Multidisciplinary microscopy course for undergraduate research students in the Natural Sciences

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UNCA Microscopy Courses: A Brief History

2004: SEM purchased through NSF MRI/RUI grant

2005 – 2012: SEM prep and Forensics courses taught by Bill Miller (ENVR) and Herb Pomphrey (BIOL)

2013 – present: "Methods in Microscopy", 1-credit SEM prep course taught in Fall by Dr. Langille (ENVR), Dr. Perkins (PHYS), and/or Dr. McNamee (ENVR)

Fall 2016: "Methods in Microscopy" expanded to 3-credits and include instruction of light microscopy and X-ray diffraction

“Methods in Microscopy”

1-credit course	**3-credit course**
does not count towards instructor course load	does count towards instructor course load
meet for 3-hr lab for 1st 6 weeks	meet for 2.5 hr lecture and 2.5 hr lab each week
SEM	SEM and other electron microscopes, XRD, and light microscope
assignments include portfolio, practicum, and presentation of research project at UGR symposium	assignments include lab worksheets, portfolio, practicum, project abstract, presentation of research given during Finals
6-9 enrollment with 1 student from Warren Wilson College	13 enrollment

UGR Projects using SEM

- Identification of minerals in sulfide body within granite host at North Buncombe Quarry in Western North Carolina. *M. Daniels and B. Governo (2017)*
- Mapping garnet compositions in the Ashe Metamorphic Suite to show garnet thermal history. *J. Corradino (2017)*
- Growing Silver Nanowires. *P. Friel (2016)*
- Synthesis and Characterization of Titanium Dioxide Nanoparticles. R. Jacques (2016)
- Mineralogical studies of medium to high grade metamorphic rocks at Mount Mitchell State Park, North Carolina, USA. *A. Coburn (2016)*
- Mineral phase identification of Hendersonville Gneiss at Chimney Rock State Park, North Carolina. *K. Wright (2014)*

Course Assignments

Calculate optimal resolution at different light wavelengths and accelerating voltages.

Chart 1: The de Broglie wavelength of electrons of various accelerating voltages

Accelerating voltage, V	1 kV	10 kV	30 kV
Electron velocity, v (in m/s) $eV = \frac{1}{2} m_e v^2$	$v = \sqrt{(\frac{e \cdot V}{1/2}) / m_e}$ $= 1.87E^{7}$ m/s	$= 5.9E^{7}$ m/s	$= 1.03E^{8}$ m/s
Electron momentum, p (in kg·m/s) $p = m \cdot v$	$9.11E^{-31} \cdot v$ $= 1.70E^{-23}$ kg·m/s	$= 5.37E^{-23}$	$= 9.38E^{-23}$
De Broglie wavelength, $\lambda_{de\ Broglie}$ (in nm)	$\frac{h}{p} \div 10^{-9}$ $= 0.0390$ nm	0.0123 nm	= 0.00706 nm

Chart 2: The optimal spatial resolution of various optical and electron microscopies

wave	UV light	Yellow light	Red light	1 kV electrons	10 kV electrons	30 kV electrons
λ (in nm)	250 nm	590 nm	750 nm	0.0390 nm (from above)	0.0123 nm (from above)	0.00706 nm (from above)
NA (unitless)	1.4	1.4	1.4	--	--	--
Working distance, f	--	--	--	5 mm	5 mm	5 mm
Final aperture radius, r	--	--	--	50 µm NA = 50/5	50 µm	50 µm
Resolution, d (in nm)	250/2(1.4) = 89.3 nm	= 210.7 nm	= 267.9 nm	0.0390 / 2(50/5) d = 0.00195	0.0123 / 2(10) = 6.15E-4	0.00706 / 2(10) = 5.53E-4

n = 1

Course Assignments

Calculate Z_{avg} of different materials in a back-scattered electron (BSE) image.

calcite $CaCO_3$
tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$
talc $Mg_3Si_4O_{10}(OH)_2$

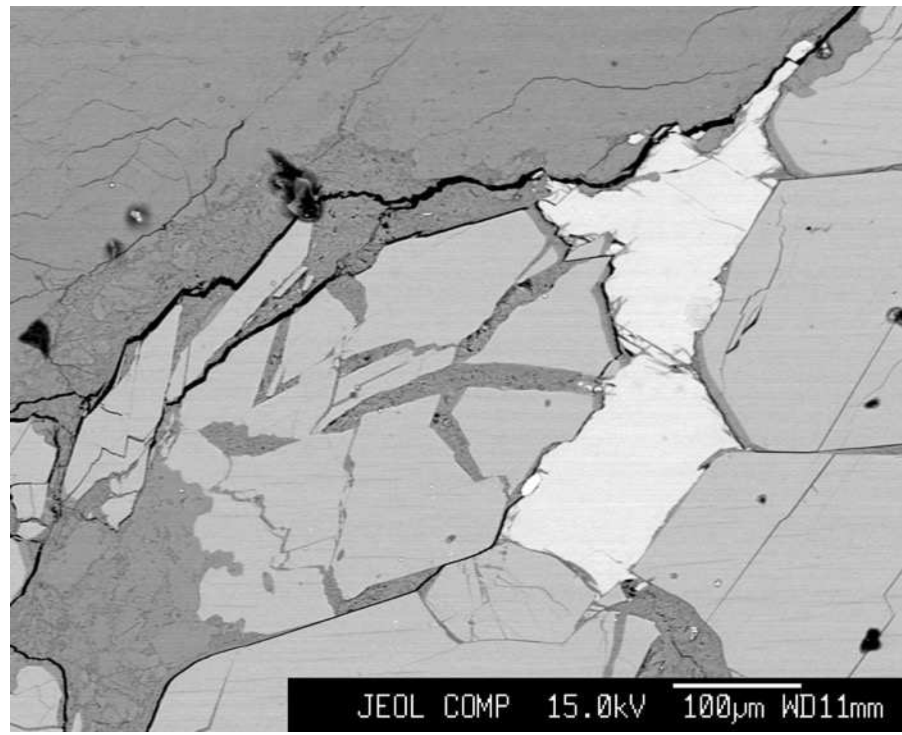
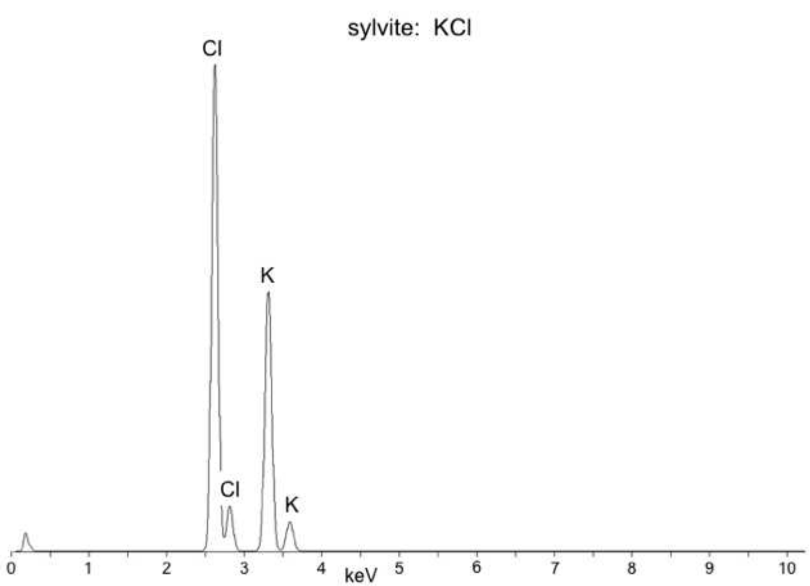
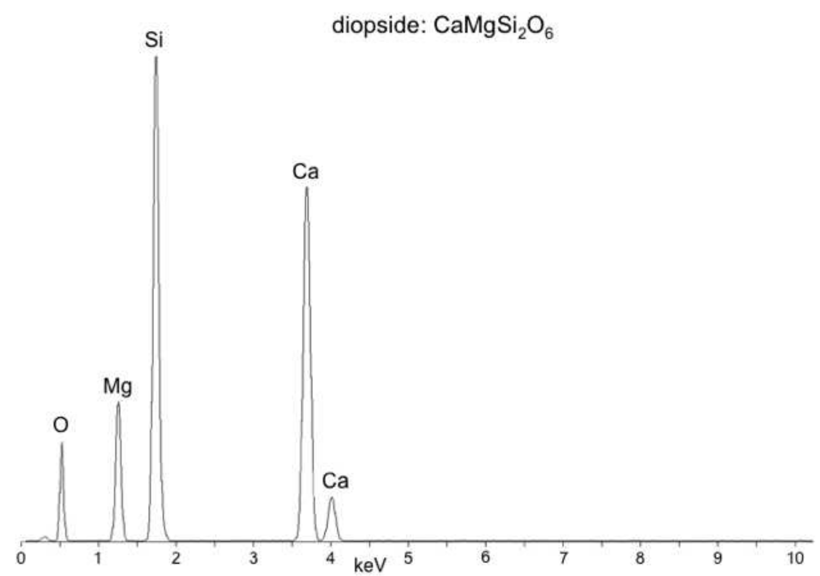


photo by B. McNamee

Course Assignments

Calculate and compare weight percents of elements in minerals (ideal amounts) to observed peak heights in energy dispersive spectra (EDS).

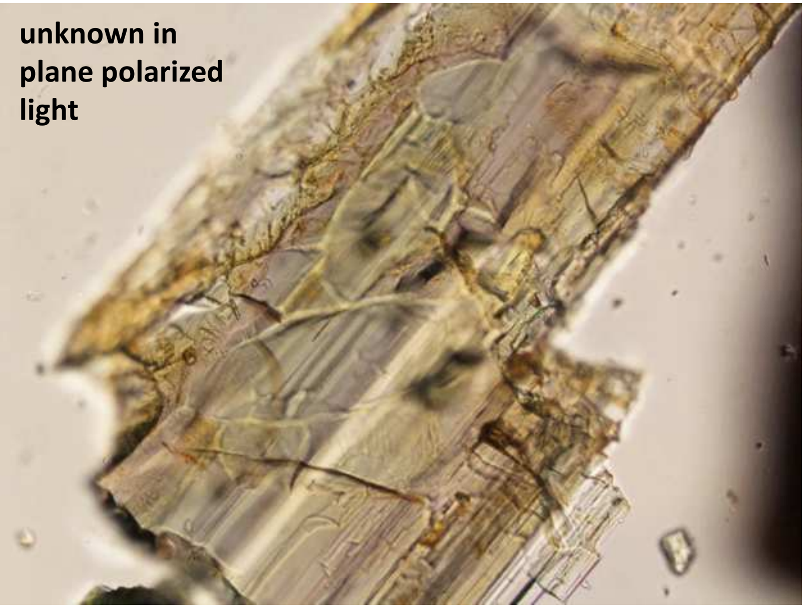


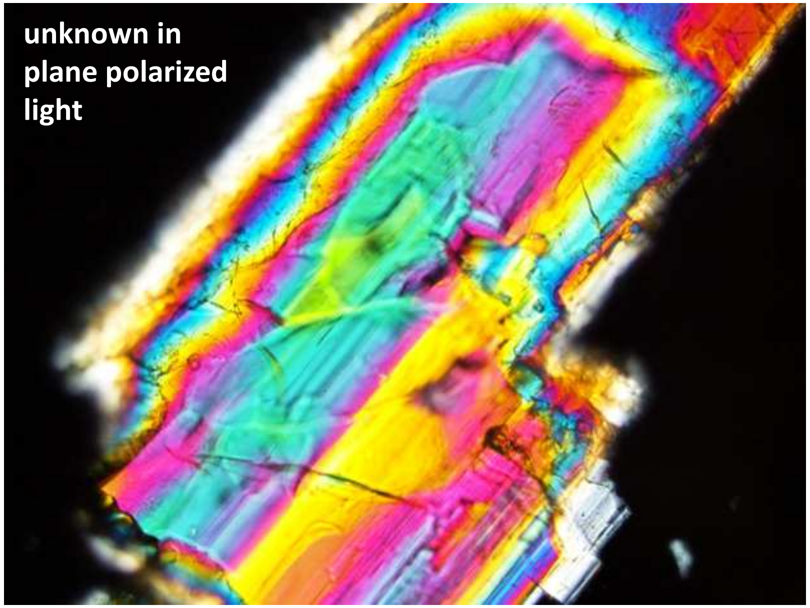


spectra from Mineralogy and Optical Mineralogy textbook DVD by M.D. Dyar, M.E. Gunter, and D. Tasa (2008)

Course Assignments

Identify optical properties of quartz and an unknown mineral using a polarized light microscope.

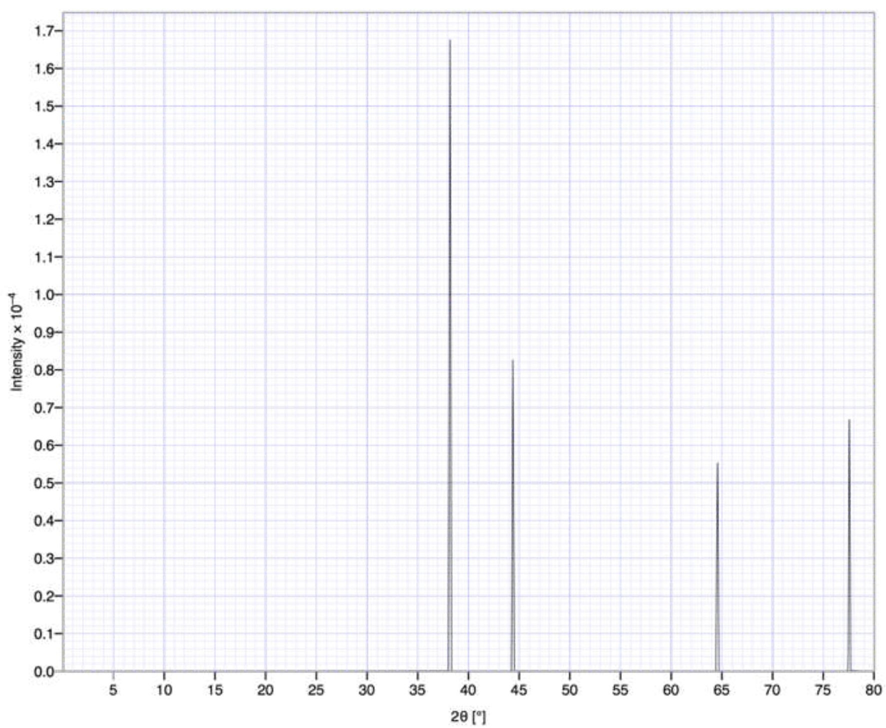




photos by N. Brown

Course Assignments

Identify mineral phases from X-ray diffraction patterns using WebMineral's online XRD peak database.

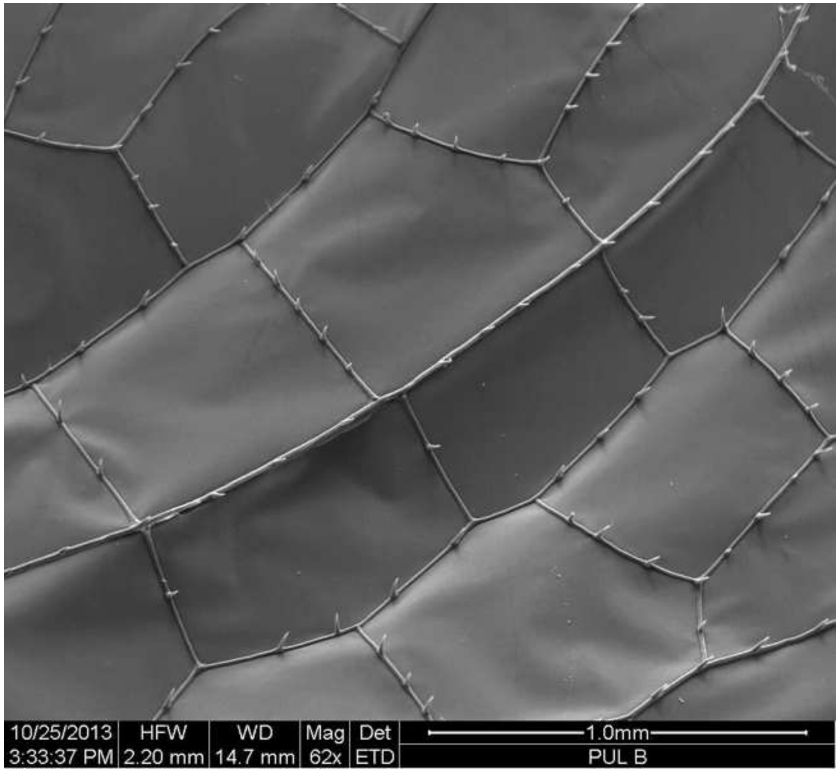


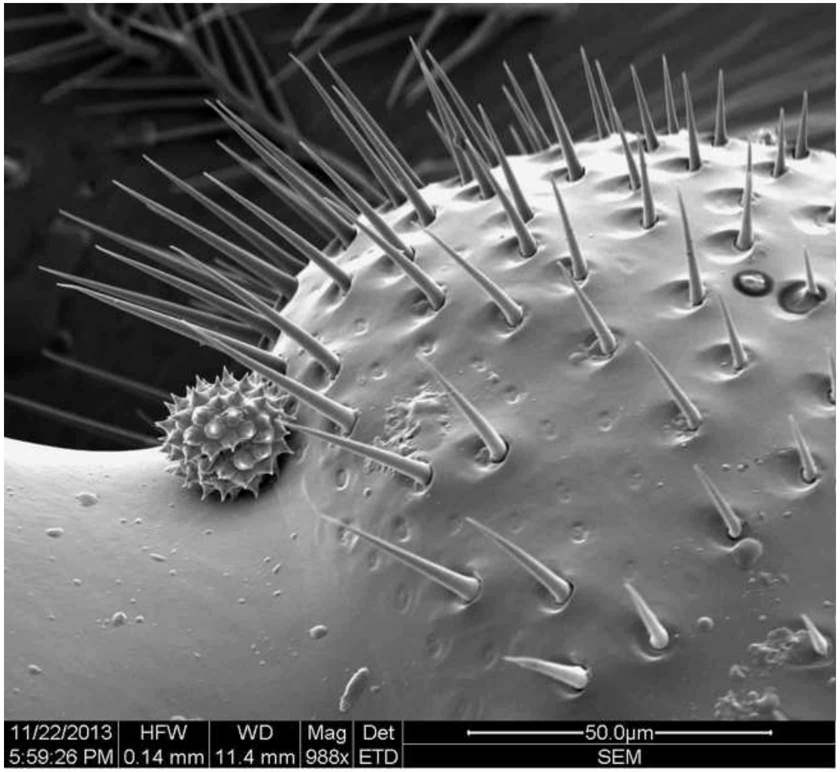
quartz from CrystalDiffract database

Course Projects

Scanning electron microscope parameters for imaging insects

T. Elliott (previous semester)

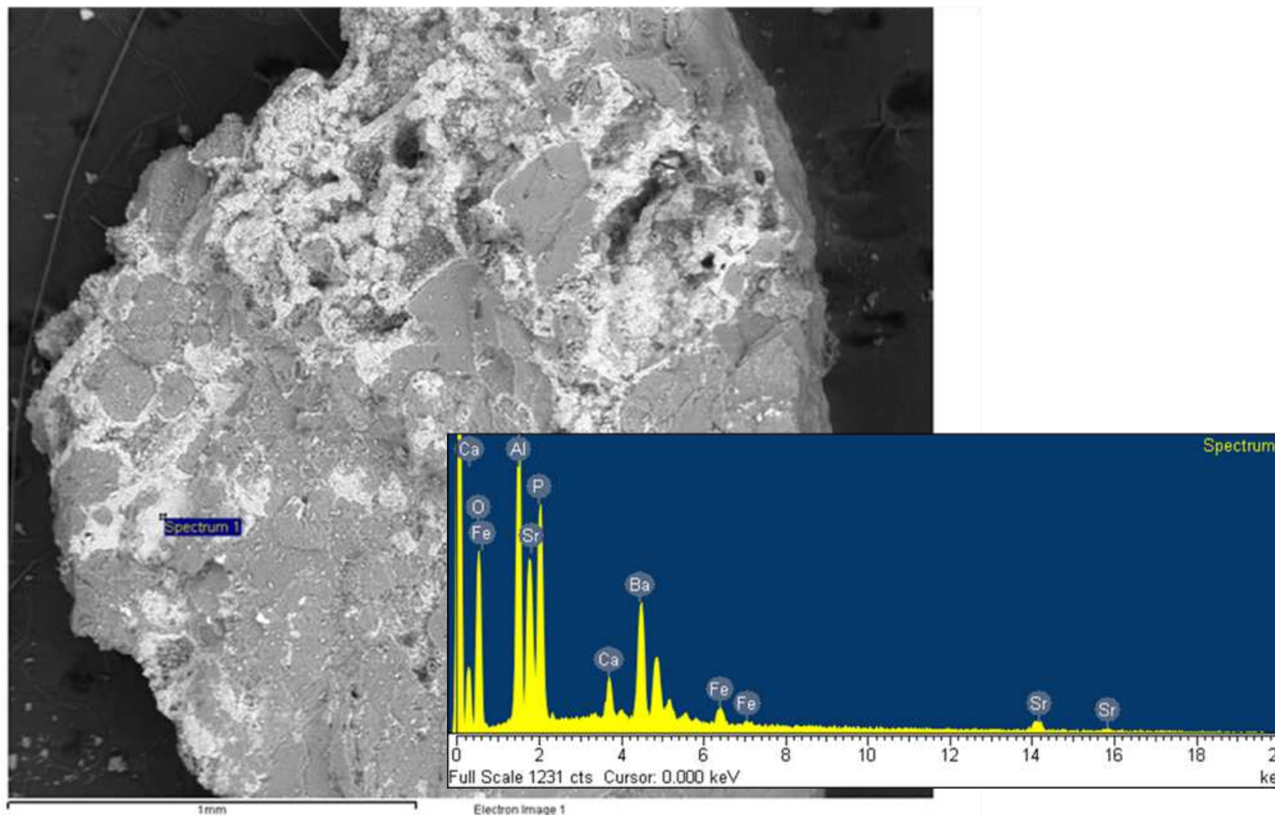




Course Projects

Identification of unknown blue mineral found in quartzite cliffs of Sauratown Mountains, NC Piedmont

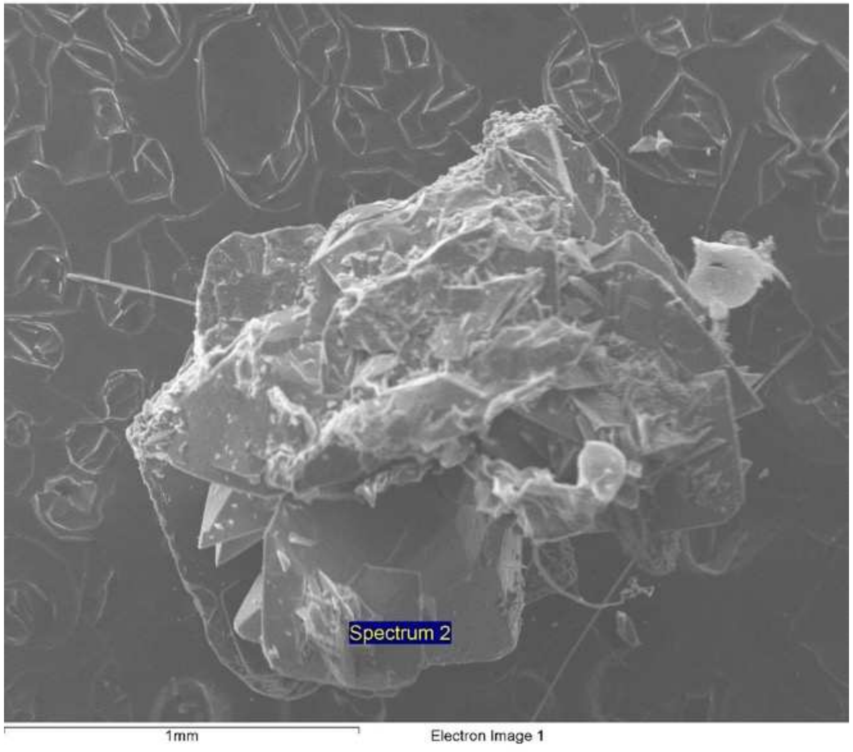
N. Brown

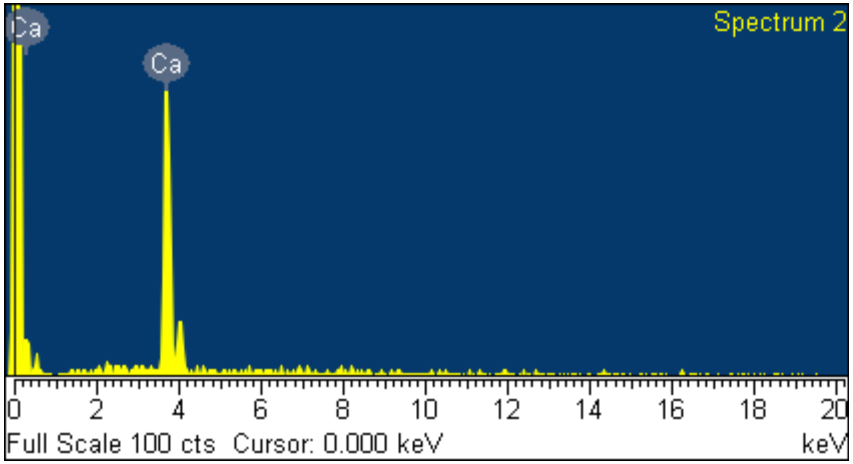


Course Projects

Chemical analysis of lab sample of a kidney stone

T. Dawson

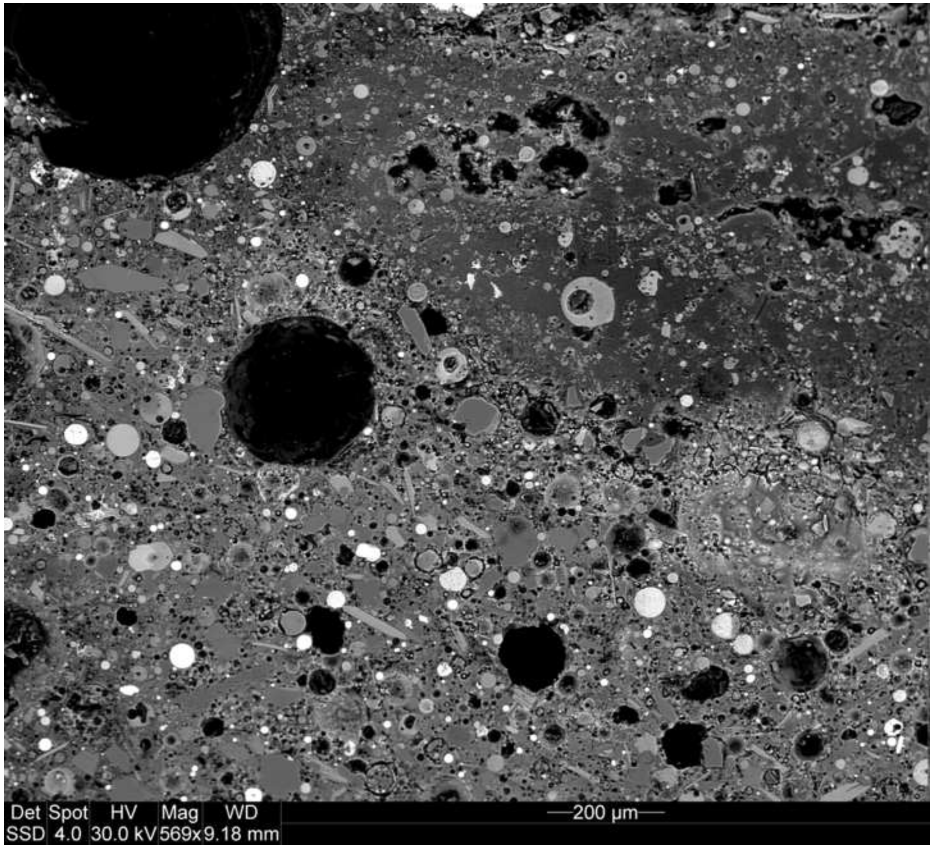




Course Projects

Cement and aggregate relationships in coal fly ash concrete

B. Strausborger



What exceeded our expectations?

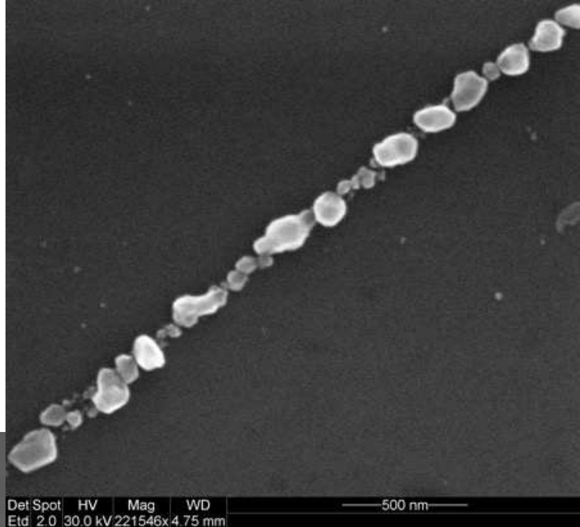
- Explore interdisciplinary uses of each instrument.
- Explore integration of different analyses.
- Encourage students to work on a research project.

What were the challenges?

- Increased enrollment created large lab groups or lab groups rotating every other week.
- Increased problems with equipment (or decreased troubleshooting time between users?)
- Time/lab management for 13 students and 2 professors from 3 different departments.

What do we want to do in the future?

- Continue the interdisciplinary approach.
- Alternate offering 1-credit option and 3-credit option.
- Tweak course structure by incorporating "Kanban" concepts.
- Make the course sustainable at UNCA.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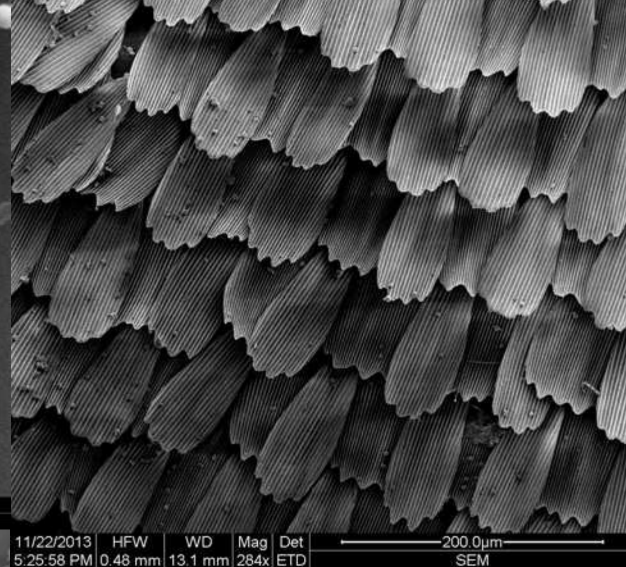
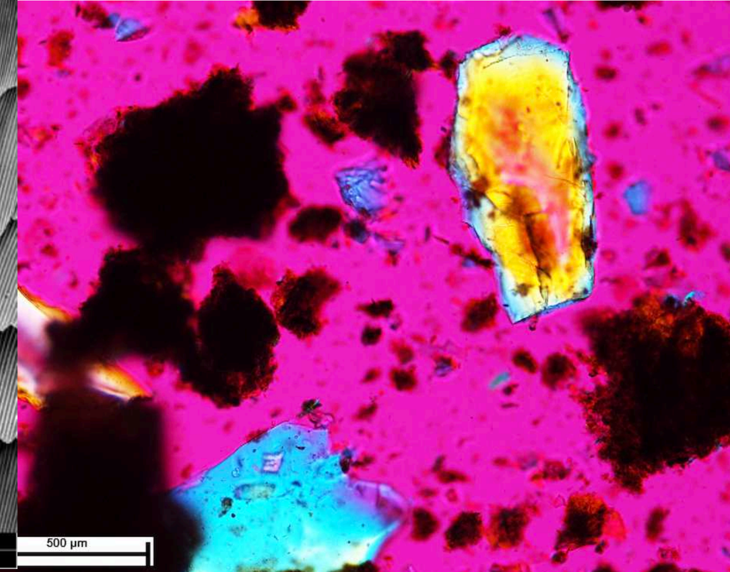
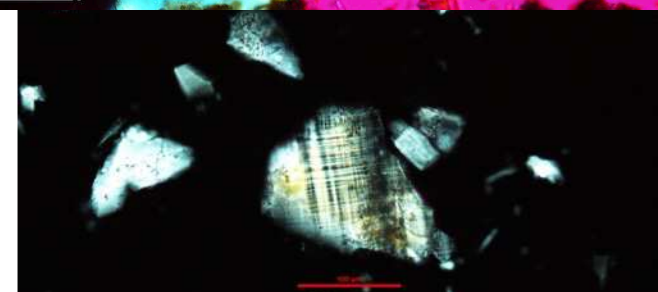
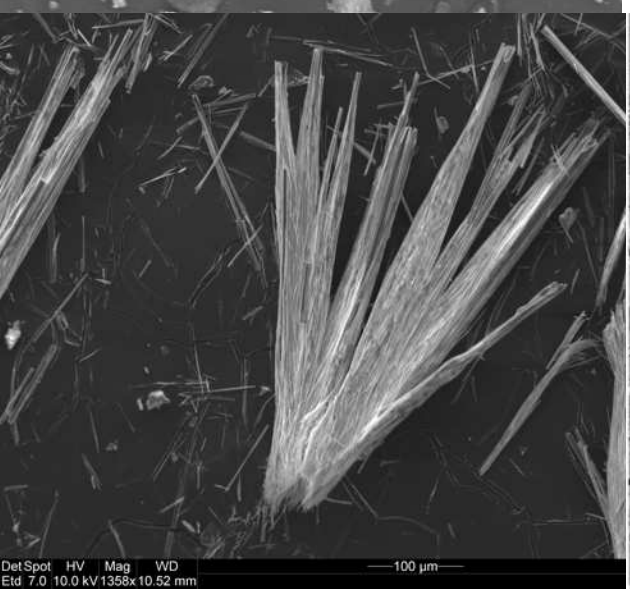
500 nm

11/22/2013 HFW WD Mag Det
5:25:58 PM 0.48 mm 13.1 mm 284x ETD
200.0µm
SEM

500 µm


Thank you!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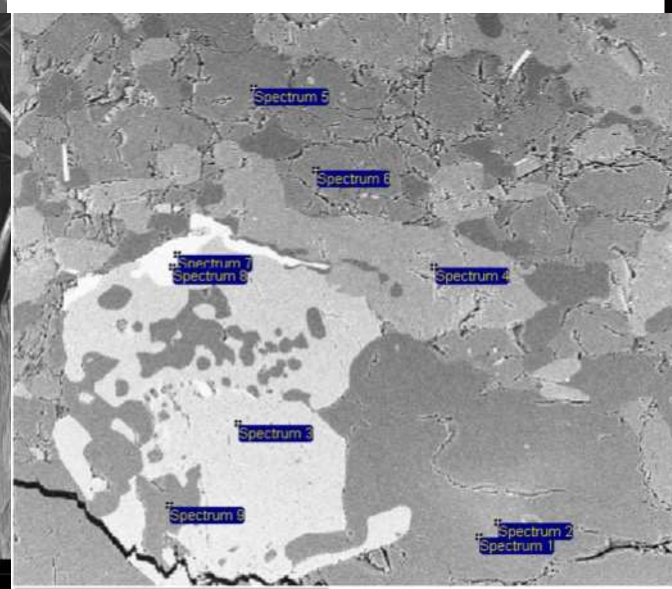
100 µm

Spectrum 5
Spectrum 6
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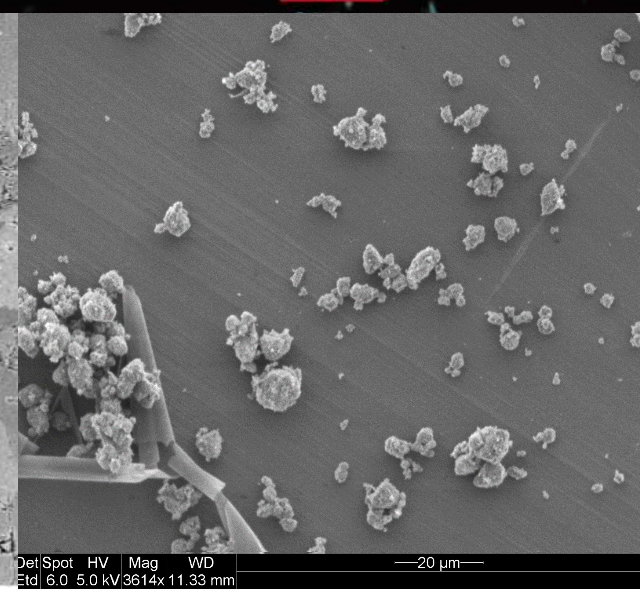
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20 µm