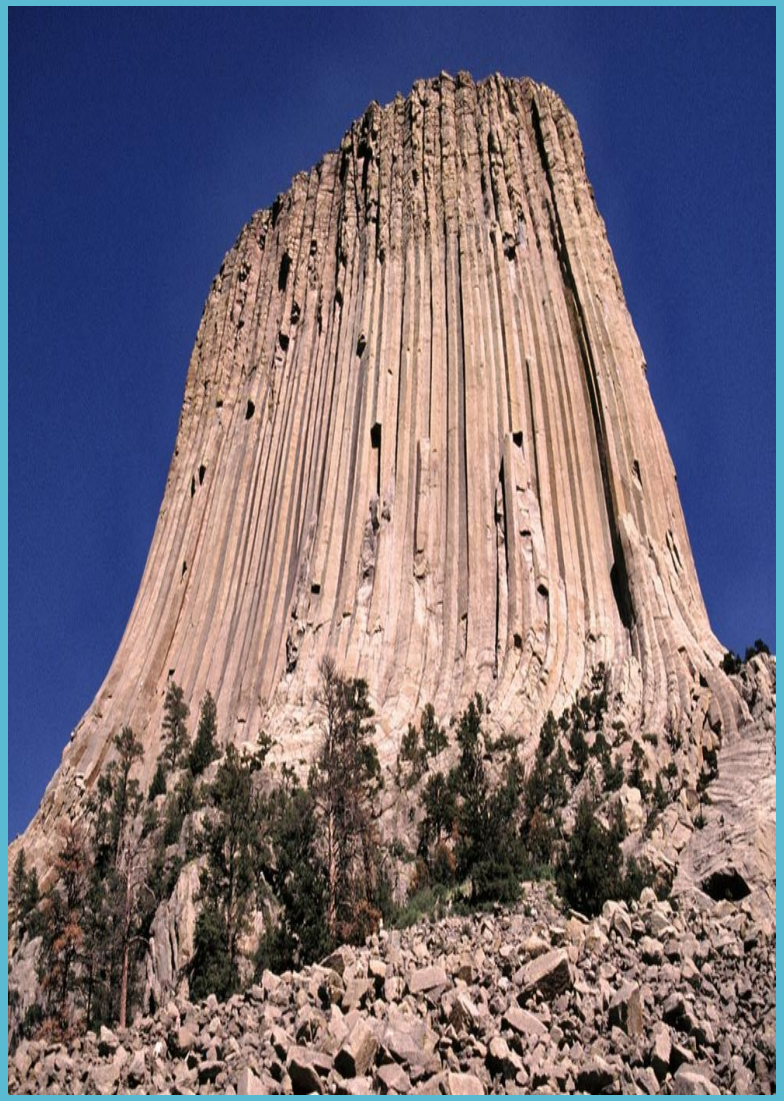
Comparative Analysis of Devils Tower and Bridal Veil Falls



By Mitch Halseth and R.J. Glander
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NDSU Petrology 422

Devils Tower

Location

(Holverson, 1980)

Devils Tower is located in northeast Wyoming, near the South Dakota and Montana boarders.

Positioned in the Wyoming stretch of the Black Hills.

534.6 Miles southwest of Fargo, North Dakota

303 Miles north of Wyoming's capital city Cheyenne.

412 miles east of Yellowstone National Park.

Theories

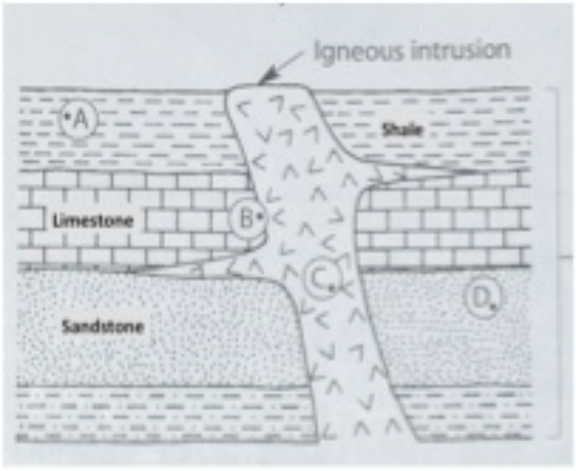
1. **Intrusion or Laccolith** - The intrusion theory explains the phenomenon of Devils Tower quite well, and is the most accepted theory to date. The theory suggests that an igneous body of magma intruded the sedimentary rock formations surrounding the area. As the magma ascended it cooled and over time it was uplifted and eroded forming what we know today as Devils Tower.

2. **Volcanic Neck-** The volcanic neck theory explains Devils Tower with volcanism. Supporters of the theory believe that the tower represents remnants of an underground magma chamber in which the "plumbing" of the system became plugged and this "plug" is what we now call Devils Tower. Scientific research shows no evidence of any volcanism in the area; including ash deposits, lava flows, or magma chambers. Believers in this theory believe that any volcanic evidence has been merely eroded away; needless to say believers were more numerous at the turn on the 20th century before any hard scientific research had been done.

3. **Native American Lore-** The earliest of the theories, it suggests Devils Tower is a "gift from God" and its existence cannot be explained. Some Native American tribes in the area believe that what we see today is what has always been there and the tower is the same shape and size that it has always been.

(Holverson, 1980)

Genesis



Magma ascends into overlying sedimentary rocks and cools, forming a laccolith. Regional uplift and erosion, by wind and the meandering Belle Fourche river, start to expose Devils Tower over time.

(Winter, 2010)

The Cretaceous Interior Seaway, or Western Interior Seaway, is a body of water that existed during the mid to late Cretaceous period (120 – 65 myr). It completely covered the areas of Devils Tower and Bridal Veil falls and its evaporation deposited the underlying Gypsum Springs Formation.

(Holverson, 1980)

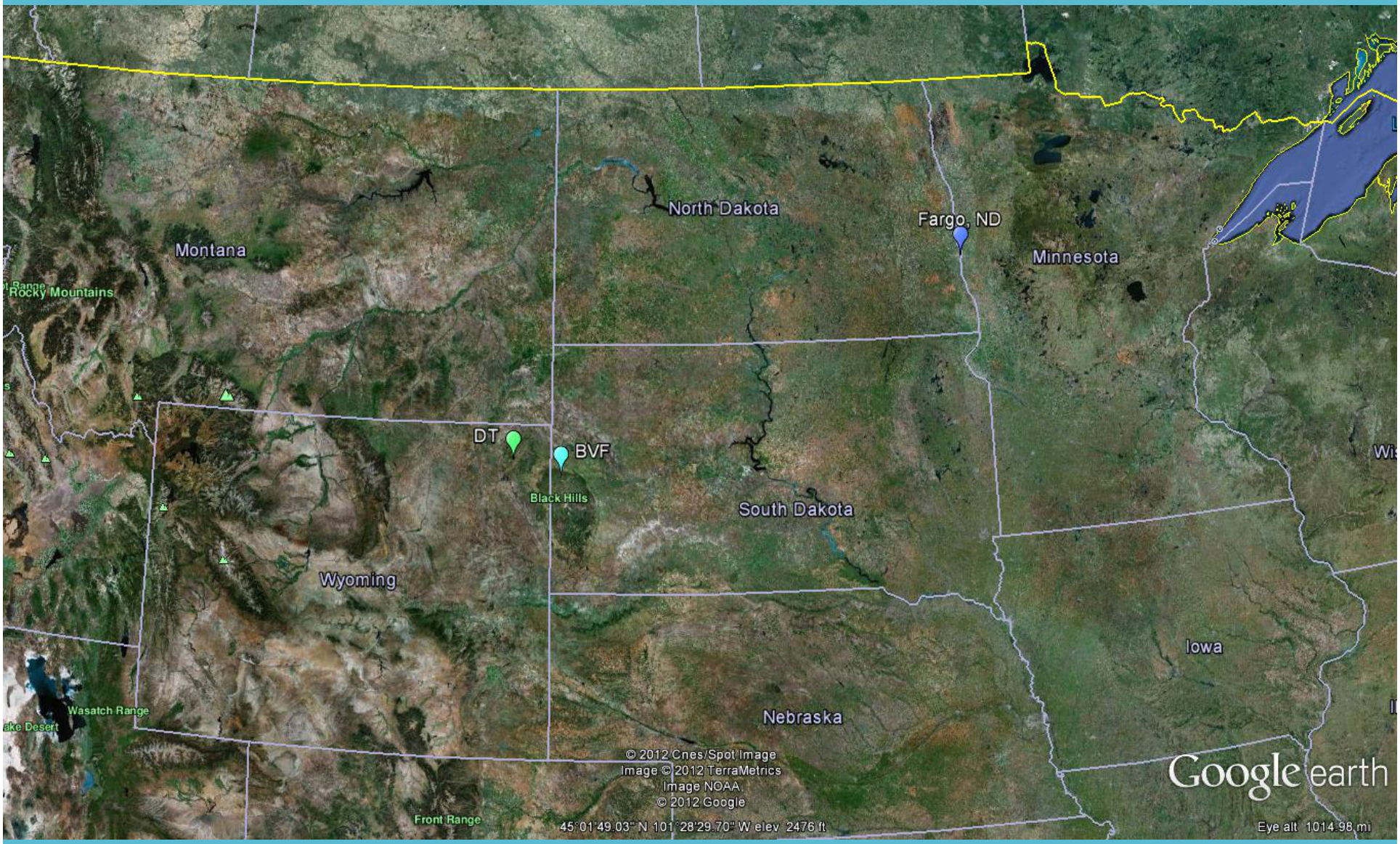
Quick Facts

- Designated as the first National Park by Theodore Roosevelt in 1906
- Rises 1,267 feet above the surrounding area.
- Approximately 53 million years old (Eocene)
- Classified as a Phonolite Porphyry
  - Early explorations of the area by Newton and others (1880) classified it as a trachyte.
- Originally known as “Bad God’s Tower”
- Intrusive
- Completely covered by sea water in the past
- 400,000 visitors annually
- The first climbers used wooden ladders

(Holverson, 1980)


Bridal Veil Falls
(Fogarty, 2012)

Location


Montana
Rocky Mountains
North Dakota
Fargo, ND
Minnesota
DT
BVF
Black Hills
South Dakota
Wyoming
Iowa
Nebraska
Wasatch Range
Front Range
© 2012 Cnes/Spot Image
Image © 2012 TerraMetrics
Image NOAA
© 2012 Google
45°01'49.03" N 101°28'29.70" W elev 2476 ft
Google earth
Eye alt 1014.98 mi

Genesis

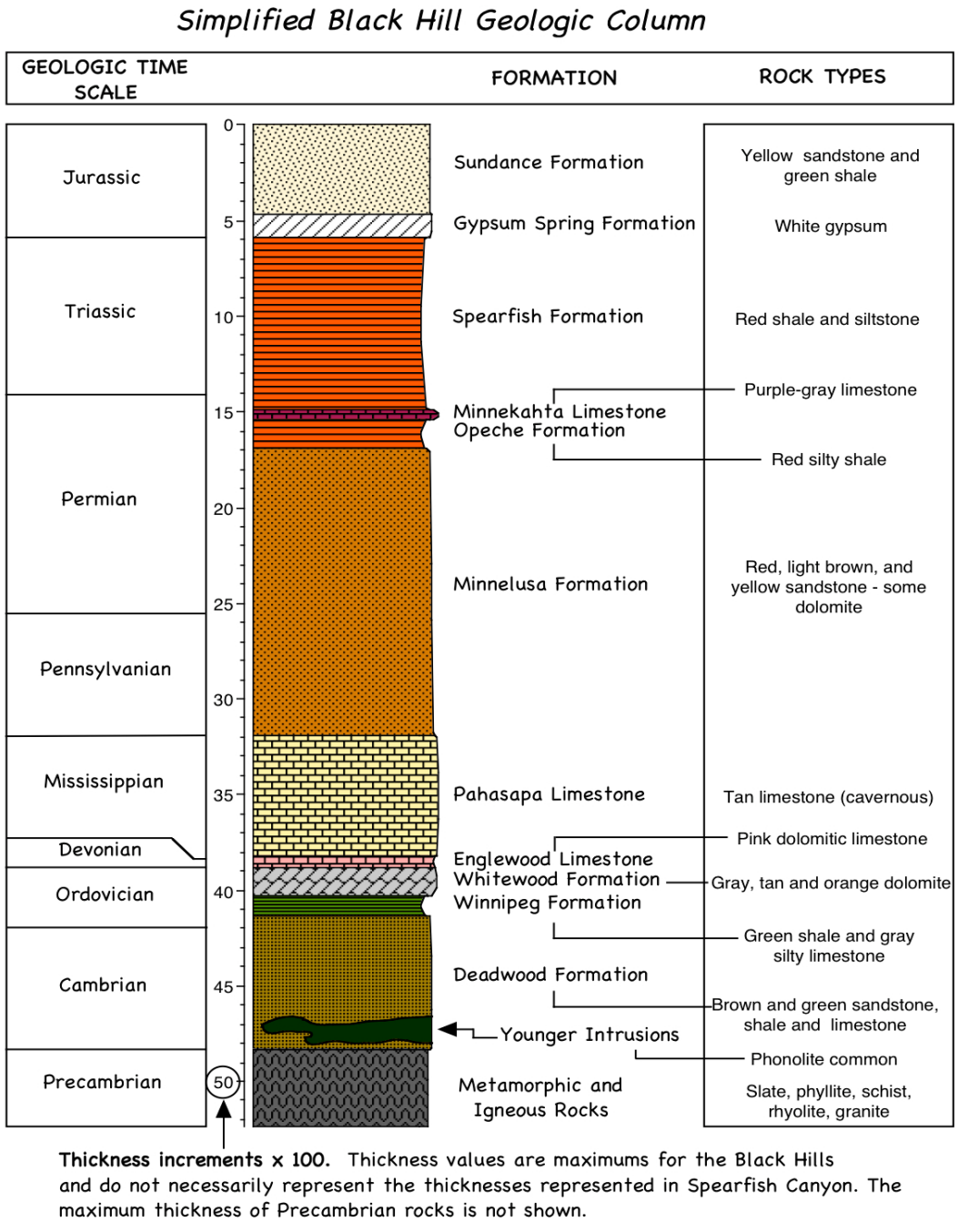
- Cretaceous Interior Seaway covered this area.
- Bridal Veil Falls is found in the Spearfish Canyon, which is part of the Black Hills
- Spearfish Canyon has three distinct rock types throughout
  - -Deadwood shale at the bottom, which can be identified by the brown color and multi-layered appearance. Formation is ranges from 10 to 400 feet thick
  - -Englewood limestone in between is a pink to red in color. Thickness ranges from 30 to 60 feet.
  - -Paha sapa limestone at the top and is a buff color and weathered gray; ranges from 300 to 600 feet in thickness.
- Bridal Veil Falls is classified as a greenish-gray phonolite porphry or a trachyte , which was formed by igneous intrusions in the Deadwood Formation 30-55 million years ago when the Black Hills were being uplifted. The intrusion had lifted and tilted the Deadwood Formation
- This intrusion is called a laccolith, due to the mushroom shaped cross- section.

(Fogarty, 2012)

Bridal Veil Falls Layering

(Fogarty, 2012)

Formations



(Fogarty, 2012)

Thin Section

Devils Tower

Bridal Veil Falls

Microscopy Pictures

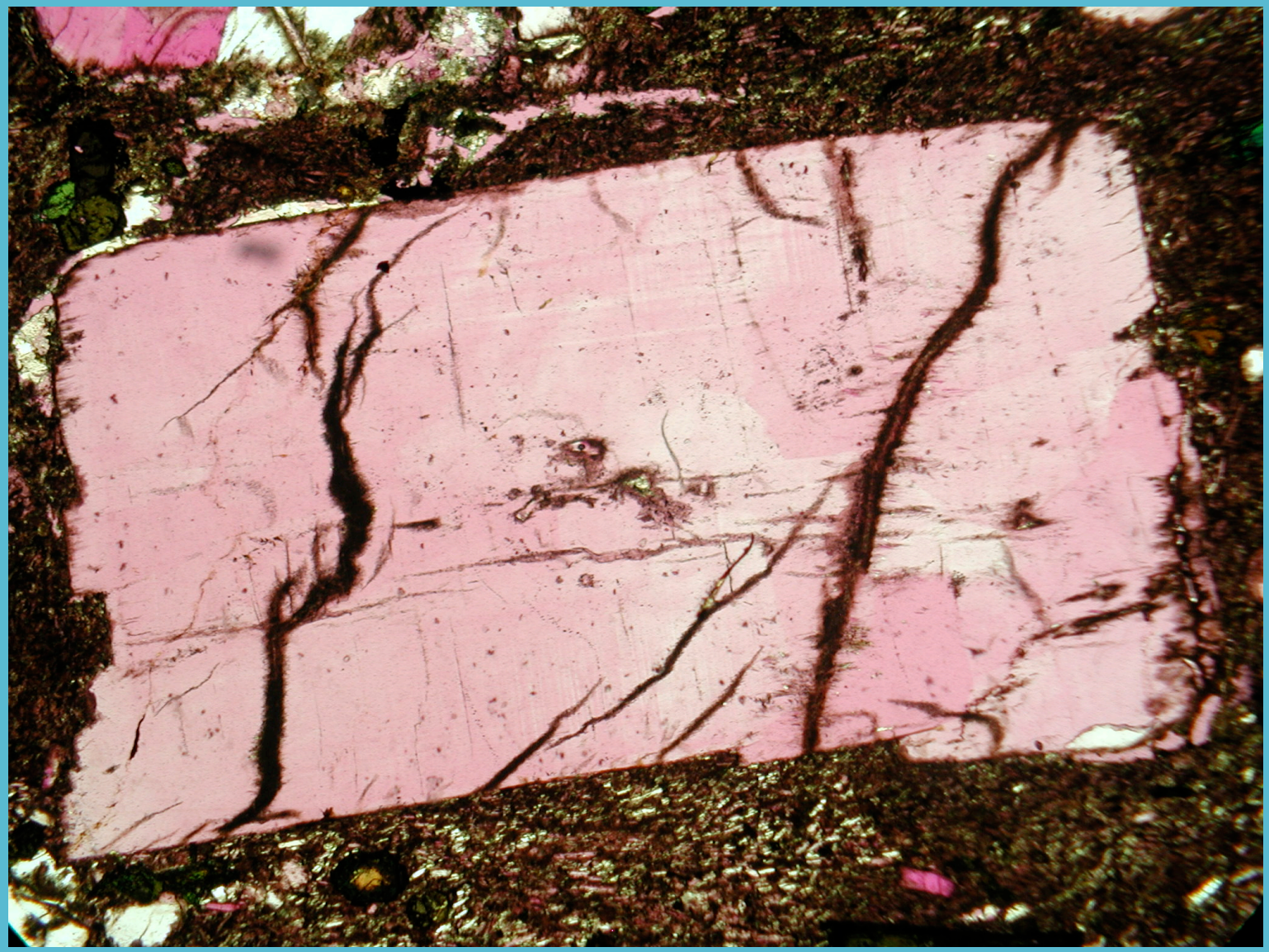
Devils Tower

PPL- FOV = 7.3 mm

Microscopy Pictures

Devils Tower

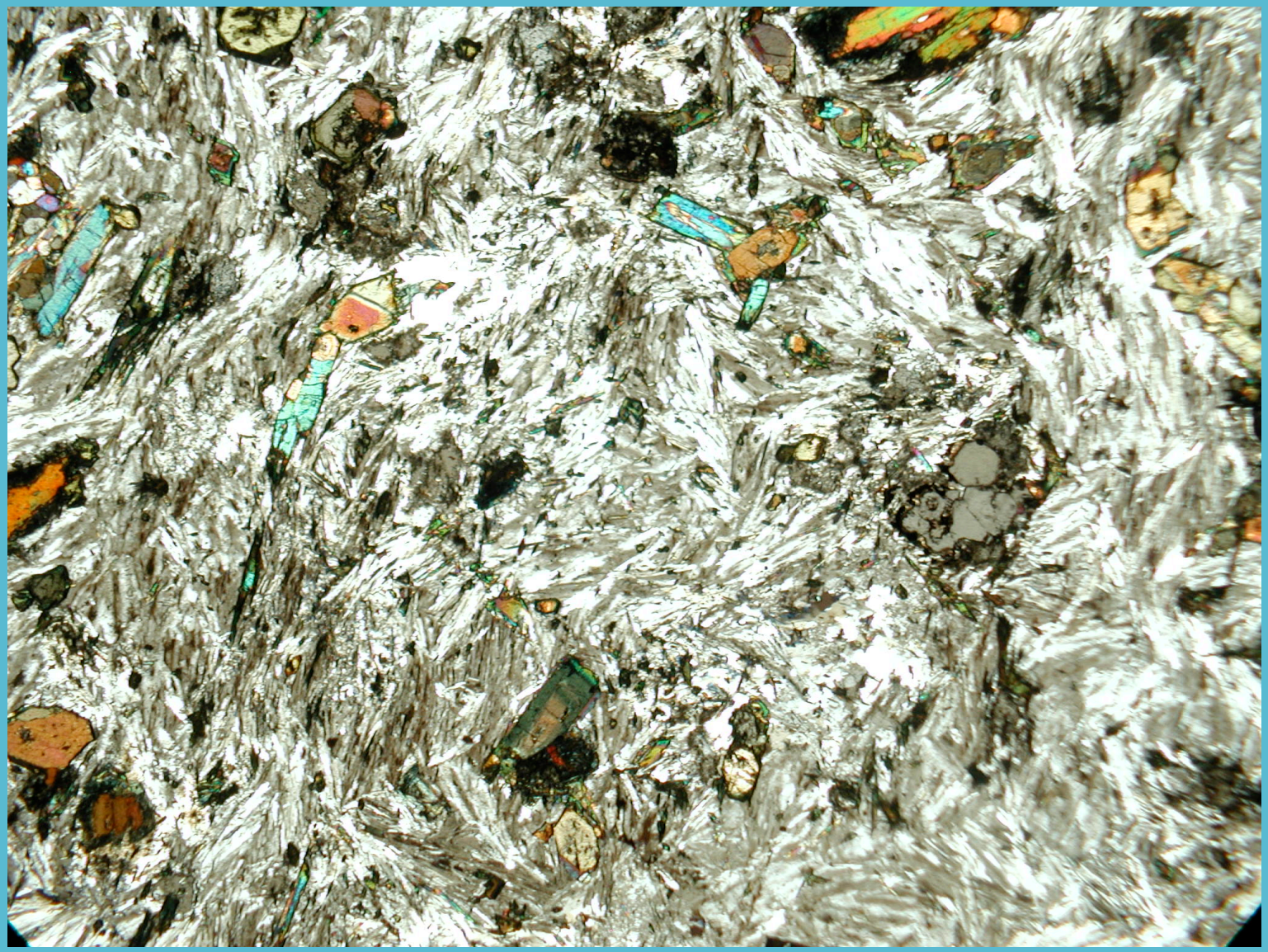
XPL-FOV= 7.3 mm



Microscopy Pictures

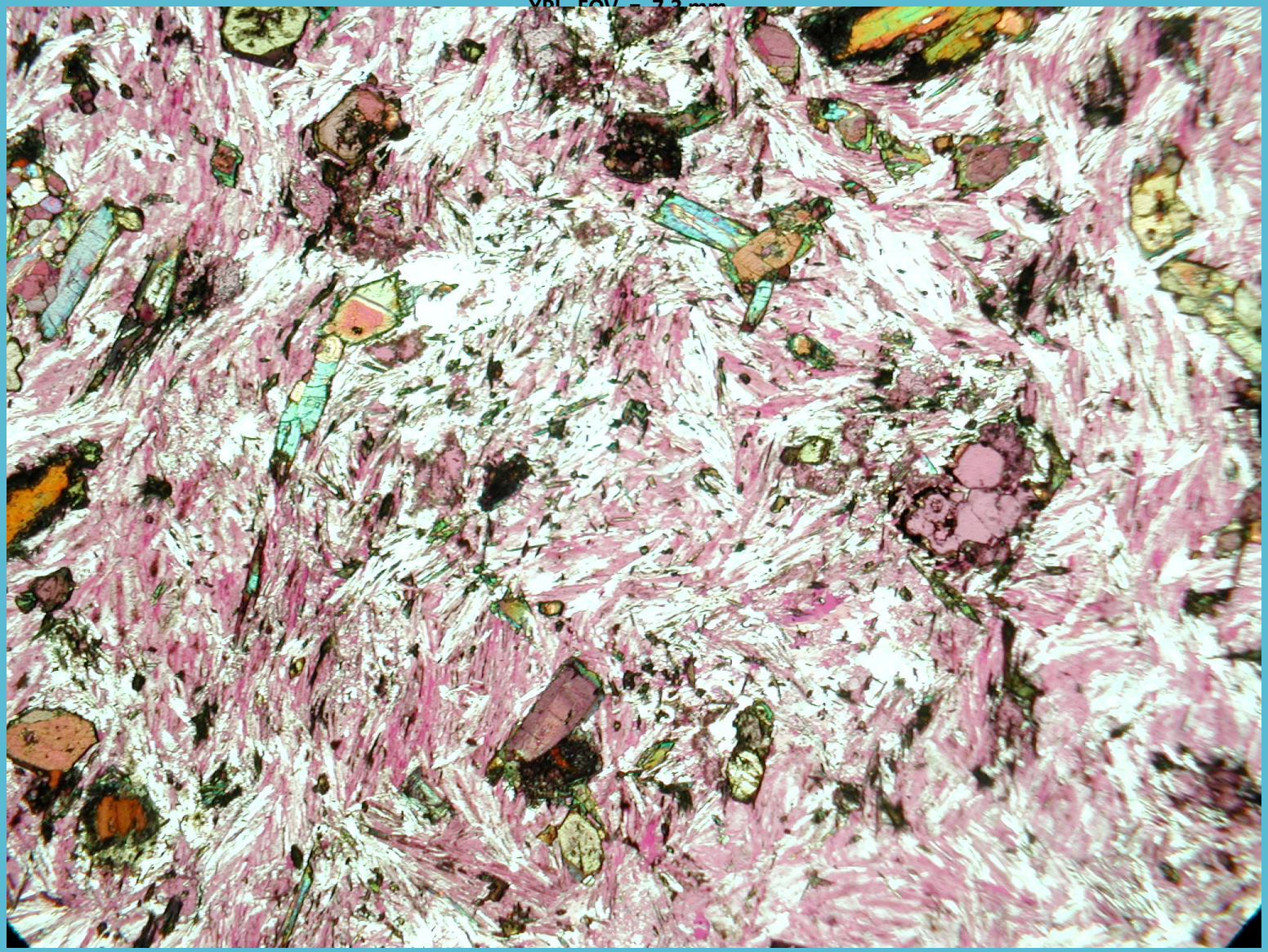
Bridal Veil Falls

PPL – FOV = 7.3 mm



Microscopy Pictures

Bridal Veil Falls

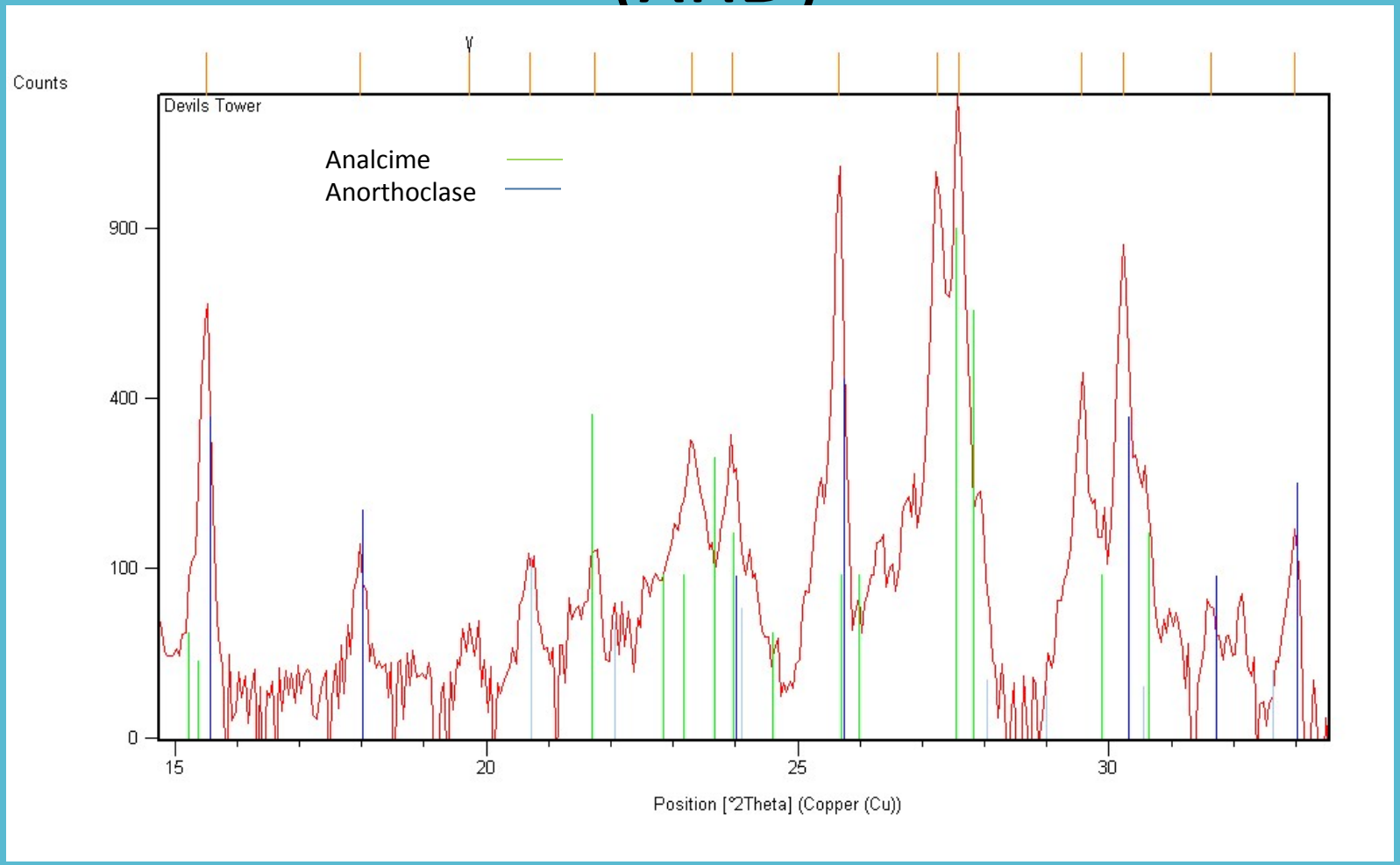


Results

Methods Used:

- X-ray Diffraction
  - X'PERT Software for mineral analysis
- X-ray Fluorescence
  - GCDkit to analyze chemical composition
- Microscopy
  - Thin Sections
- Literature Research
  - Journals, Thesis Papers, Textbooks

X-Ray Diffraction Analysis for Devils Tower (XRD)



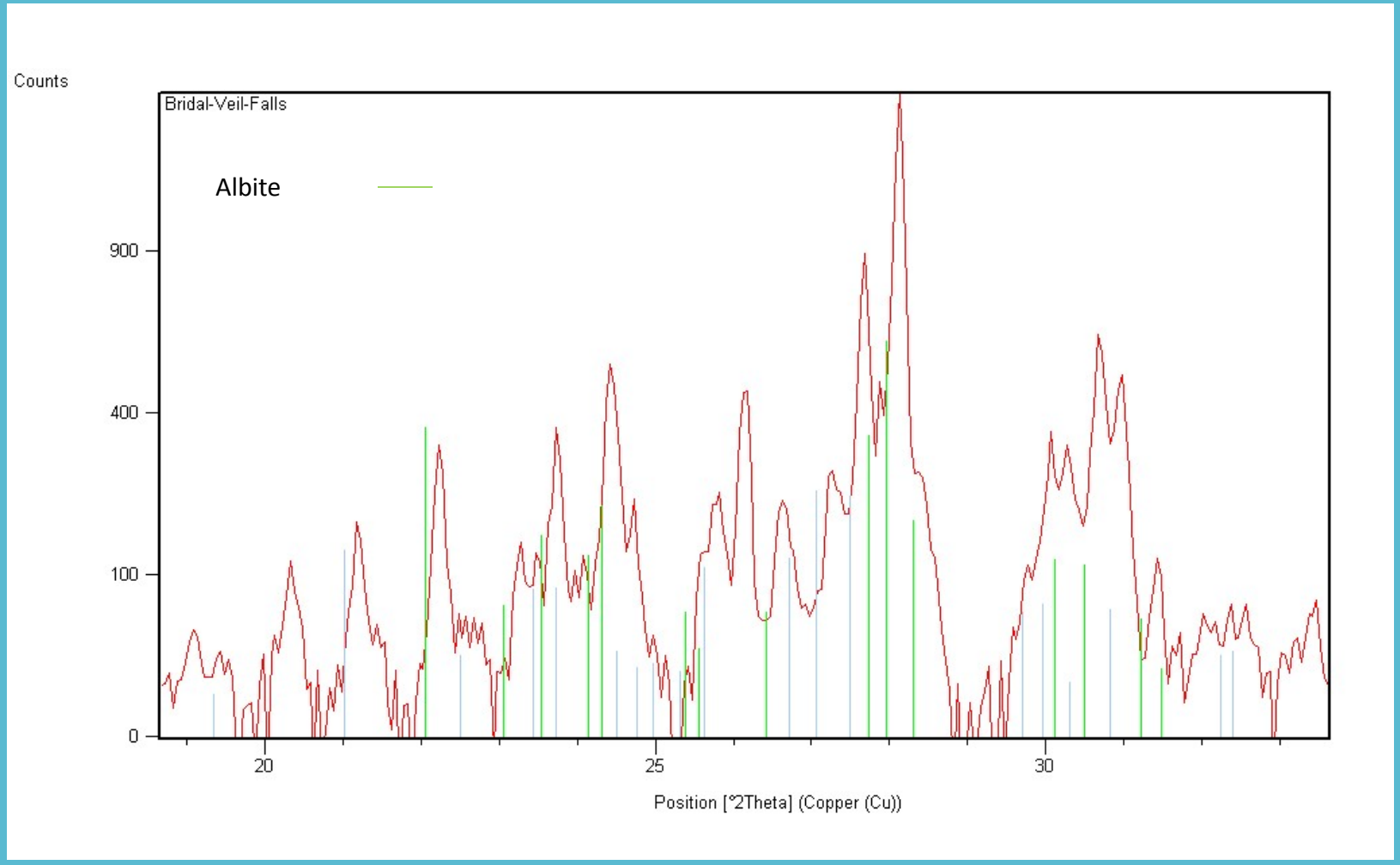
Analcime

$NaAlSi_2O_6 \bullet H_2O$

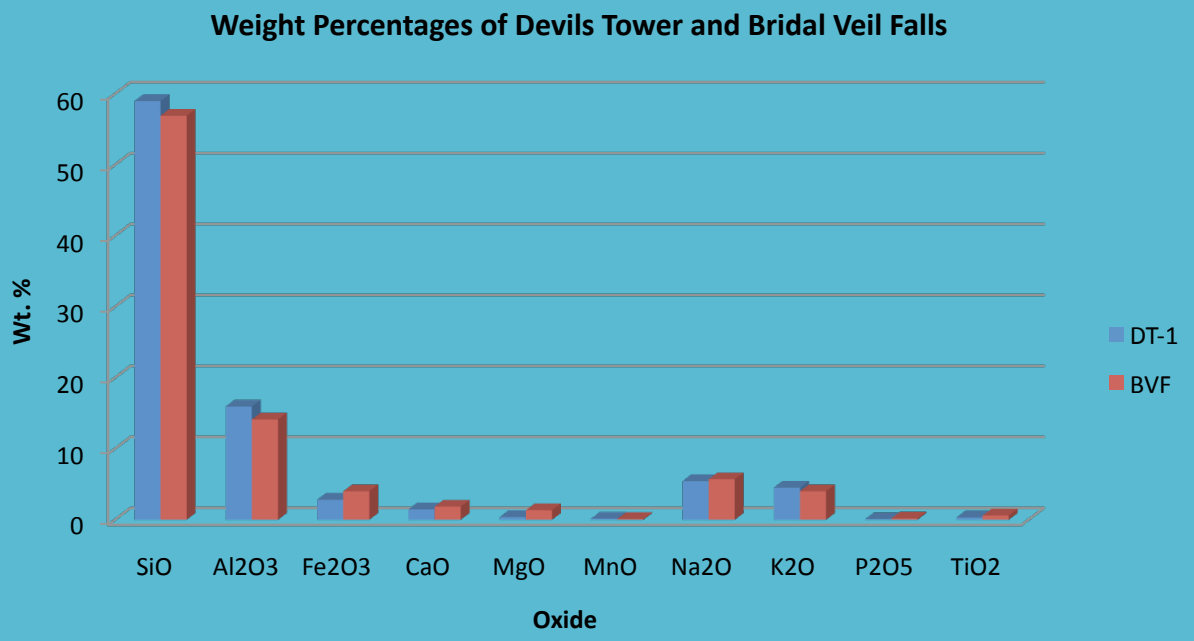
- White, grey, or colorless tectosilicate
- Classified as a zeolite mineral
- Cubic
- Structurally and chemically similar to a feldspathoid
- Commonly occurs in Analcime basalt and other alkali igneous rocks
- Silica Undersaturated
- Sodium Rich
- Replaces anorthoclase in regions of Devils Tower

(Holverson, 1980)

X-Ray Diffraction for Bridal Veil Falls (XRD)

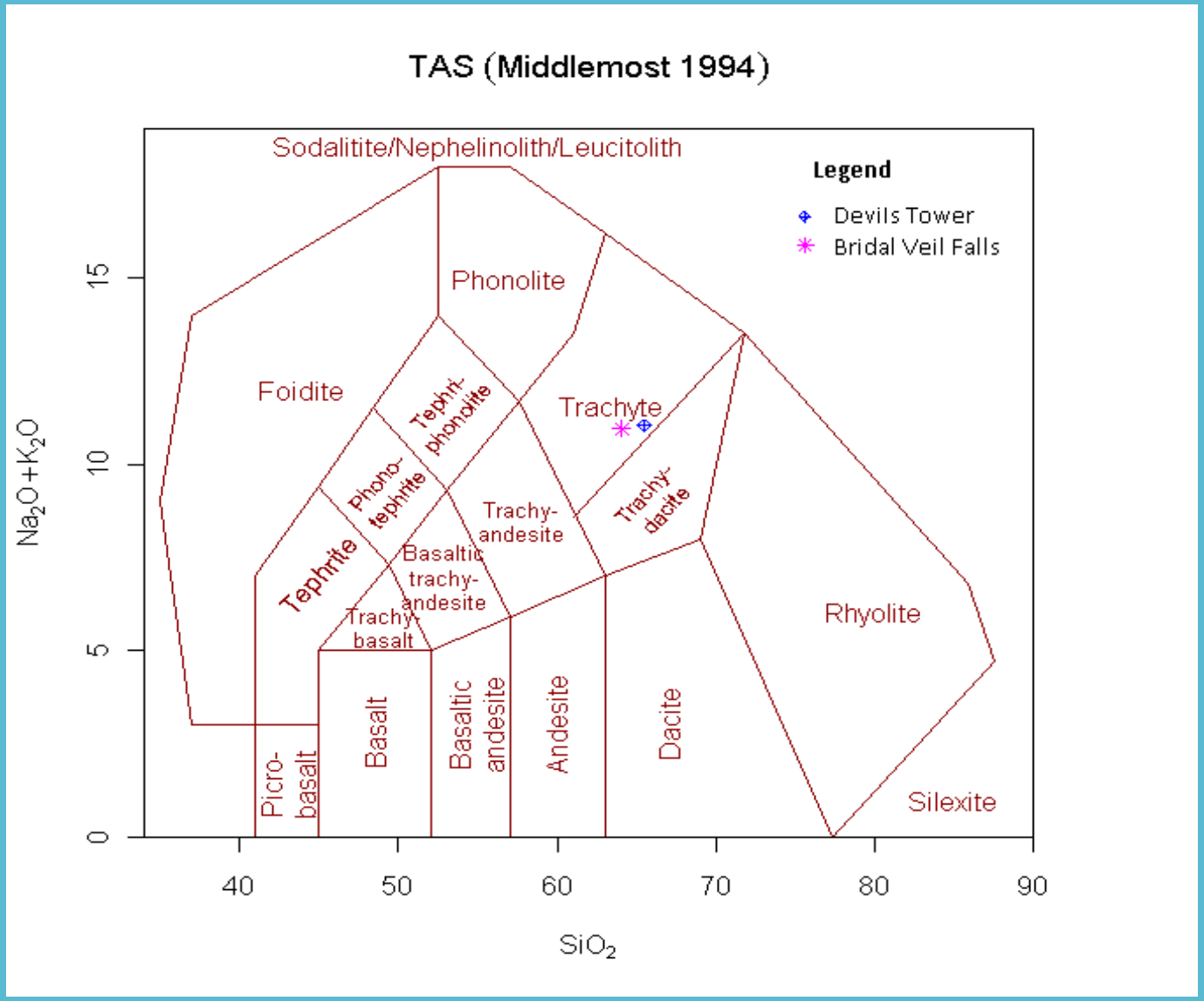


X-Ray Fluorescence Analysis (XRF)

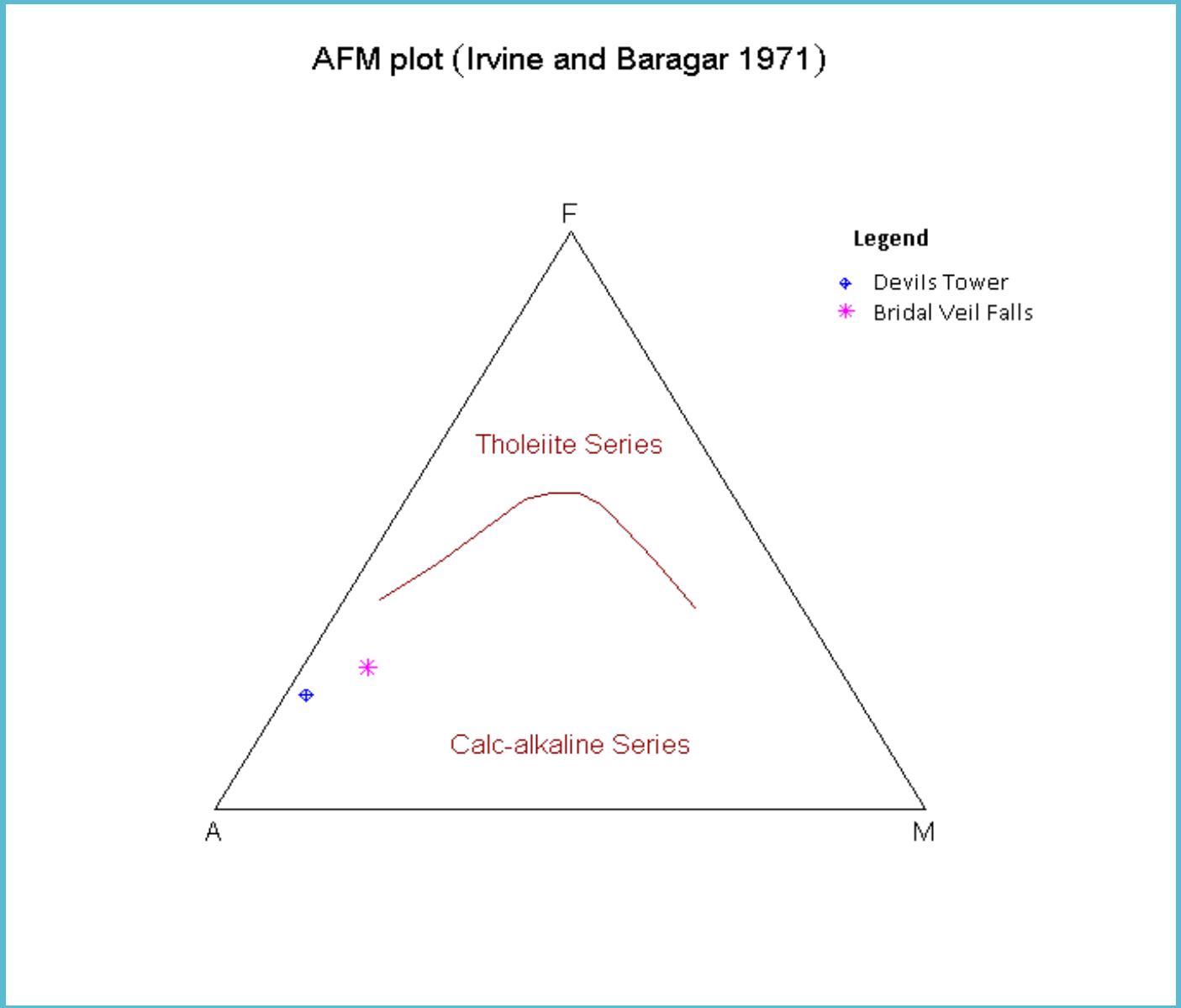


	SiO	Al2O3	Fe2O3	CaO	MgO	MnO	Na2O	K2O	P2O5	TiO2
DT	58.977	15.955	2.811	1.468	0.384	0.15	5.423	4.516	0.074	0.322
BVF	56.922	14.132	4.005	1.846	1.35	0.1	5.699	4.029	0.185	0.587

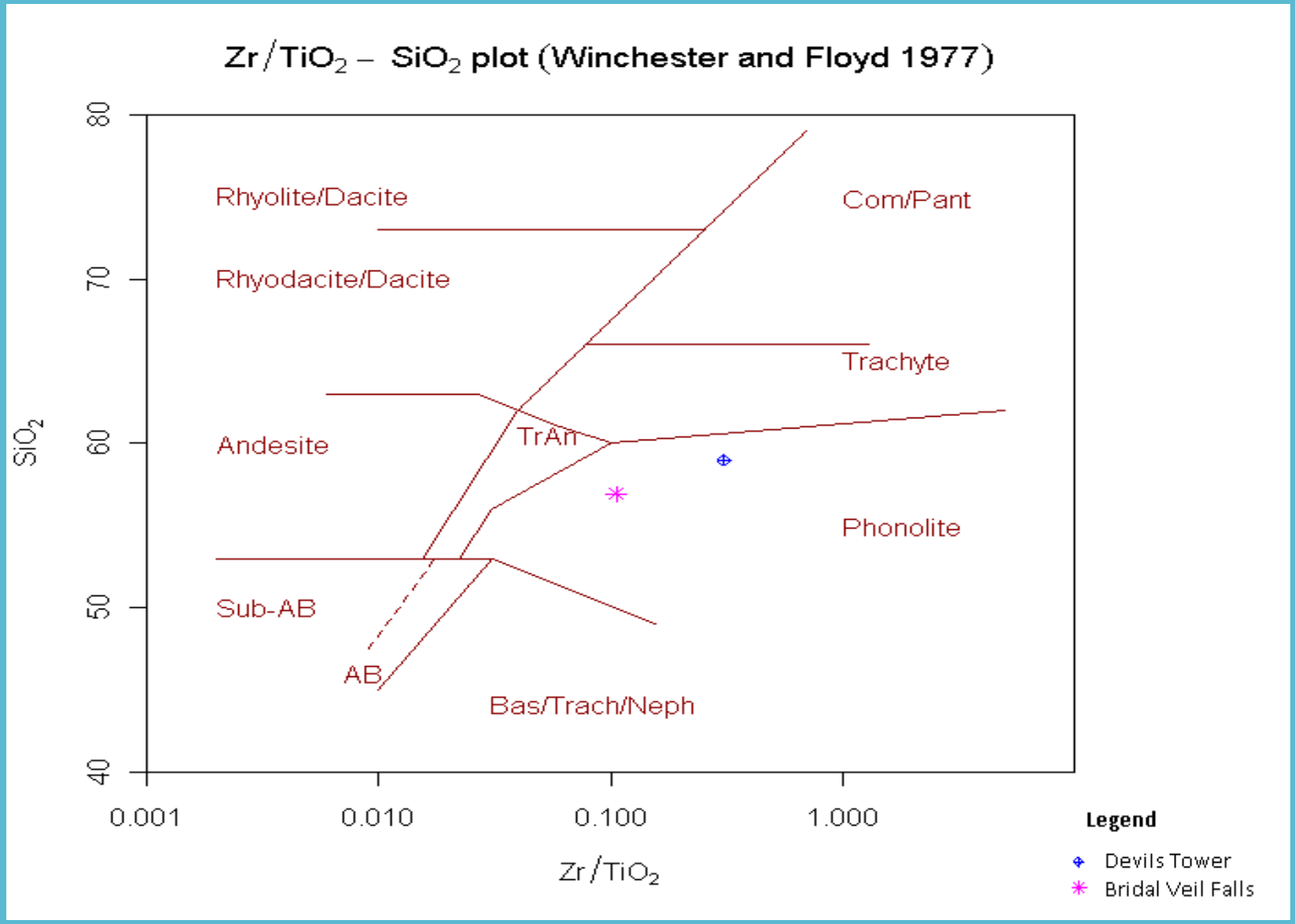
TAS Diagram


TAS (Middlemost 1994)
Sodalitite/Nephelinolith/Leucitolith
Legend
Devils Tower
Bridal Veil Falls
Phonolite
Foidite
Tephri-phonolite
Trachyte
Phono-tephrite
Trachy-andesite
Trachy-dacite
Tephrite
Basaltic trachy-andesite
Trachy-basalt
Rhyolite
Picro-basalt
Basalt
Basaltic andesite
Andesite
Dacite
Silexite
0
5
10
15
40
50
60
70
80
90
Na_2O+K_2O
SiO_2

AFM Diagram


AFM plot (Irvine and Baragar 1971)
F
A
M
Legend
Devils Tower
Bridal Veil Falls
Tholeiite Series
Calc-alkaline Series

Zr/TiO2-SiO2 Diagram



Phonolite vs. Trachyte

Phonolite

- Aphanitic to Porphyritic
- Silica Undersaturated
- Matrix consists of mainly Alkali Feldspar
- Rare on Earth
  - Only found in Montana, Wyoming, and West Africa
- Essentially Feldspathoids (Nepheline) and Alkali Feldspars (Sanidine and Anorthoclase)

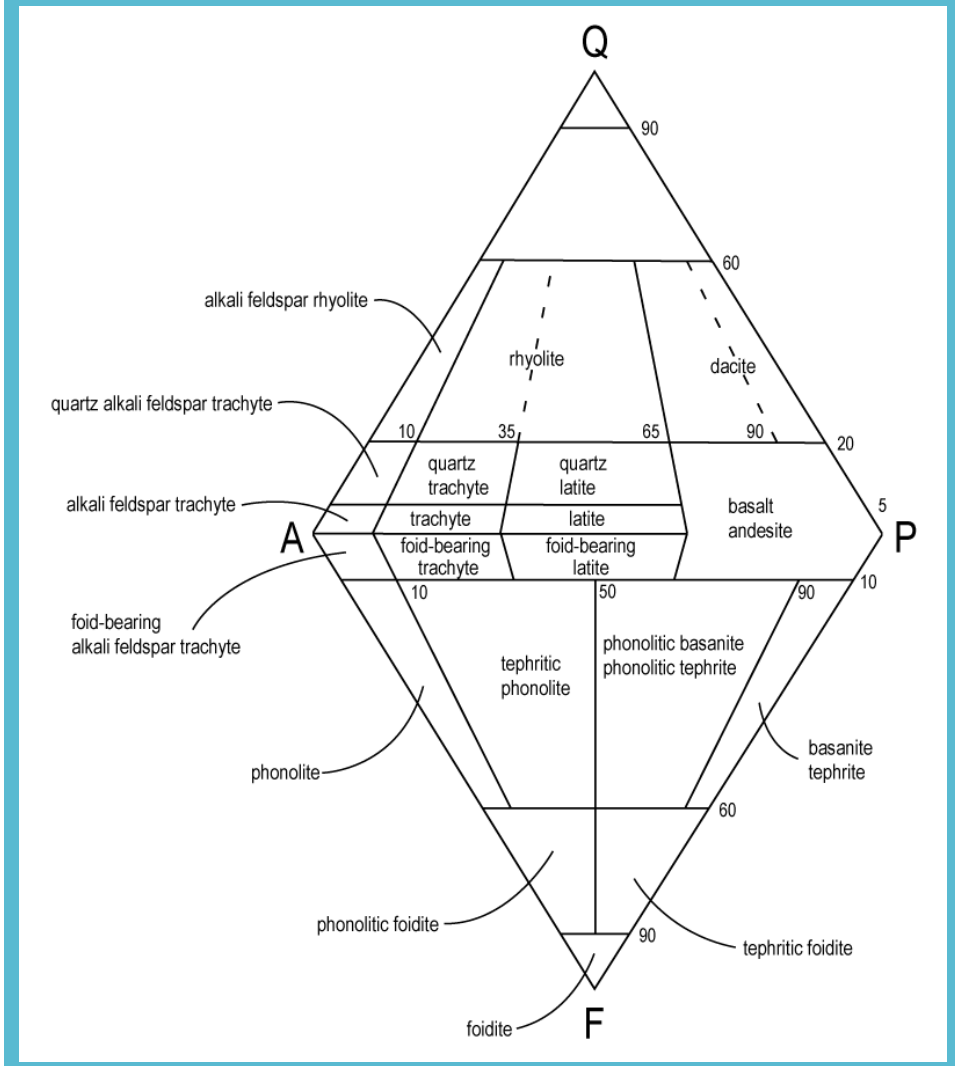
(Britannica Encylopedia, 2012)

Trachyte

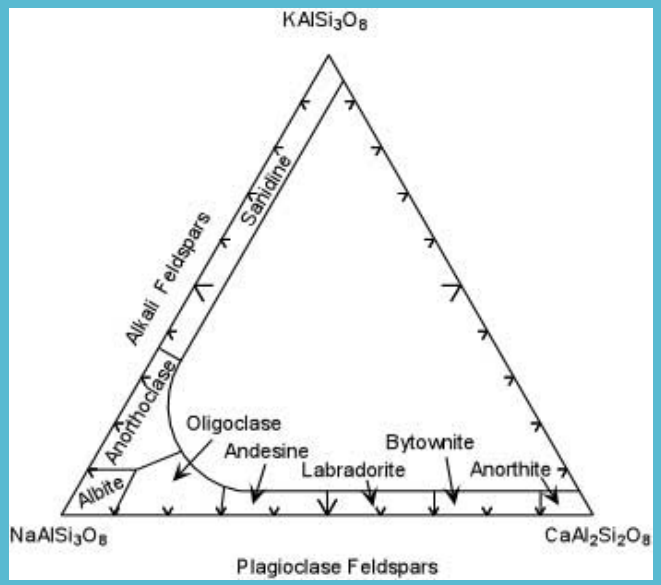
- Aphanitic to Porphyritic
- Silica Undersaturated
- Matrix consists of mainly Alkali Feldspar
- Rare in the United States
- Essentially Alkali Feldspar
- (Sanidine and Albite)

(Karner, 1989)

QAPF-Feldspar Triangle



(Winter, 2010)



(Winter, 2010)

Summary

- Both Devils Tower and Bridal Veil Falls are igneous intrusions exposed by uplift and erosion.
- The phenocrysts from Devils Tower are many times larger as that from Bridal Veil Falls meaning that the magma that came up at Devils Tower had cooled for a much longer time.
- XRD results concluded that there were very strong peaks that match up with analcime and anorthoclase for Devils Tower and albite for Bridal Veil Falls. This analysis does coincide with the mineral composition of the classified rocks for each location.
- XRF results show our samples in the trachyte region of the TAS diagram rather than the phonolite region, after normalizing the percentages.

Sources

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- Karner, Frank R., 1989, Devils Tower- Black Hills Alkalic Igneous Rocks and General Geology, American Geophysical Union, Washington D.C.
- Winter, J.D., 2010, Principles of Igneous and Metamorphic Petrology, 2nd ed: Upper Saddle River, NJ, Prentice Hall, 702

Questions???