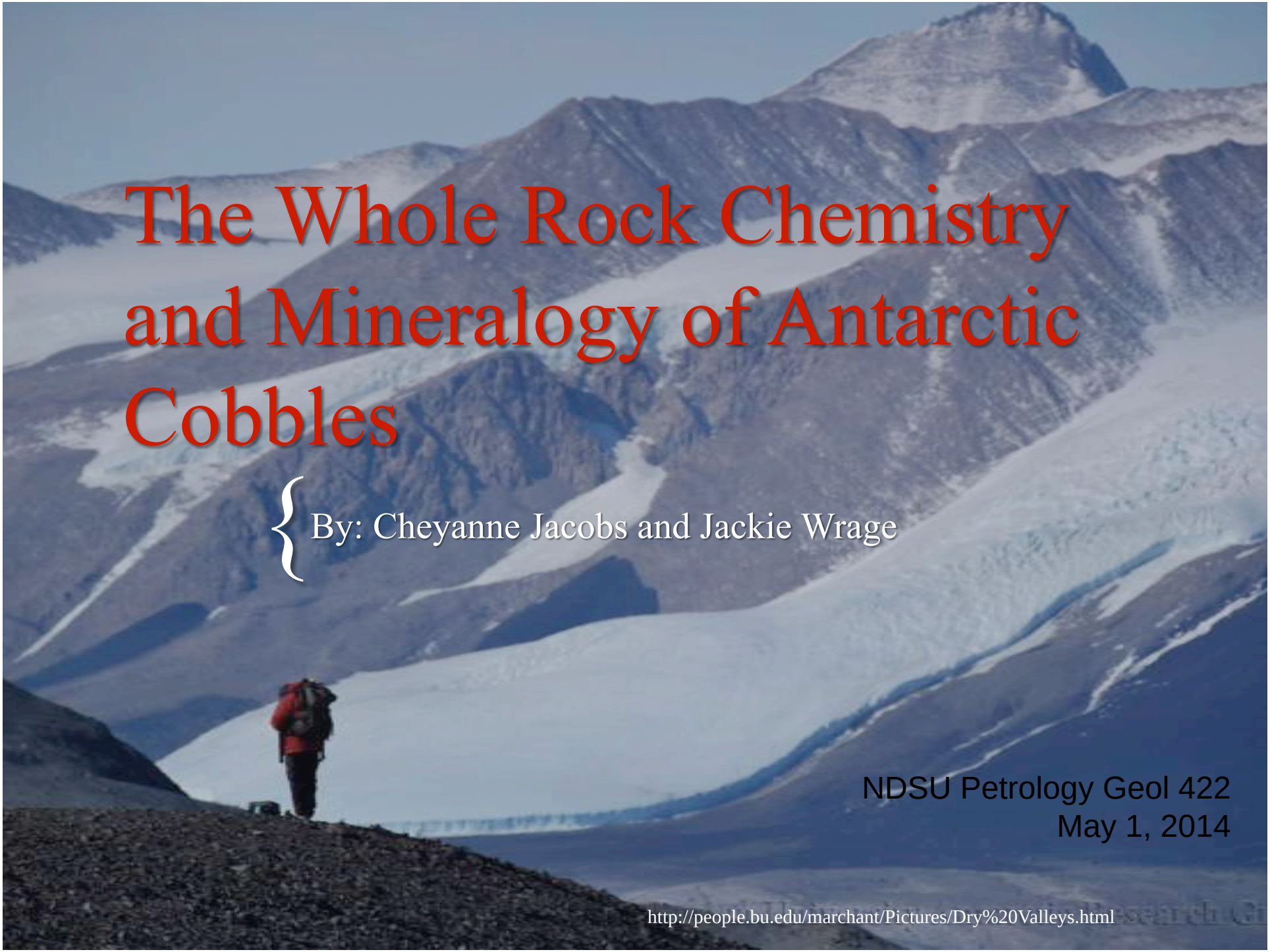


The Whole Rock Chemistry and Mineralogy of Antarctic Cobbles

By: Cheyanne Jacobs and Jackie Wrage

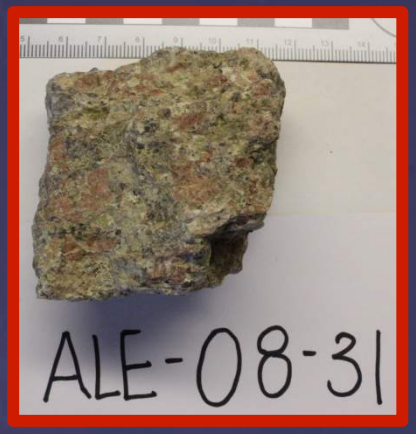
NDSU Petrology Geol 422
May 1, 2014

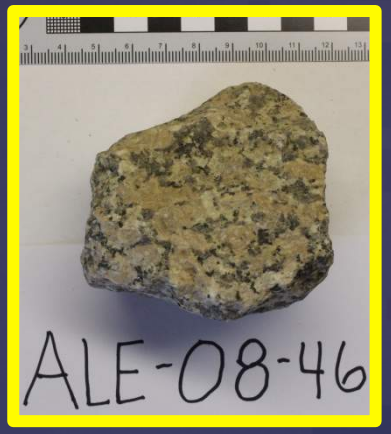
http://people.bu.edu/marchant/Pictures/Dry%20Valleys.html

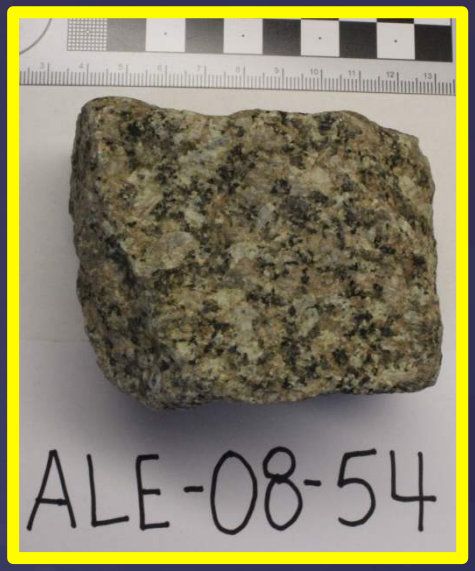
A Cobble's Journey

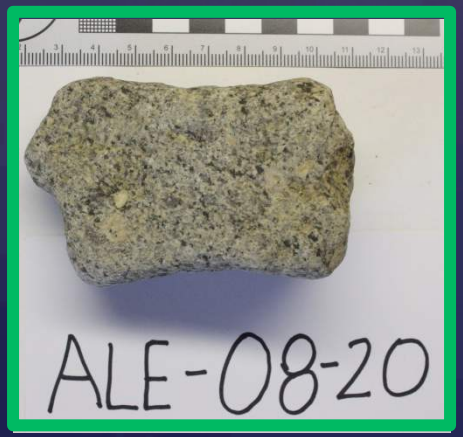
- Cobble's Back Story
- The Journey
  - From rock to powder
  - From powder to glass
- Unlocking K-Spar's Secret
- The Cobble's Conclusion

Meet the Cobbles





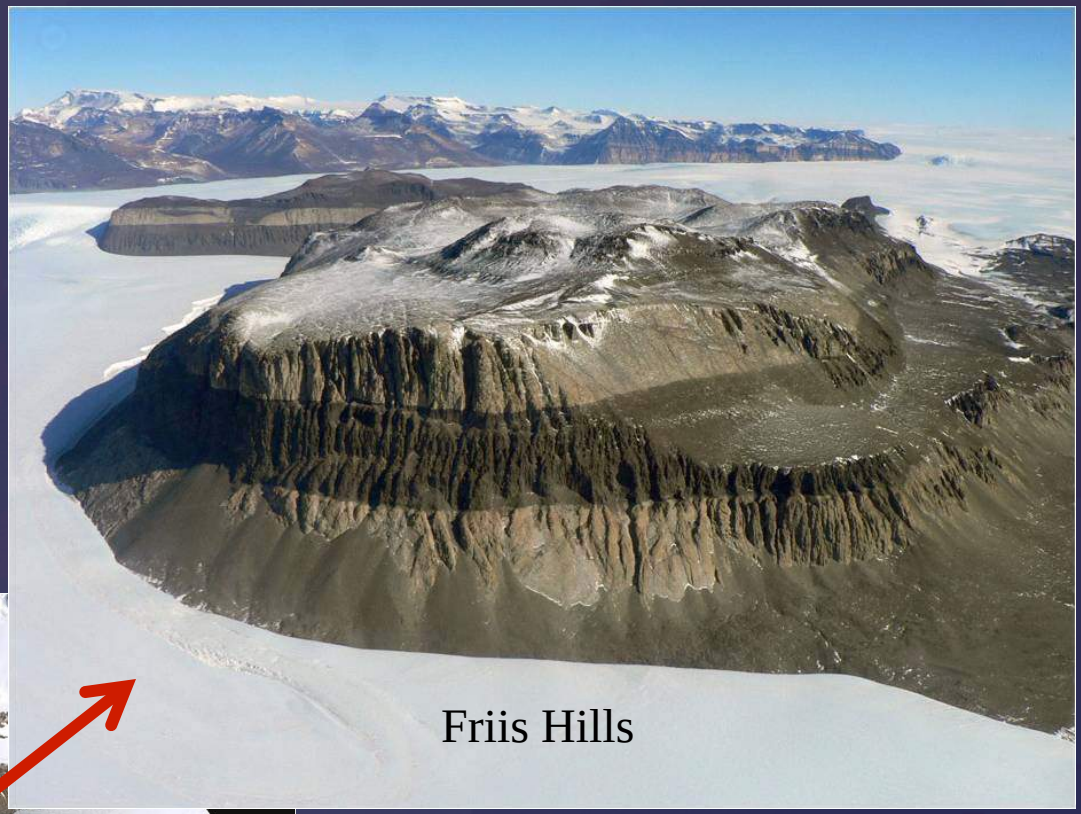




Cobble's Back Story

Photos Courtesy of 2010 presentation by Kelsey Froward, Alex Smith, and Brian Hall

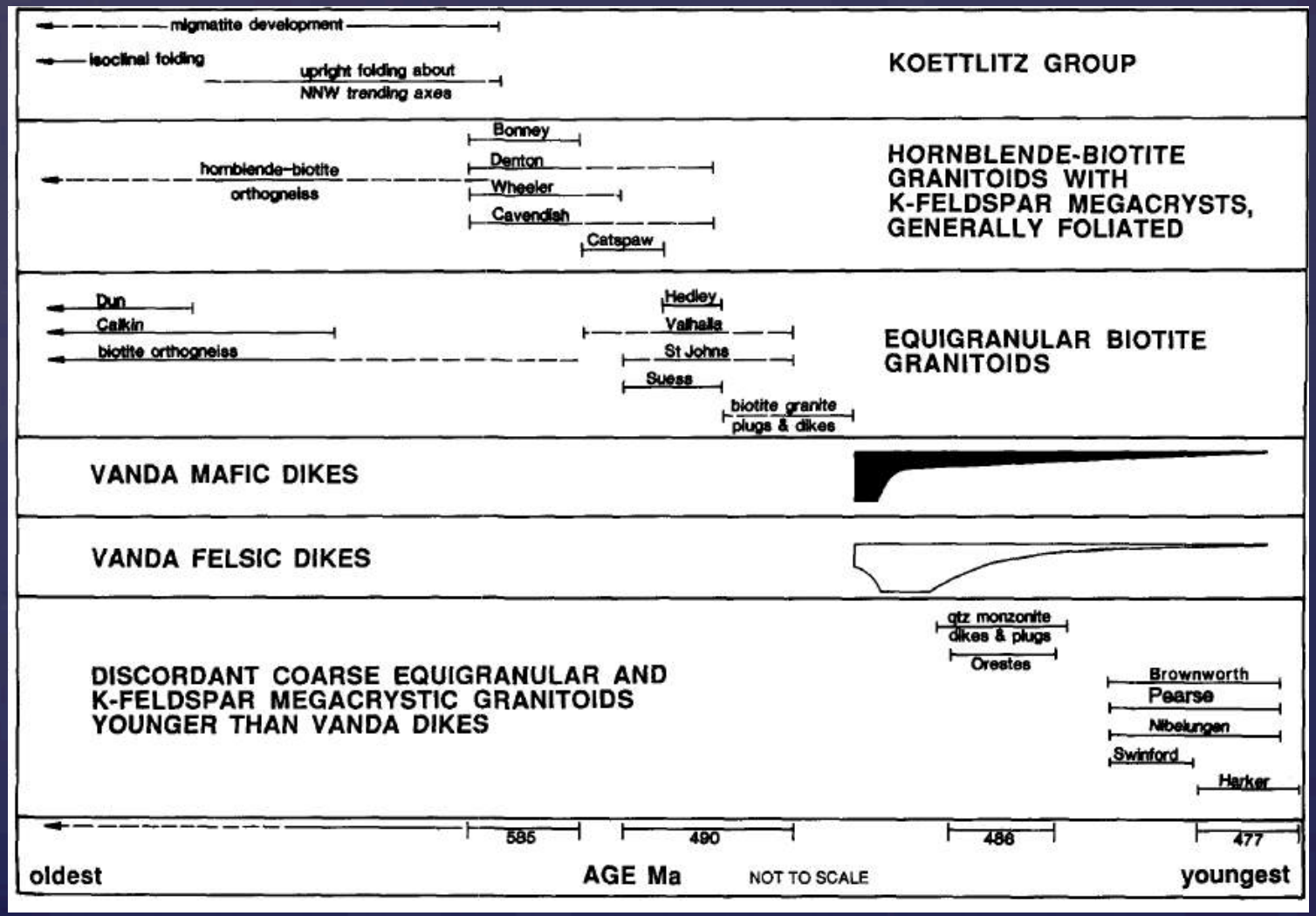
The Dry Valleys



Friis Hills

Photos Courtesy of 2010 presentation by Kelsey Froward, Alex Smith, and Brian Hall

The Plutons of Antarctica



(Allibone et al, 1993)

Possible Parents

- The Bonney, Cavendish, Denton, and Wheeler Plutons
  - Foliated, alkali megacrystals, hornblende, mafic enclaves
- Hedley, Valhalla, St. Johns, and Suess Plutons
  - Lack mafic enclaves, biotite, plagioclase, alkali
- Pearse Pluton
  - Alkali, plagioclase, hornblende, biotite
- Nibelungen Pluton
  - Alkali, porphyritic with aligned phenocrysts, chloritization

Questions of the Cobbles

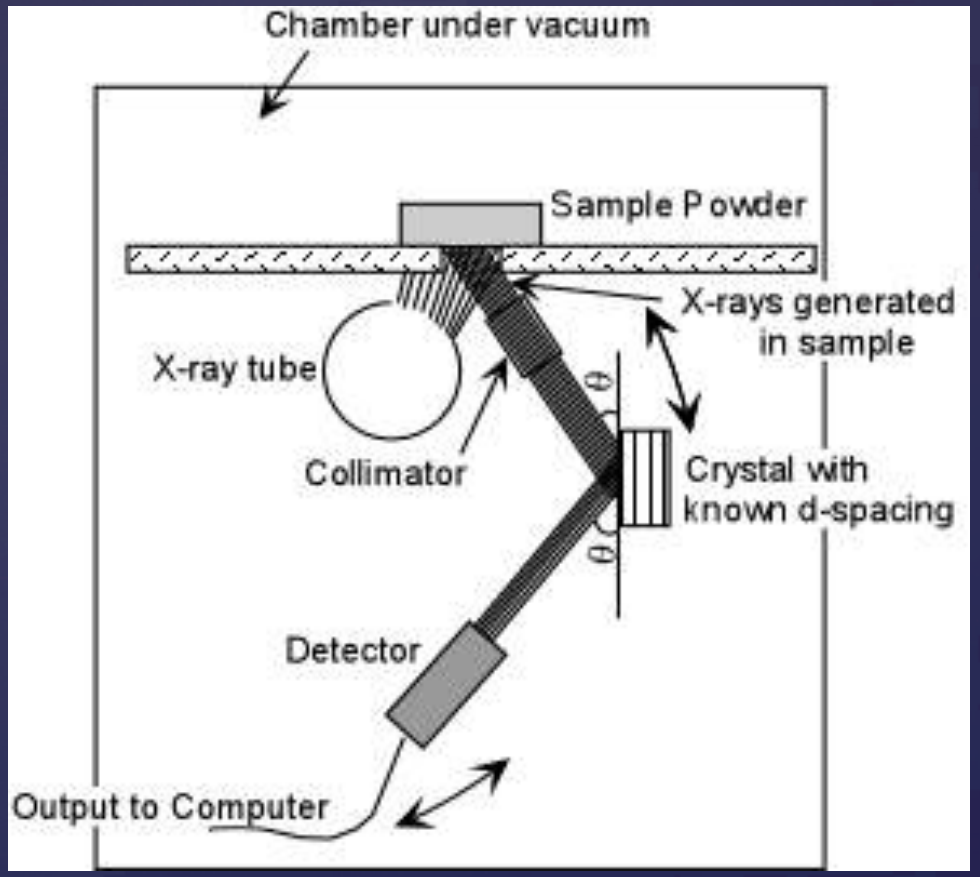
- What is the composition of the cobbles?
  - Using whole rock chemistry data from XRF
- What are the crystallization characteristics of the k-spar grains?
  - Using mineral data from XRD
- Can these cobbles be traced back to a specific pluton?

What is XRF?

X-Ray Fluorescence

Signal intensity generated by an element is compared to a standard of known composition to determine concentration

Signal is directly proportional to concentration in specimen



http://www.tulane.edu/~sanelson/eens211/mineral_chemistry.htm

From Rock to Powder

First the sample has to be cut and powdered

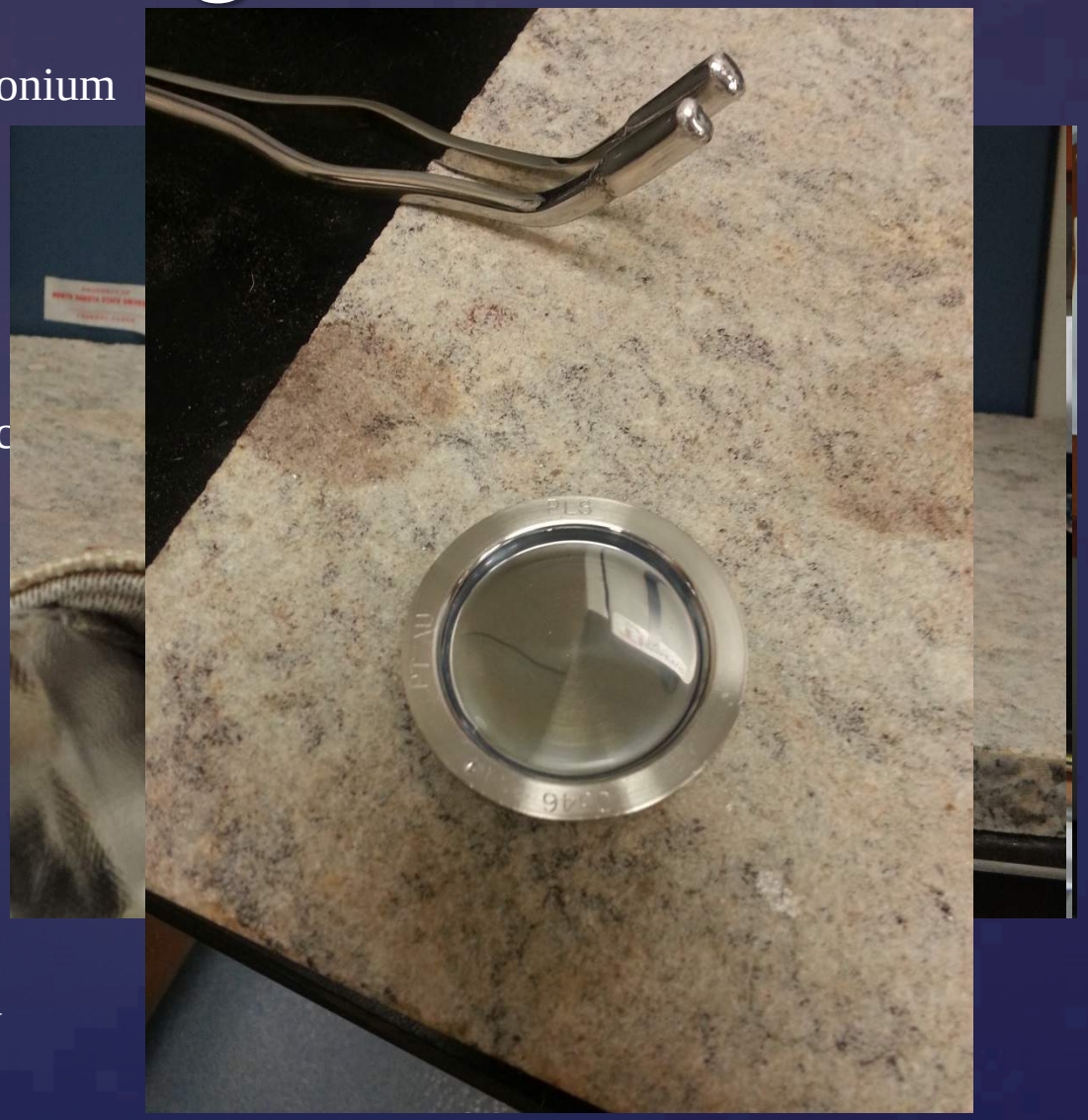
Sample can then be presses into a powder pellet

This pellet is then placed in the XRF

Photos Courtesy of Cheyanne Jacobs

From powder to glass

- Mixed sample, flux, and Ammonium Nitrate
- Placed mixture in platinum crucible
- Melted sample in muffle furnac at 1100 ^{o}C for 5 minutes
- Swirled sample and added the mould to the furnace
- Heated for another 4 minutes
- Remove and pour immediately into mould



Photos Courtesy of Cheyanne Jacobs and Bernhardt Saini-Eidukat

AFM Diagram

- Glass Discs
- Powder Discs

Calc-Alkaline

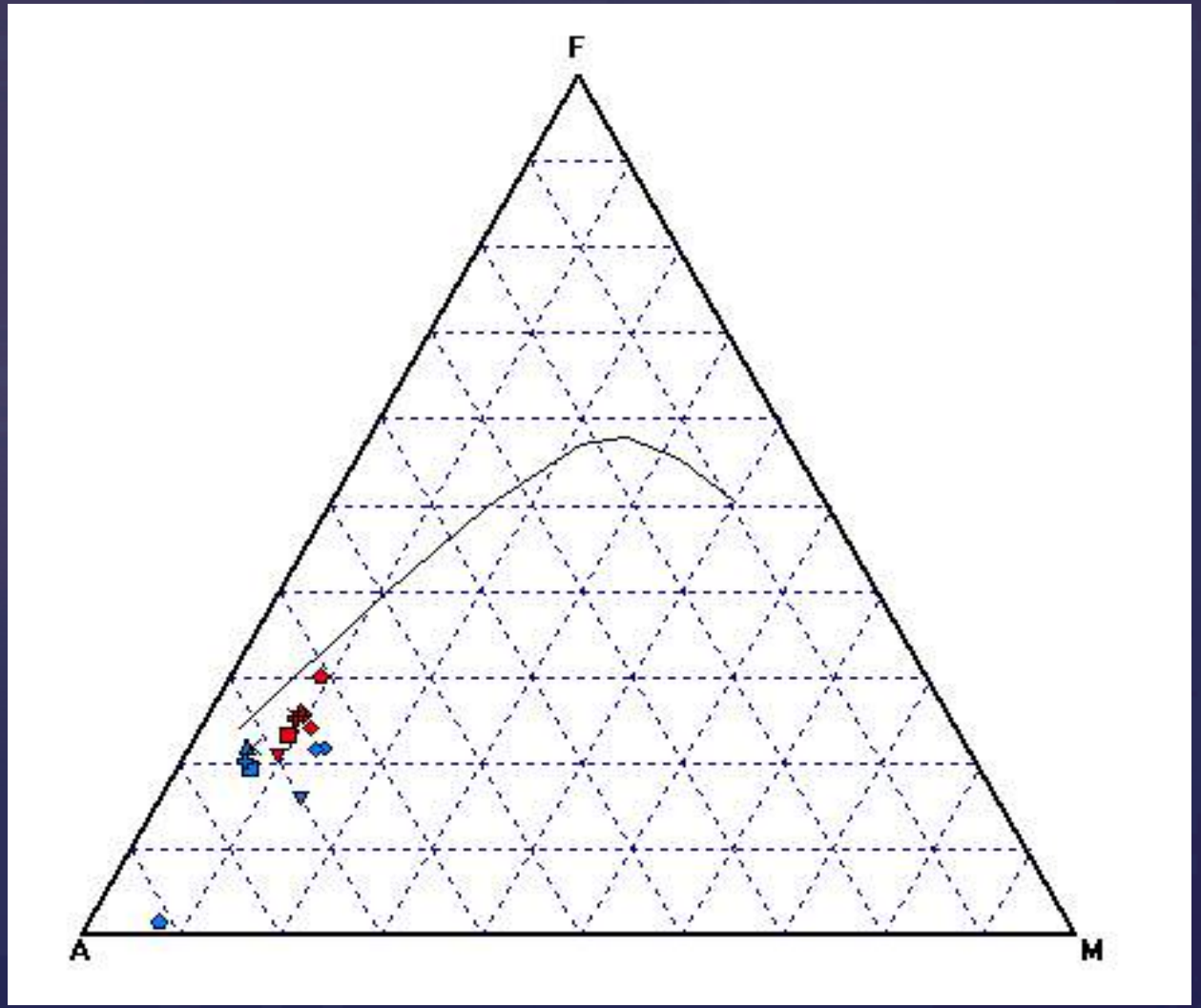


Diagram from Petrograph program

TAS Diagram

Samples
- ALE-08-39
- ALE-08-44
- ALE-08-36
- ALE-08-54
- ALE-08-46

Plotted in the syenite section

Glass samples tend to plot higher on the diagram than powder discs

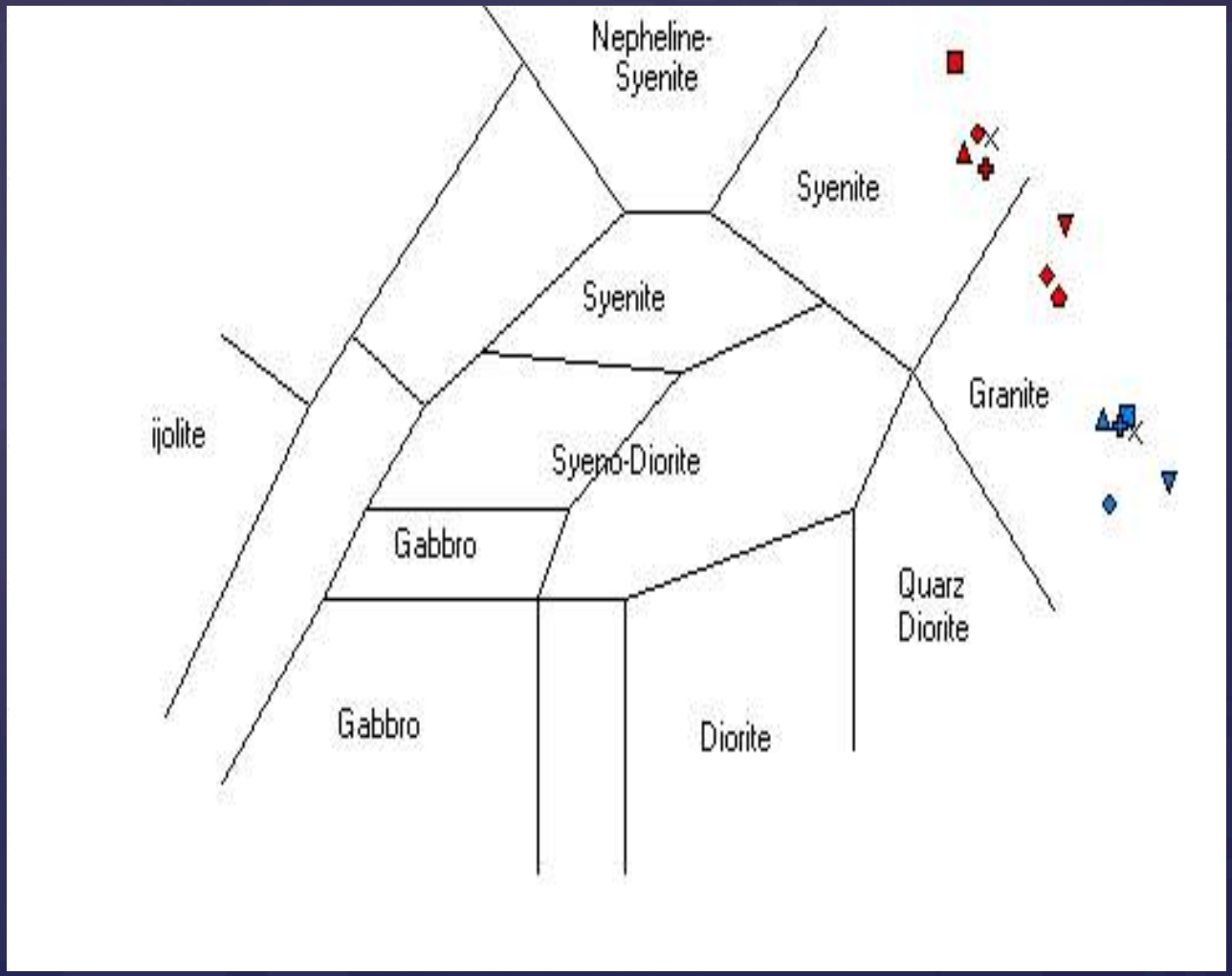


Diagram from Petrograph program

Unlocking K-spars Secret

K-spar Stats

Silicate Group	Tectosilicates (3-D framework)
Chemical Formula	$KAlSi_3O_8$
Varieties	Microcline Orthoclase Sanidine

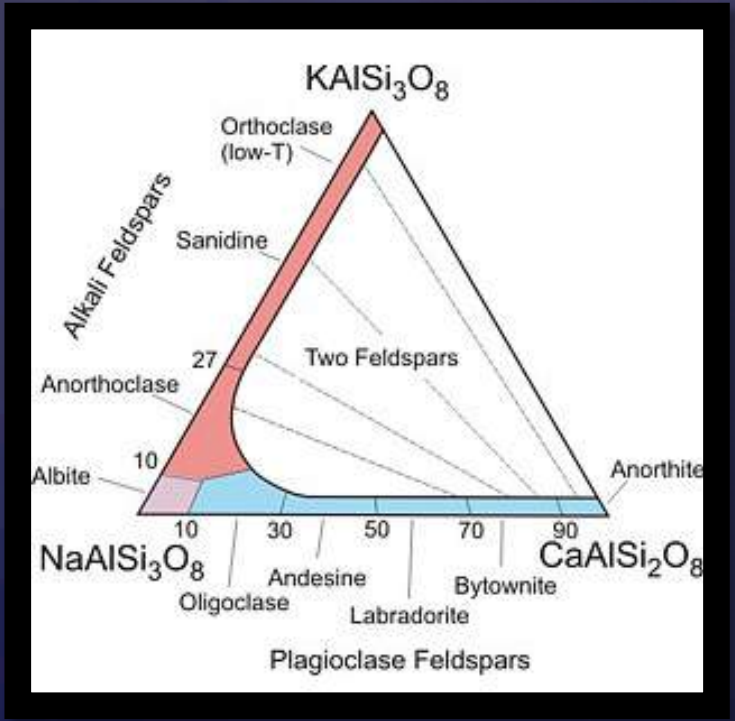


Diagram from: www2.imperial.ac.uk

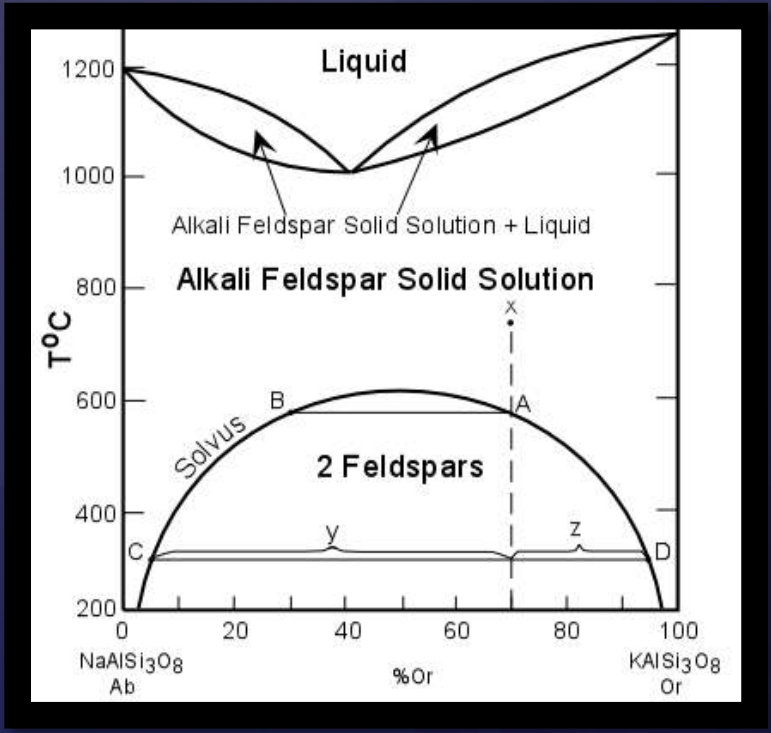


Diagram from: www.tulane.edu/

What's K-spars secret?

- Al^{3+} substitutes for Si^{4+} because of its similar size and charge
- The extent of substitution can be calculated using unit cell parameters measured from XRD
- Can give us information on crystallization setting, such as:
  - Amount of order/disorder
  - When the crystals formed during cooling
- Using this information alongside stratigraphy of rock units, depth of formation can be estimated

Sample preparation

- Select grains from sample ALE-08-26
- Powder them in agate mortar & pestle
- Place in slide cavity
- Insert slide into x-ray powder diffraction machine

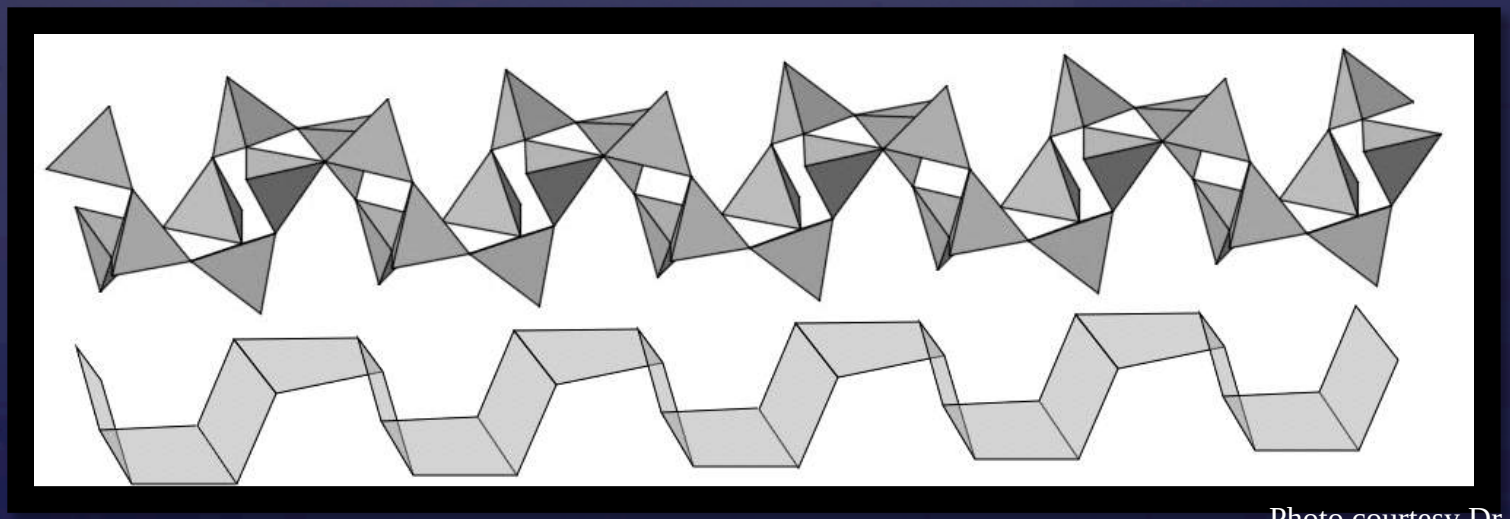
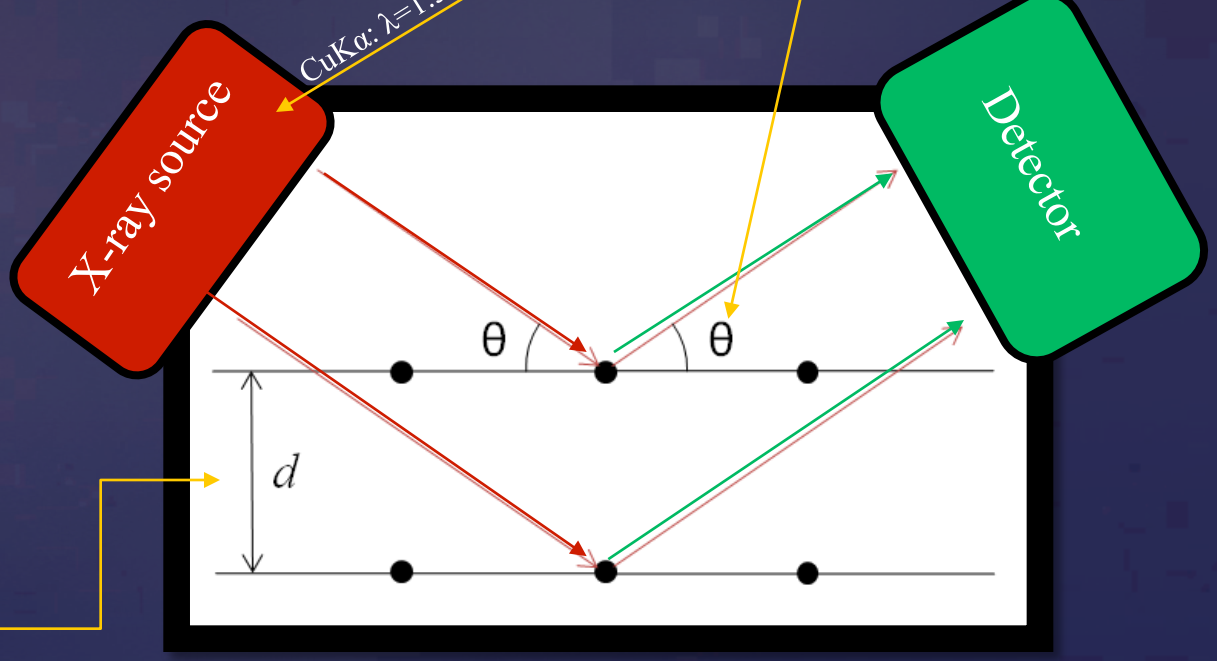


Photo courtesy Dr. Eidukat

X-Ray Powder Diffraction

Bragg equation: $n\lambda=2d\sin\theta$

http://serc.carleton.edu/



http://chemwiki.ucdavis.edu/

D-spacing is unique to each mineral & is used for mineral identification & to determine cell parameters

XRD Results

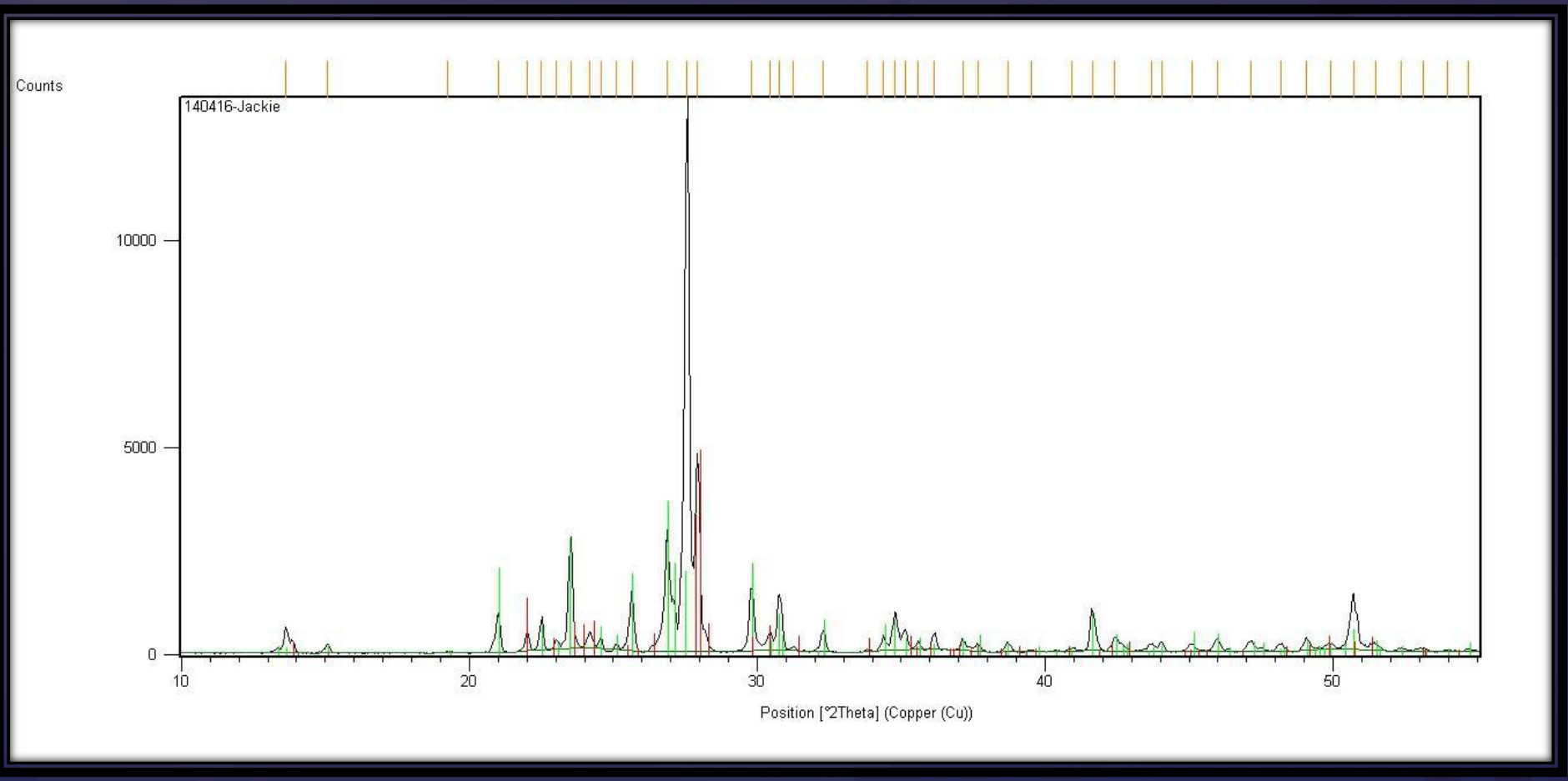


Photo courtesy Dr. Angel Ugrinov

Orthoclase

Albite

Comparing peaks

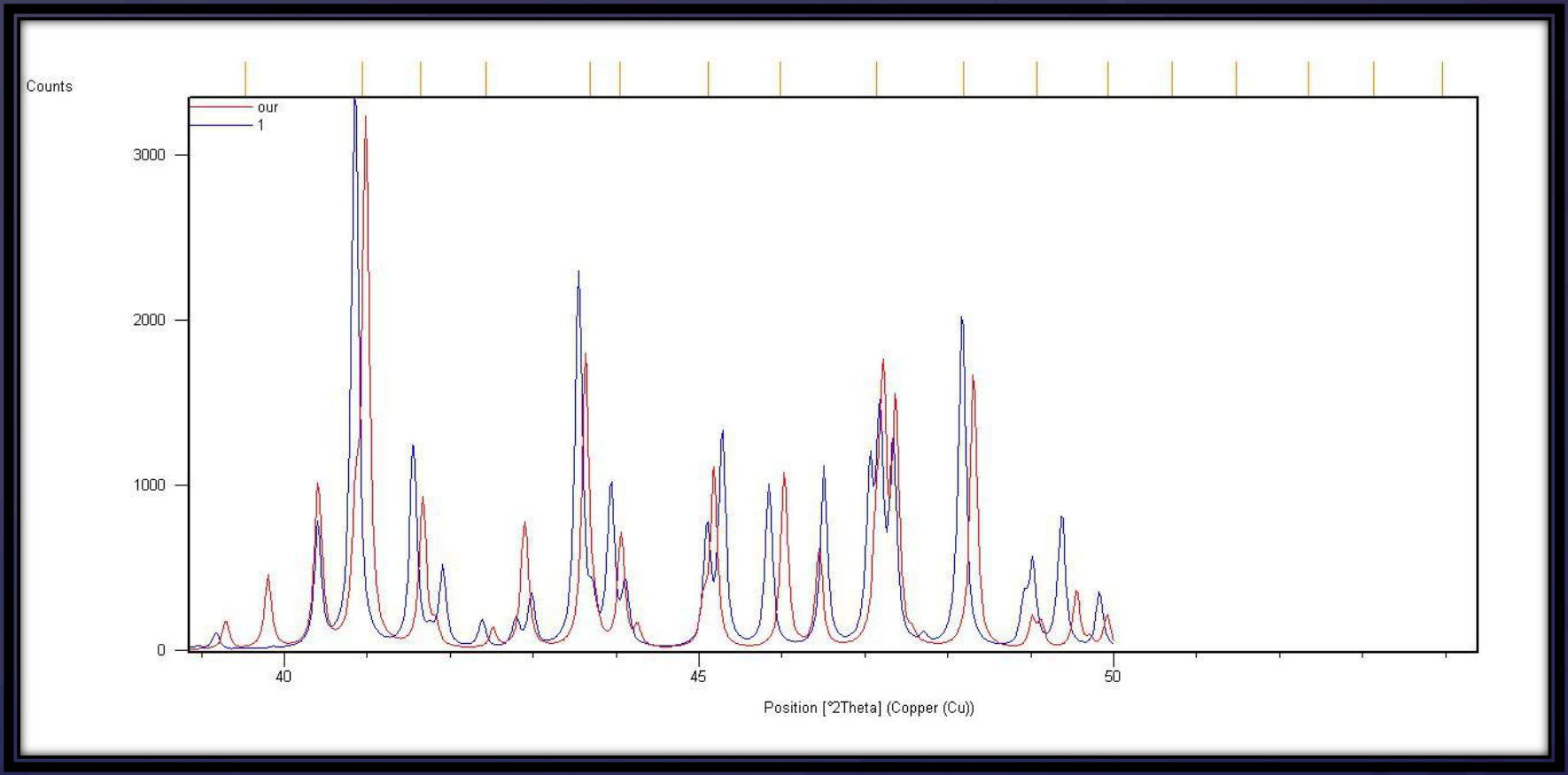


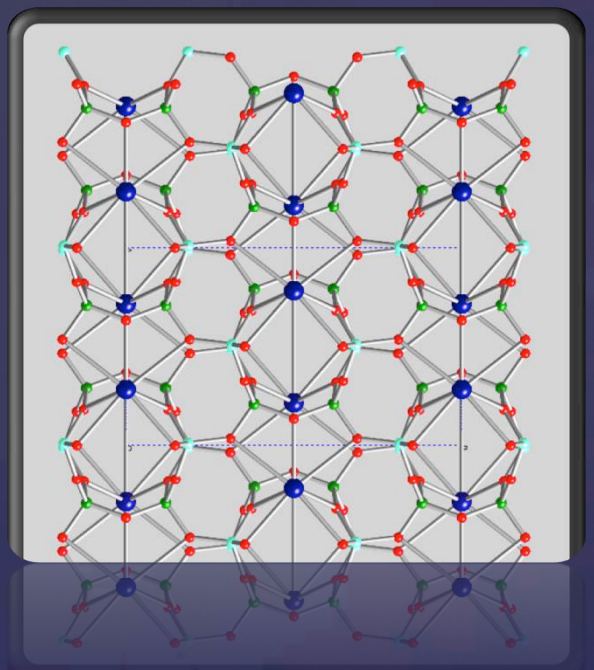
Photo courtesy Dr. Angel Ugrinov

Orthoclase template that matched our peaks

Other orthoclase template

XRD Results

Photo courtesy Dr. Ugrinov



Unit Cell Details	
a	8.5610 A
b	12.9960 A
c	7.1920 A
α	90.0000˚
β	116.0000˚
γ	90.0000˚
Crystal system	Monoclinic
Space group	C2/m
Unit cell volume ($V=abc\cdot\sin\beta$)	719.19 A^3

Unlocking K-spar: Step 1

Determine ^{n}Or – the % orthoclase compared to albite in crystal

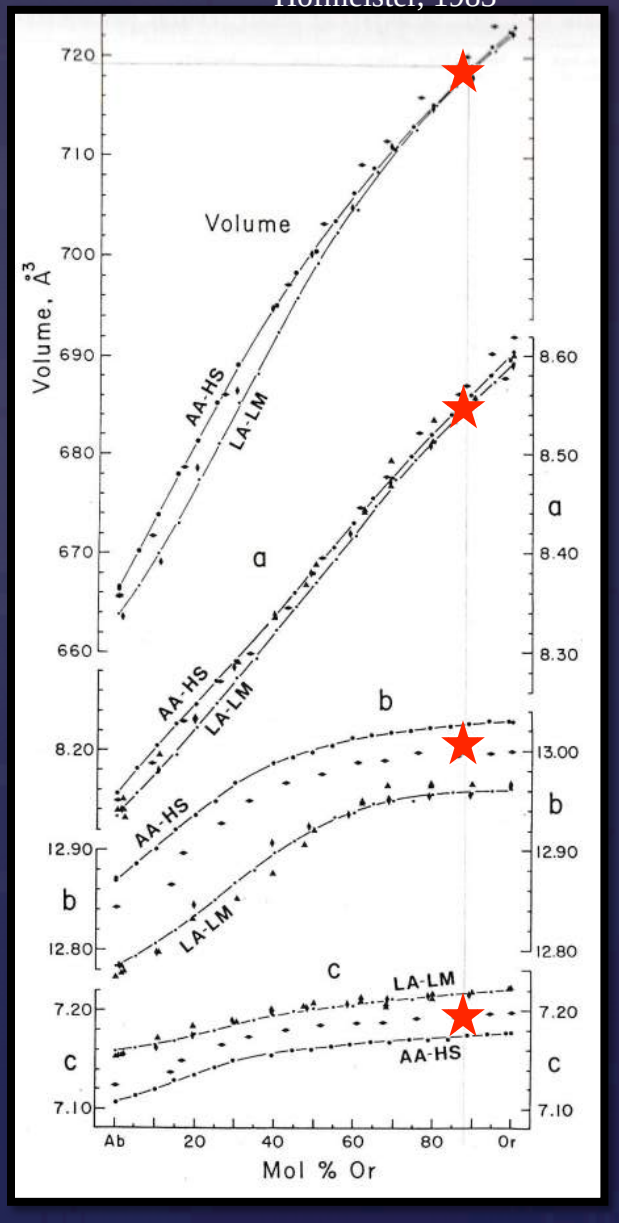
- Use equation from Ribbe & Hofmeister:

$$^{n}Or = (-584.6683) + (2.58732\ V) - (3.83499E\text{-}3\ V^2) + (1.90428E\text{-}6\ V^3)$$

$^{n}Or = 89.07$

- Our cell parameters match AA-HS system the closest (Analbite-High Sanidine) when plotted on the graph

Photo from Ribbe & Hofmeister, 1983



Using the b•c method to determine crystallization characteristics

b and c cell parameters depend on both composition & Al, Si order in alkali feldspars and plagioclases

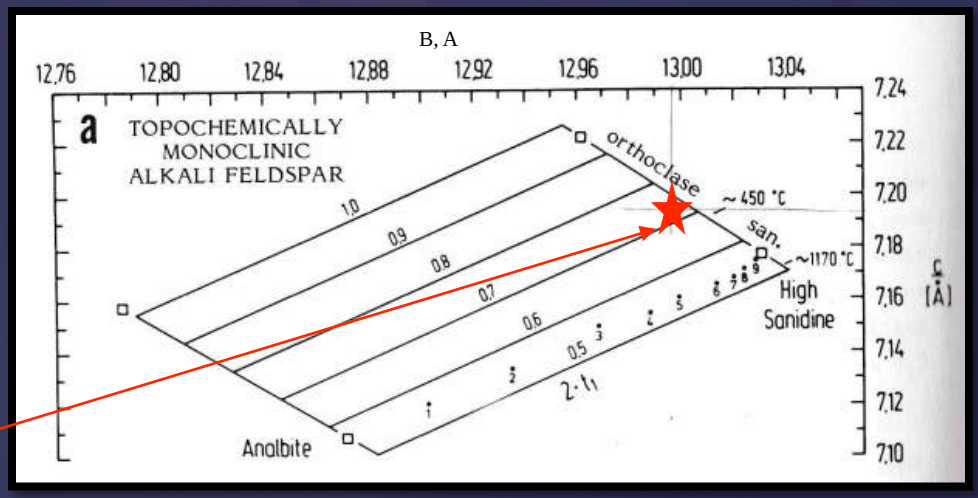


Photo from Ribbe & Hofmeister, 1983

From graph & equations from Ribbe & Hofmeister,

$2t_1 = 0.7194$

LA-LM series: fully ordered ($2t_1 = 1.00$)
AA-HS series: fully disordered ($2t_1 = 0.50$)

From this, our sample is found to be slightly disordered.

Conclusion from b•c method

Database predictions for T1 & T2 Al concentrations:
T1= 35% Al, 65% Si
T2= 15% Al, 85% Si

Al from T2 concentrated/migrated to T1 site, but no Al from t_1m migrated to t_1o site-

Therefore, our K-spar is relatively disordered & formed in the 1st half of crystallization.

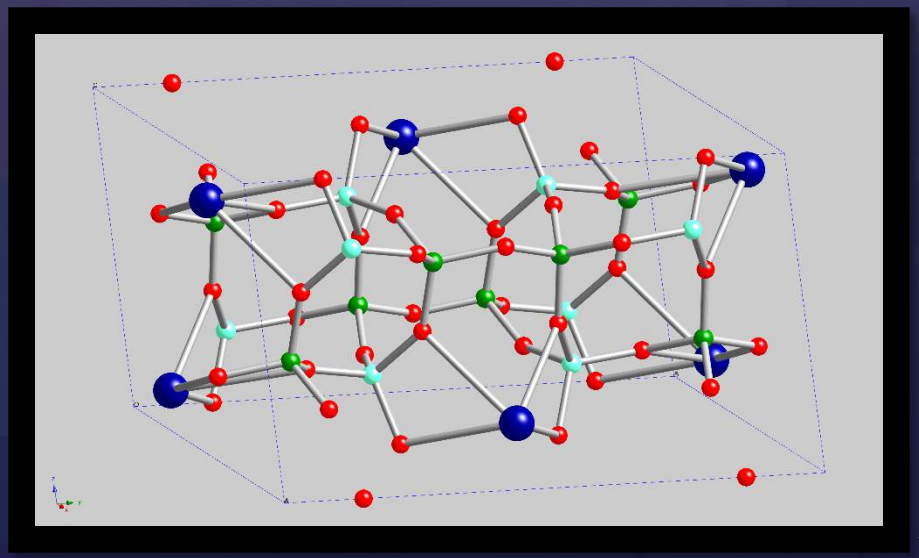


Photo courtesy Dr. Ugrinov

The [110] Method

- During ordering Al concentrates in the t_1o tetrahedra sites.
- 4-fold rings arranged along [110] become depleted
- In monoclinic feldspars the most contraction is along the b axis
- Translation distances along [110] and [110] are measured to determine ordering

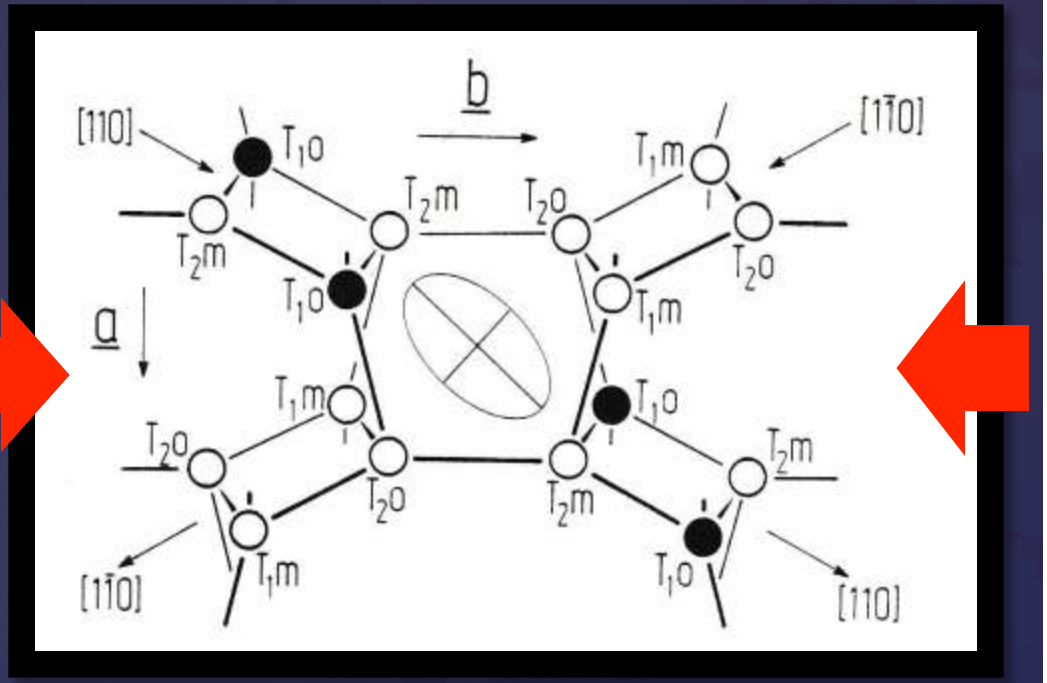
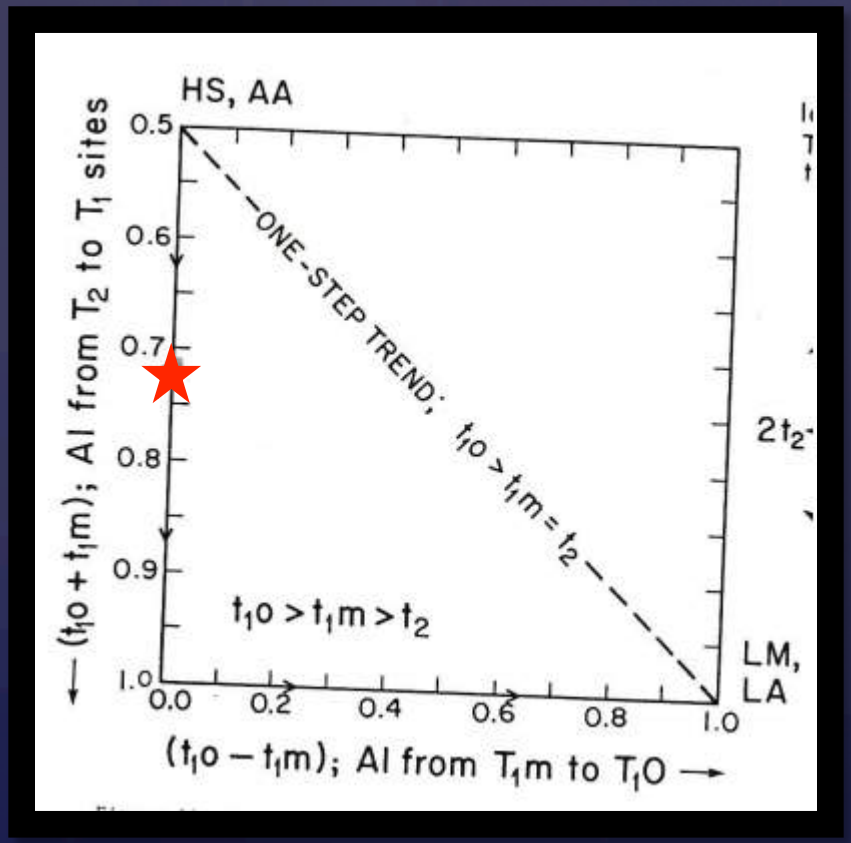


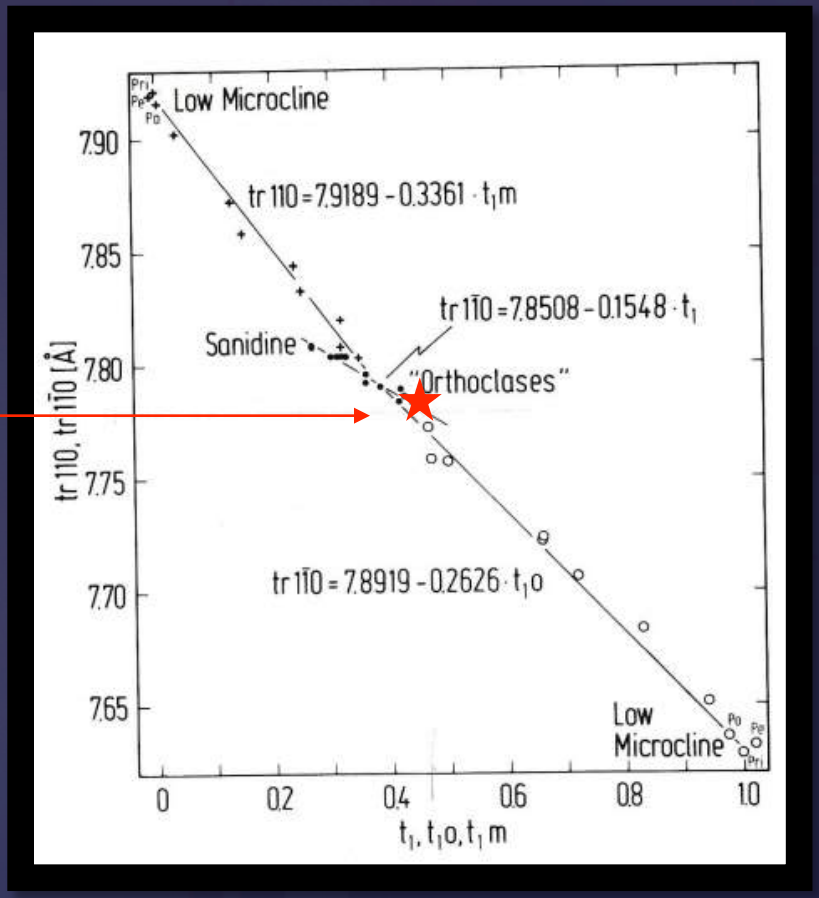
Photo from Ribbe & Hofmeister, 1983

From Ribbe & Hofmeister equations:

tr[1$\bar{1}$0] = 7.7812 A
tr[11$\bar{0}$] = 7.7812 A

T_1, t_1o, t_1m = 0.465





[110] Method conclusions:
Relatively disordered crystal that formed in the 1st half of crystallization

Photos from Ribbe & Hofmeister, 1983

Cobble's Conclusion

What is the whole rock chemistry?

The samples are calc-alkaline

The powder pellet results show that the samples are all granitic

The glass bead results show most of the cobbles to be syenites

Crystallization Characteristics?

K-spar is relatively disordered and formed during first half of crystallization

Is it possible to trace samples to a pluton?

No

With the data we collected, it is not possible to determine a parent pluton due to the striking similarities between plutons.

Although their secret was unlocked, the cobble's did not find their home…

Thank you!

References

Allibone, A. H., Cox, S. C., Graham, I. J., Smillie, R. W., Johnstone, R. D., Ellery, S. G., Palmer, K., 1993. Granitoids of the Dry Valleys area, southern Victoria Land, Antarctica: plutons, field relationships, and isotopic dating. New Zealand Journal of Geology and Geophysics 36, 281-297.

Smillie, R. W., 1992. Suite subdivision and petrological evolution of granitoids from the Taylor Valley and Ferrar Galcier region, south Victoria Land. Antarctic Science 4, 71-87.

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Thank you

Dr. Eidukat

Dr. Lewis

Dr. Ugrinov

WERG Lab