A Dive into Sonju Lake

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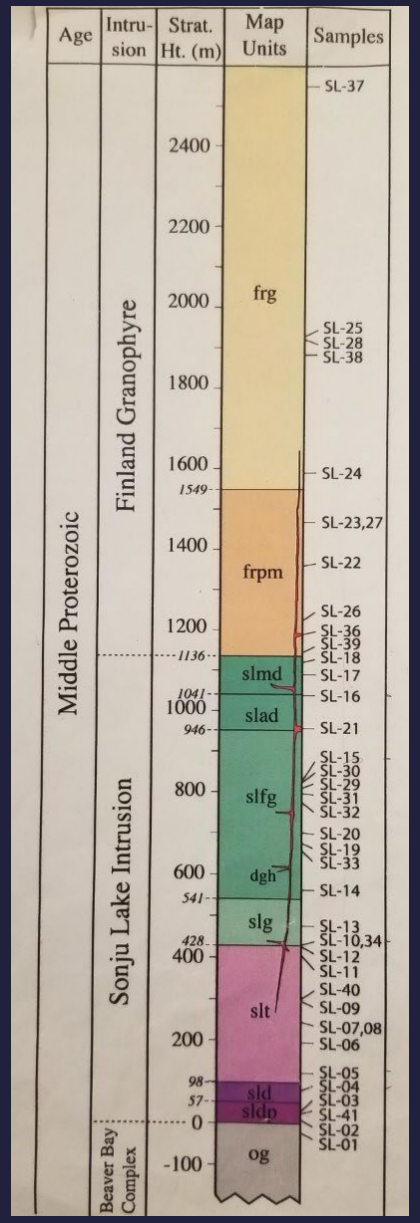
NDSU GEOL 422 - Petrology

April 28, 2022

What is Sonju Lake?

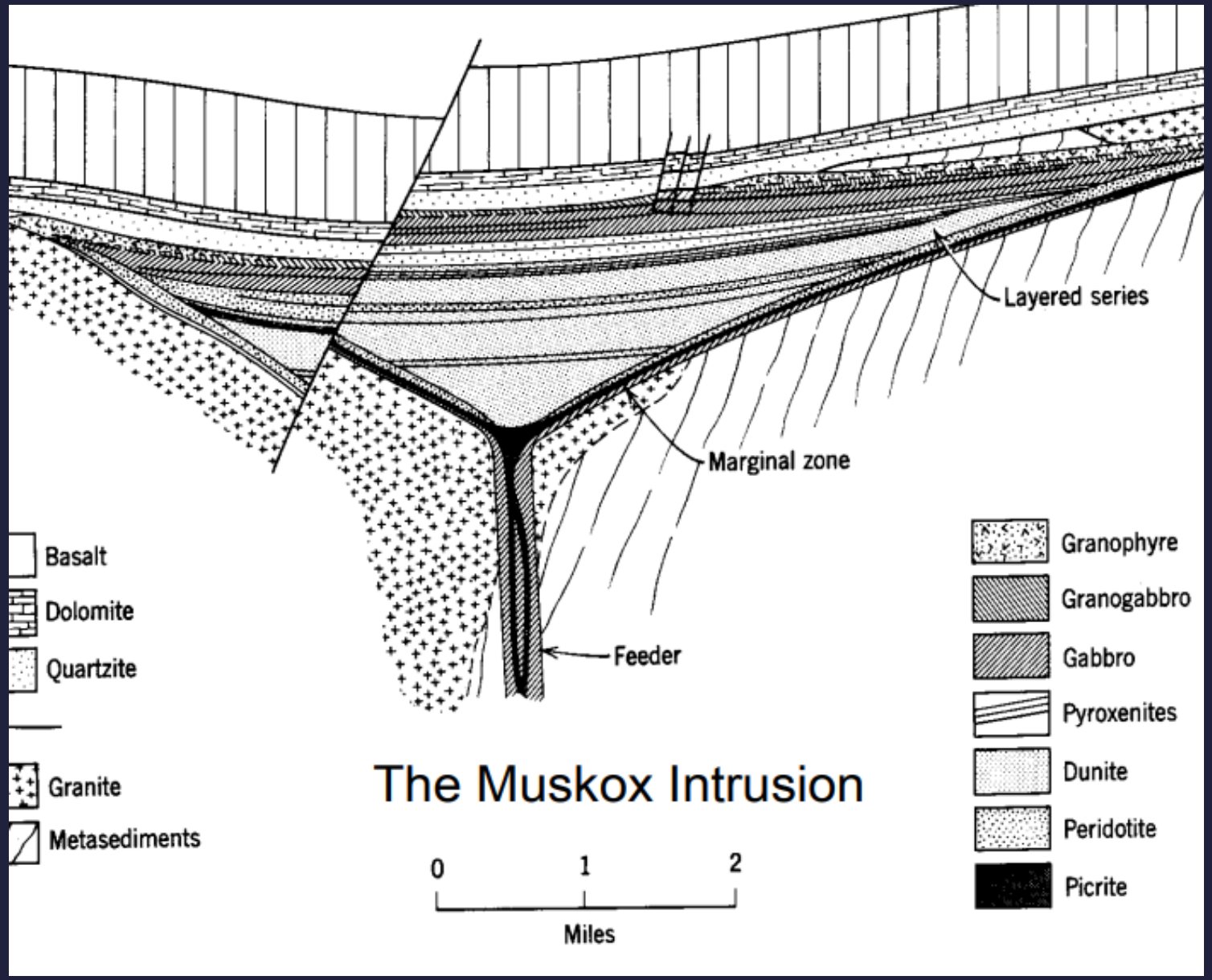
- ❑ Layered Mafic Intrusion; U-Pb Age of 1096.1 ± 0.8 Ma
- ❑ 1 – 1.5 km thick
- ❑ Part of a Sequence of Mesoproterozoic Rocks in NE Minnesota
  - Keweenawan Supergroup
    - North Shore Volcanic Group
    - Midcontinent Rift Intrusive Supersuite
      - Beaver Bay Complex
        - Silver Bay Intrusion
        - Beaver River Diabase
        - Sonju Lake Intrusion
        - Finland Granophyre
        - Cloquet Lake Layered Series
      - Duluth Complex



What is a Layered Mafic Intrusion (LMI)?

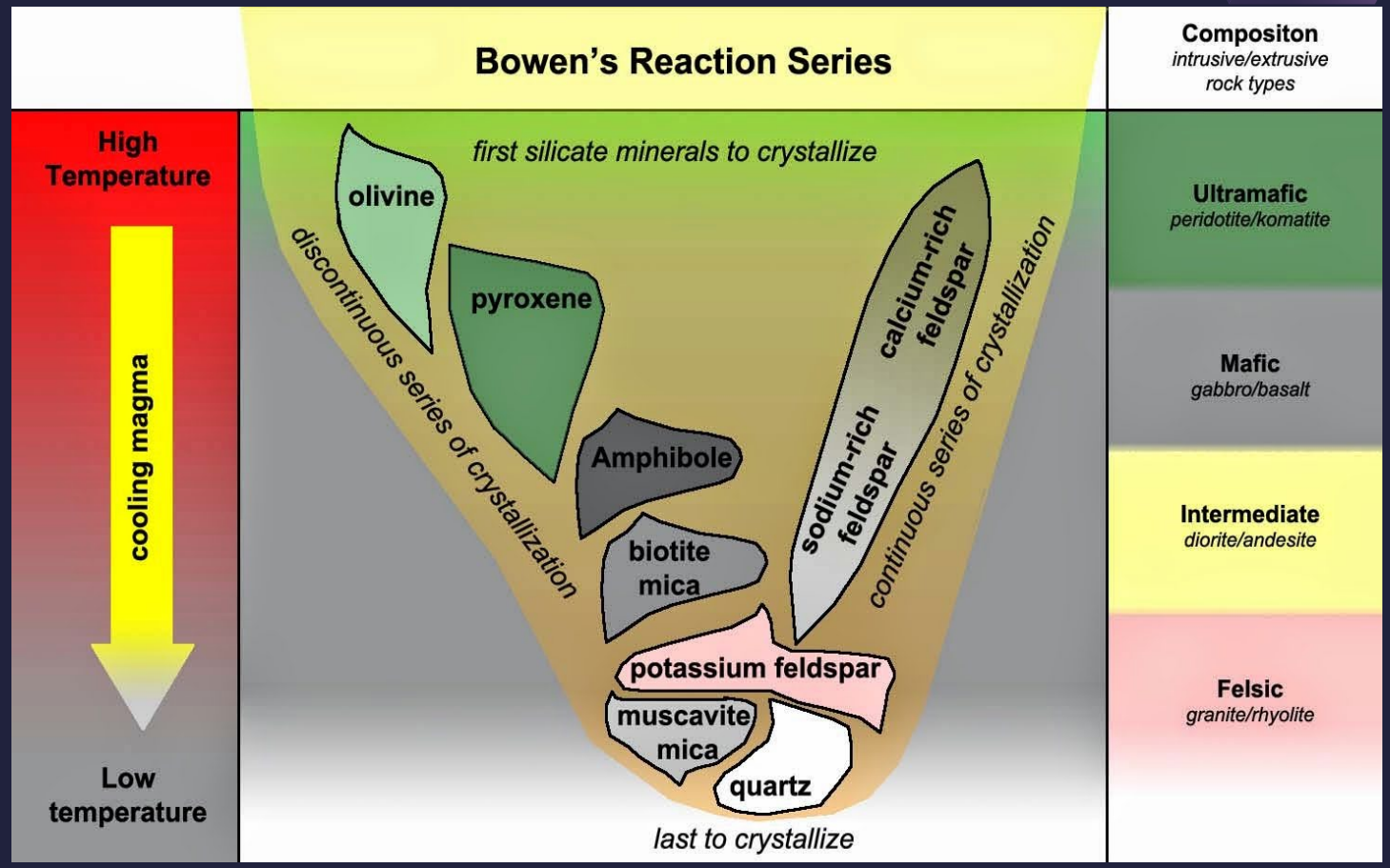
- cumulate texture
- Layering present (Sonju Lake has cryptic layering)

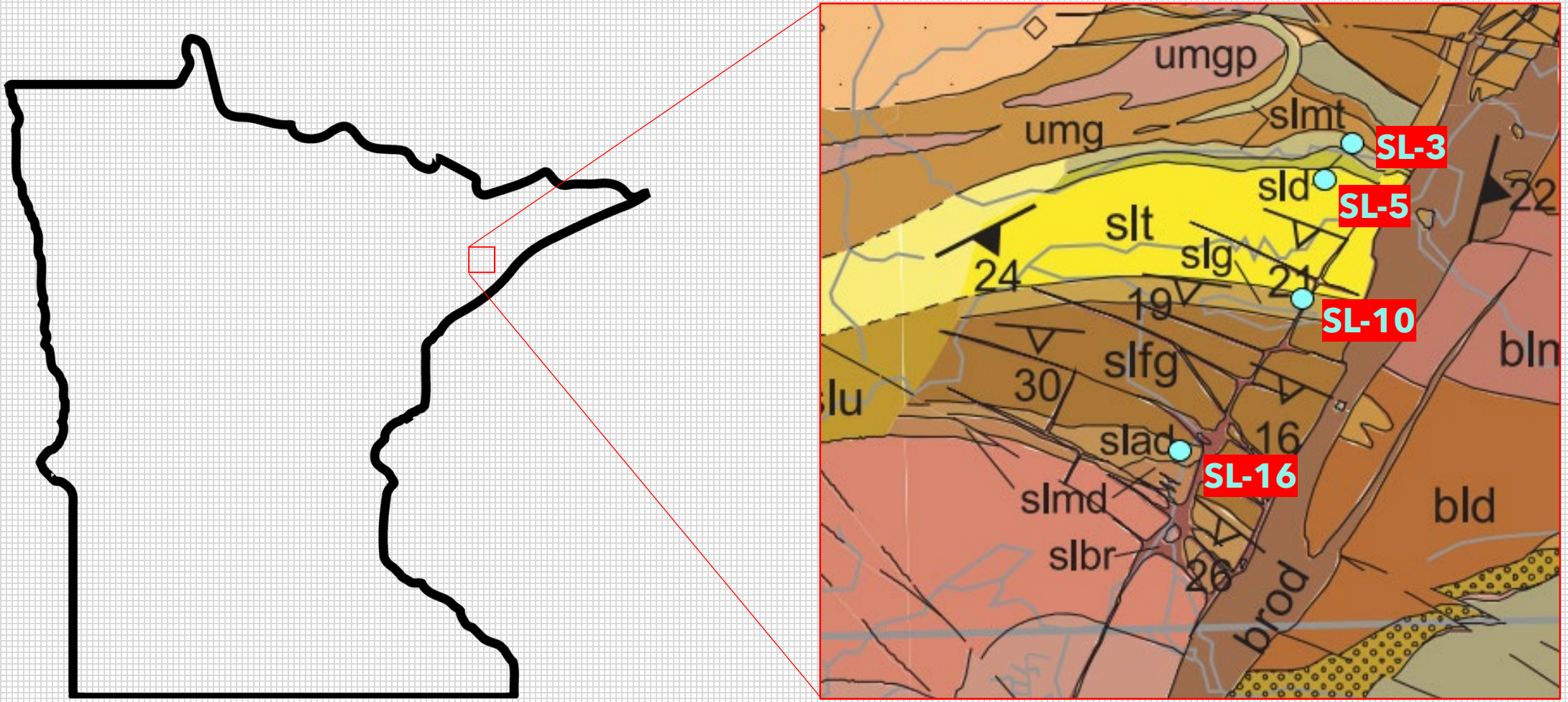
"Systematic variation in the chemical composition of certain minerals with stratigraphic height in a layered sequence " (from LMI slide packet)



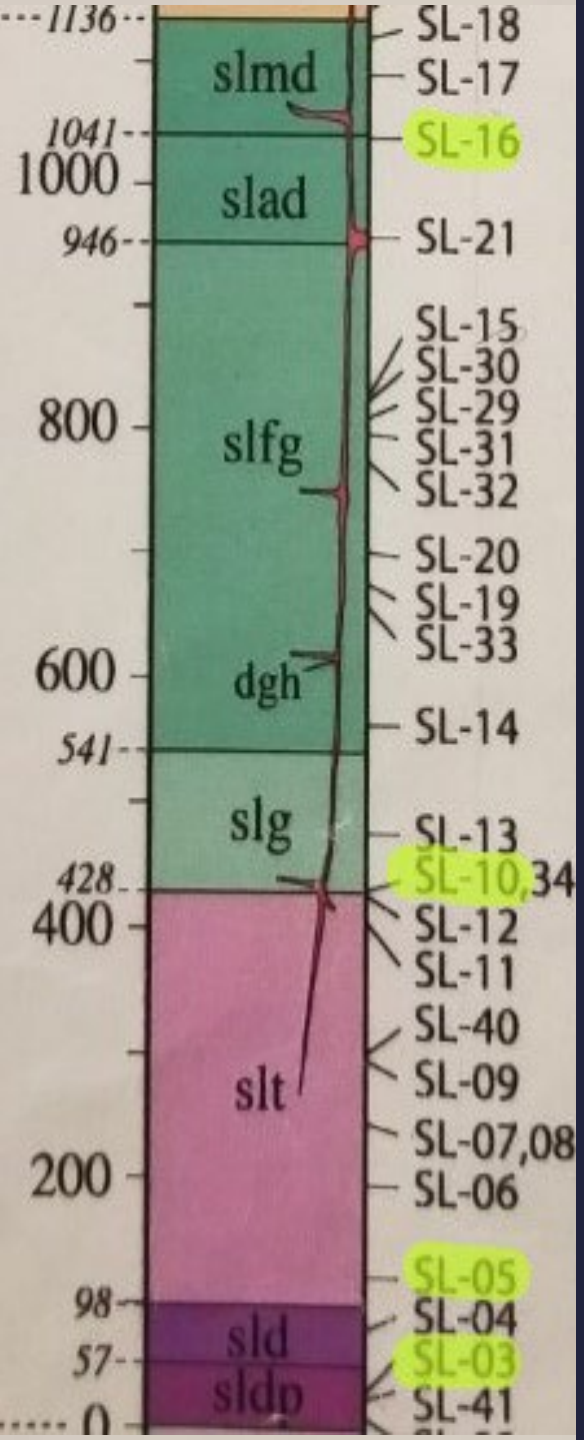
The Project

- How does the mode of each rock change throughout the Sonju Lake Intrusion?
- How does mineral chemistry change?
  - Olivine (Mg/Fe)
  - Plagioclase (Ca/Na)





Where is the Sonju Lake Intrusion?



Preparing the Project

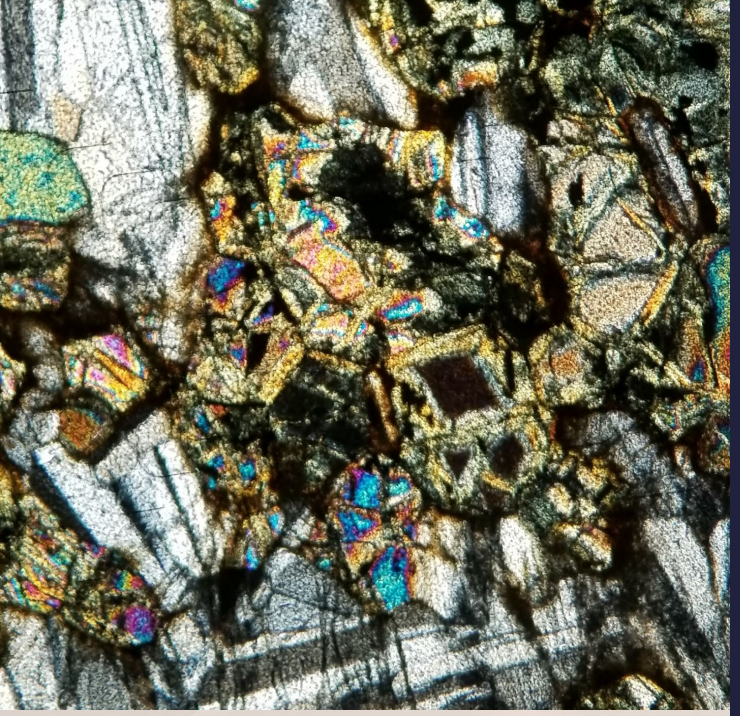
- Sample Selection
  - SL-03
  - SL-05
  - SL-10
  - SL-16
- Project Procedures
  - Transmitted Light Microscopy
  - Scanning Electron Microscopy

Processing samples

Transmitted Light Microscopy

Using the Transmission Microscope

- Standard Petrography
  - Identifying the minerals in our samples
  - Using extinction method to determine plagioclase composition
  - Finding the mode of each sample
  - Finding the microscopic textures



SL-03 · Diabasic Picrite

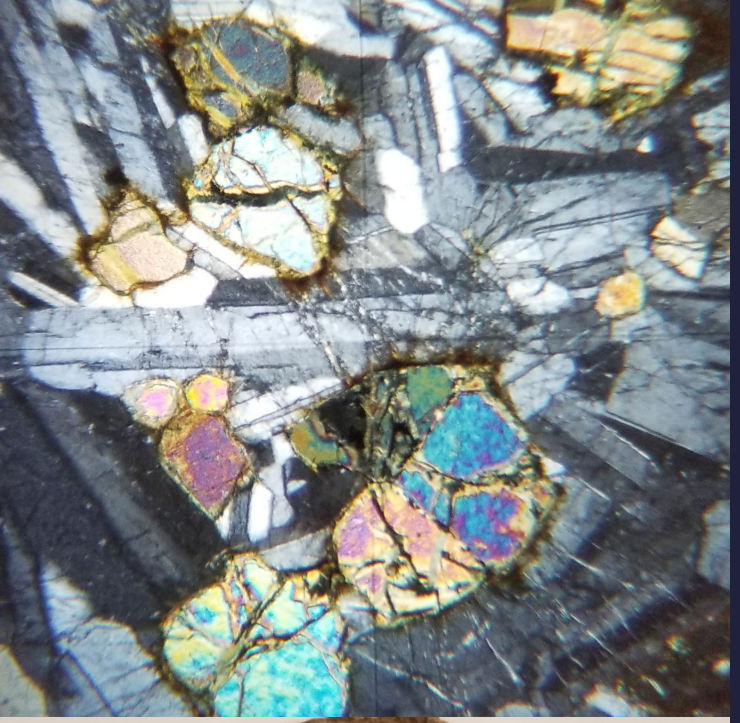
Geologic Context: Located at the base of the Sonju Lake Intrusion within unit “sldp”. This was the first unit to crystallize in Sonju Lake and has a thickness of about 70 meters.

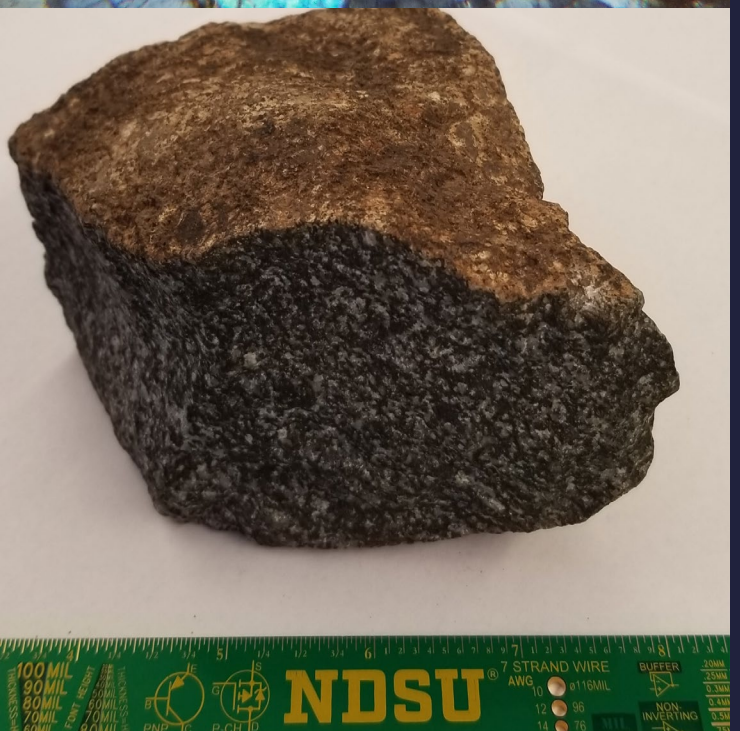
Hand Sample: The SL-03 specimen is medium- to fine- grained and dark gray to dull brown in color. Similar texture to diabase.

Microscopic Texture: Subhedral to euhedral plagioclase with anhedral olivine and ophitic augite crystals.

Notes: Weakly magnetic.

Mineral	Volume %
Olivine	65%
Bytownite	30%
Augite	5%





SL-05 · Troctolite

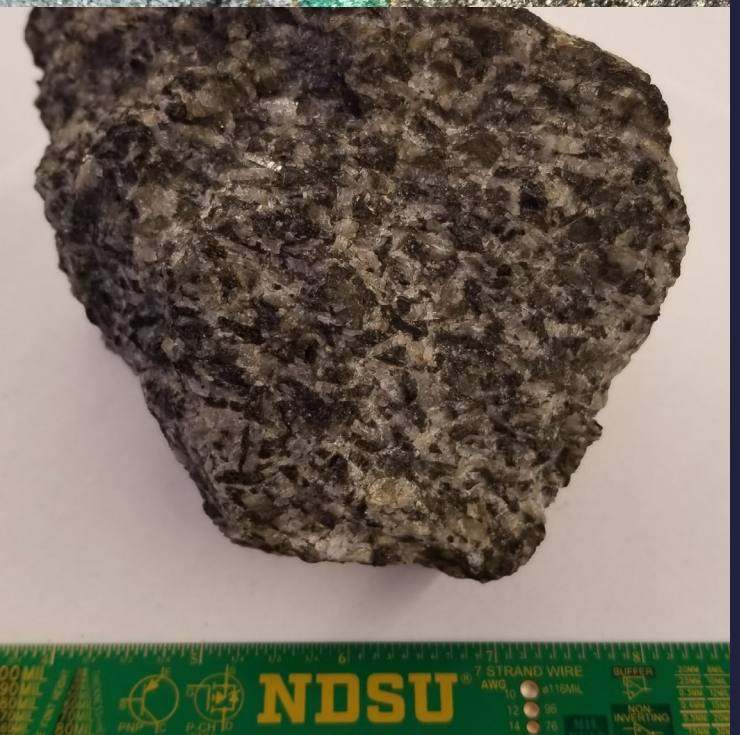
Geologic Context: SL-05 originates from the “slt” unit, the third layer of the Sonju Lake Intrusion. This unit is about 400 meters in thickness.

Hand Sample: The rock contains moderately-laminated, medium-grained crystals with a “salt and pepper” texture. Exposed surfaces are heavily altered to varying shades of brown.

Texture: Subhedral to euhedral plagioclase with subhedral to anhedral olivine and ophitic augite crystals.

Notes: Weakly magnetic.

Mineral	Volume %
Bytownite	65%
Olivine	25%
Augite	9%
Iron Oxides	1%



SL-10 · Gabbro

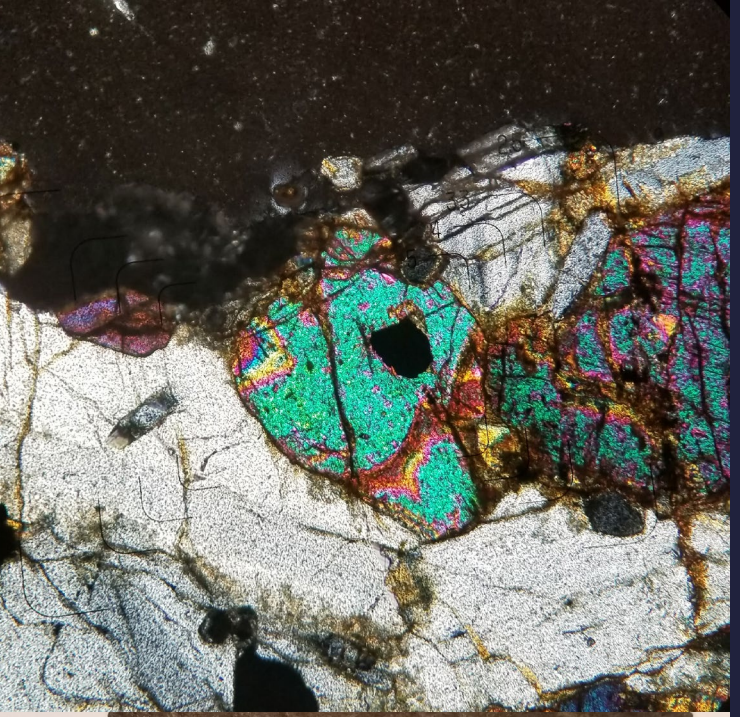
Geologic Context: This sample originates from the “slg” rock unit of the Sonju Lake Intrusion. It is about 70 meters thick and marks the boundary where labradorite becomes more common than bytownite.

Hand Sample: The hand sample is comprised of coarse-grained crystals of various colors, ranging among white, black, brown, and a dull green where weathering has occurred.

Texture: Subhedral to euhedral plagioclase with subhedral to anhedral olivine and inclusion-bearing augite crystals.

Notes: Weak magnetism.

Mineral	Volume %
Bytownite - Labradorite	70%
Olivine	10%
Augite	20%



SL-16 · Apatite Olivine Ferrodiorite

Geologic Context: Sample SL-16 comes from the "slad" unit of the intrusion, a unit near the top of the intrusion sequence that varies in thickness from about 80 to 130 meters.

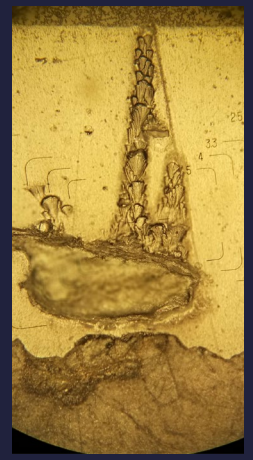
Hand Sample: Sample is medium-grained with poor to moderate laminations. Colors are mostly dark brown but vary to light brown and tan in some spots. Occasional flecks of lustrous minerals are present.

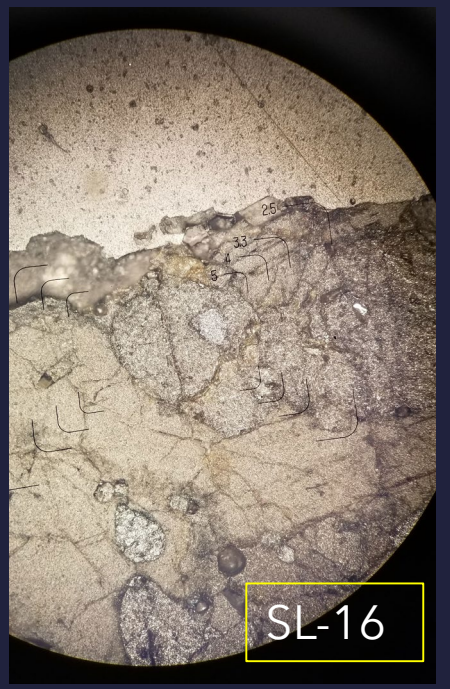
Texture: Heavily-altered, subhedral to anhedral augite and plagioclase crystals

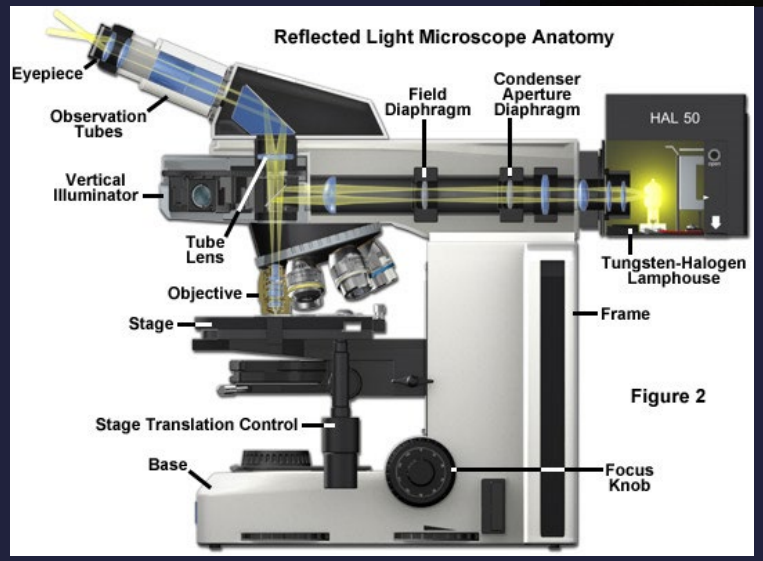
Notes: Magnetic.

Mineral	Volume %
Labradorite	50%
Augite	25%
Olivine	12%
Ilmenite/Other Oxides	10%
Apatite	3%

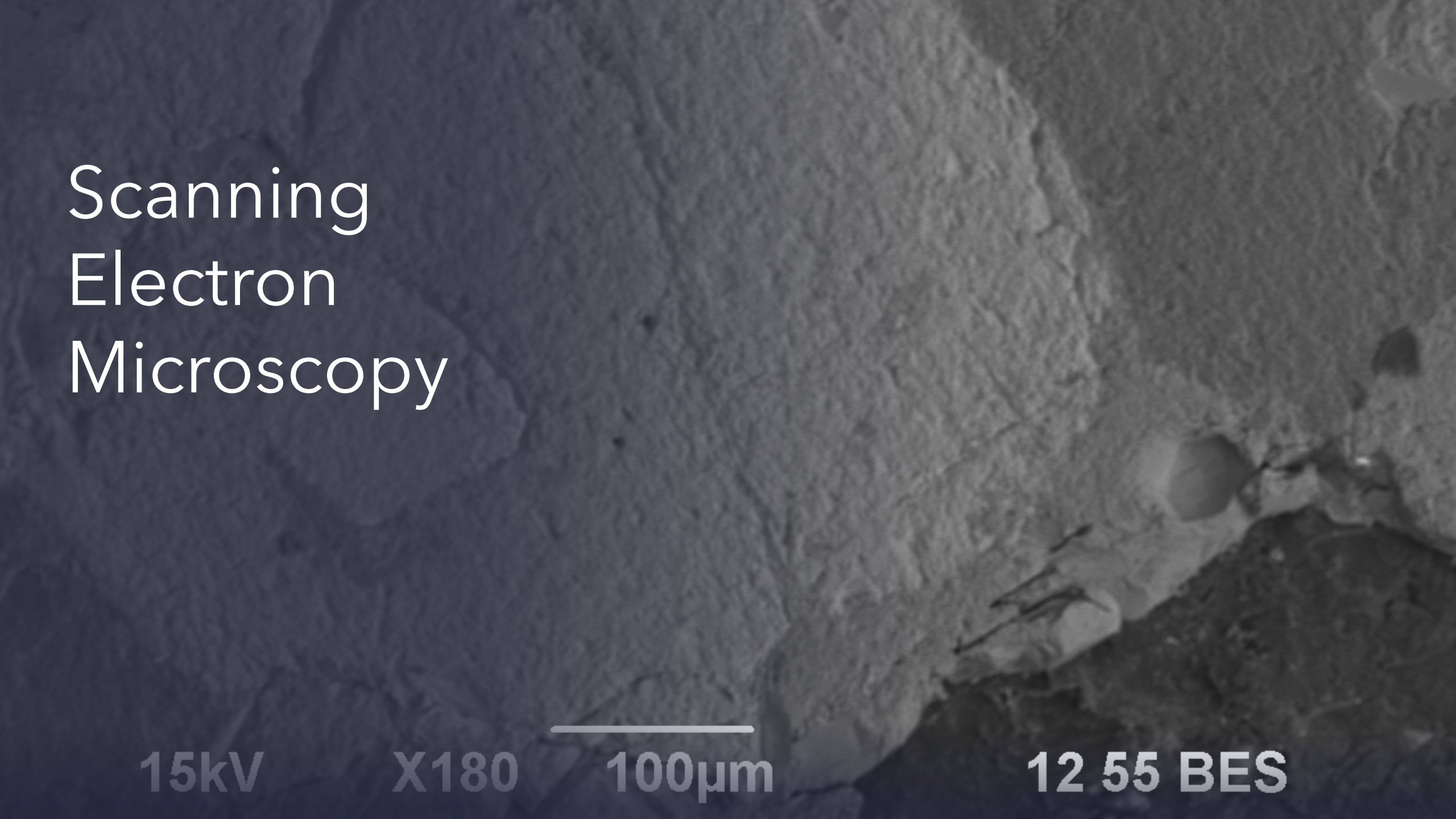
Reflective light microscope





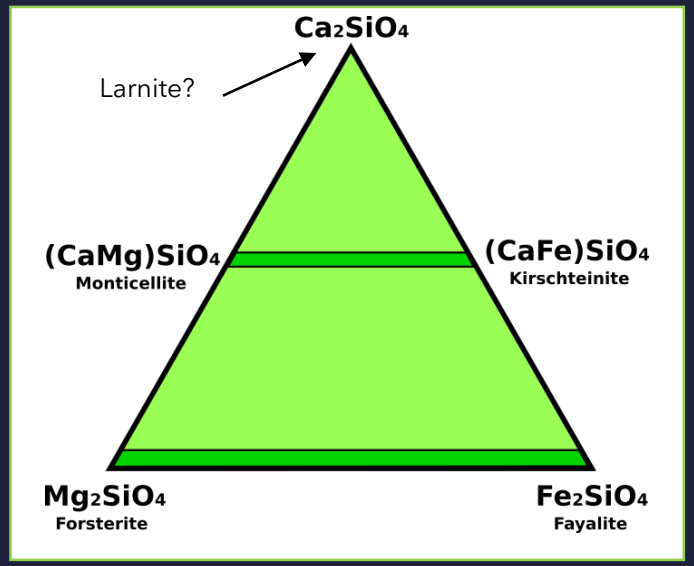


Scanning Electron Microscopy

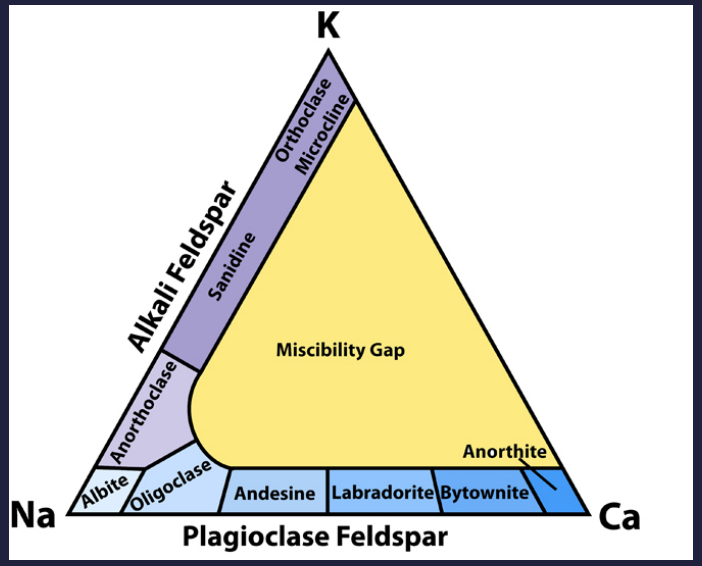


The Goal/Purpose of Using SEM

- Chemical Petrography
- Allows us to select and analyze individual grains
- helps when you are working with cryptic layering
- Chemical analysis of olivine and plagioclase

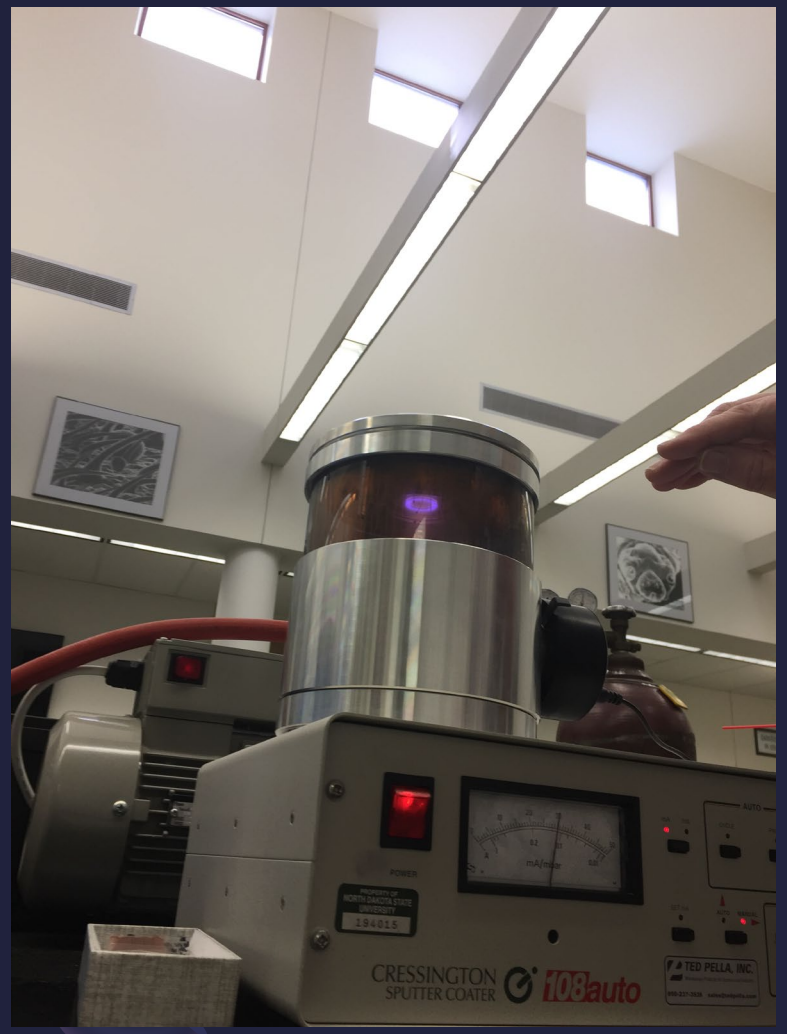


Ternary system for olivine minerals (https://www.alexstrekeisen.it/english/vulc/olivine.php)



Ternary system for Feldspar mineral (https://www.alexstrekeisen.it/english/vulc/plagioclase.php)

Our day at the SEM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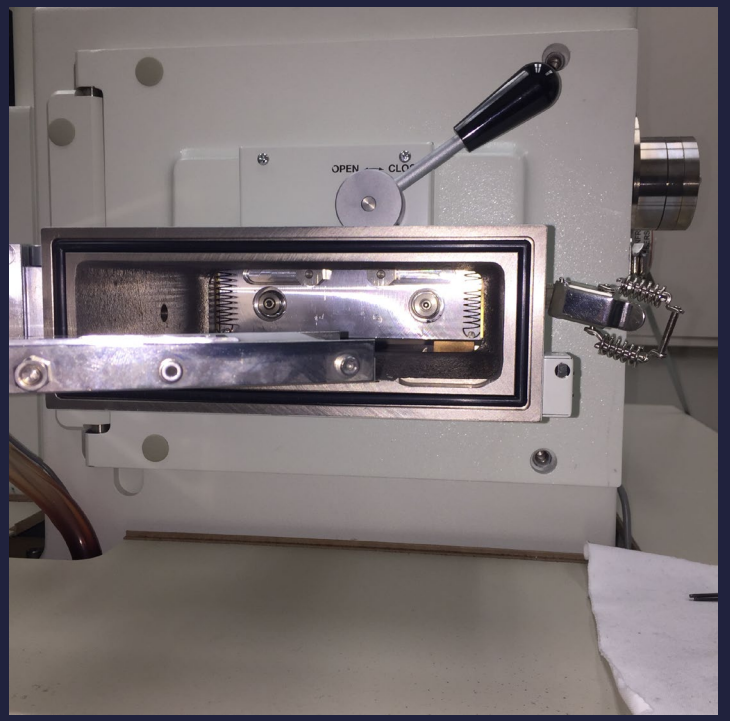
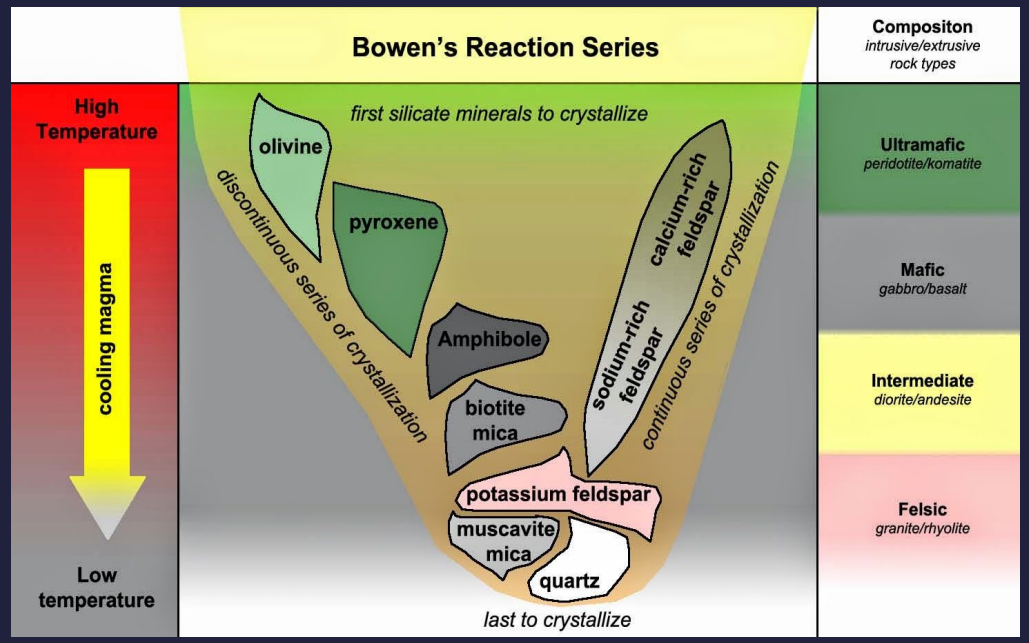


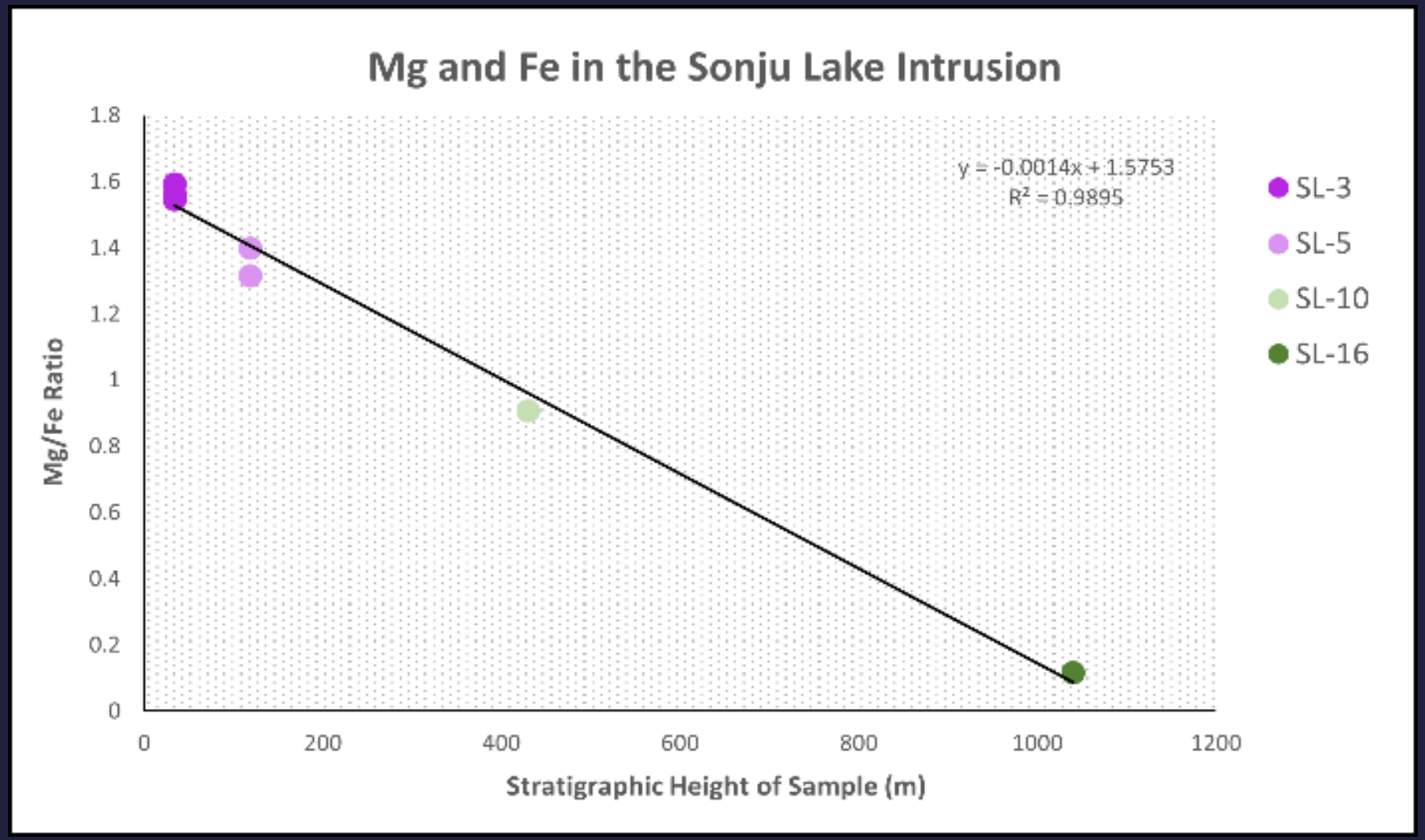
SEM DATA

Table 2. Summary of sample chemical data.

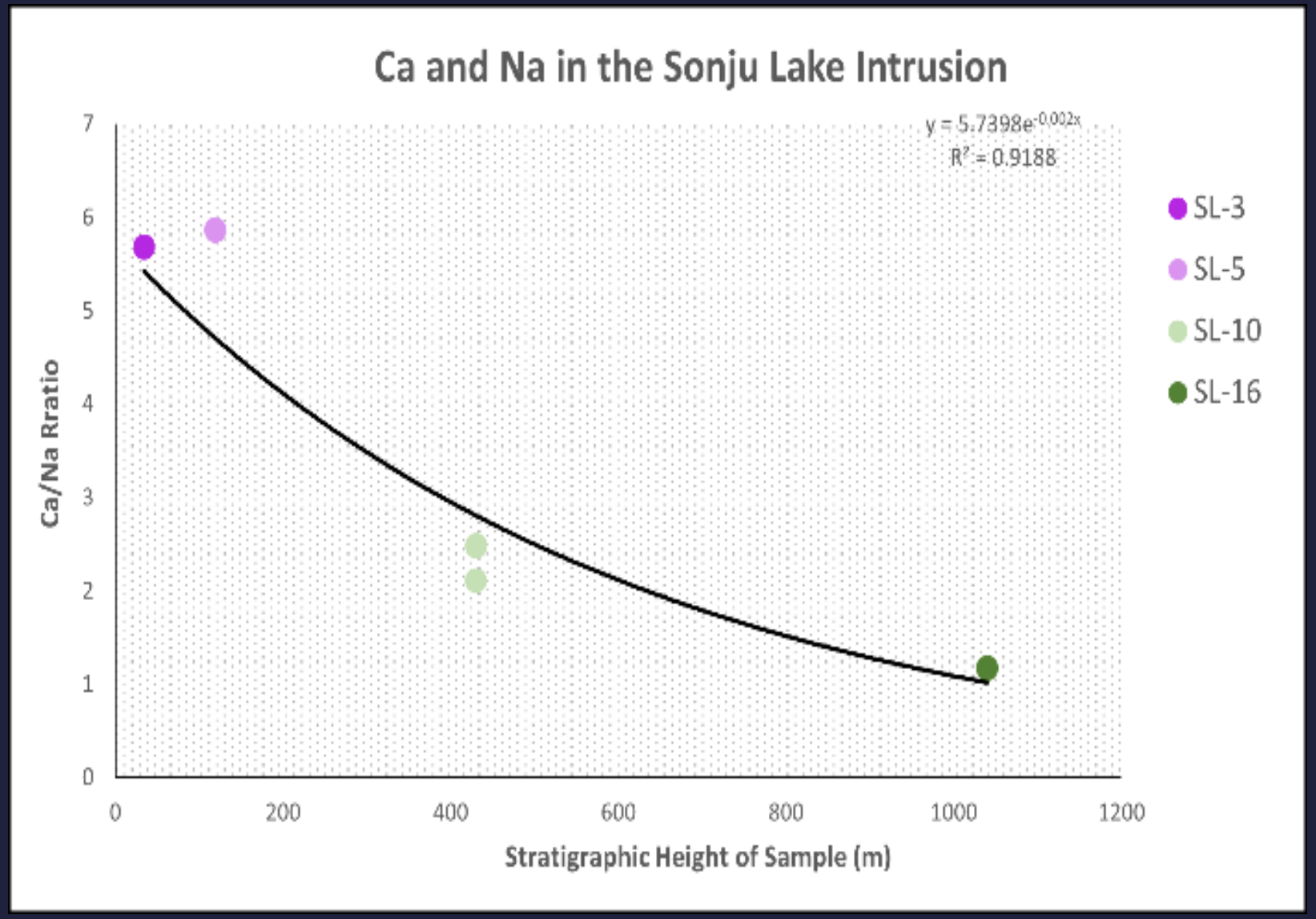
SL-03		SL-05		SL-10		SL-16	
Mineral	Comp.	Mineral	Comp.	Mineral	Comp.	Mineral	Comp.
Olivine	Fo_{61}	Olivine	Fo_{58}	Olivine	Fo_{45}	Olivine	Fo_{11}
Plagioclase	An_{85}	Plagioclase	An_{85}	Plagioclase	An_{70}	Plagioclase	An_{54}



SEM DATA

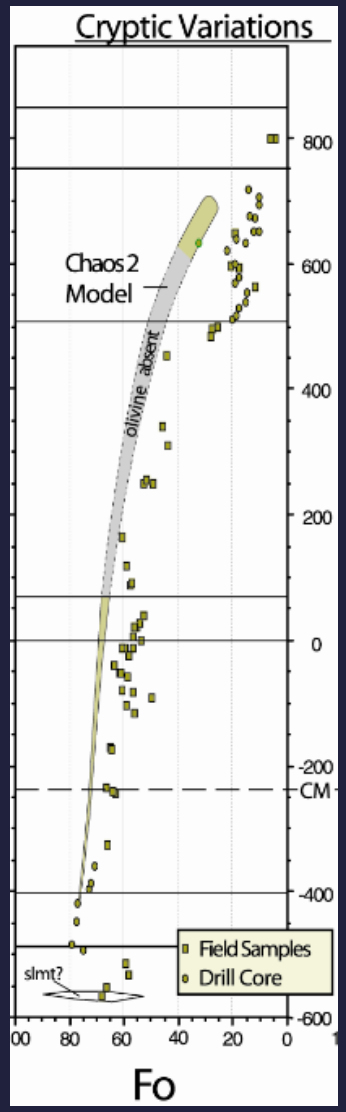

Mg and Fe in the Sonju Lake Intrusion
y = -0.0014x + 1.5753
R² = 0.9895
Mg/Fe Ratio
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
Stratigraphic Height of Sample (m)
SL-3
SL-5
SL-10
SL-16

SEM DATA


Ca and Na in the Sonju Lake Intrusion
y = 5.7398e-0.002x
R² = 0.9188
SL-3
SL-5
SL-10
SL-16
Ca/Na Rratio
Stratigraphic Height of Sample (m)
0
1
2
3
4
5
6
7
0
200
400
600
800
1000
1200

Comparison to miller chaos model

Model shows olivine absent where we have detected olivine in SL-10



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