Analysis of the Chalky Buttes Member

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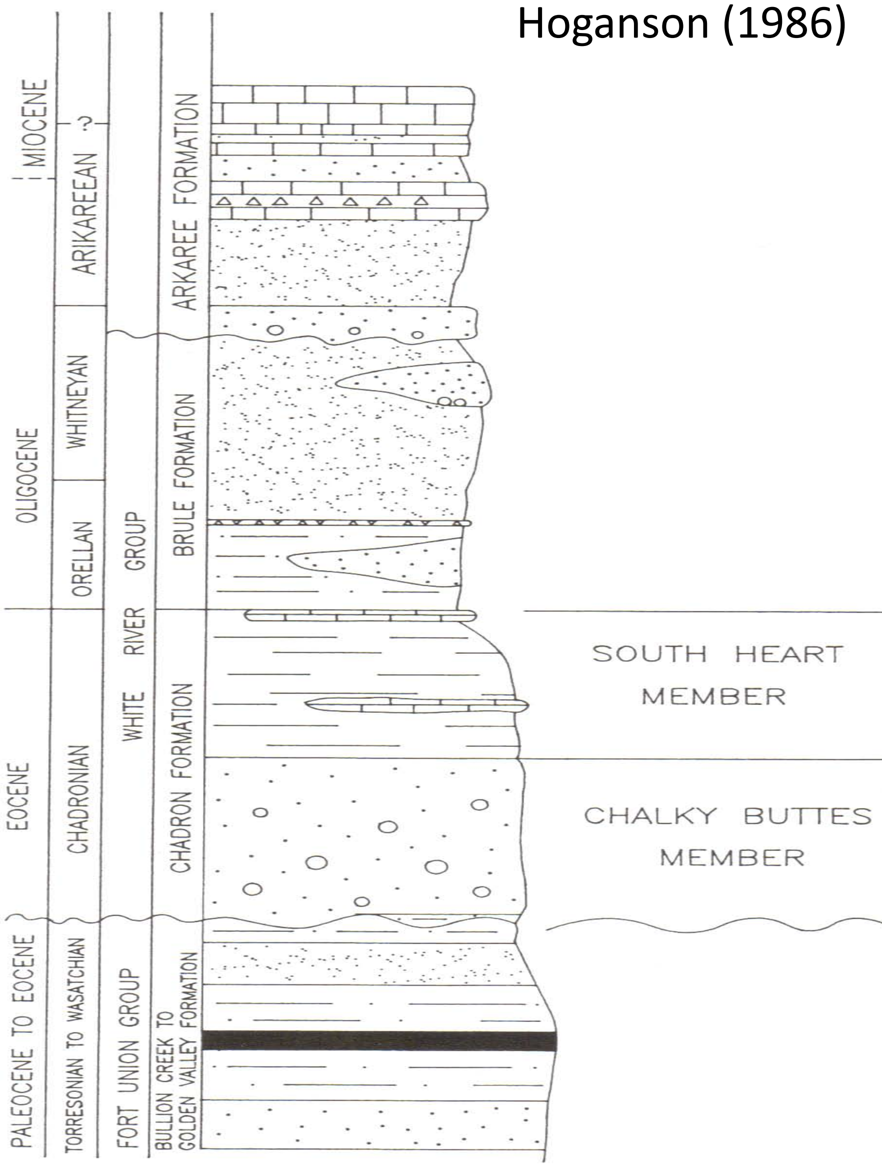
Petrology Term Project

Overview

- Background information
- What we want to determine
- Methods
- Results
- Further research

Generalized North Dakota Stratigraphy

Hoganson (1986)



Picture of little badlands near South Heart, North Dakota.
(Courtesy of Ashley Steffen)

Cobbles of the Chalky Buttes Member

- Igneous
  - Volcanic porphyry
  - Pumice
  - Ignimbrite
  - Granite (Hoganson 1986)
- Sedimentary
  - Sandstone
  - Conglomerate
  - Breccia
  - Chert
- Petrified wood
- Quartzite

What we want to Determine

- What exactly are the volcanic porphyry's?
- Are the phenocrysts related to the sediment that the porphyries lie in?
- What is the depositional environment?
- Where is the origin of the cobbles?

Analytical Methods

- Hand specimen observation
- Petrographic microscope
- XRD
- SEM
- Binocular microscope

Volcanic Porphyry

- An igneous rock that is formed by the cooling of magma in two stages.

  1) Slow cooling forms large crystals in the melt called phenocrysts.

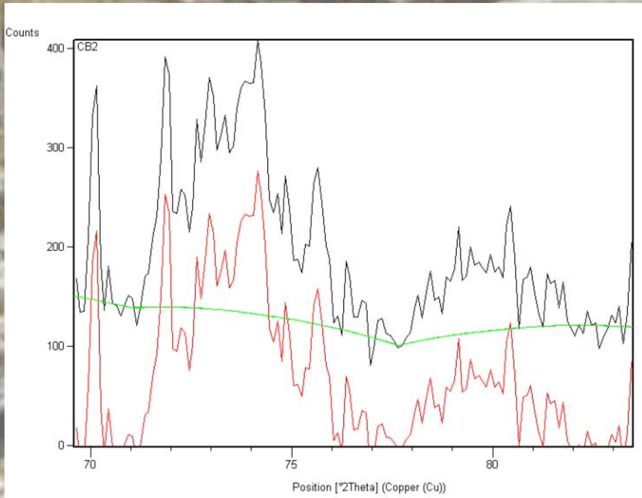
  2) Rapid cooling, possibly caused by an eruption, produces a fine grained matrix that surrounds the phenocrysts.

So what are the Volcanic Porphyries?

- Rock history
  - Phenocrysts
  - Matrix
- Rock classification
  - Composition
- Methods used
  - XRD
  - Petrographic Microscope

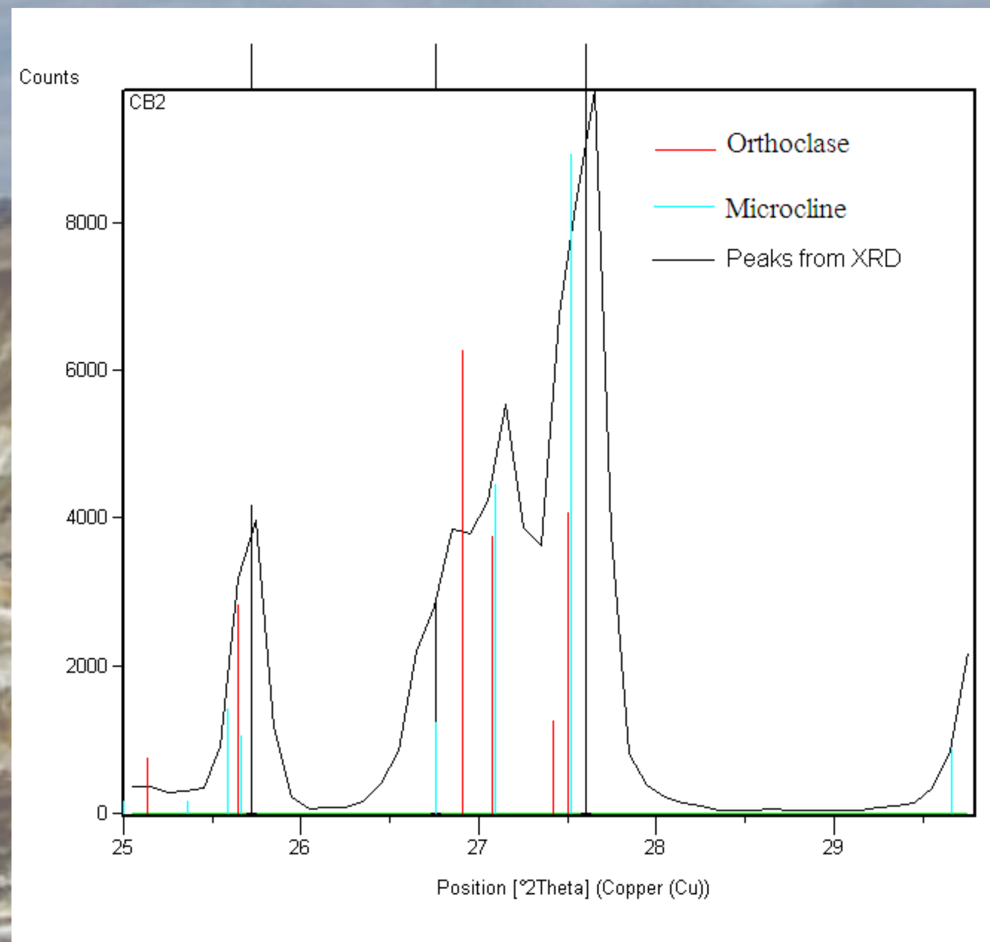
X-Ray Diffraction

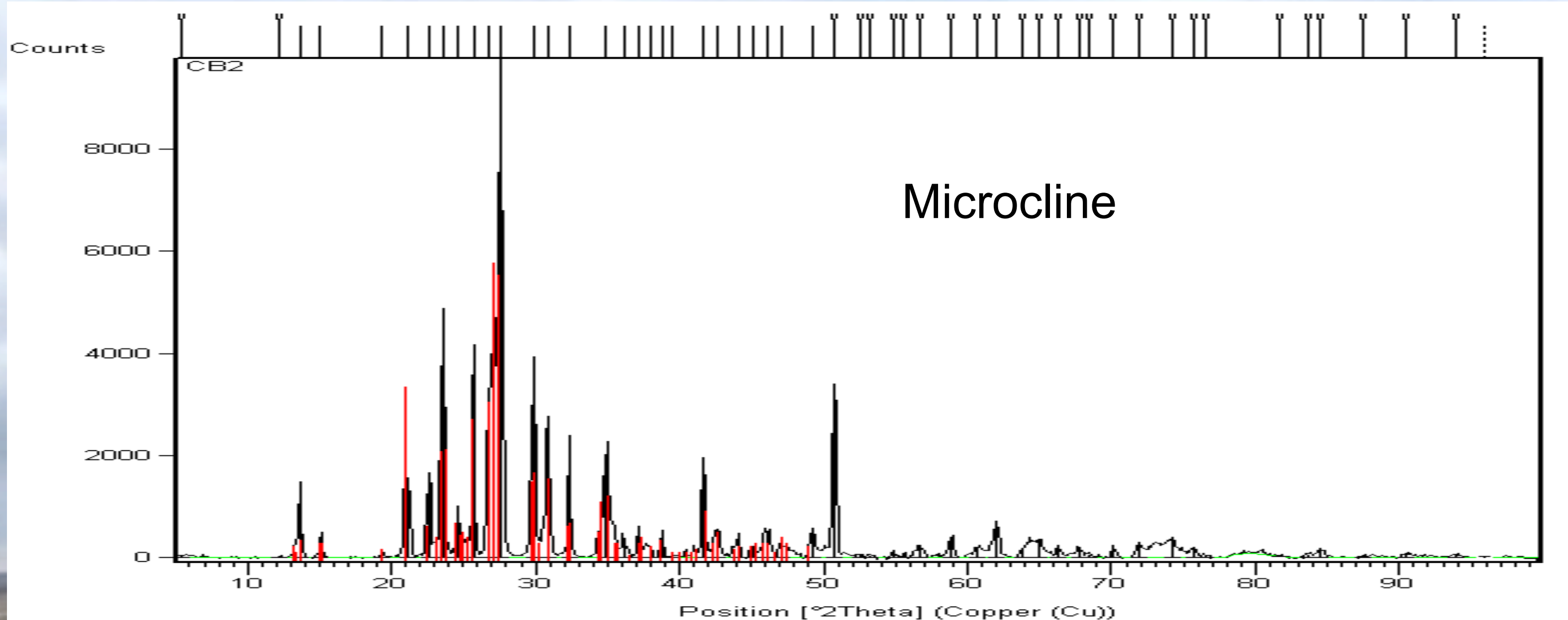
- Preparation
  - Crushed rock
  - Separated phenocrysts
  - Powdered
- Angel ran the samples!
- Removed background
  - Data easier to work with

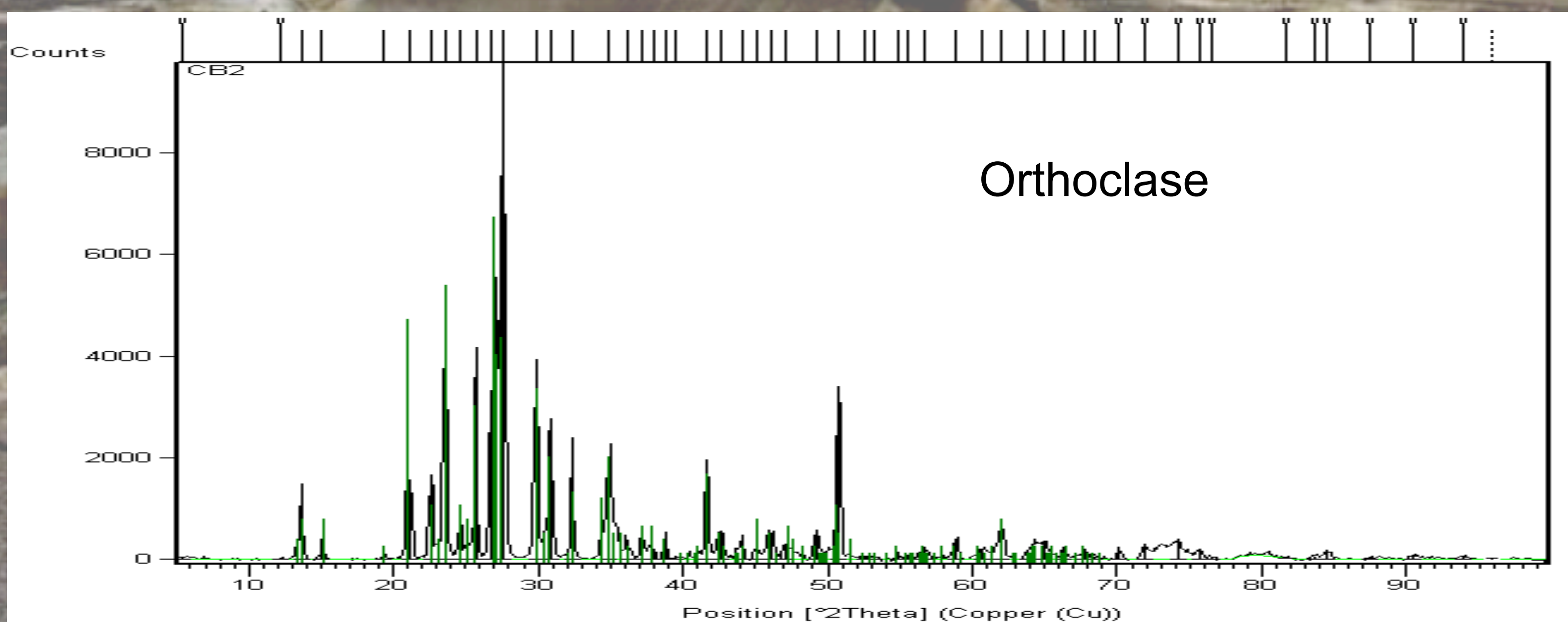


X-Ray Diffraction

- Phenocrysts
  - Orthoclase
    - Highest score
  - Microcline
    - Very close second
    - Shifted

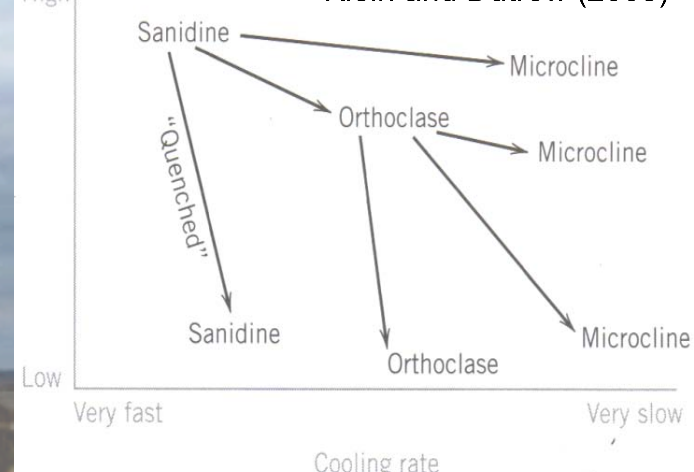



Counts
CB2
Microcline
8000
6000
4000
2000
0
10
20
30
40
50
60
70
80
90
Position [°2Theta] (Copper (Cu))

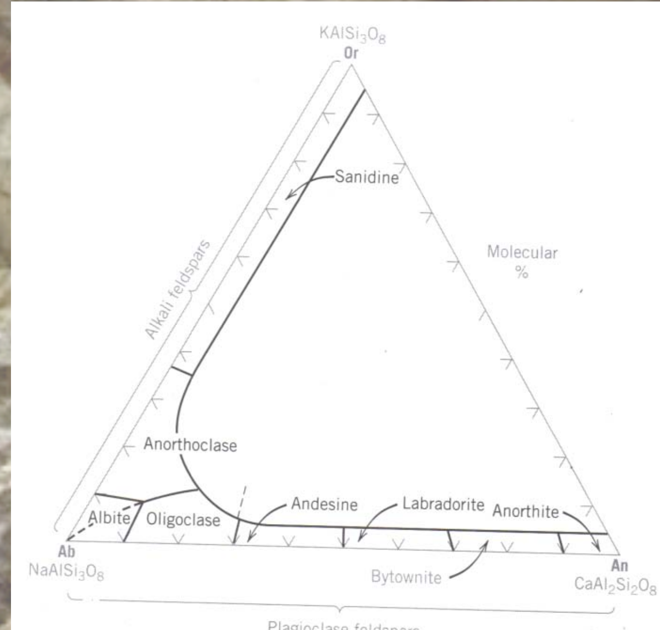

Counts
CB2
Orthoclase
8000
6000
4000
2000
0
10
20
30
40
50
60
70
80
90
Position [°2Theta] (Copper (Cu))

X-Ray Diffraction

- Matrix
  - Sanidine
    - Cooled faster than Phenocrysts
    - Na content
  - Anorthoclase
    - Na content
  - Orthoclase
    - Cooled quicker than phenocrysts
  - Microcline
    - Possibly contamination
  - No Quartz
    - Bottom half of QAPF

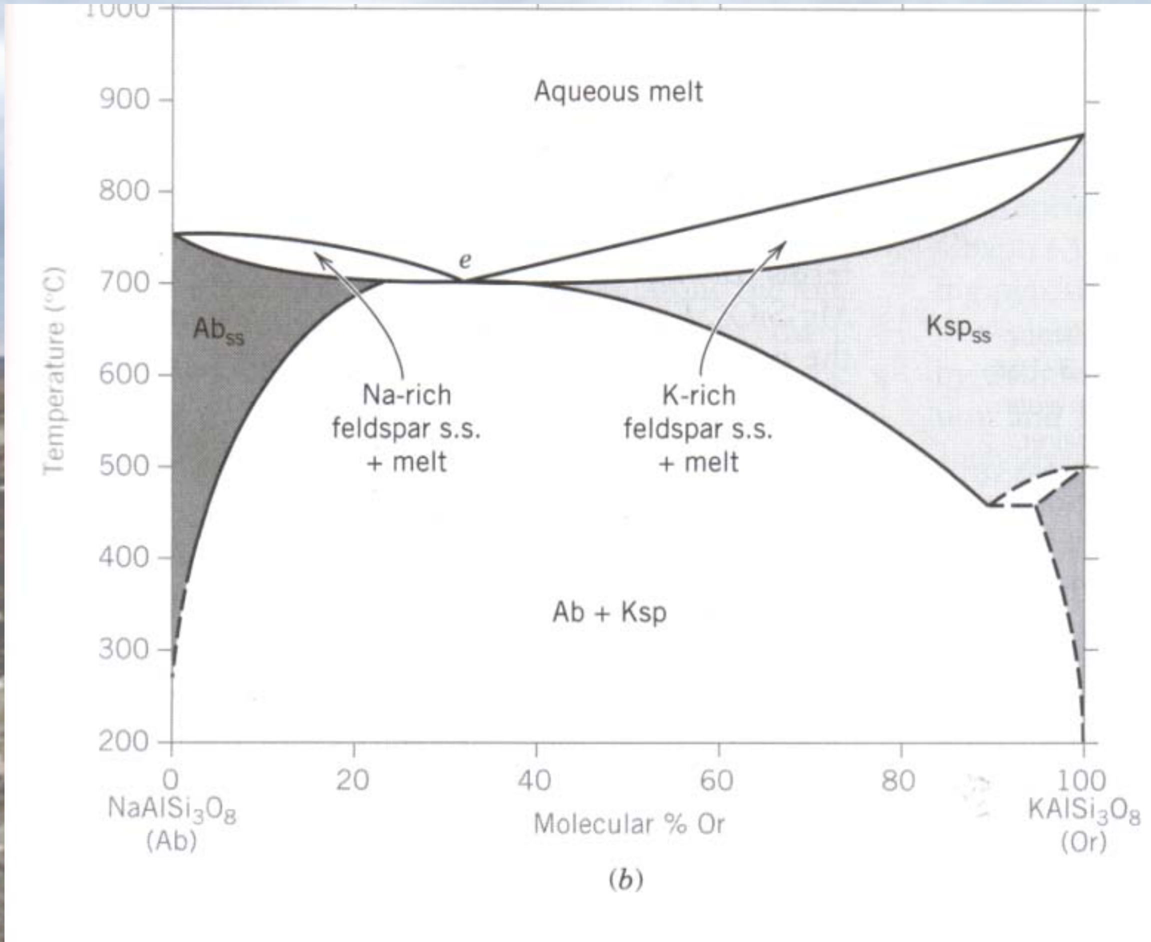


Klein and Dutrow (2008)



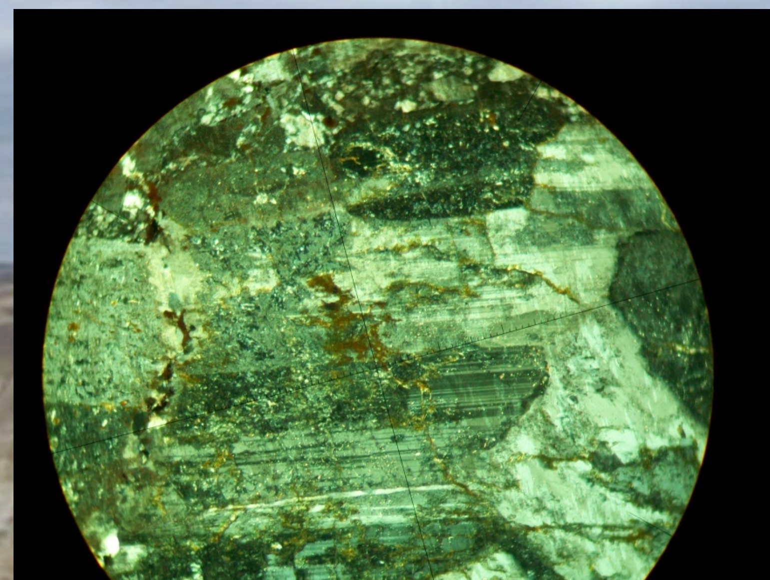
Klein and Dutrow (2008)

Phase Diagram



Petrographic Microscope

- Phenocrysts
  - Nepheline-$(Na,K)AlSiO_4$
    - Uniaxial (-)
  - Orthoclase-$KAlSi_3O_8$
    - Biaxial (-)
  - Plagioclase-$CaAl_2Si_2O_8$, $NaAlSi_3O_8$
- Matrix
  - Mostly unidentifiable
- Accessory minerals
  - Biotite



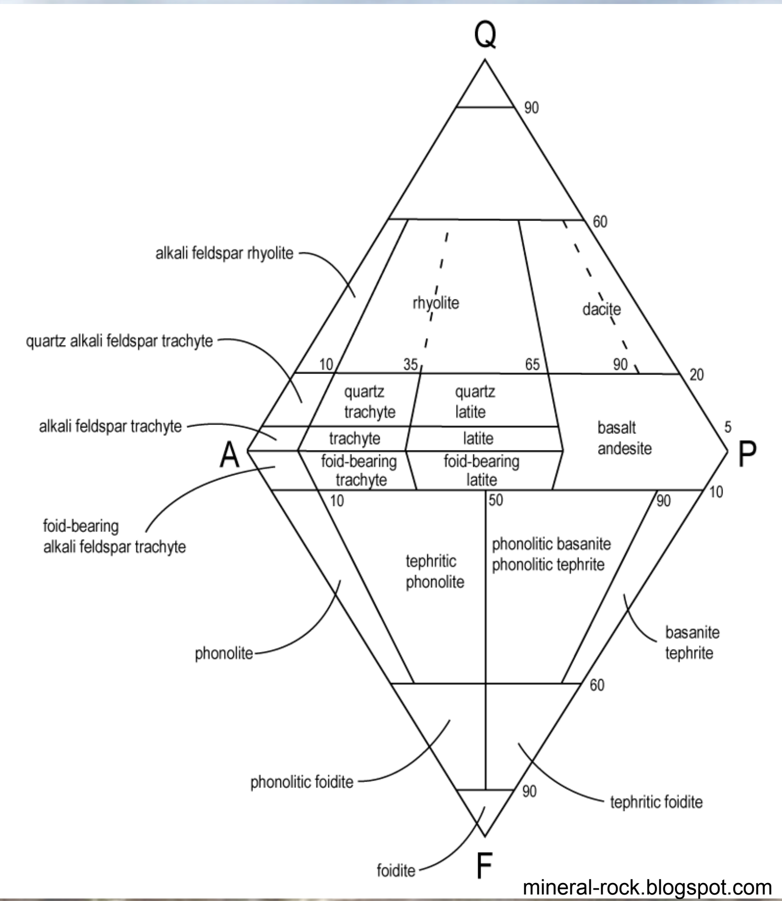
Thin Section from different rock than XRD sample

Implications

- XRD data and petrographic microscope analysis did not correlate
  - Contamination
  - Analytical Error
  - Absolutely no human error
  - Samples came from different porphyritic cobbles
    - Porphyries can vary

So what are the Volcanic Porphyries?

- Hoganson (1986)
  - Quartz Latite Porphyry
    - No Quartz!
    - Felspathoid Minerals!
- Foid Bearing Trachyte Porphyry?
  - Unsaturated
  - Alkali rich
  - Some plagioclase



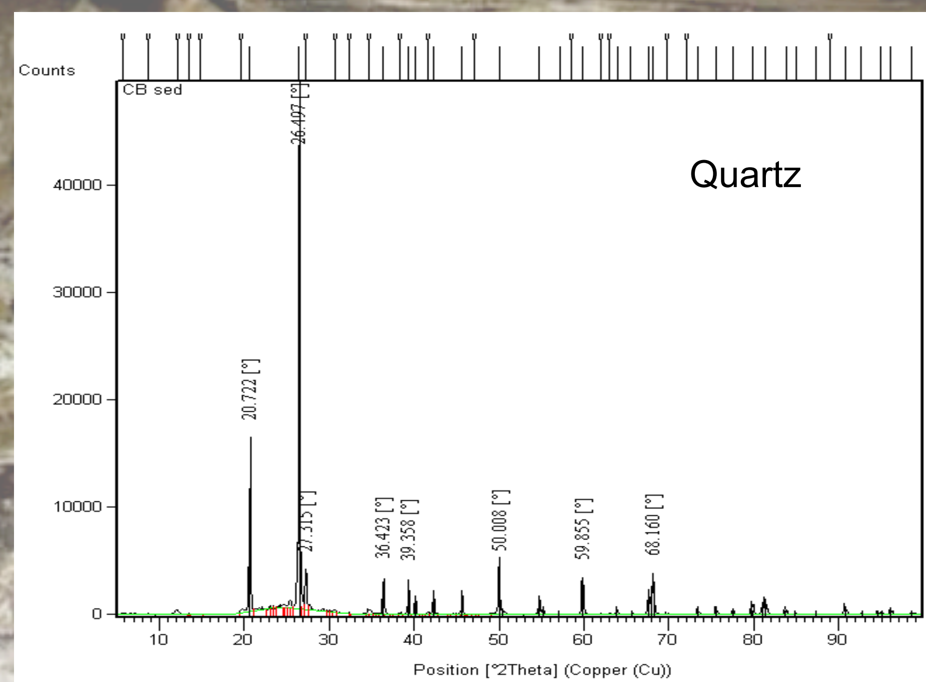
We used two thin sections and XRD analysis and they were all different in composition.

Is the Sediment Related to the Phenocrysts?

- Methods
  - XRD
  - Petrographic microscope
  - Binocular microscope
- Phenocrysts
  - Microcline (XRD)
  - Orthoclase (XRD and PM)
  - Nepheline (PM)

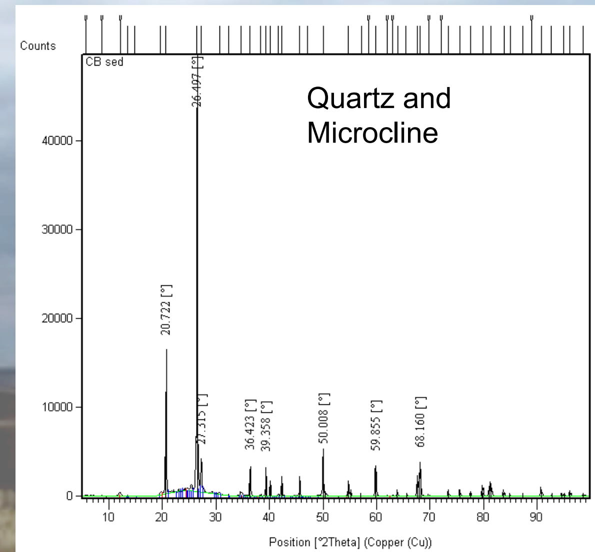
Sediment Composition

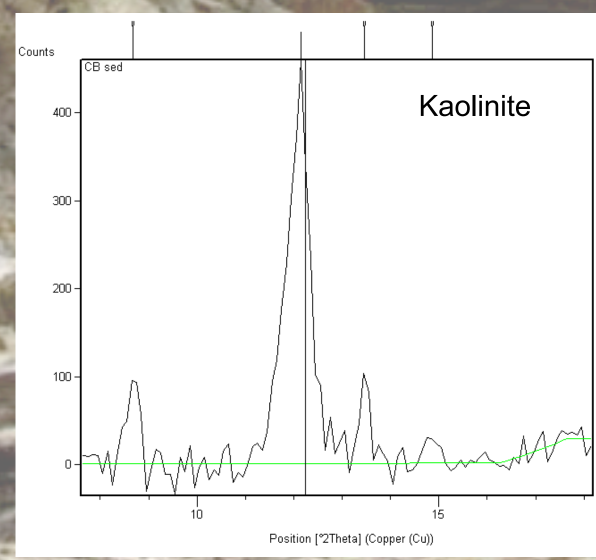
- XRD
  - Quartz is obvious
    - 50,000 COUNTS!
    - Other peaks are present though
- Binocular microscope
  - Know that feldspar is present



Sediment Composition

- Microcline
  - Highest feldspar score
  - Represents many peaks
- Peak at 12.25
  - Kaolinite
    - Weathered product of K-spar



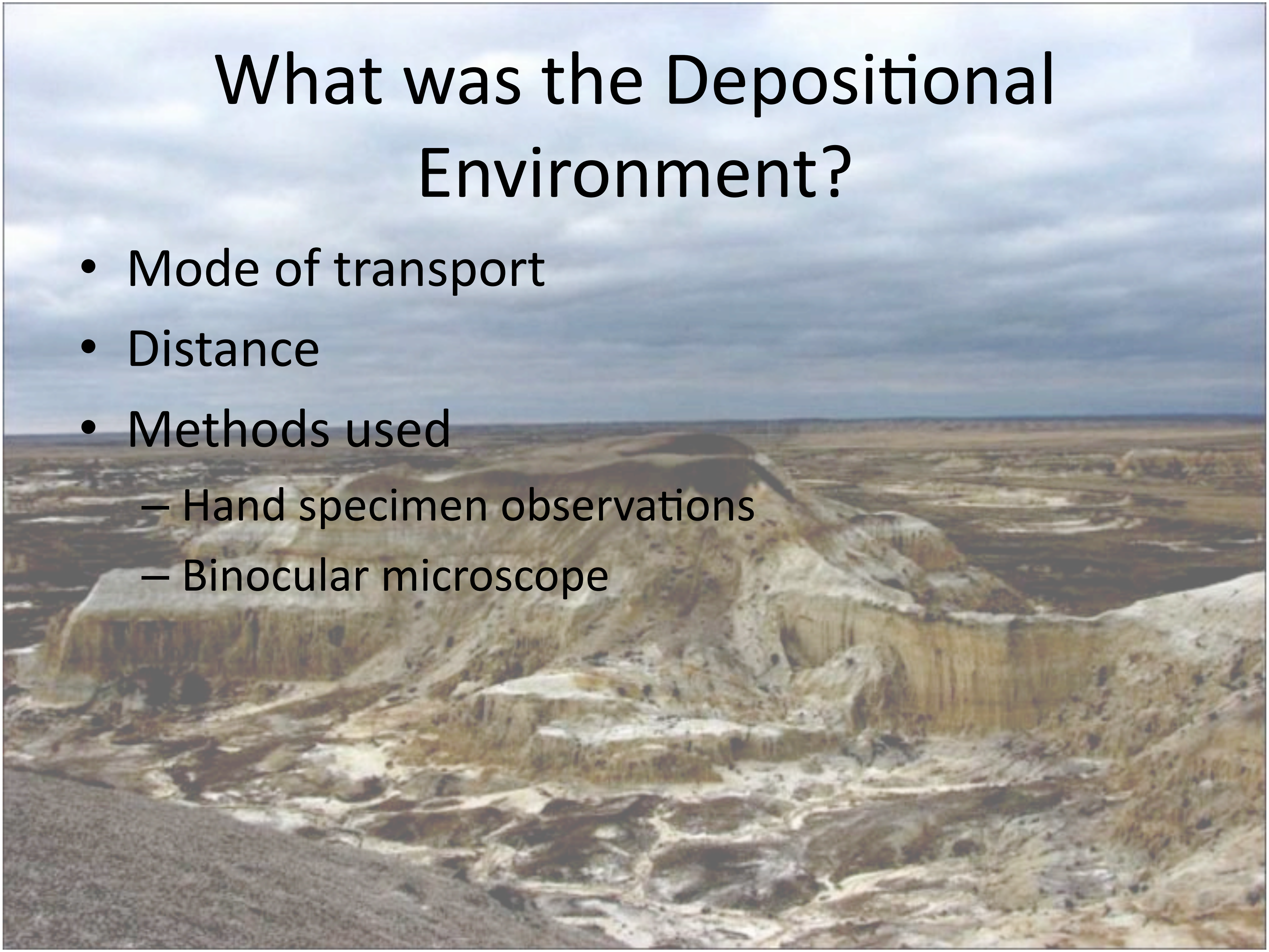


Are they related?

- Microcline present in phenocrysts and sediment
- Found orthoclase and nepheline in phenocrysts, but none found in sediment

PLAUSIBLE

What was the Depositional Environment?



- Mode of transport
- Distance
- Methods used
  - Hand specimen observations
  - Binocular microscope

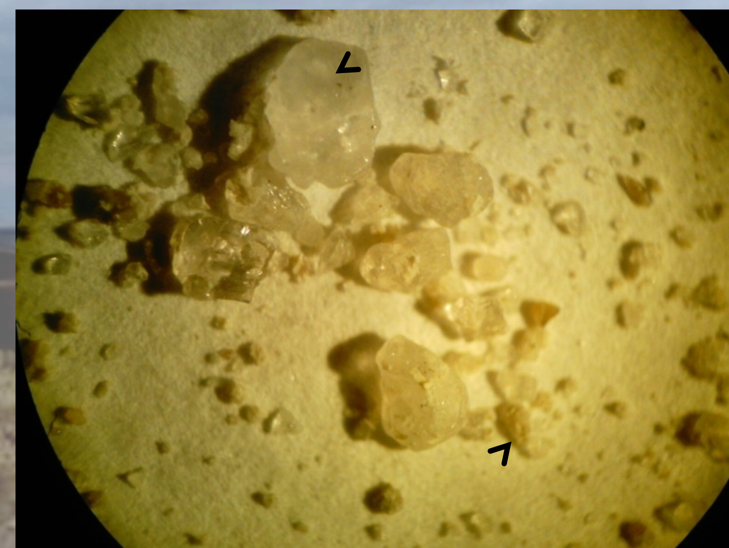
Mode of Transport

- Braided river
  - Cobbles
  - High amounts of erosion
    - Laramide Orogeny
  - Steep gradient
- Climate-Cooling trend in Cenozoic
  - Provides right conditions for alpine glaciers


http://gsc.nrcan.gc.ca/landscapes/details

Binocular Microscope

- Sandstone grains
  - Feldspar
    - Smaller
      - Hardness 6
    - Subrounded
  - Quartz
    - Larger
      - Hardness 7
    - Subrounded



The size of the cobbles imply a nearby source while sandstone grains imply a distant source = A HUGE braided river that experienced periodic flooding from a distant source

Criteria for Source of Cobbles

- Volcanic Area
- Sedimentary Rocks
- Not too far and Not too close
- Alpine glaciers
- Uplift in Early Cenozoic
- High relief

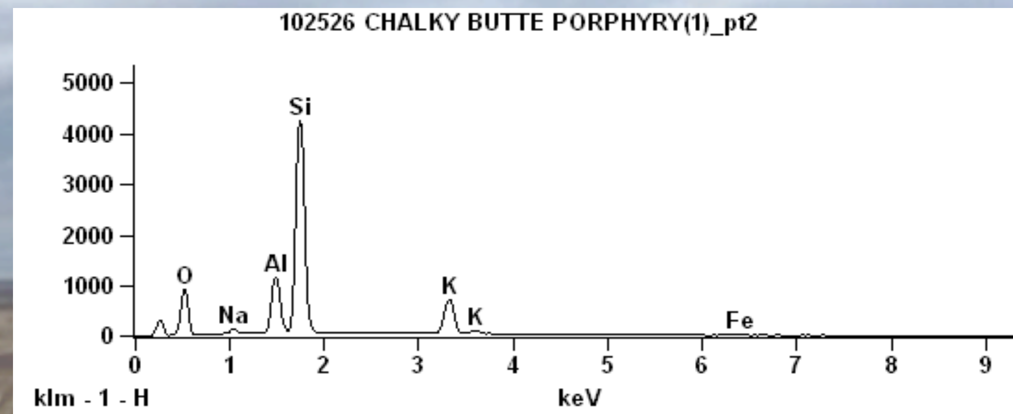
Clausen (1983)

- Source to the North
  - Glaciofluvial
  - Pleistocene age
  - Crossbedding = South (Ashworth 1986)
- Hand samples
  - Don't represent Canadian Shield rocks
  - No striations

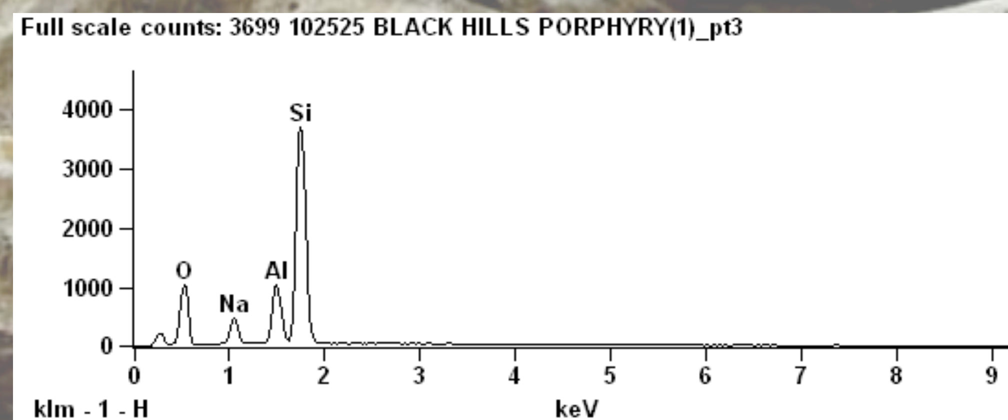
"In order to accept Clausen's claim for a Pleistocene age for the Chadron Formation, fundamental geological principles such as superposition and faunal succession would have to be abandoned."
Ashworth (1986)

Stone (1973)

- Black Hills origin
  - No glaciation
  - Little volcanics
  - Relatively low relief
  - Some porphyries



Chalky Buttes porphyry matrix



Black Hills porphyry matrix

Comparisons on the analysis of both areas preclude the area as a source (Ashworth, 1986).

Denson and Gill (1965)

- Northern Wyoming origin
  - Absaroka and Beartooth Mountains (Carson et al, 1997)
    - Glaciated
    - Volcanic activity during Eocene
    - High relief
    - Eocene dominated by uplift
    - Sedimentary rocks
  - Eocene and Oligocene explosive volcanic activity blanketed the Yellowstone National Park area (Levin 2006).
    - Possible source of Ignimbrites

AGE		STRATIGRAPHIC UNIT		LITHOLOGY	
Cenozoic	Quaternary			drift, alluvium, colluvium	
	unconformity				
	Tertiary (Eocene)	Absaroka Volcanic Supergroup		tuffs, breccias, and other volcaniclastic rocks; flows, dikes, sills, and stocks; generally andesitic/dioritic	
		Crandall Conglomerate (west)	Willwood Formation (east)	conglomerate with carbonate clasts	clay, sandstone, and shale; thick conglomerate at base
unconformity					
Mesozoic	Cretaceous	seven formations		sandstone, shale	
	Jurassic	three formations		shale, sandstone, limestone, gypsum	
	Triassic	Chugwater Formation		red siltstone, shale, sandstone	
		Dinwoody Formation		siltstone, gypsum, dolomite	
	Permian	Park City Formation		limestone, dolomite, chert, shale	
Paleozoic	Pennsylvanian	Tensleep Sandstone		quartzose sandstone	
	Mississippian	Amsden Formation		shale, siltstone, limestone, dolomite	
		Madison Limestone			
	Devonian	Three Forks Formation		dolomite, shale, limestone	
		Jefferson Dolomite			
		Beartooth Butte Formation		siltstone, limestone	
	unconformity				
	Ordovician	Bighorn Dolomite			
	Heart Mountain detachment horizon (2 m above base of Bighorn Dolomite)				
	Cambrian	Snowy Range Formation	Grove Creek Member	shale, flat-pebble conglomerate	
		Pilgrim Limestone			
		Gros Ventre Group	Park Shale		
			Meagher Limestone		
			Wolsey Shale		
		Flathead Sandstone		quartzose sandstone	
unconformity					
Precambrian	ARCHEAN			granitic rocks, gneiss	

Figure 4. Rock units present in the Clarks Fork area (after Pierce, 1965).

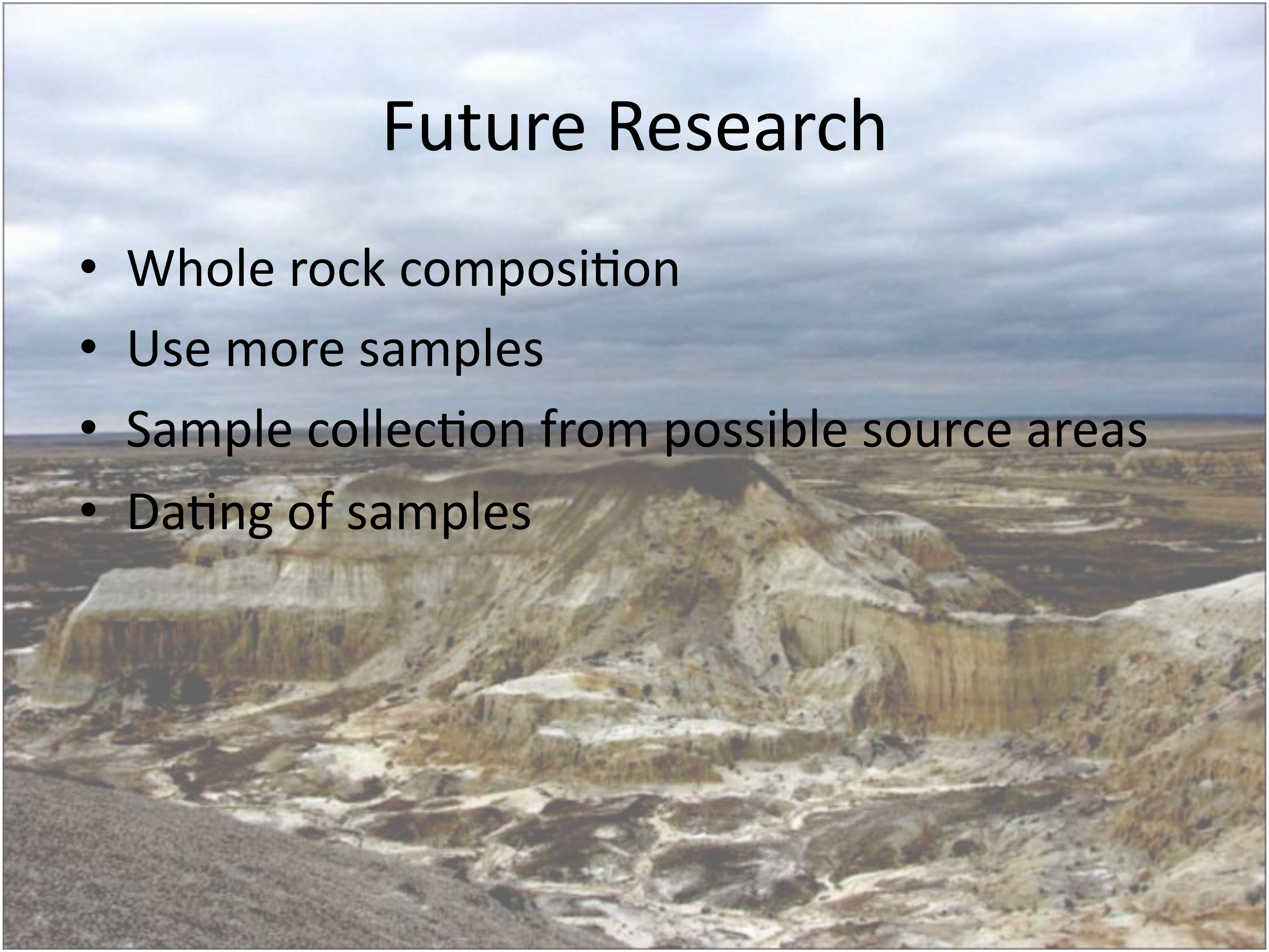
(Carson et al, 1997)

Conclusions

- The deposition of the Chalky Buttes Member could be complex with multiple source areas
- More than likely came from Northern WY
- Volcanic porphyries vary
  - Specific origin may be difficult to determine
    - Make general interpretations
- Further research is needed

Future Research

- Whole rock composition
- Use more samples
- Sample collection from possible source areas
- Dating of samples



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What is your question, ANDY?


Other Questions?

Special Thanks to:

- Angel
- Dr. Eidukat
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