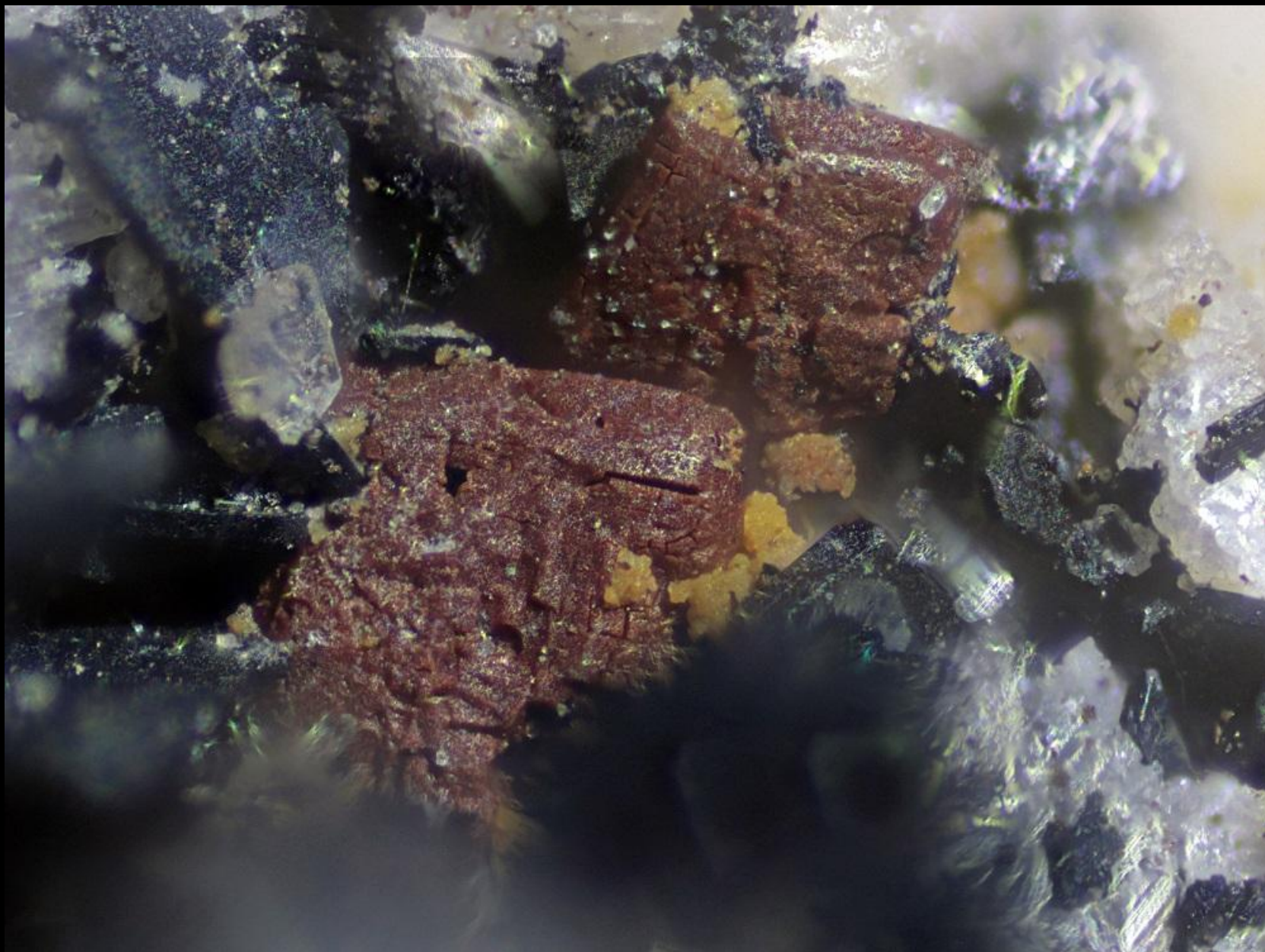
SiO<sub>2</sub>  
A K Czaja photo



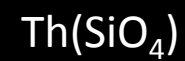
**SIDERITE** 2.5 cm specimen





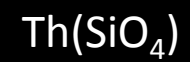


**THORITE** 1.3 mm field of view

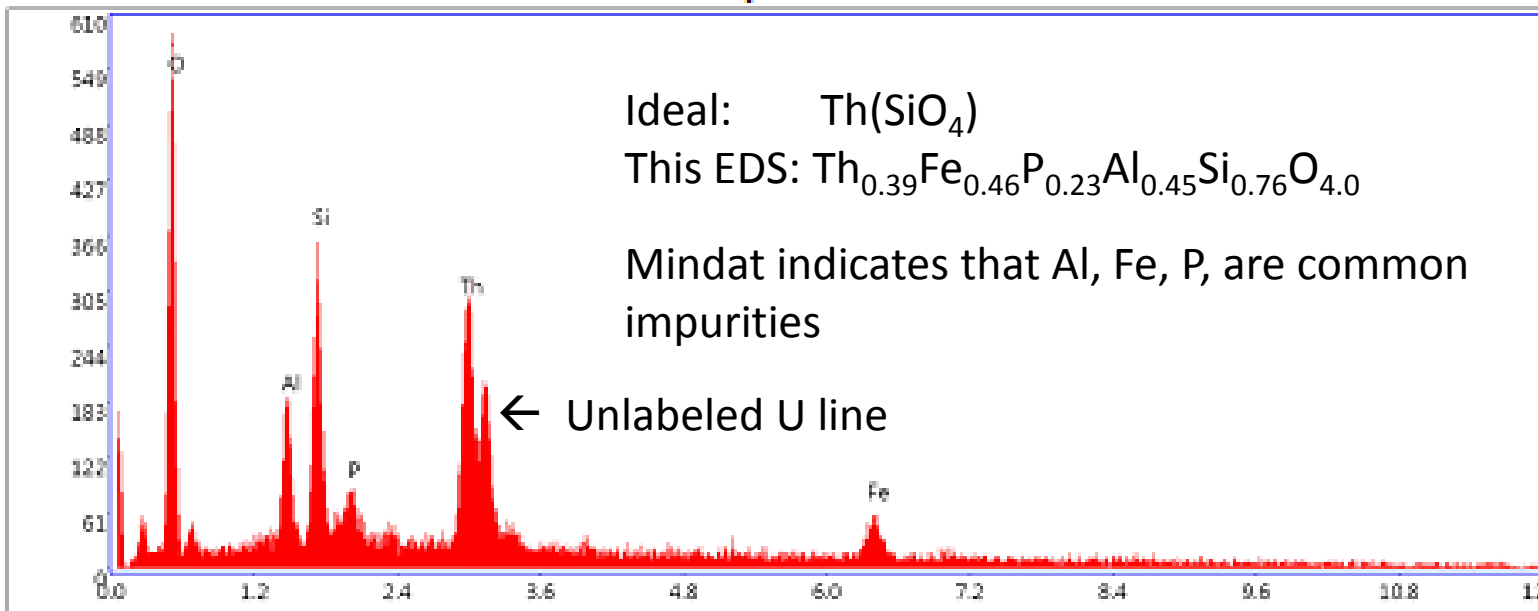




**THORITE** 0.9 mm Tabular Crystal



### EDS Spot 1 - Det 1



Loss: 0.2 84 Cnts 2.000 keV Det: Octane Plus

### eZAF Smart Quant Results with Oxides

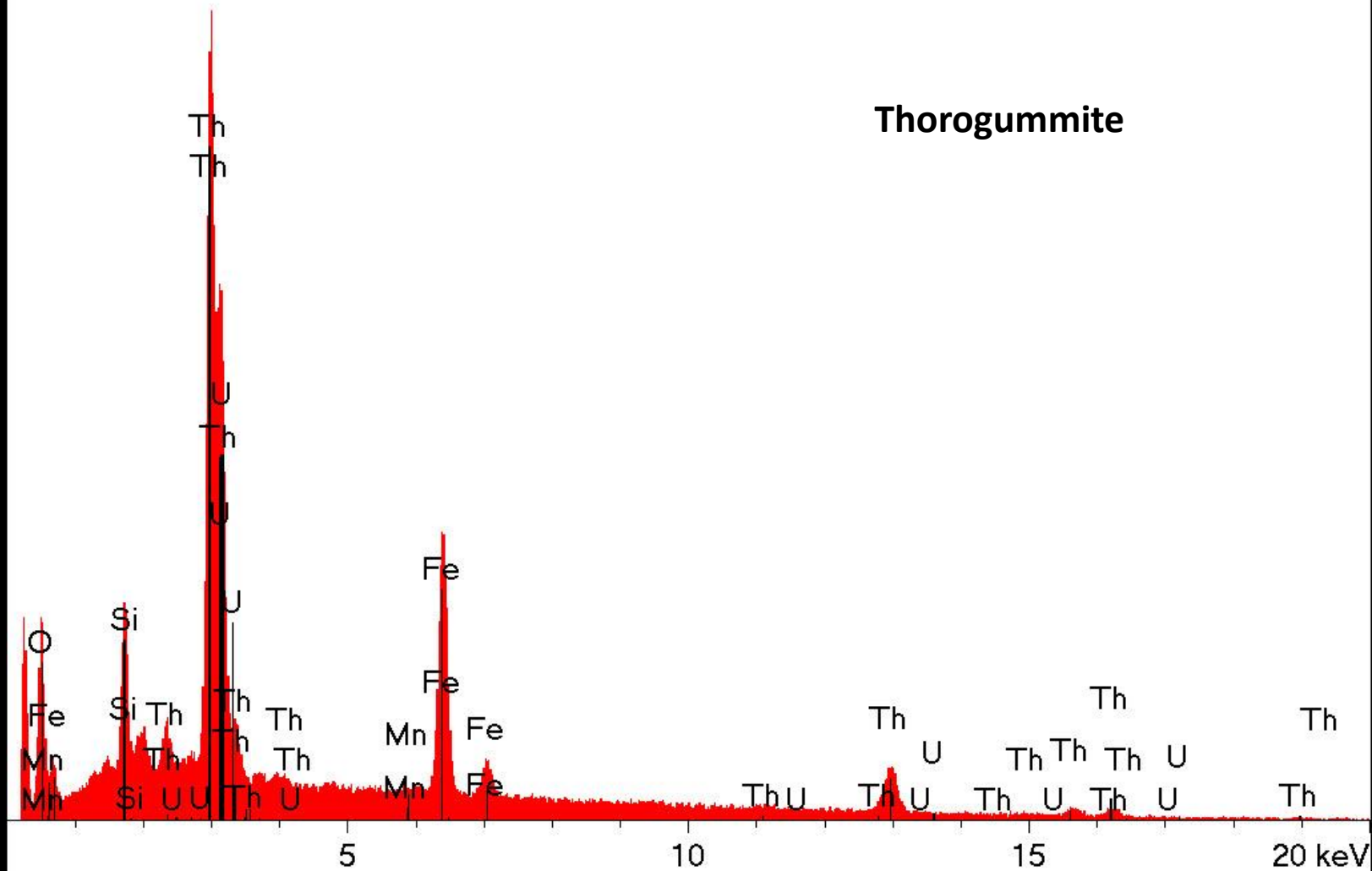
Element	Weight %	Atomic %	Net Int	Error %	Kratio	Z	A	F
Al <sub>2</sub> O <sub>3</sub>	10.36	11.47	6476.76	10.42	0.0360	1.1666	0.6812	1.0000
SiO <sub>2</sub>	20.76	39.01	12684.84	7.88	0.0718	1.1828	0.6684	1.0002
P <sub>2</sub> O <sub>5</sub>	7.31	6.81	3412.38	16.97	0.0241	1.1370	0.6982	1.0006
ThO <sub>2</sub>	46.44	19.87	16330.08	7.91	0.3018	0.7099	1.0908	1.0044
FeO	15.15	23.83	3232.64	18.86	0.1064	1.0079	0.9647	0.9879

THORITE

0.9 mm Tabular Crystal

$\text{Th}(\text{SiO}_4)$

BC533-2



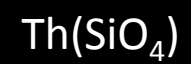
Thorogummite

Cursor=  
Vert=2005  
Window 0.005 - 40.955= 174,617 cnt

**THORITE** var. **THOROGUMMITE**      0.9 mm Tabular Crystal       $(\text{Th,U})(\text{SiO}_4)_{1-x}(\text{OH})_{4x}$

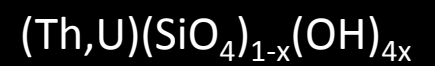


**THORITE** 4.5 cm specimen  
Harvard Mineral Museum #151082.

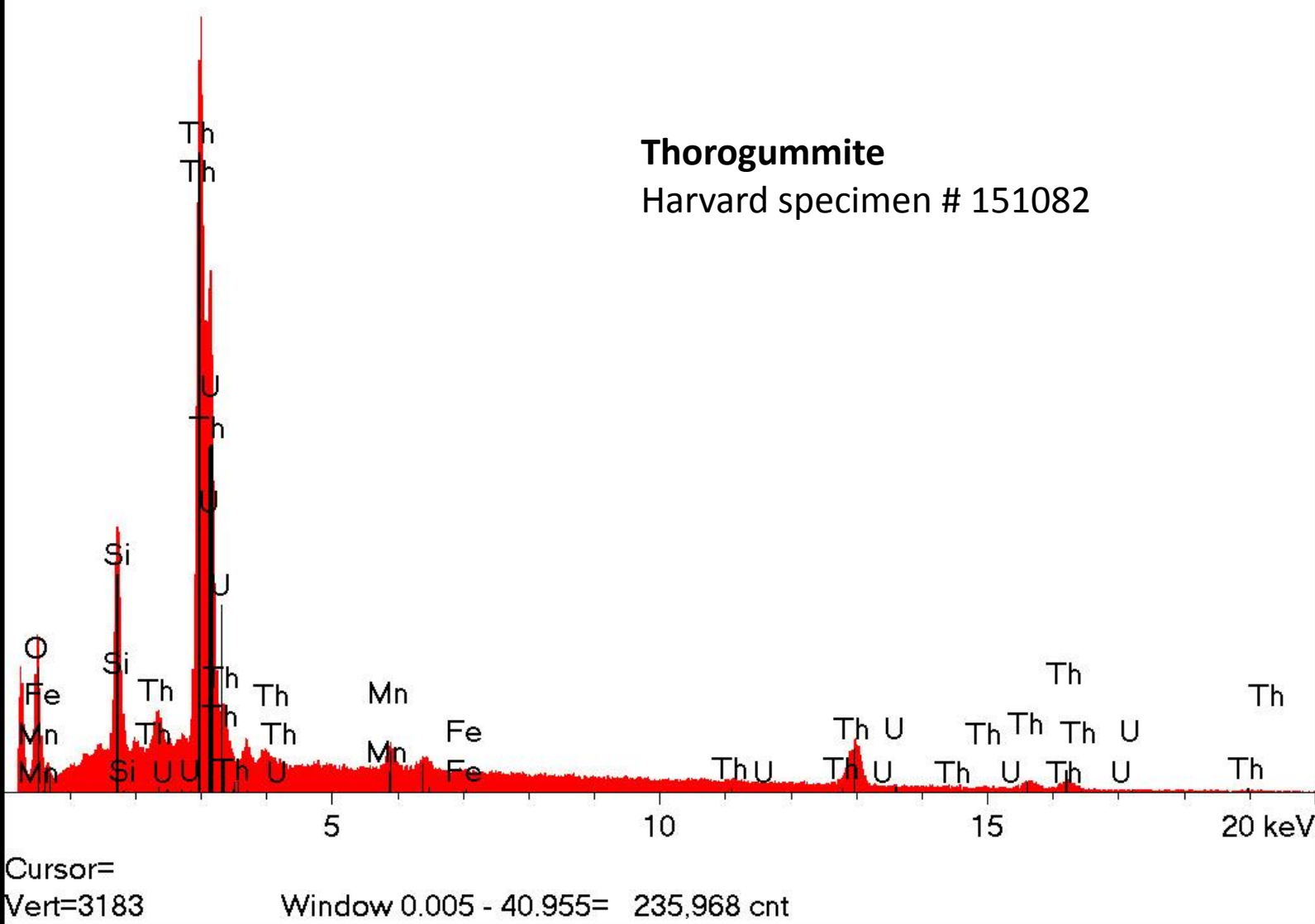




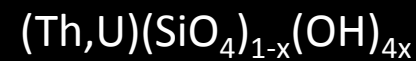
**THORITE** var. THOROGUMMITE    2 cm field of view  
Harvard Mineral Museum #151082.



BC533-1



**THORITE** var. **THOROGUMMITE** 2 cm field of view  
Harvard Mineral Museum #151082.





**TOPAZ** with Fluorite & Smoky Quartz 4.5 cm specimen  
Harvard Mineral Museum #131115. A gift from E. Lerer, 12/89.

$\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$   
A K. Czaja photo





**ZIRCON** 1.2 cm crystal group  
A Don Dallaire specimen & photo





**ZIRCON**

2.0 mm field of view

$\text{ZrSiO}_4$



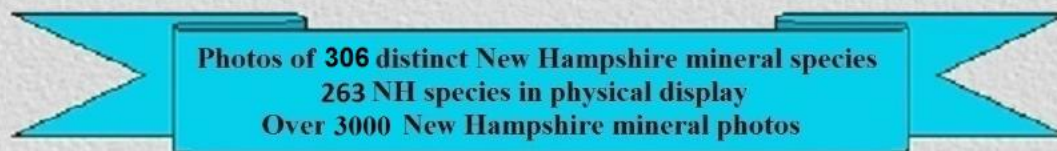
**ZIRCON** 3 mm zircon crystal – two views



These photos are posted on my website:  
<https://mindatnh.org>

## New Hampshire Mineral Species

From the collection of Tom Mortimer and friends



Go to New Hampshire Mineral Species [List View](#) , [Best Photo View](#) or [Locality Galleries](#)

OVER 500  
MINERAL  
ANALYSES  
(EDS, XRD,  
RAMAN)

[NH Species List & photos](#)

[Mission statement](#)

[NH Species Display Exhibitions](#)

[Tips for touring this site](#)

[Specimen example selection](#)

[Notes on mineral identification](#)

[Site content](#)

### Site Mission Statement

This site is dedicated to the documentation and confirmation of [New Hampshire](#) mineral species. Many states, particularly New England states, have mineral species lists that have evolved over the years. Typically these are an alphabetical listing of mineral species to be found within the borders of the state. Frequent updates to these lists have been necessary as the science of mineralogy has developed. New species names have been added, others renamed or deleted. The lists on this site contains 334 New Hampshire species, (including 40 species [Added after 2010](#) documented in a separate gallery). Ideally, state mineral lists conform to the currently approved species definitions. Many minerals have names that are not recognized as species names, (eg. mica, tourmaline). A [Reference list](#) is provided to assist with associating these names with approved species names. This site was developed in conjunction with a [display of New Hampshire mineral species](#), presently on loan to the McAuliffe-Shepard Discovery Center, Concord, NH. The display was designed to be permanent and self contained, with size and weight such that it could be easily transported, (see [design criteria](#)). **This display may be electronically coupled to a local copy of these web pages, so that as each specimen is viewed on a web page, the physical specimen is illuminated in the display.**

QUESTIONS

