

Geochemical Evolution of Pegmatites as Monitored by Select Indicator Elements*

Kristen F. Camp¹

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¹Earth and Environmental Sciences, University of New Orleans, Slidell, LA (kfcamp@uno.edu)

Abstract

Pegmatites are extremely coarse-grained igneous rocks characterized by textures in which the crystals are predominantly three centimeters or more in length. They possess a unique petrogenesis, petrology and mineralogy making these rock bodies fascinating to study and economically important to our society. They are the primary source of some rare-elements and provide the world's largest, most valuable gems. Single pockets within a pegmatite have yielded several million dollars' worth of gem rough. The factors that allow these rock bodies to grow gigantic crystals and comprise exotic-elements are a combination of a low nucleation rate, high water pressure, high diffusivity, high concentration of volatiles, and a low geothermal gradient.

This study explores how pegmatite minor and trace element geochemistry correlates with the degree of pegmatite evolution. Whole rock, wall zone samples of pegmatites from 17 different locations in southern Maine were analyzed using an ARL-SEMQ Electron Microprobe and a Direct-Coupled Plasma Spectrophotometer.

Results show that rubidium, manganese and cesium correlate positively with pegmatites that contain highly evolved mineral assemblages such as spodumene, lepidolite, spessartite, manganese and tantalum enriched columbite group minerals, pollucite and elbaite tourmaline. Magnesium, iron and potassium negatively correlate with highly evolved pegmatites.

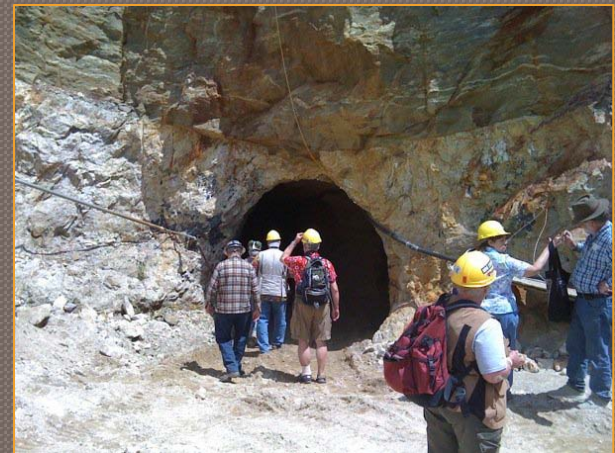
In conclusion, the more evolved pegmatites in the study area with significant concentrations of rubidium, manganese and cesium are Mount Mica, Mount Marie, Black Mountain Quarry, Bennett Quarry, and the Orchard Quarry. The more primitive pegmatites with high concentrations of magnesium, iron and potassium are the Granitic Roadcut, Songo Pond, Mount Marie, the La Flame Outcrop, and Consolidated Quarry.

GEOCHEMICAL EVOLUTION OF PEGMATITES AS MONITORED BY SELECT INDICATOR ELEMENTS



Kristen Camp

Earth and Environmental Sciences
University of New Orleans
MP² Research Group
kfcamp@uno.edu



What constitutes a pegmatite



- Intrusive, commonly granite, rock
- Greatest range of grain sizes
- Enormous crystals of the finest quality
- Rare, exotic minerals
 - With exceptional concentrations of rare, exotic elements

How pegmatites form

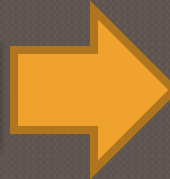
Low nucleation rate

High rates of diffusion

High water pressure

High concentration of fluxes

Rapid rates of crystallization



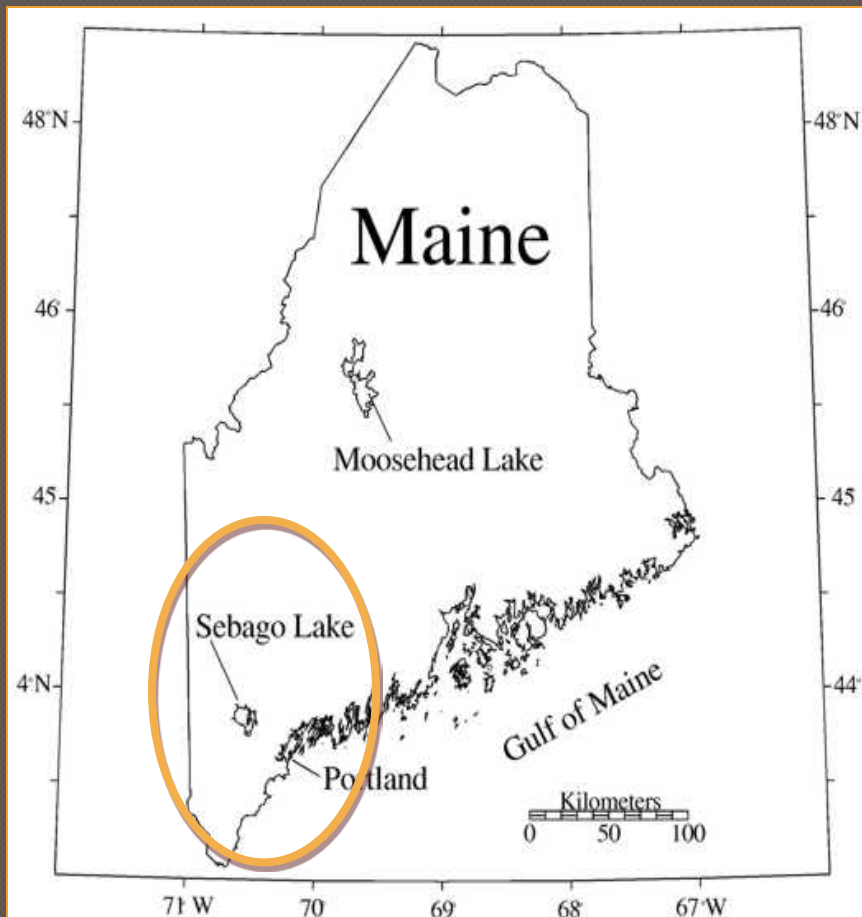
Formation of gigantic
crystals with exotic-
element enrichment
in a relatively short
period of time



Purpose

- Explore how minor element and trace element geochemistry correlate with the degree of pegmatite evolution
- Using whole rock, wall zone samples from several pegmatites associated with the Sebago batholith, southern Maine

Study area



○ Pegmatites Sampled:

- Bennett quarry
- Black Mountain quarry
- Brooker quarry
- Consolidated quarry
- Emmons quarry
- Granitic road cut
- La Flame outcrop
- Mount Marie
- Mount Mica
- Orchard quarry
- Songo Pond
- Tallus at hill
- Tyron Mount quarry

Bennett Quarry



Emmons Quarry



Mount Marie



005

Orchard Quarry



ORCHARD

Mount Mica



Minerals used for analysis





Feldspar



Mica



Tourmaline



Garnet



Beryl



Apatite



Zircon



Columbite group
minerals



ARL-SEM Electron Microprobe
for minor element analysis



Direct-Coupled Plasma
Spectrophotometer for trace
element analysis

Elements analyzed

Aluminum

Boron

Calcium

Cesium

Fluorine

Iron

Gallium

Potassium

Lithium

Magnesium

Manganese

Sodium

Rubidium

Titanium

Thallium

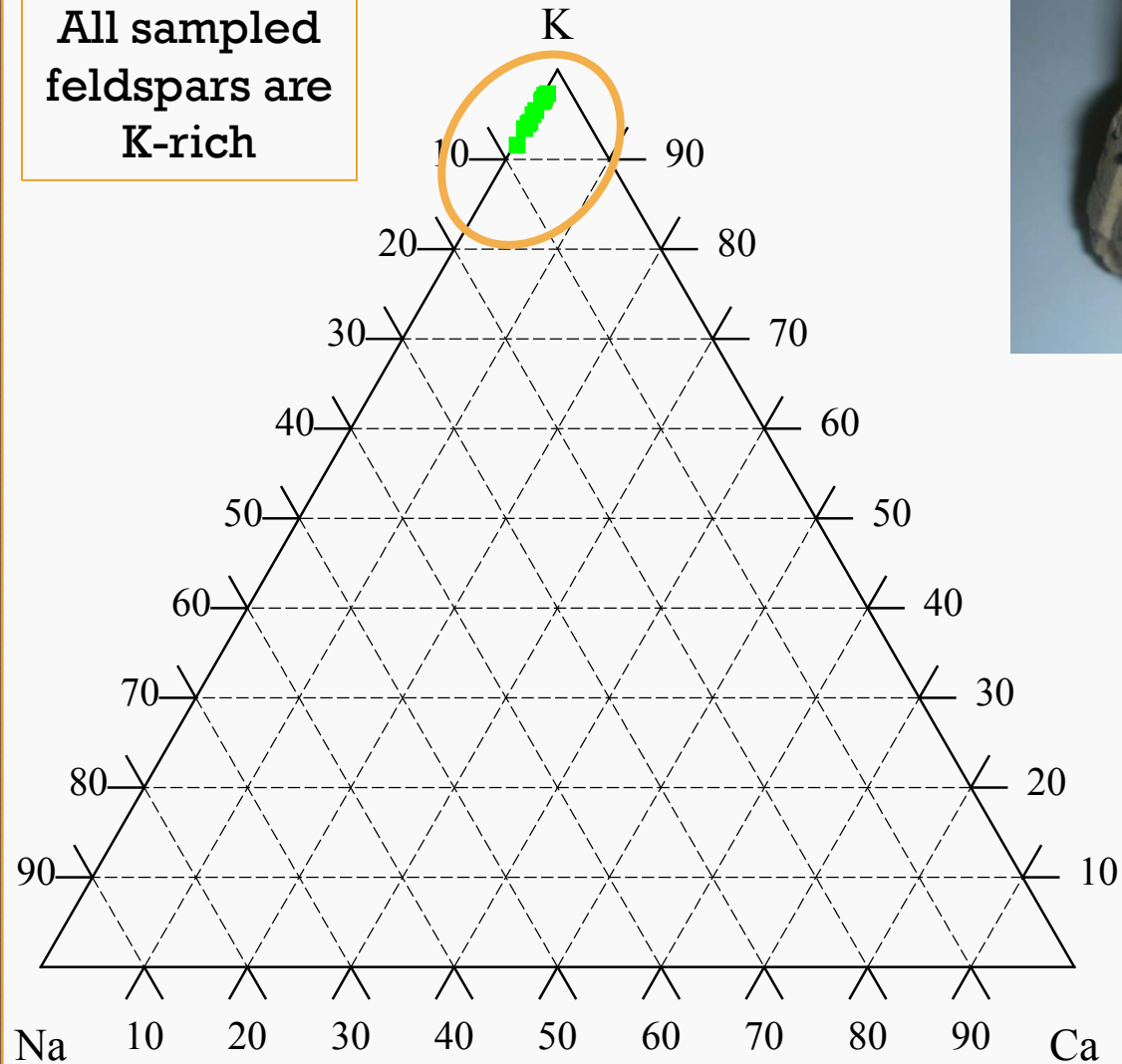
Concentrations of these elements were then used to construct graphic comparisons which help determine the degree of the pegmatites evolution

Interpretations

- **Cs, Mn, Rb** → positively correlate with highly evolved mineral assemblages
 - i.e. spodumene, lepidolite, spessartine, manganese and tantalum enriched columbite group minerals, pollucite and elbaite tourmaline
- **Fe, K, Mg** → positively correlate with more primitive mineral assemblages
- Concentrations plotted in APFUs

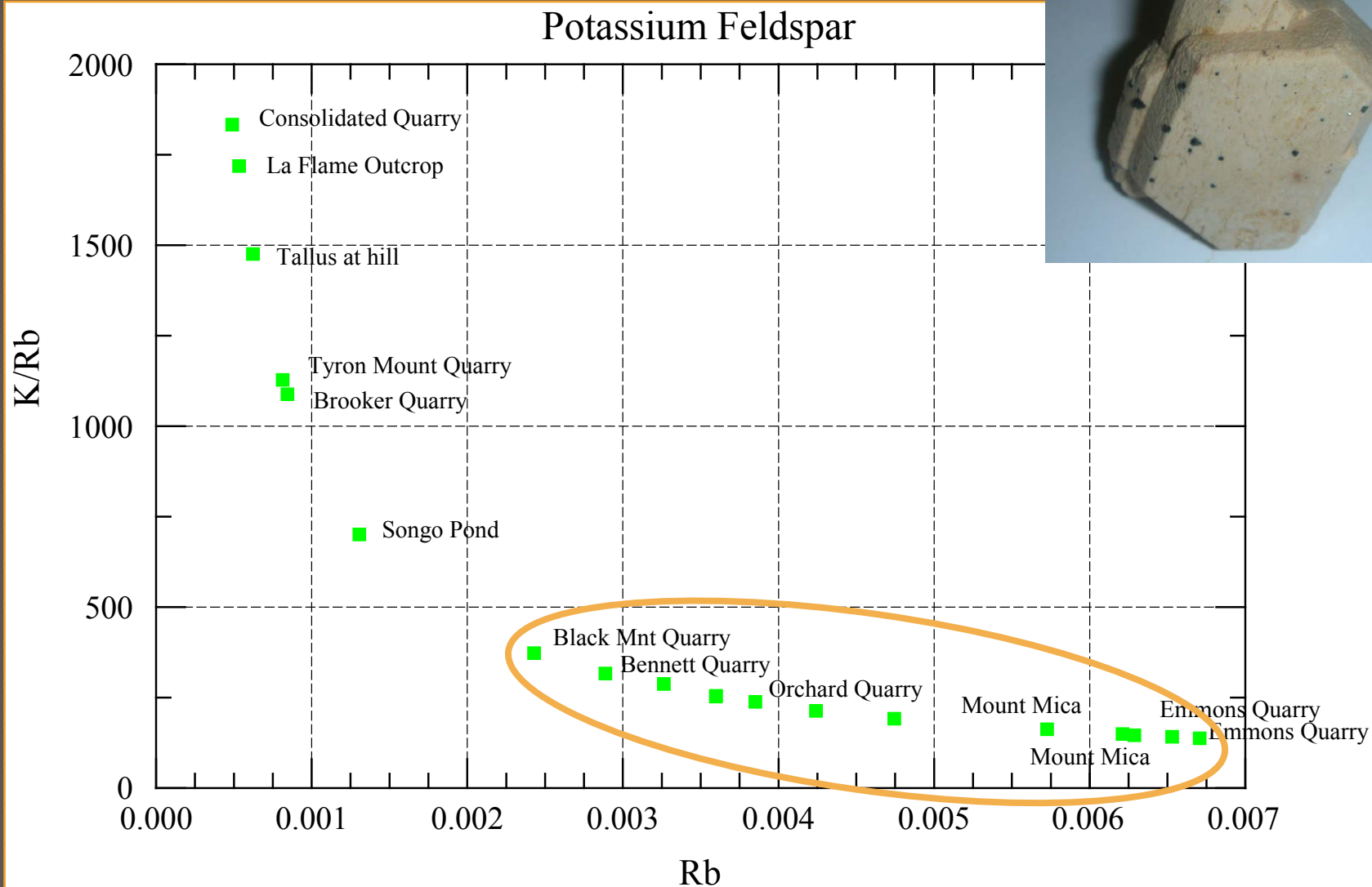
Potassium Feldspar

All sampled
feldspars are
K-rich



Ternary diagram showing the end-member composition for potassium feldspars from the pegmatites.

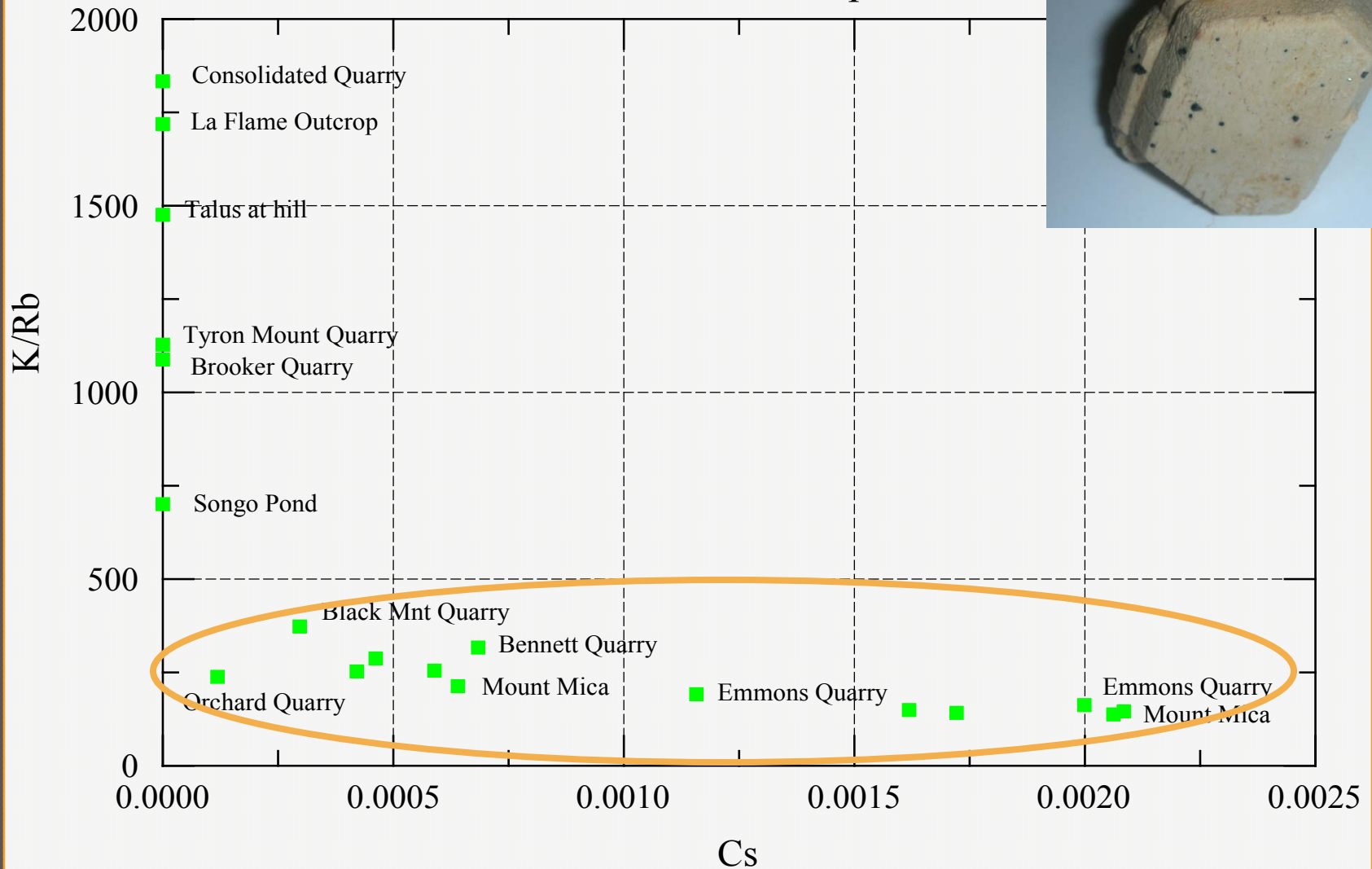
High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved



Plot of K/Rb vs Rb in potassium feldspar

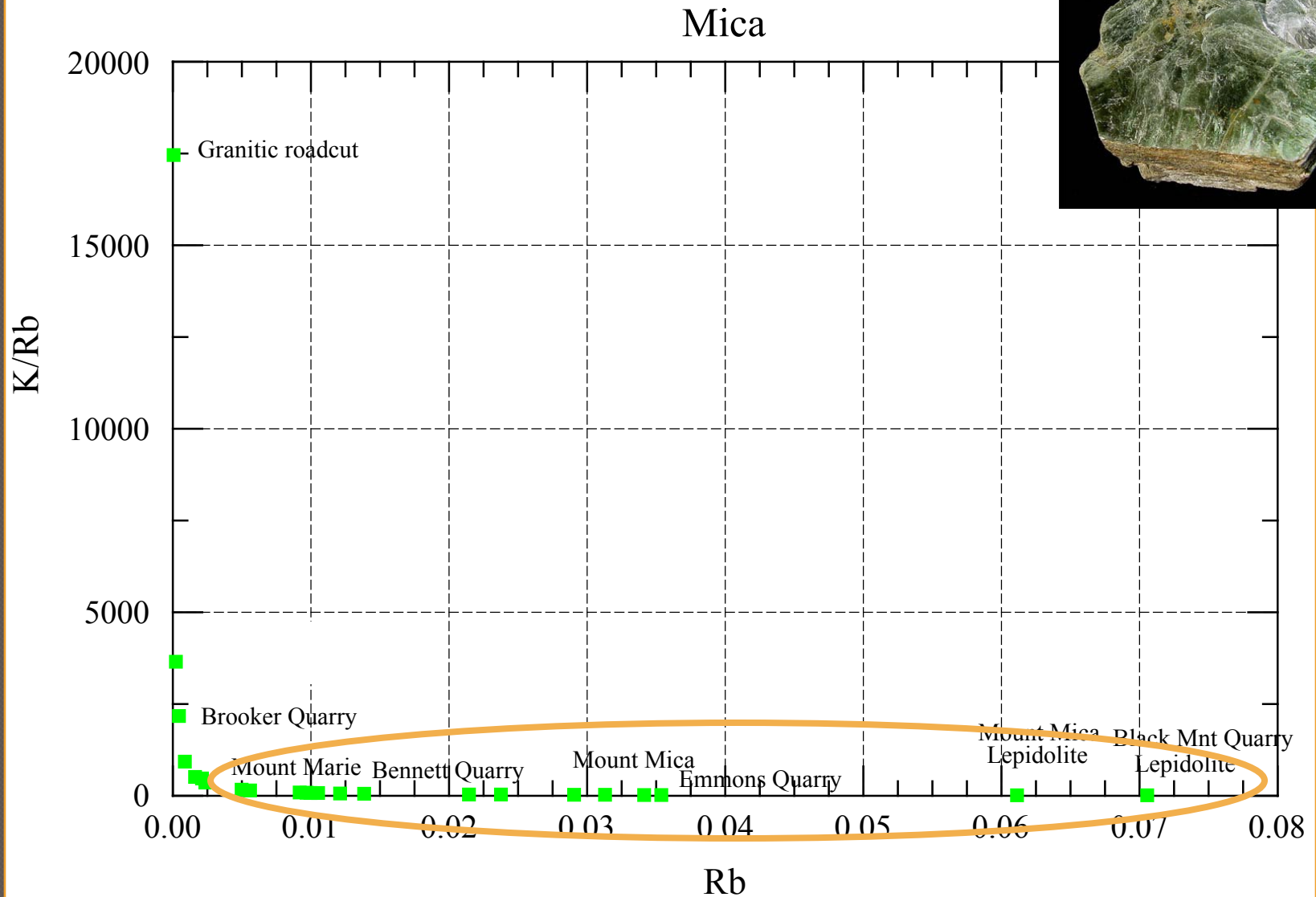
High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved

Potassium Feldspar



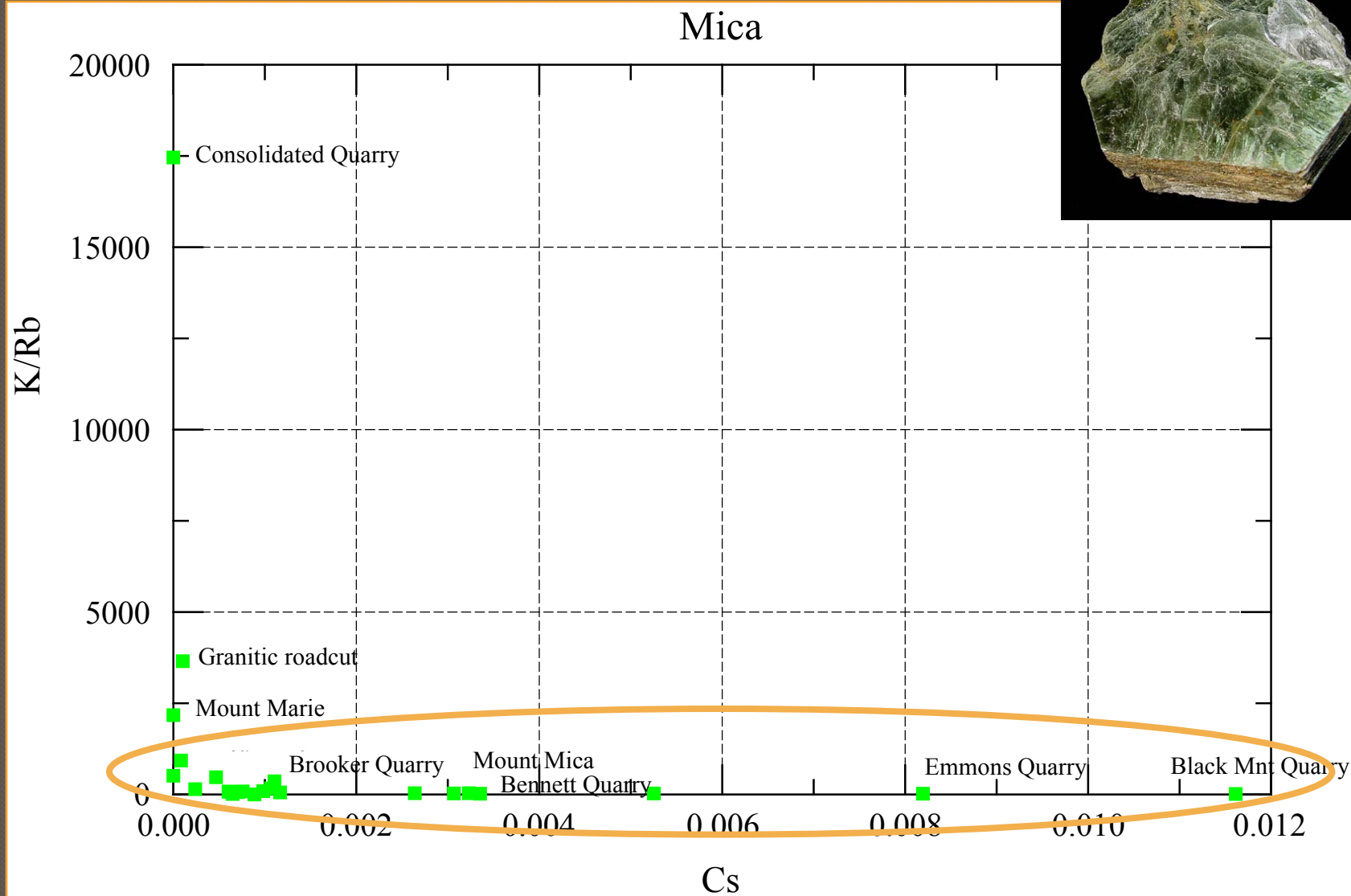
Plot of K/Rb vs Cs in potassium feldspar

High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved



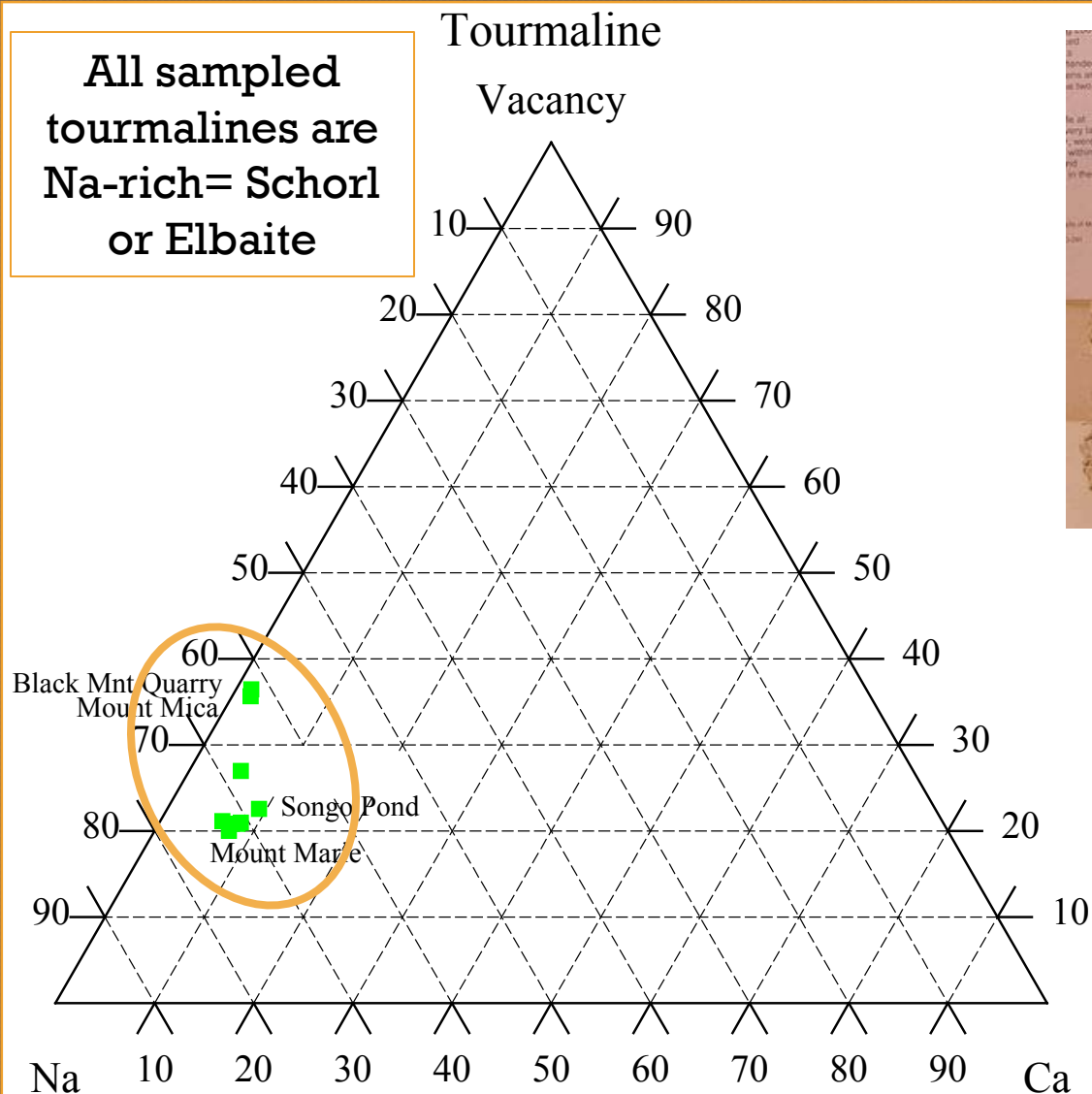
Plot of K/Rb vs Rb in mica

High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved



Plot of K/Rb vs Cs in mica

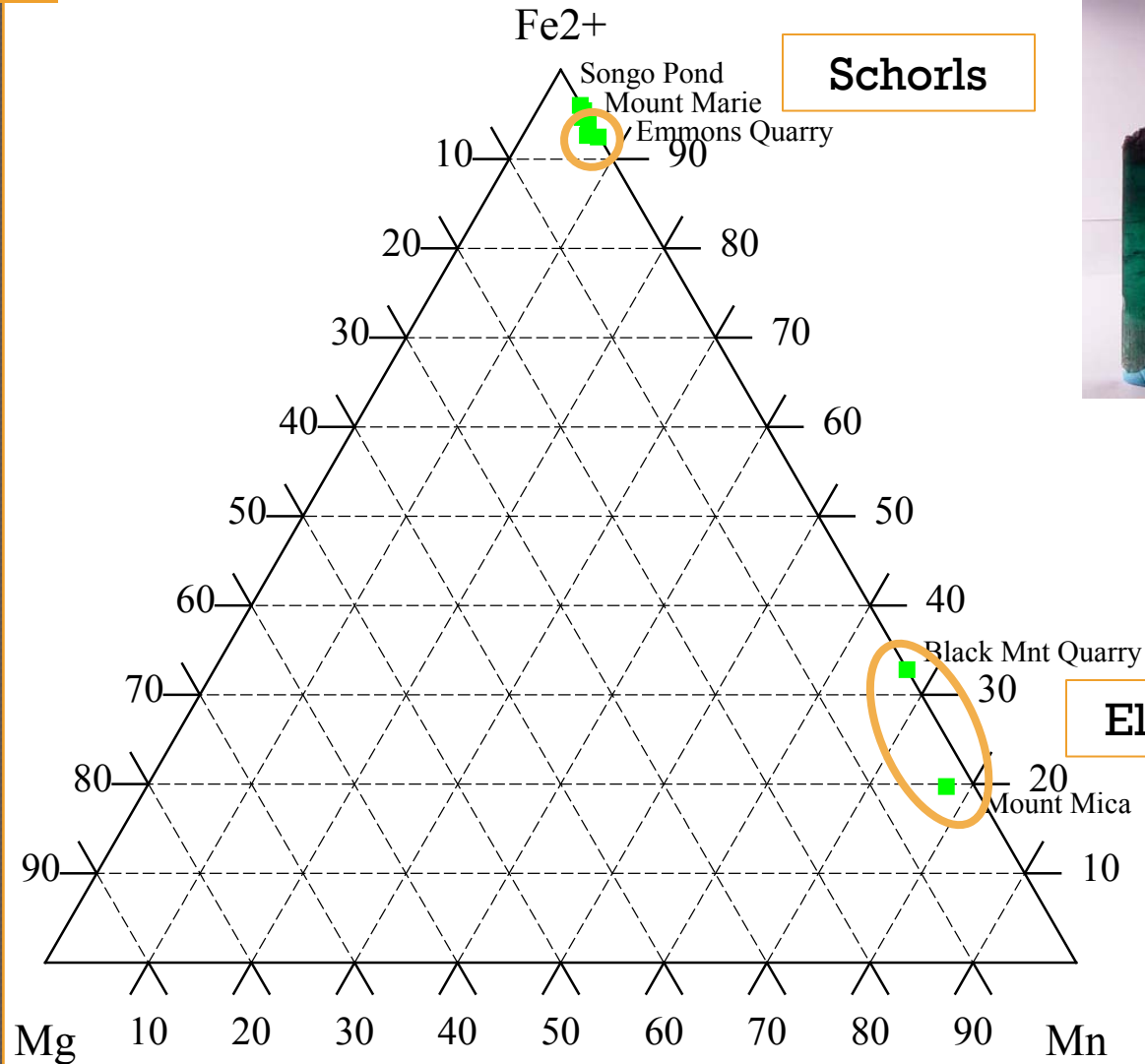
All sampled
tourmalines are
Na-rich= Schorl
or Elbaite



Vacancy, Na, Ca Ternary at the X-site of tourmaline.

High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved

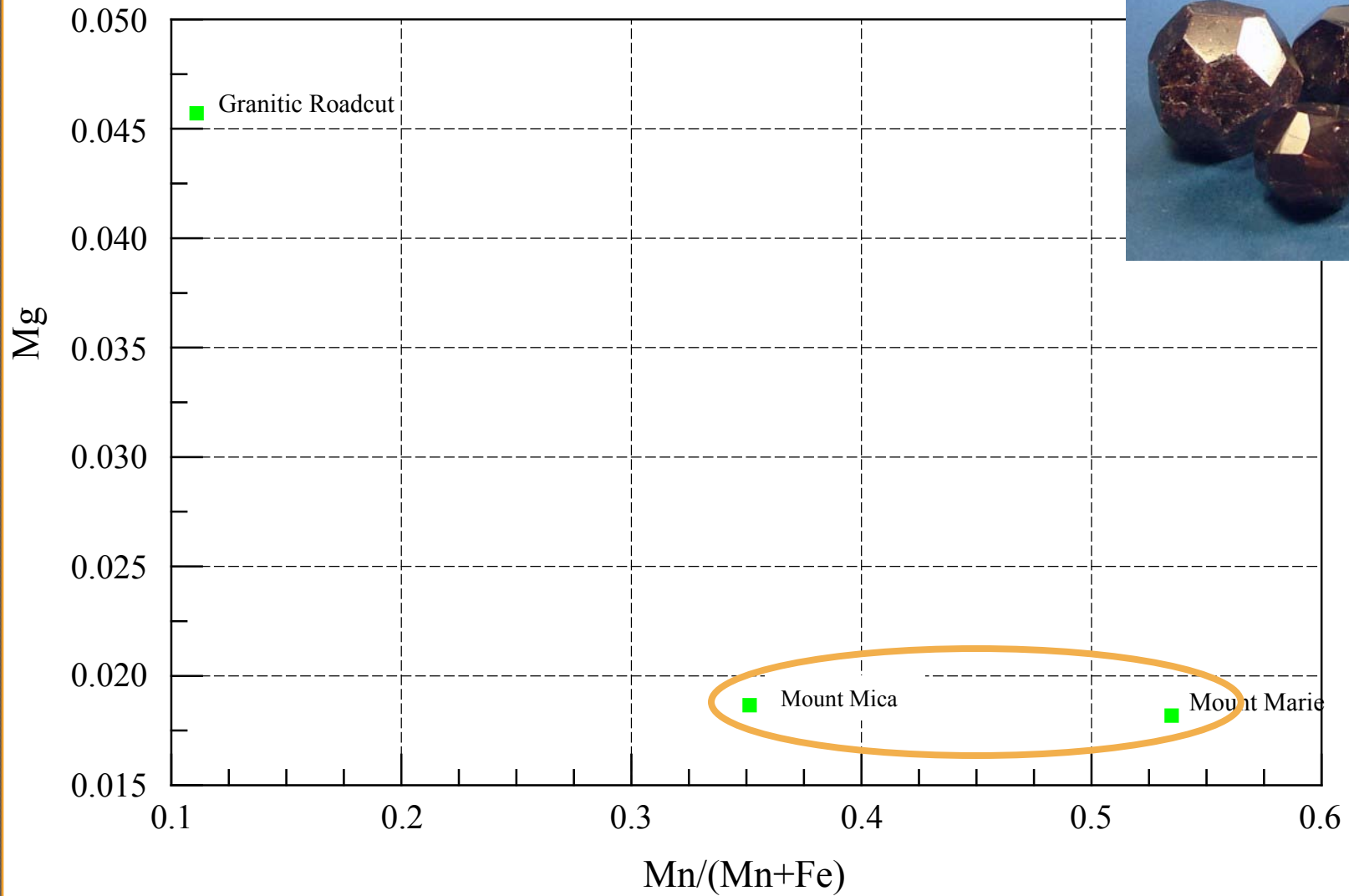
Tourmaline



Ternary diagram showing the end-member composition for tourmalines from the pegmatites.

High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved

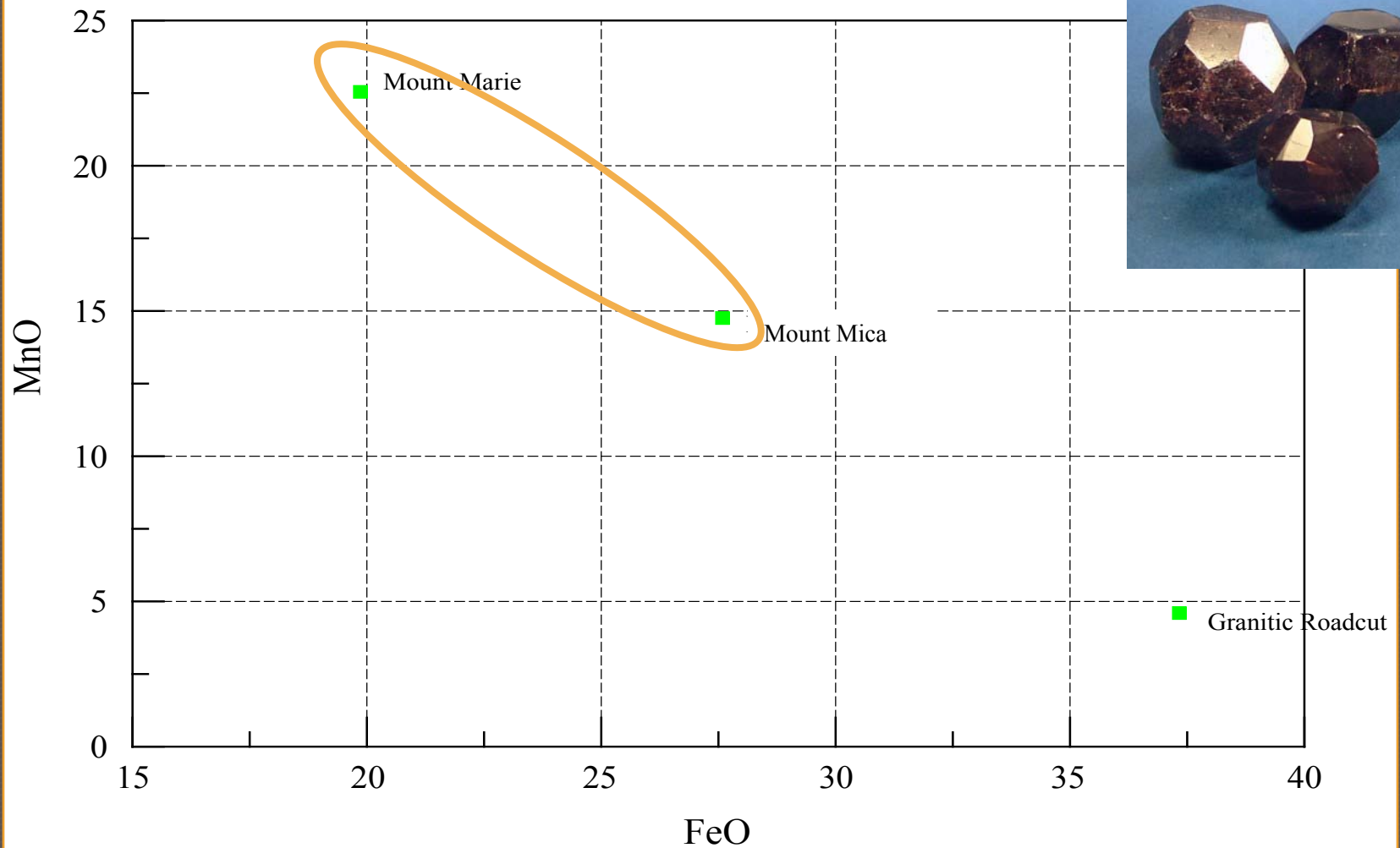
Garnet



Plot of Mg vs Mn/(Mn+Fe) in garnet.

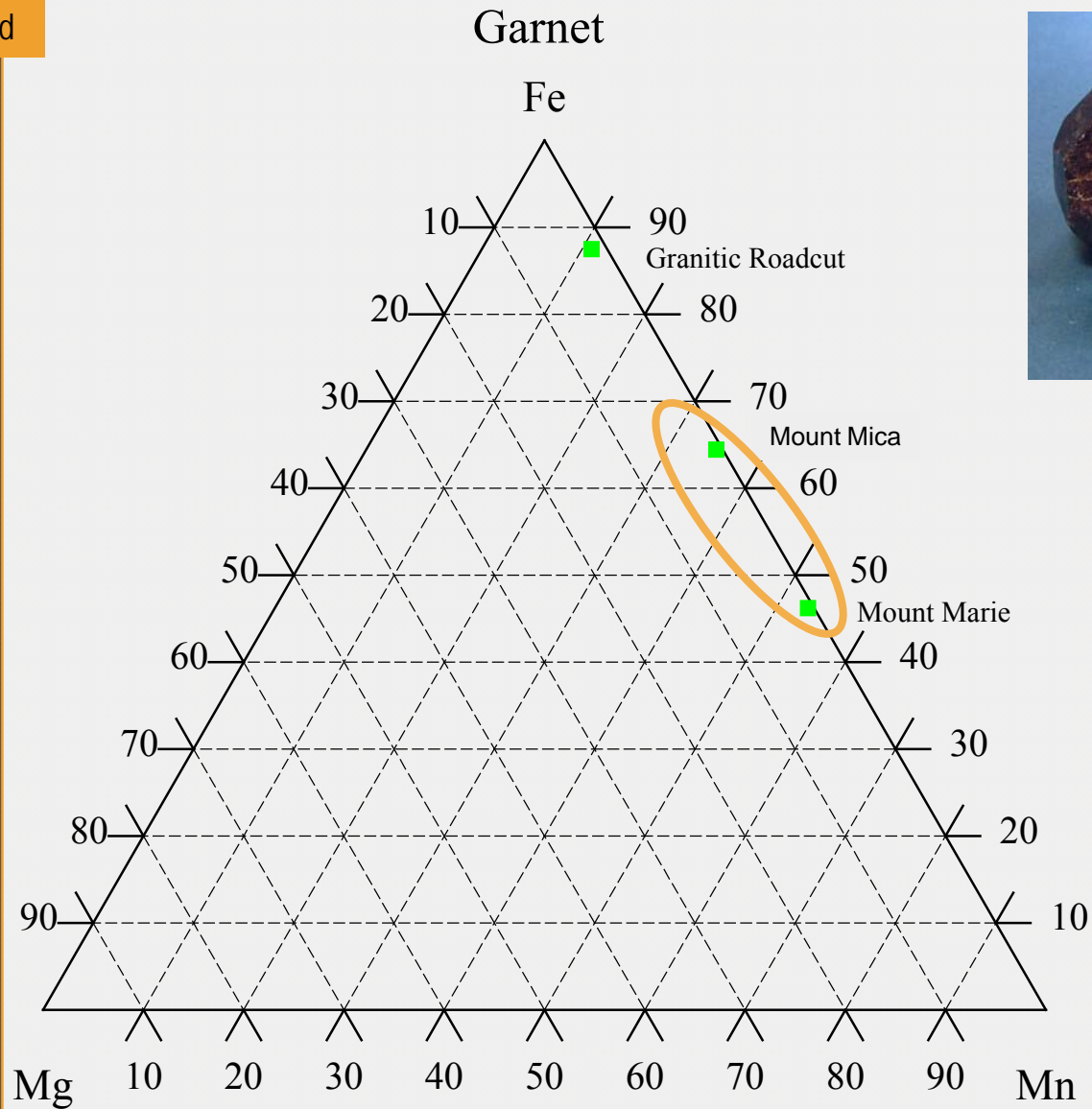
High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved

Garnet



Weight percent MnO vs weight percent FeO
for garnet compositions in pegmatite locations.

High Fe, K, Mg = primitive
High Cs, Mn, Rb = evolved



Ternary diagram showing the end-member composition for garnets from the pegmatites.

Conclusions

More evolved
pegmatites with
significant
concentrations of
Cs, Mn, Rb :

- Emmons quarry
- Mount Mica
- Mount Marie
- Black Mountain Quarry
- Bennett Quarry
- Orchard Quarry

More primitive
pegmatites with
significant
concentrations of
Fe, K, Mg :

- Granitic Road cut
- Songo Pond
- La Flame Outcrop
- Tallus at hill
- Brooker Quarry
- Tyron Mount Quarry
- Consolidated Quarry

Importance



- The more evolved the pegmatites → the more valuable and rare its mineralogical constituents
 - Pegmatites are primarily mined for gem-stock
- Its minerals contain commercially used elements that are primarily to exclusively found in pegmatites
 - i.e. Be, Cs, Li, Rb, Ta



Used as a moderator
in nuclear reactors



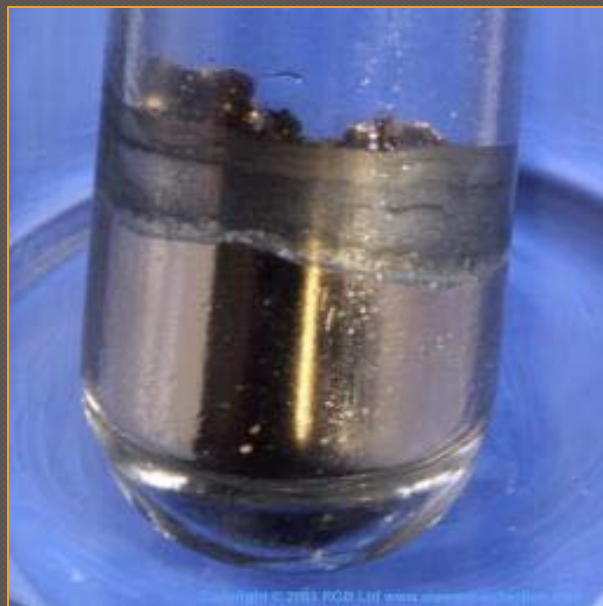
Beryllium



Beryllium foil used in
X-ray lithography



Computer parts



Cesium



Atomic Clocks



Drilling fluid for the oil industry



Lithium



Lithium batteries



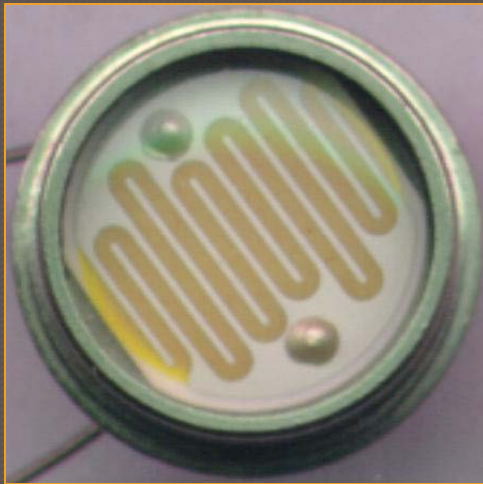
Treat bipolar disorder



Glass and ceramics



Rubidium



Photocells used in motion detectors



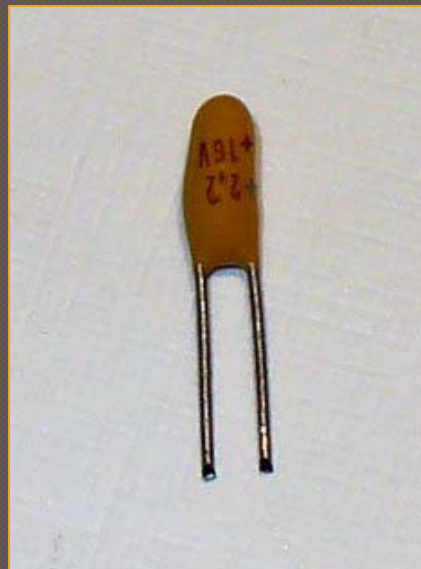
Computed Tomography equipment



Tantalum



Surgical instruments



Electrolytic capacitors used in electronics
such as cell phones, lap tops, automobiles



Camera lenses



WOW-
Pegmatites
are the best
rock ever!

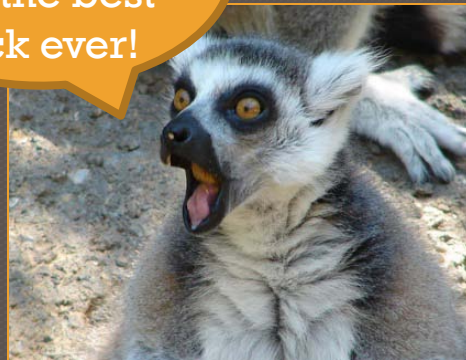


Photo: Sarah Sudcowsky