# Characterization of granite collected from SE Washington

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# Background

- What is a granite?
  - Commonly occurring intrusive, felsic, igneous rock
  - Must contain at least 20% quartz by volume

# Background

- How are granites formed?
  - Origin is not universally agreed upon
    - However, it must intrude other rocks
  - Classification schemes have been introduced in an attempt to explain the different ways and environments in which granites can form

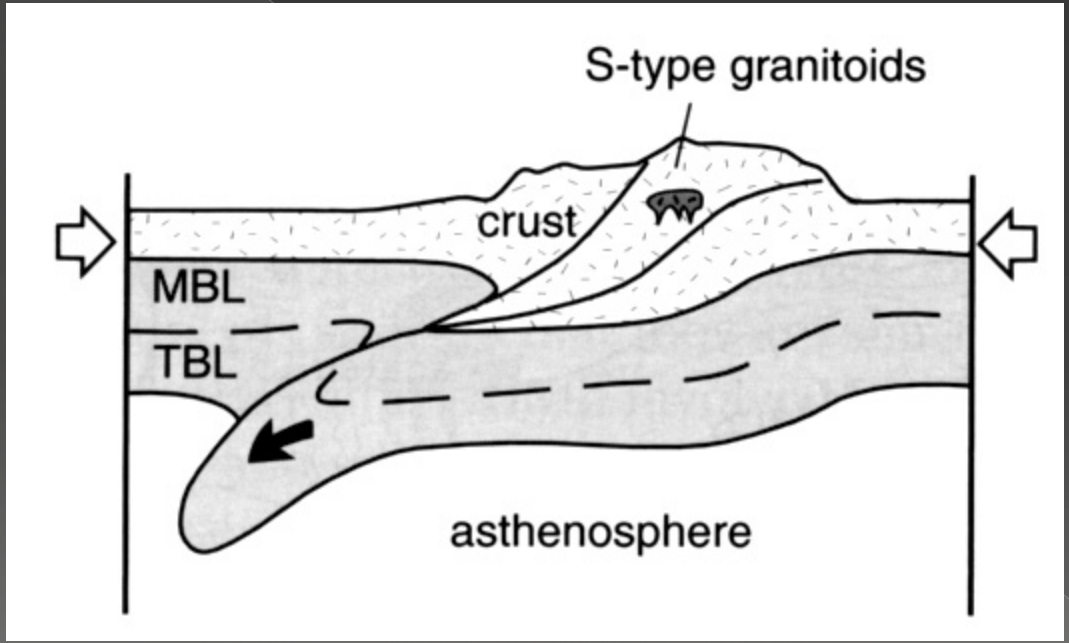
# Background

- Initially granites were divided into two groups in 1974 (Chappell & White, 2001)
  - S-type granites
  - I-type granites
- Later on, two more groups were added in 1979 (Chappell & White, 2001)
  - M-type granites
  - A-type granites

# Background

- S-type Granites
  - Found in metamorphic terranes
    - Melting of pre-existing crust and/or sediments
  - High Al content
    - No hornblende
  - Can include biotite, muscovite, cordierite and garnet
  - Parent rocks high in Rb

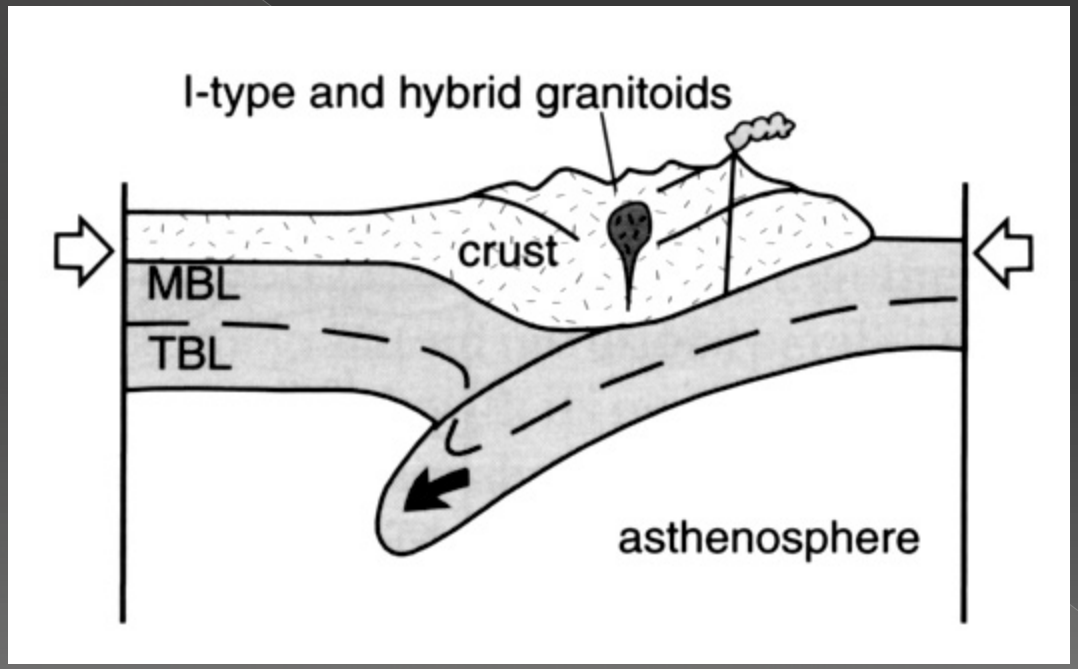
# S-type Granites



# Background

- I-type Granites
  - Typically found in subduction zones and continental margins
  - High in Ca and Na (contains hornblende and sphene)
  - Melting of deep crustal igneous rocks
    - magmatic differentiation of mafic magmas
  - Parent rocks poor in Rb

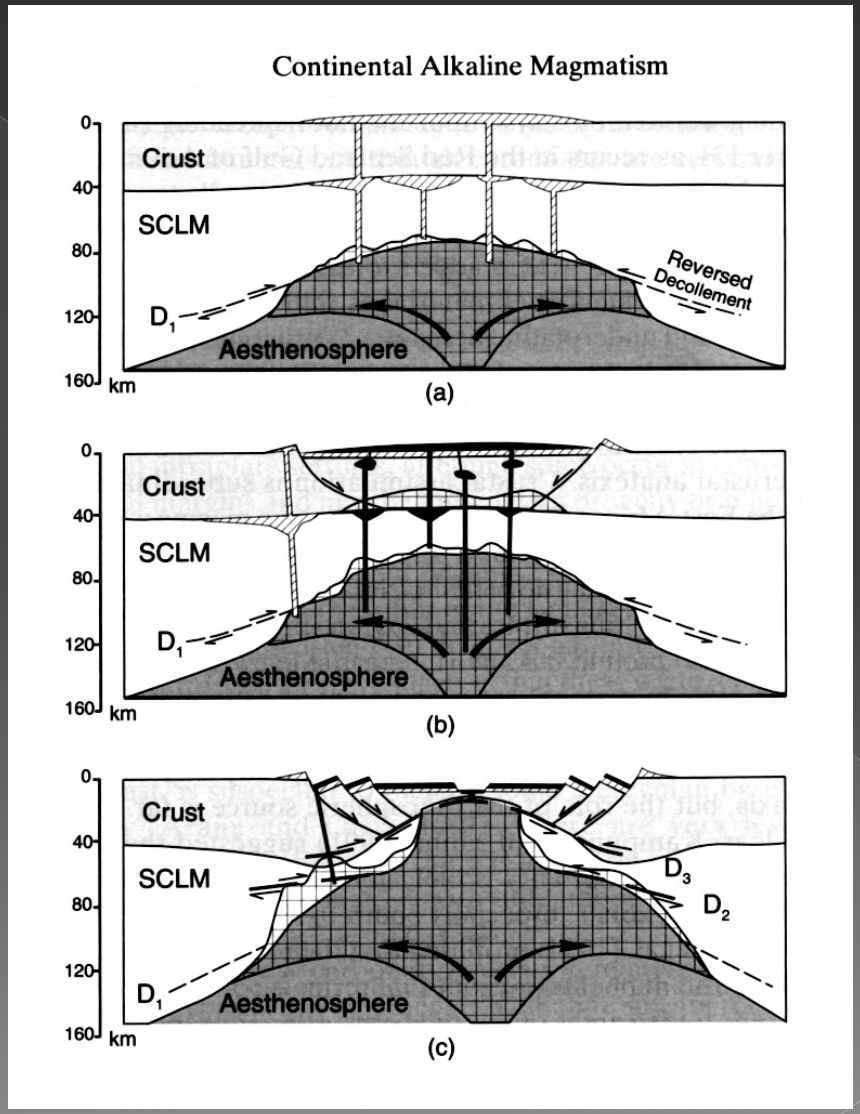
# I-type Granites



# Background

- A-type granites
  - Commonly intrudes into non-orogenic settings
    - Hot-spots
  - High $SiO_2$ content (up to 77%)
  - Higher alkalis and halogens
  - Lower in trace elements

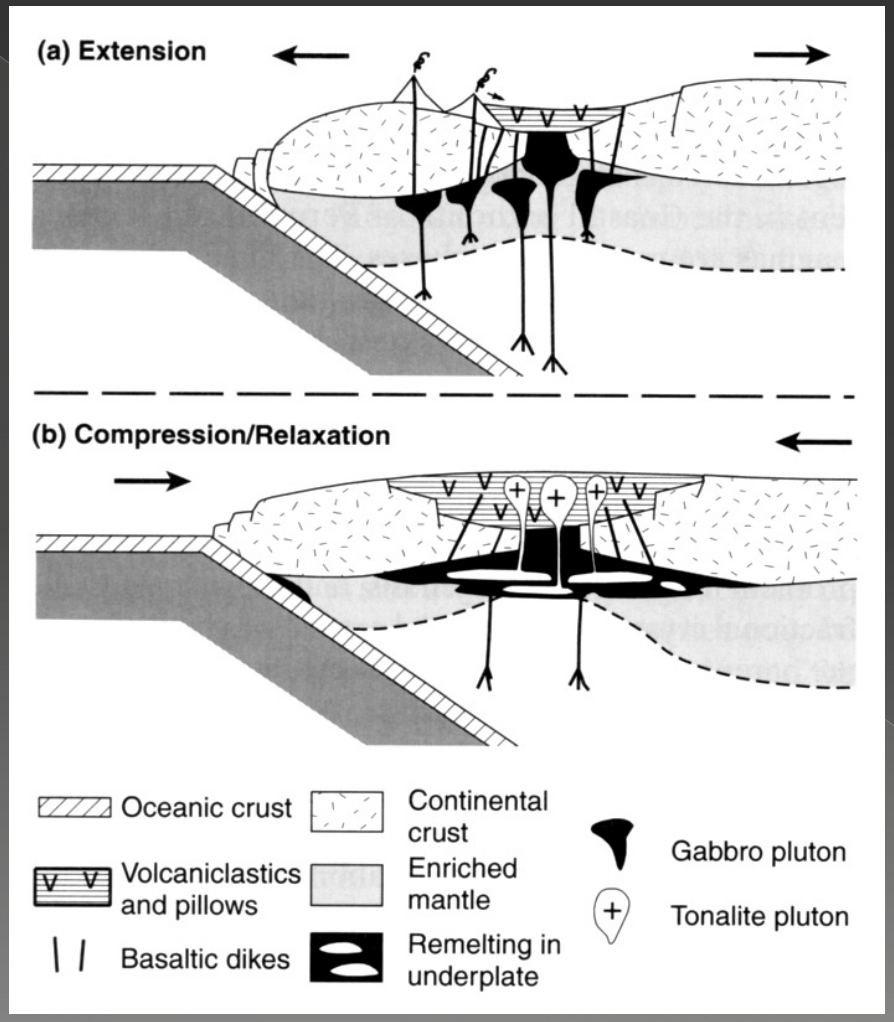
# A-type Granites



# Background

- M-type granites
  - Island arc granites (ex: Aleutians)
  - Found in ophiolites
  - Fractionated mantle melts
  - Lower $SiO_2$ content (46-70%)
  - Low Rb, Th, U
  - Forms tonalite-granitoids

# M-type Granites



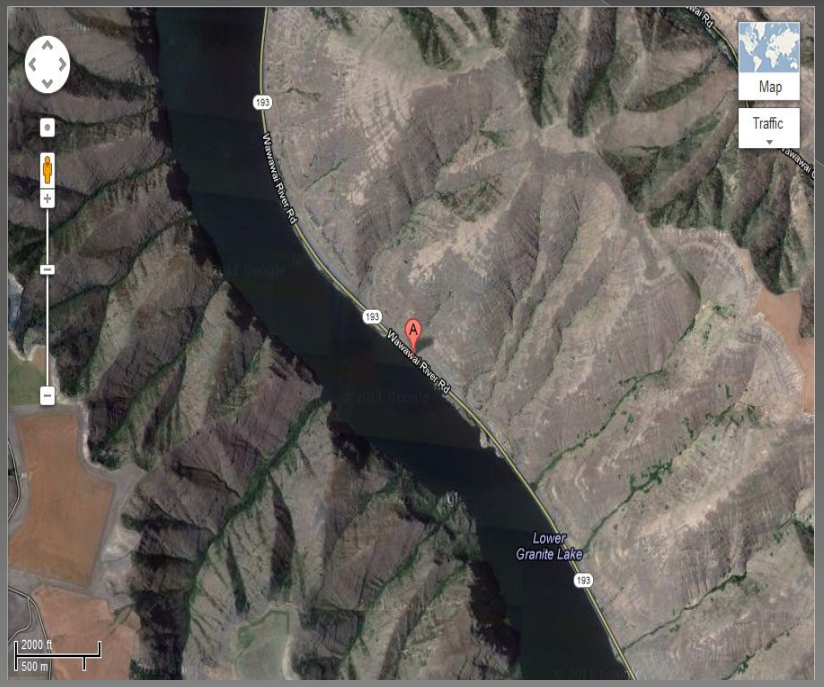
# Geology of Washington

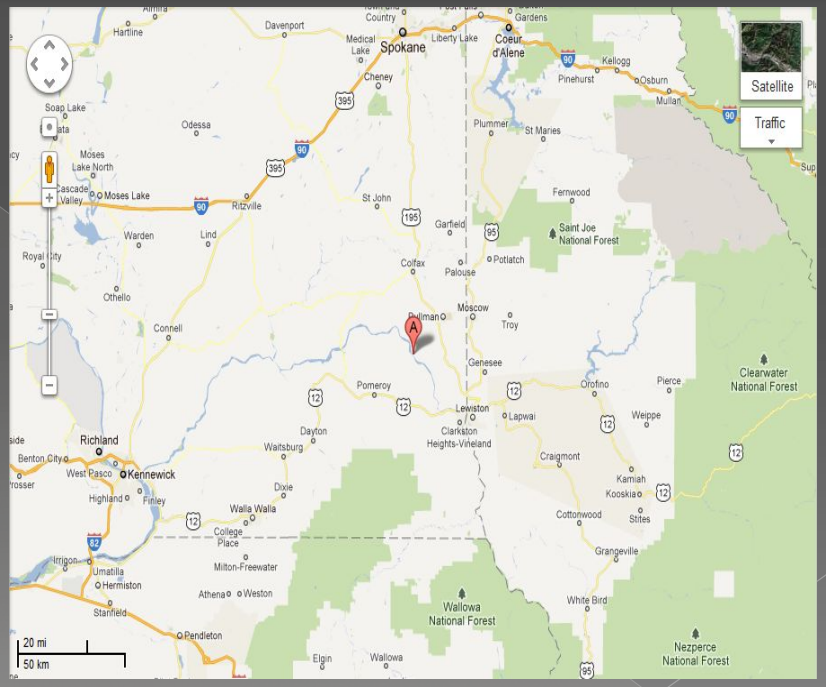
- Columbia Basin
- Very little deep granitic data
- Cretaceous granites
- Miocene basalts surrounded granites
  - Left only peaks exposed
- Granites now are extremely weathered
- Tin Oxides known to be found in the region

Lasmanis, 1991

# Point of Interest

- N 46° 36.429, W 117° 21.809




Google Maps, 2008

# Point of Interest


Google Maps, 2008

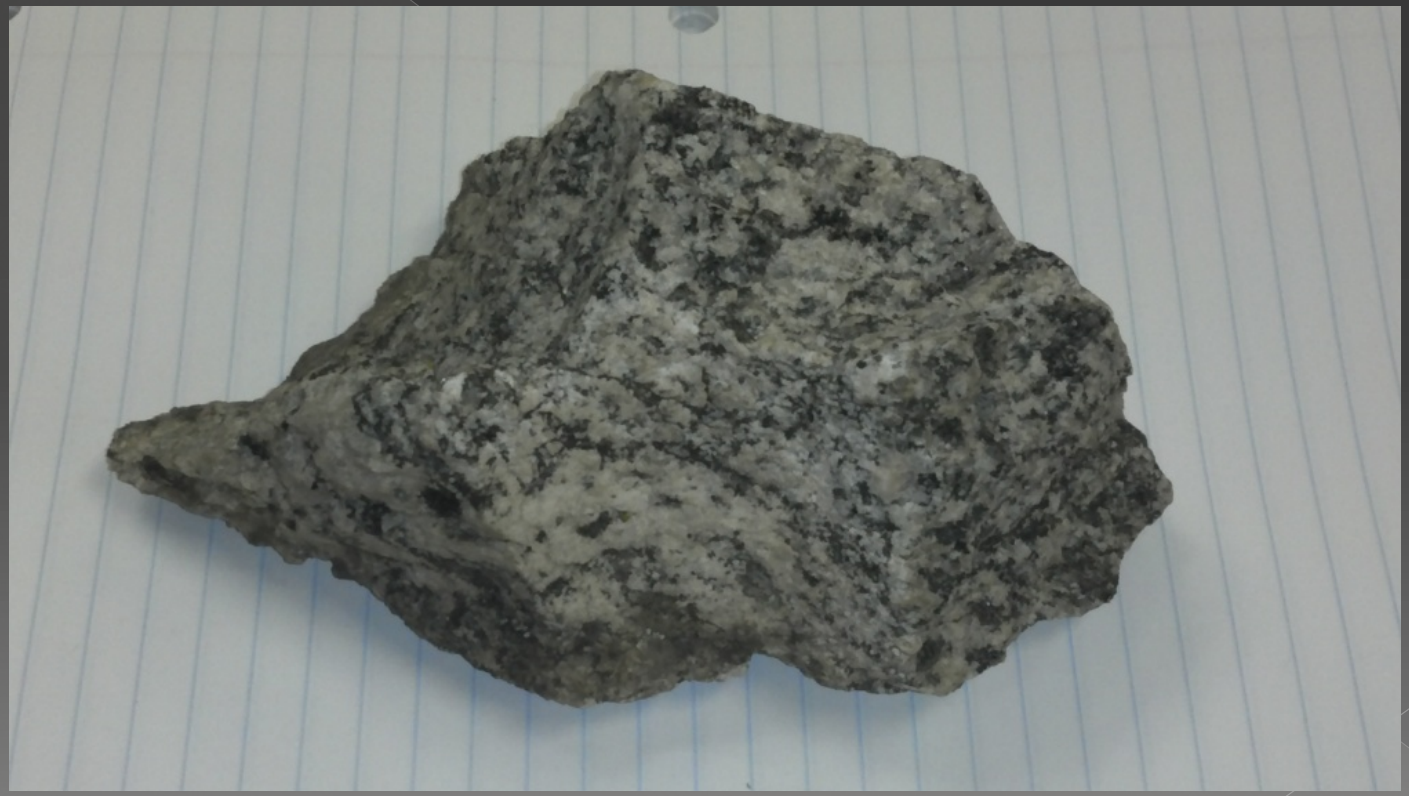
# Objectives

- Identify unknown “granite”
- Identify environment of formation
  - Classify granite according to SIAM conventions

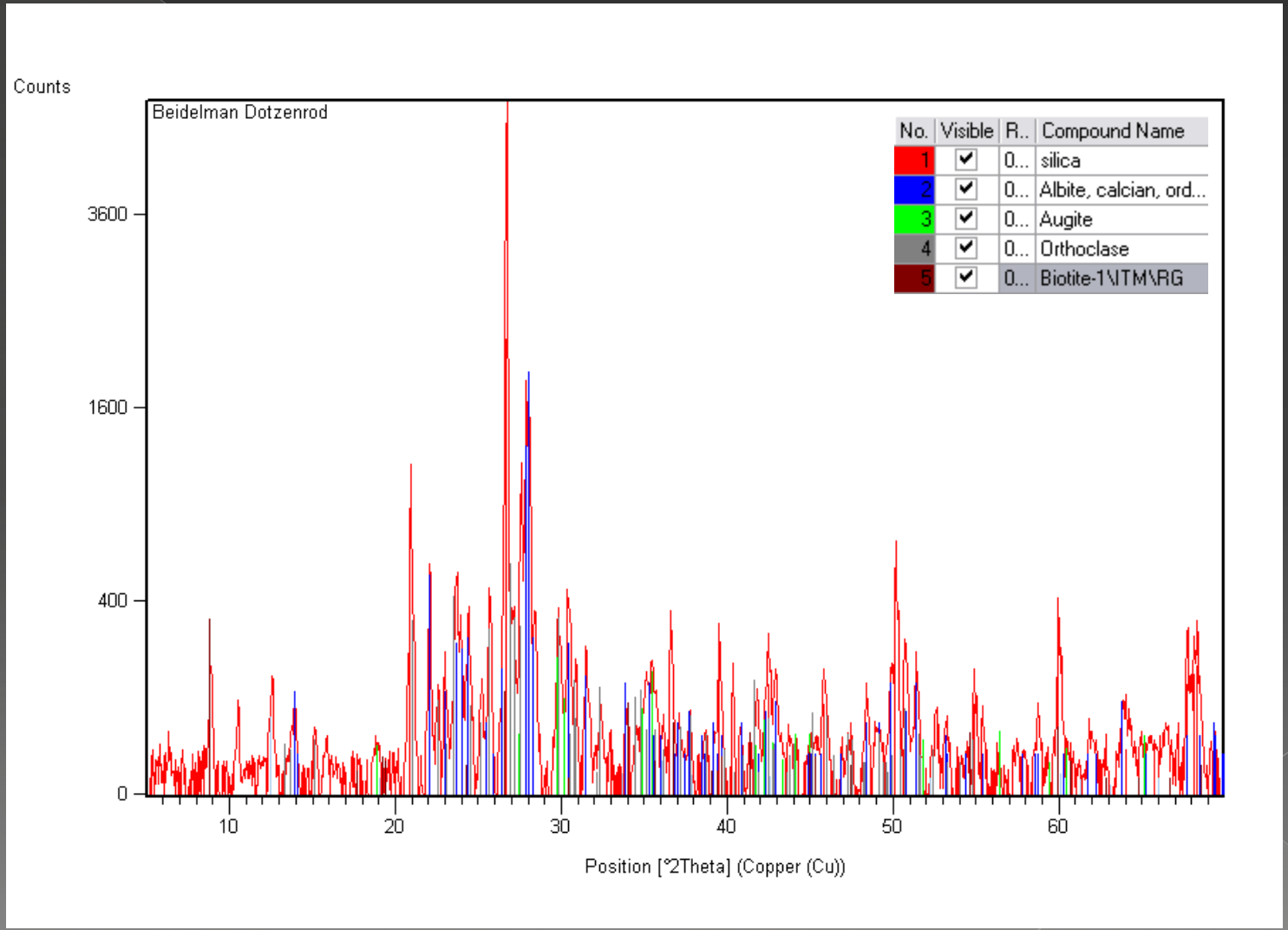
# Methodology

- XRD
  - Xpert High Score
- XRF
  - Igpet
  - GCDkit
- Microscopy

# Our Cool Rock



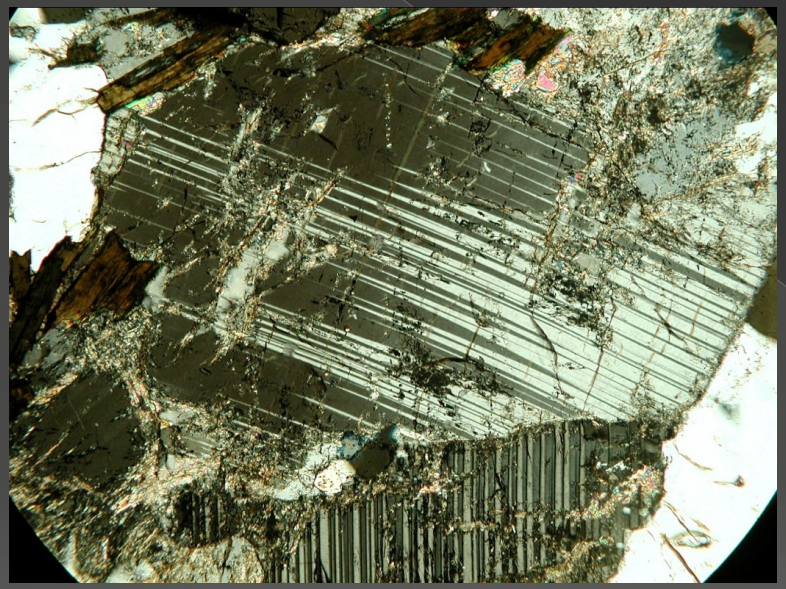
# XRD

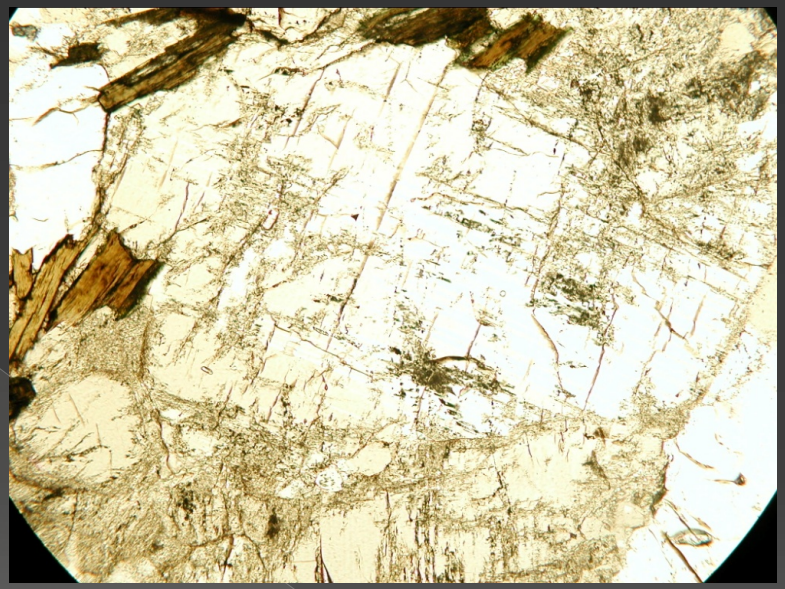

Counts
Beidelman Dotzenrod
No. Visible R.. Compound Name
1 0... silica
2 0... Albite, calcian, ord...
3 0... Augite
4 0... Orthoclase
5 0... Biotite-1\ITM\RG
3600
1600
400
0
10
20
30
40
50
60
Position [°2Theta] (Copper (Cu))

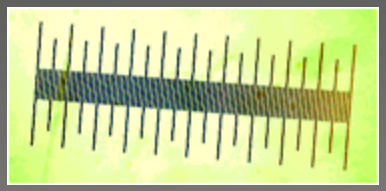
# Mineral Compostion

- Silica
- Augite
- Albite
- Orthoclase
- Biotite
- Hornblende

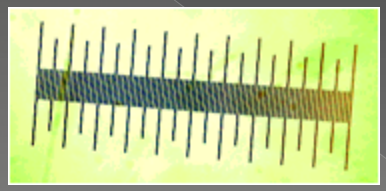
# Plagioclase - Albite



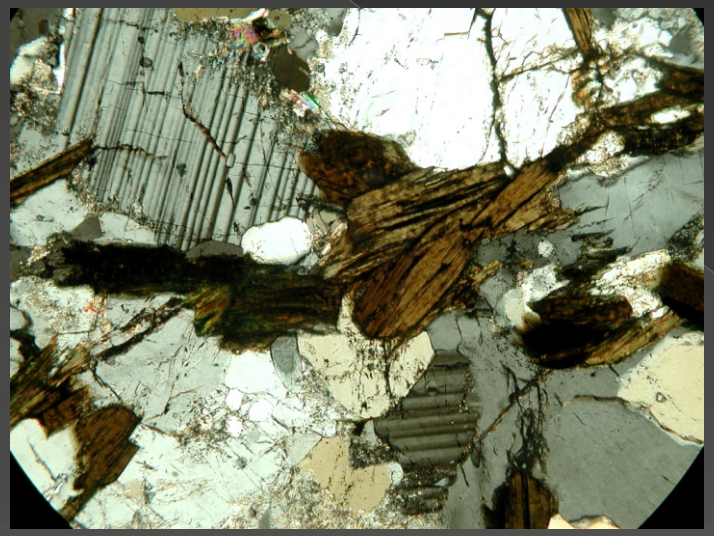


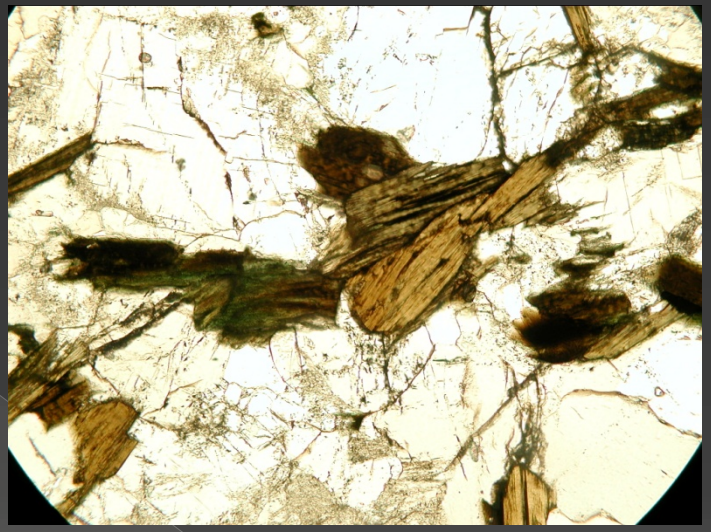


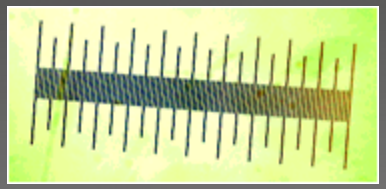
FOV 2mm



# Hornblende and Plagioclase







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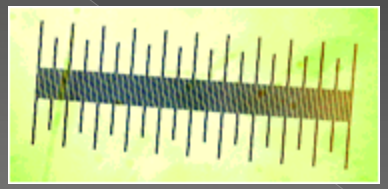
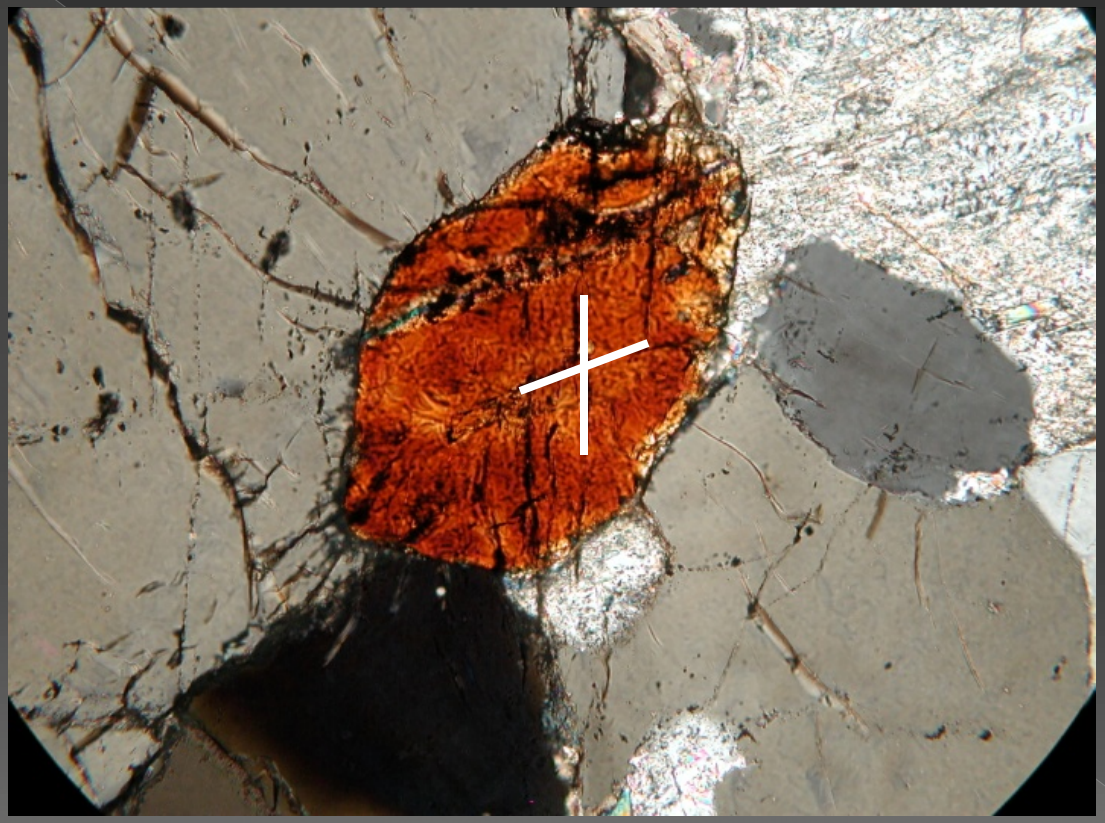


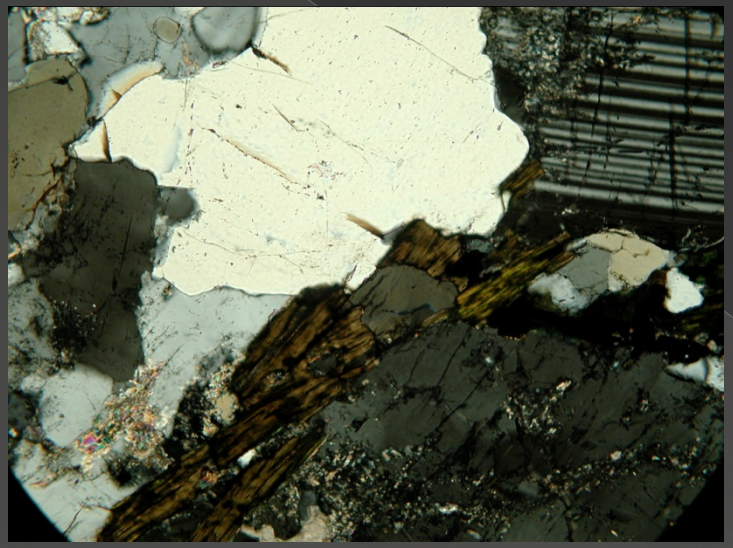
# Hornblende

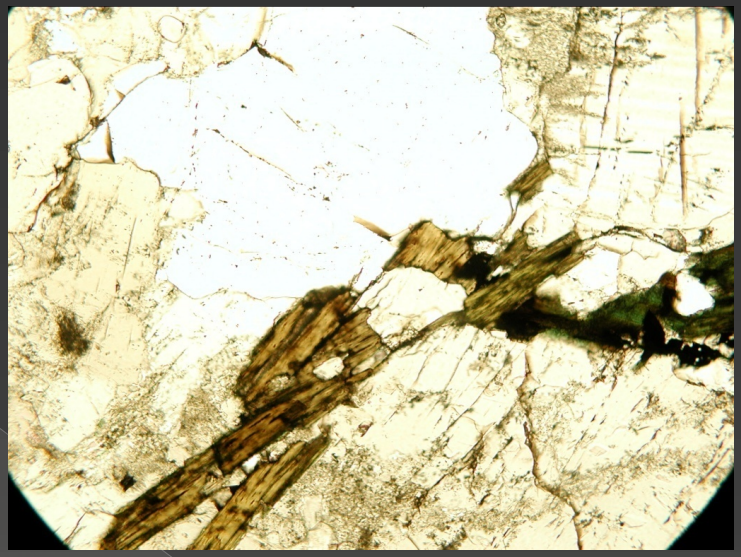


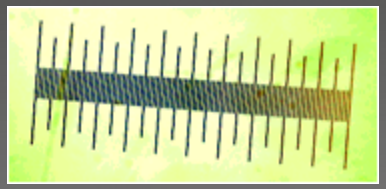
FOV 2mm

- ~60/120 ° cleavage

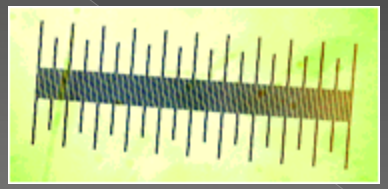
# Quartz



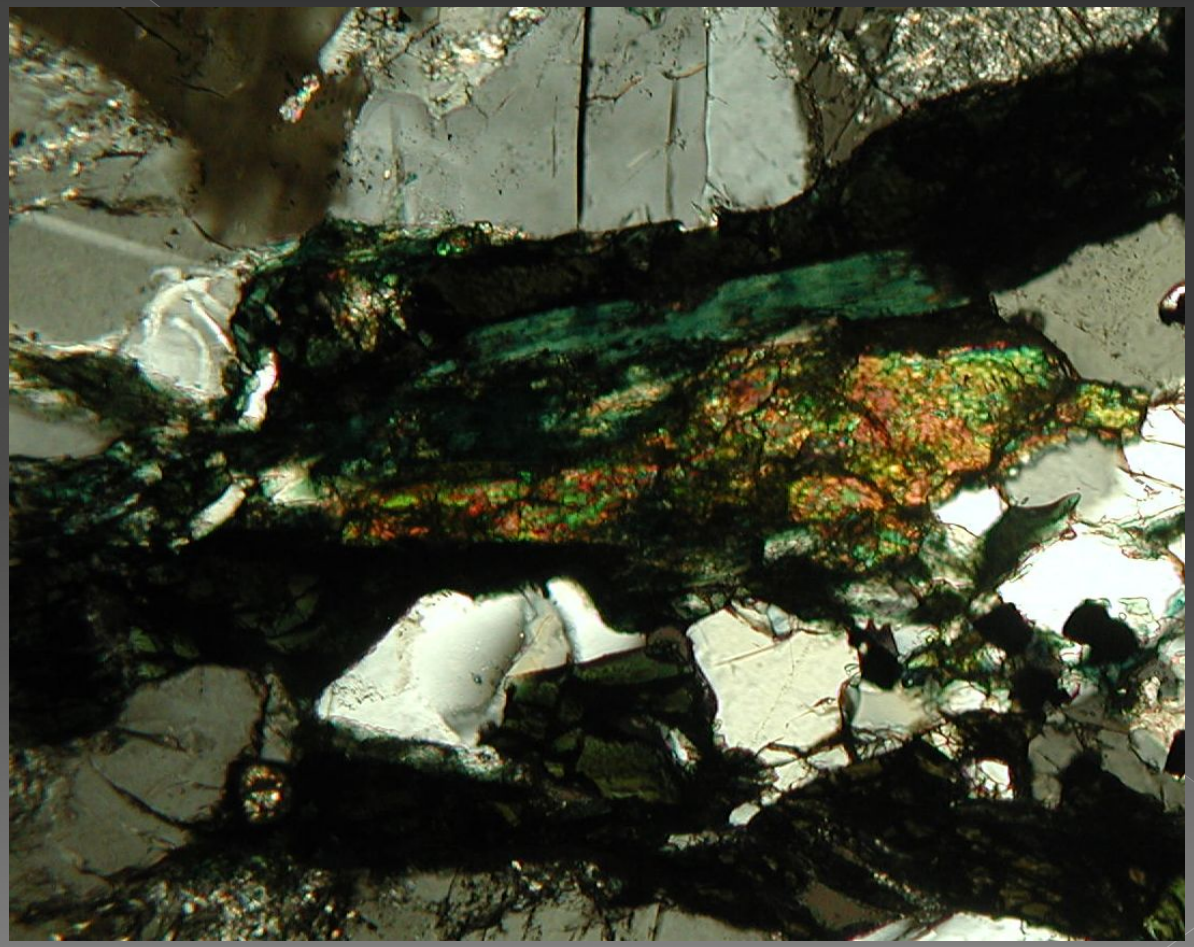




FOV 2mm



# Augite

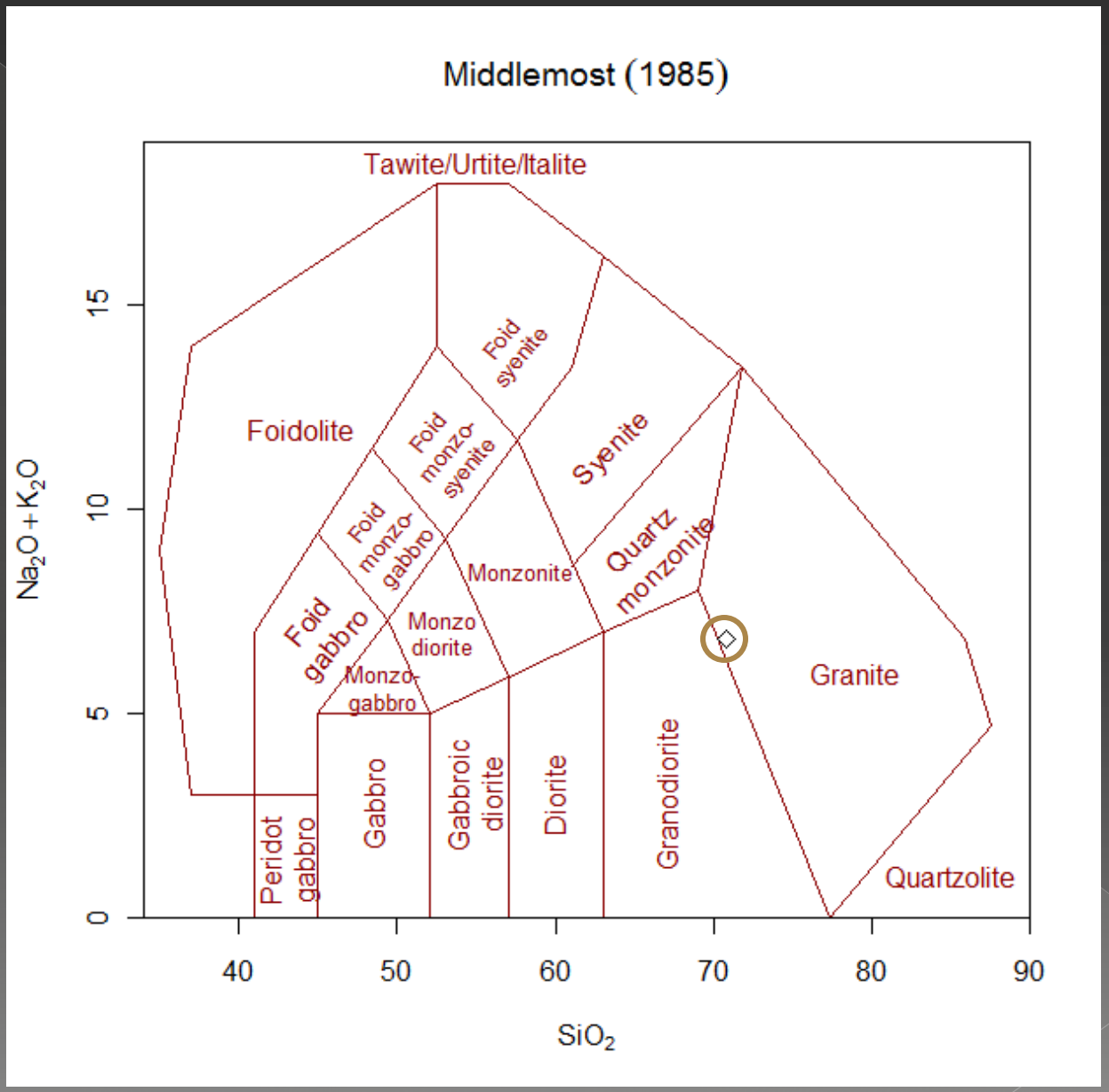


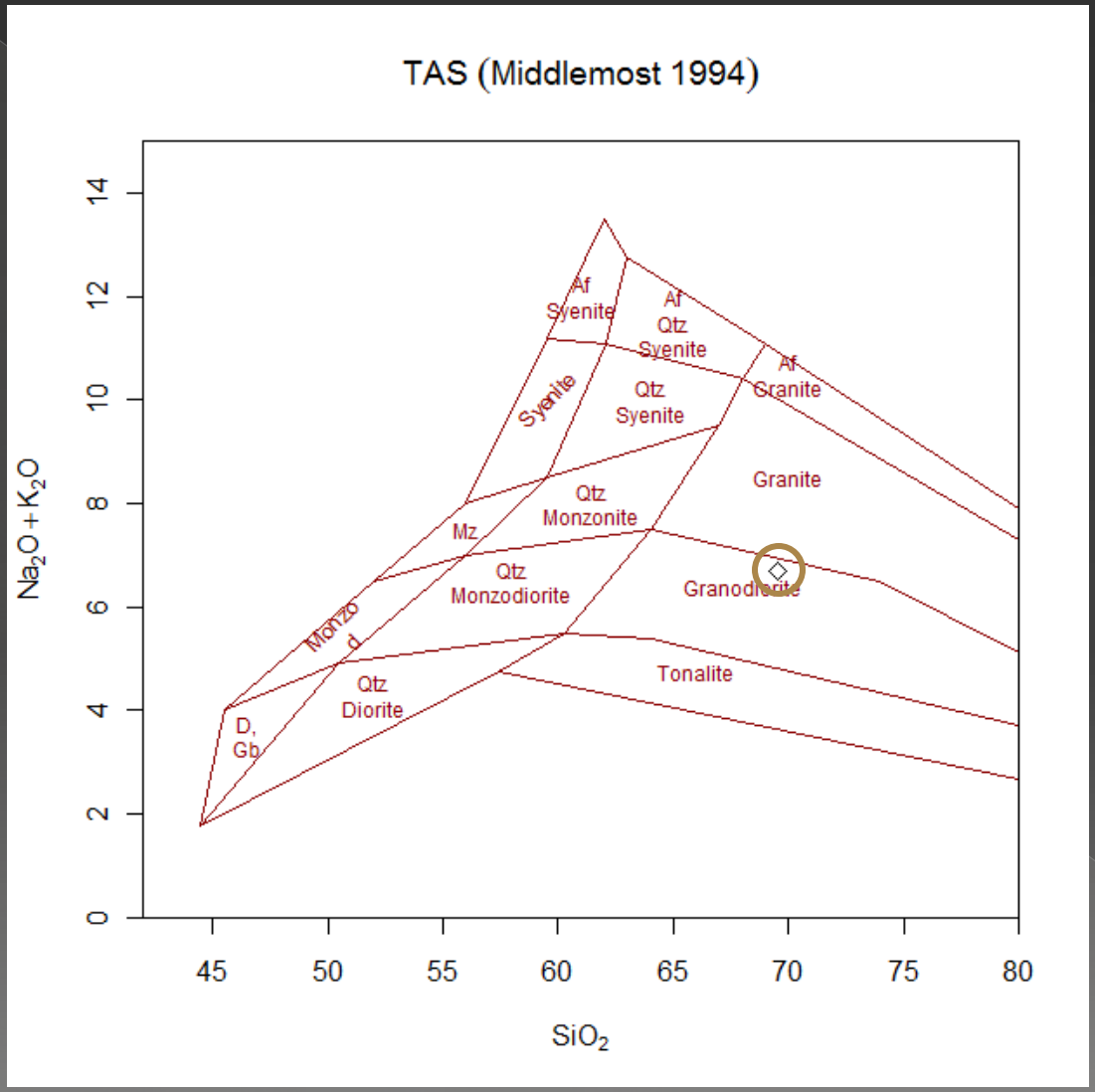
# Average Granite vs Our Granite XRF Data

- $SiO_2$ — 72.04%
- $Al_2O_3$ — 14.42%
- $K_2O$ — 4.12%
- $Na_2O$ — 3.69%
- $CaO$ — 1.82%
- $Fe_2O_3$ — 2.9%
- $MgO$ — 0.71%
- $TiO_2$ — 0.30%
- $P_2O_5$ — 0.12%
- $MnO$ — 0.05%

- $SiO_2$ — 69.55%
- $Al_2O_3$ — 15.14%
- $K_2O$ — 3.39%
- $Na_2O$ — 3.29%
- $CaO$ — 2.94%
- $Fe_2O_3$ — 2.8%
- $MgO$ — 0.581%
- $TiO_2$ — 0.43%
- $P_2O_5$ — 0.07%
- $MnO$ — 0.05%

Edited from Blatt and Tracy, 1997

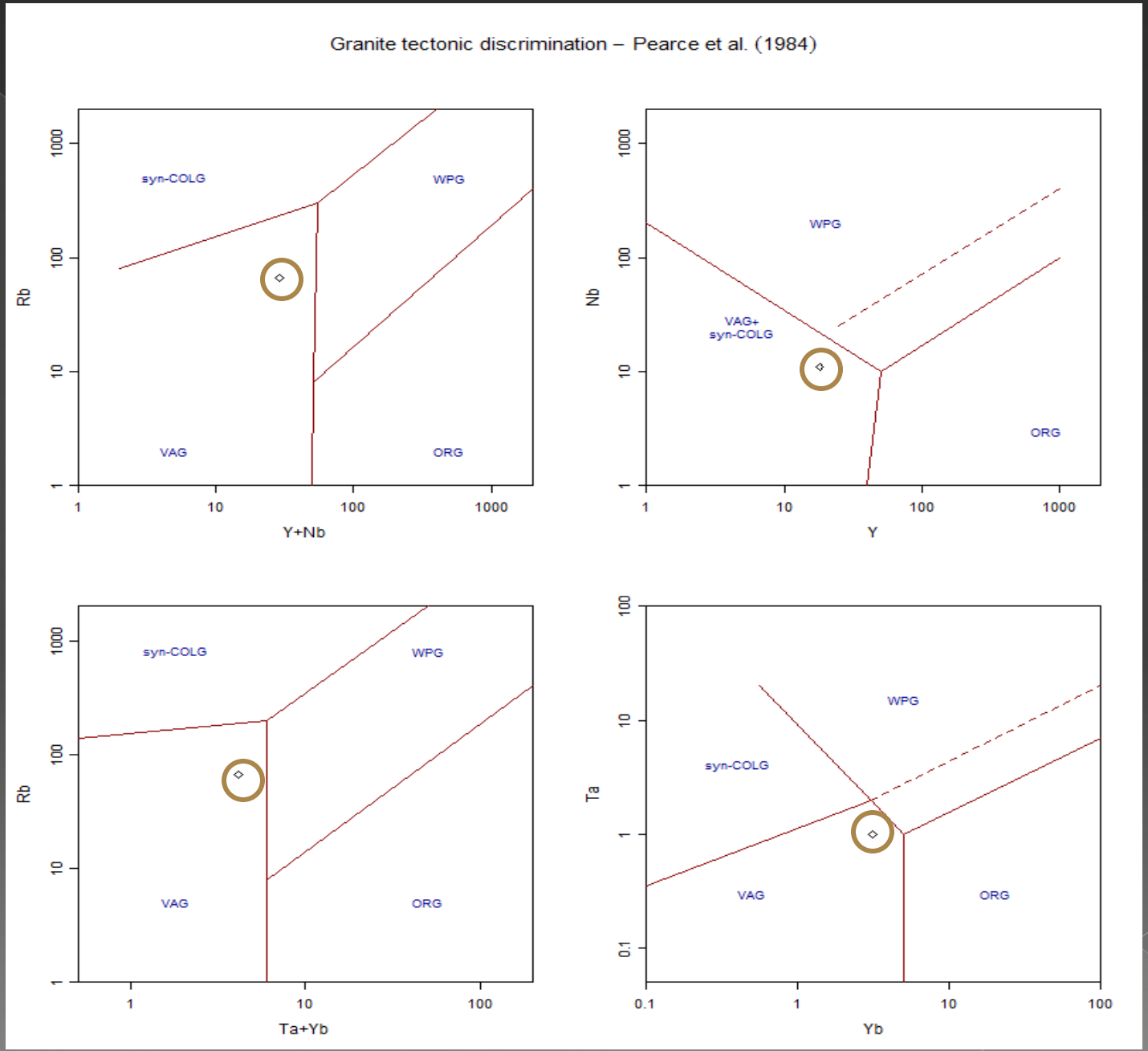

Middlemost (1985)
Tawite/Urtite/Italite
Foidolite
Foid syenite
Foid monzo-syenite
Syenite
Foid monzo-gabbro
Monzonite
Quartz monzonite
Foid gabbro
Monzo diorite
Monzo-gabbro
Granite
Peridot gabbro
Gabbro
Gabbroic diorite
Diorite
Granodiorite
Quartzolite
$Na_2O + K_2O$
$SiO_2$
0
5
10
15
40
50
60
70
80
90

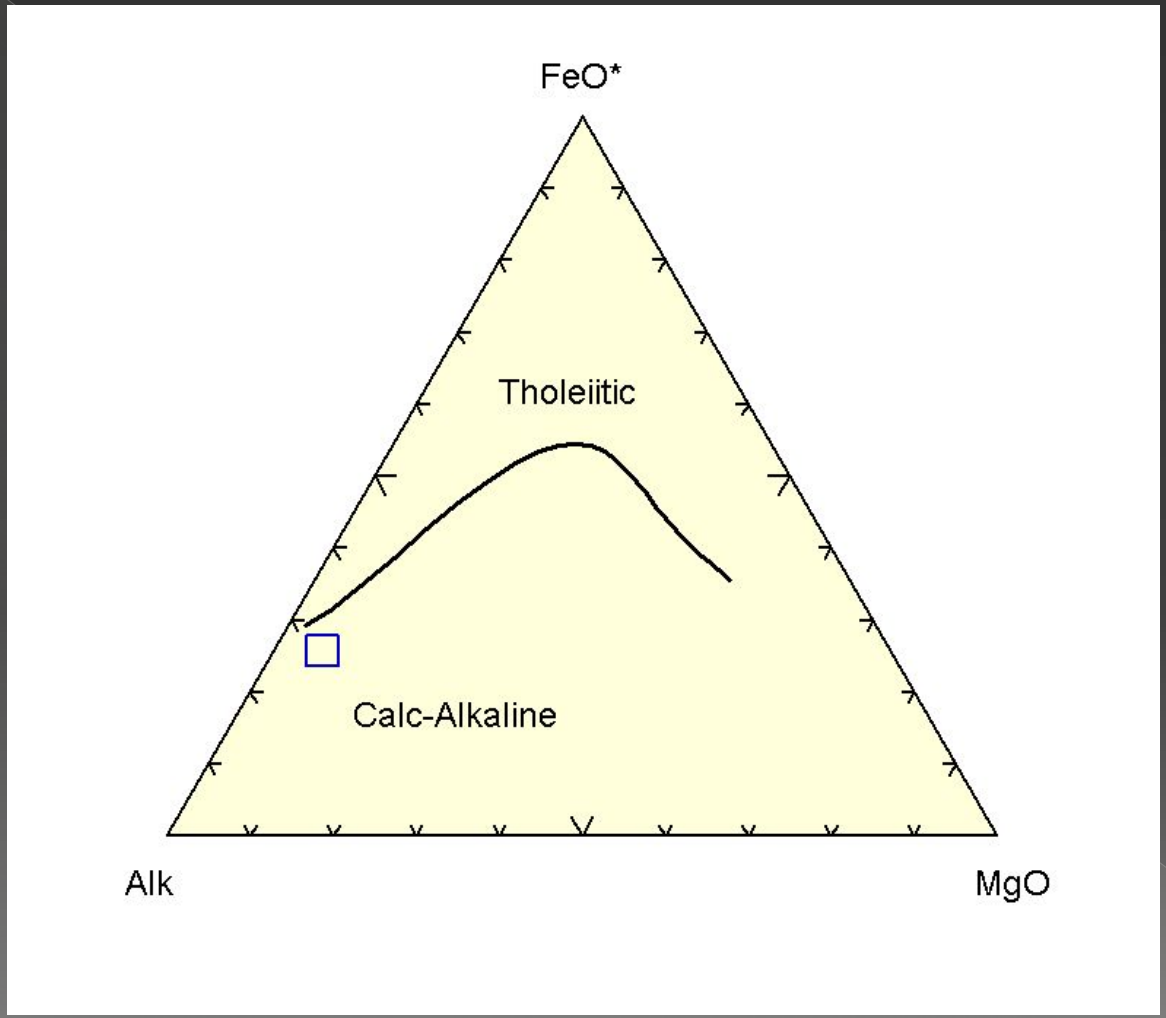

TAS (Middlemost 1994)
Af Syenite
Af Qtz Syenite
Af Granite
Syenite
Qtz Syenite
Granite
Qtz Monzonite
Mz
Qtz Monzodiorite
Granodiorite
Monzo d.
Tonalite
Qtz Diorite
D, Gb
$Na_2O + K_2O$
$SiO_2$
0
2
4
6
8
10
12
14
45
50
55
60
65
70
75
80

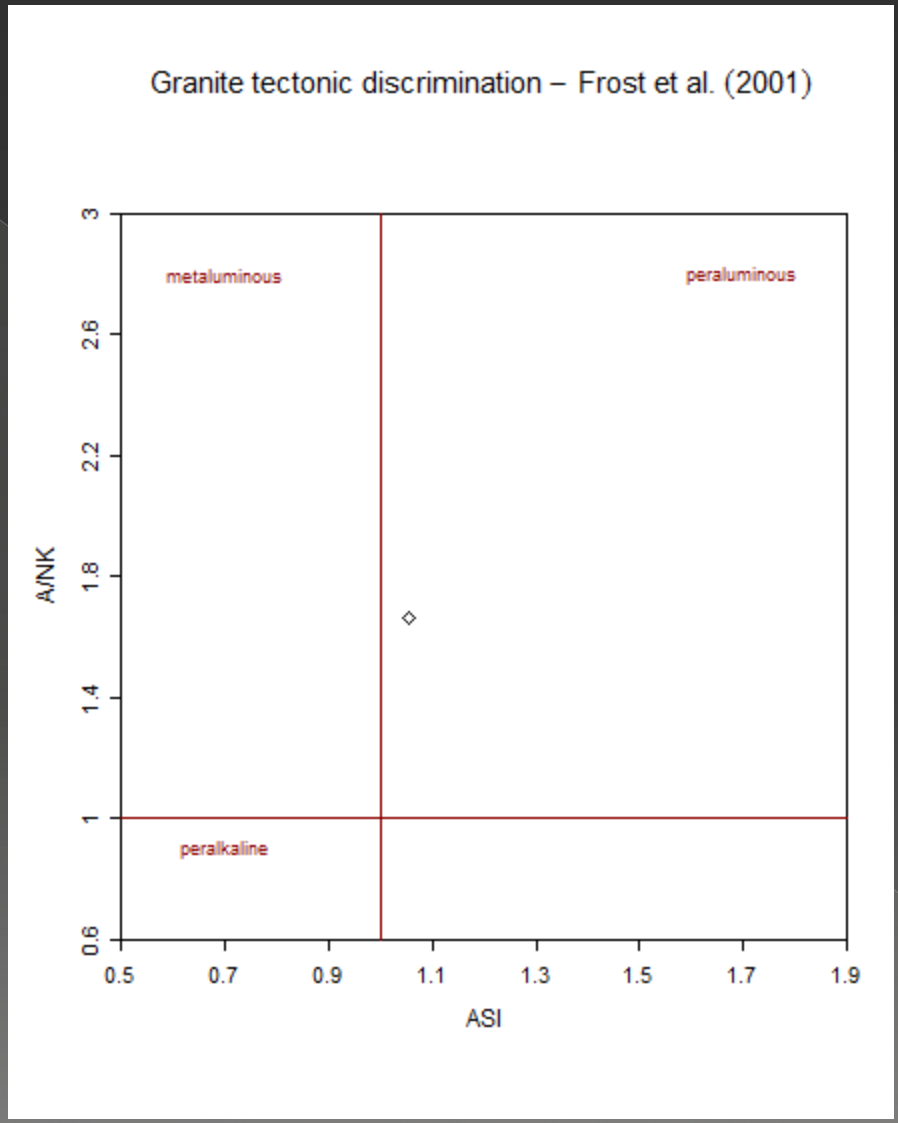
# Pearce et al. Classification

- A further way of classifying formation environments
  - ORG – ocean ridge granites
  - VAG – volcanic arc granites
  - WPG – within plate granites
  - COLG – collision granites

Pearce et al., 1984


Granite tectonic discrimination – Pearce et al. (1984)
syn-COLG
WPG
VAG
ORG
Rb
Y+Nb
1
10
100
1000
WPG
VAG+
syn-COLG
ORG
Nb
Y
syn-COLG
WPG
VAG
ORG
Rb
Ta+Yb
1
10
100
WPG
syn-COLG
VAG
ORG
Ta
Yb
0.1
1
10
100


FeO*
Tholeiitic
Calc-Alkaline
Alk
MgO


Granite tectonic discrimination – Frost et al. (2001)
metaluminous
peraluminous
peralkaline
A/NK
ASI
0.6
1
1.4
1.8
2.2
2.6
3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9

# Pearce et al. Classification

- Our sample resembles volcanic arc granites
  - Calc-alkiline
  - Slightly peraluminous
  - M to I-type granites

Pearce et al., 1984

# Conclusion

- Our rock is more or less a granite
  - On the border between granite/granodiorite
  - Transitional
- Our granite formed on a volcanic arc
  - Most likely an I-type granite

# Referenses


- Blatt, H. and Tracy, R.J.,1997. *Petrology* (2nd ed.). New York: Freeman. p. 66.
- Lasmanis, Raymond, 1991, The geology of Washington: Rocks and Minerals, v. 66, no. 4, p. 262-277.
- Map of the N 46° 36.429, W 117° 21.809, retrieved on May 01, 2012 from website maps.google.com.
- Pearce, J., Harris, N. and Tindle, A., 1984., Trace Element Discrimination Diagrams for the Tectonic Interpretation of Granitic Rocks: Oxford Journal of Petrology, p 956-983.
- Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology, 2nd ed: Upper Saddle River, NJ, Prentice Hall.