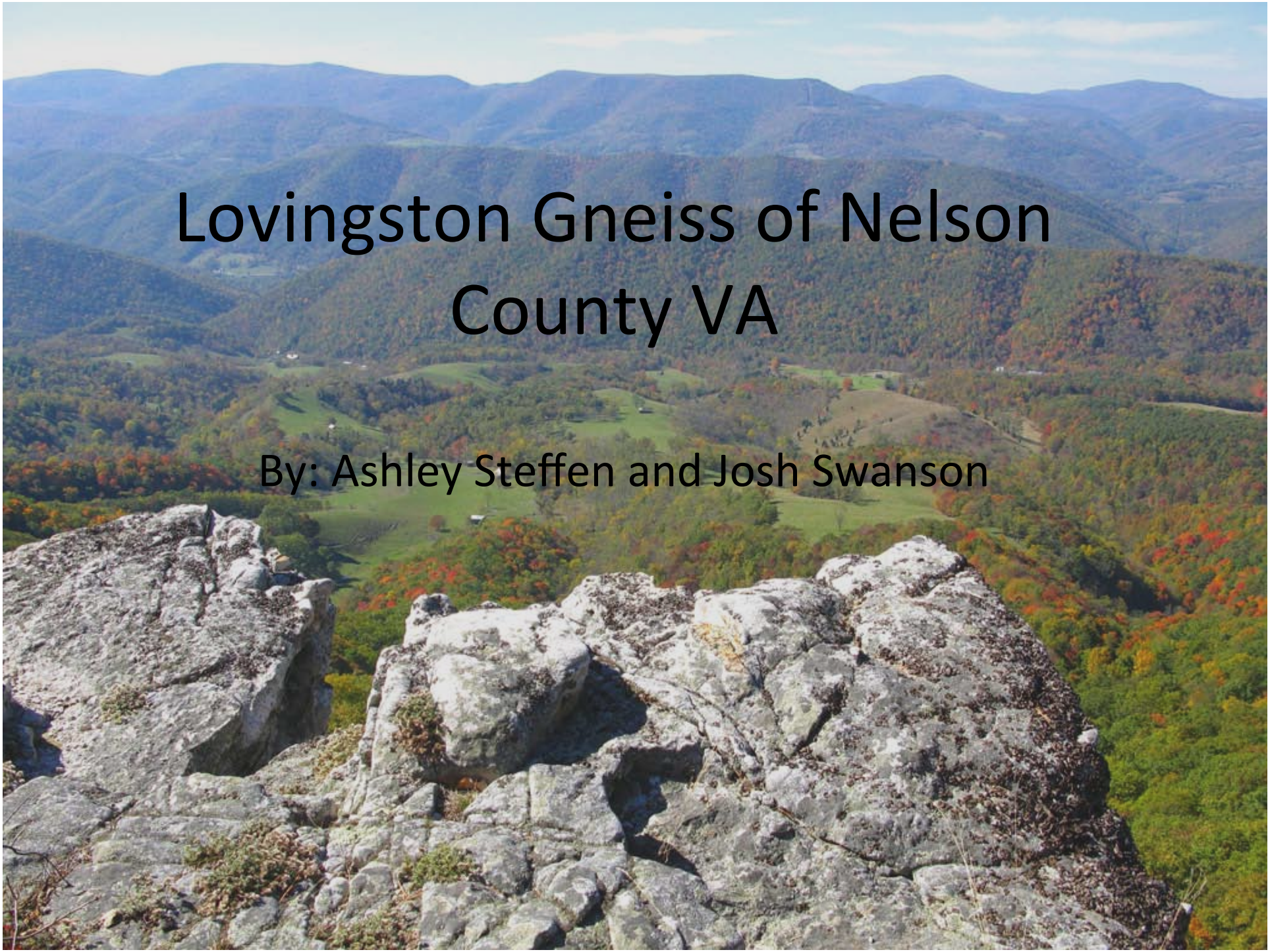
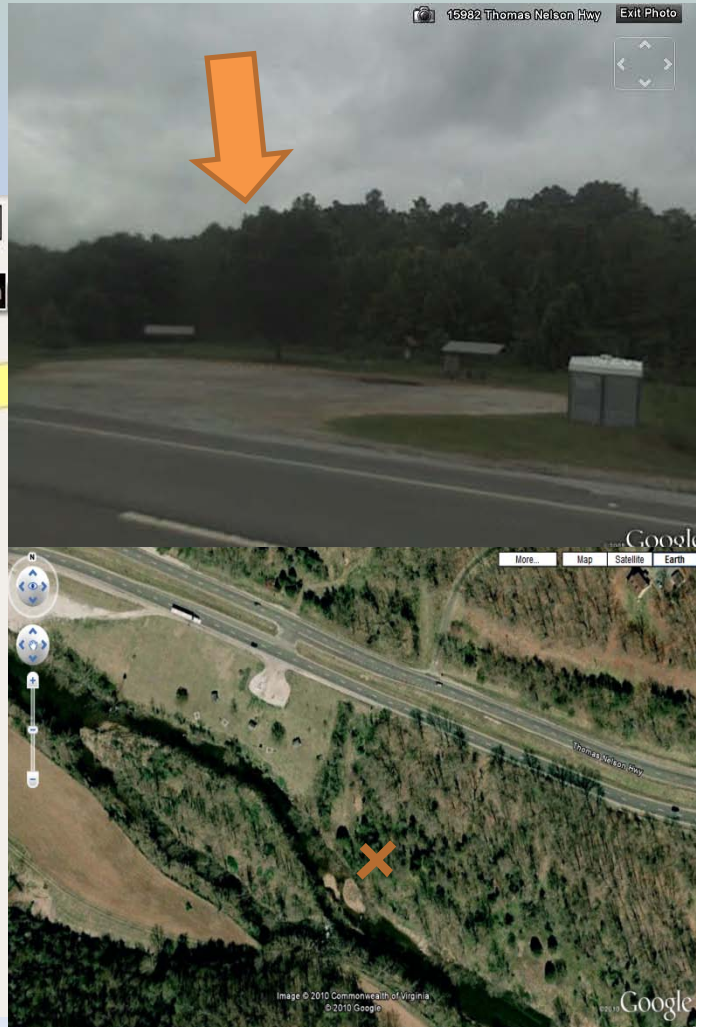


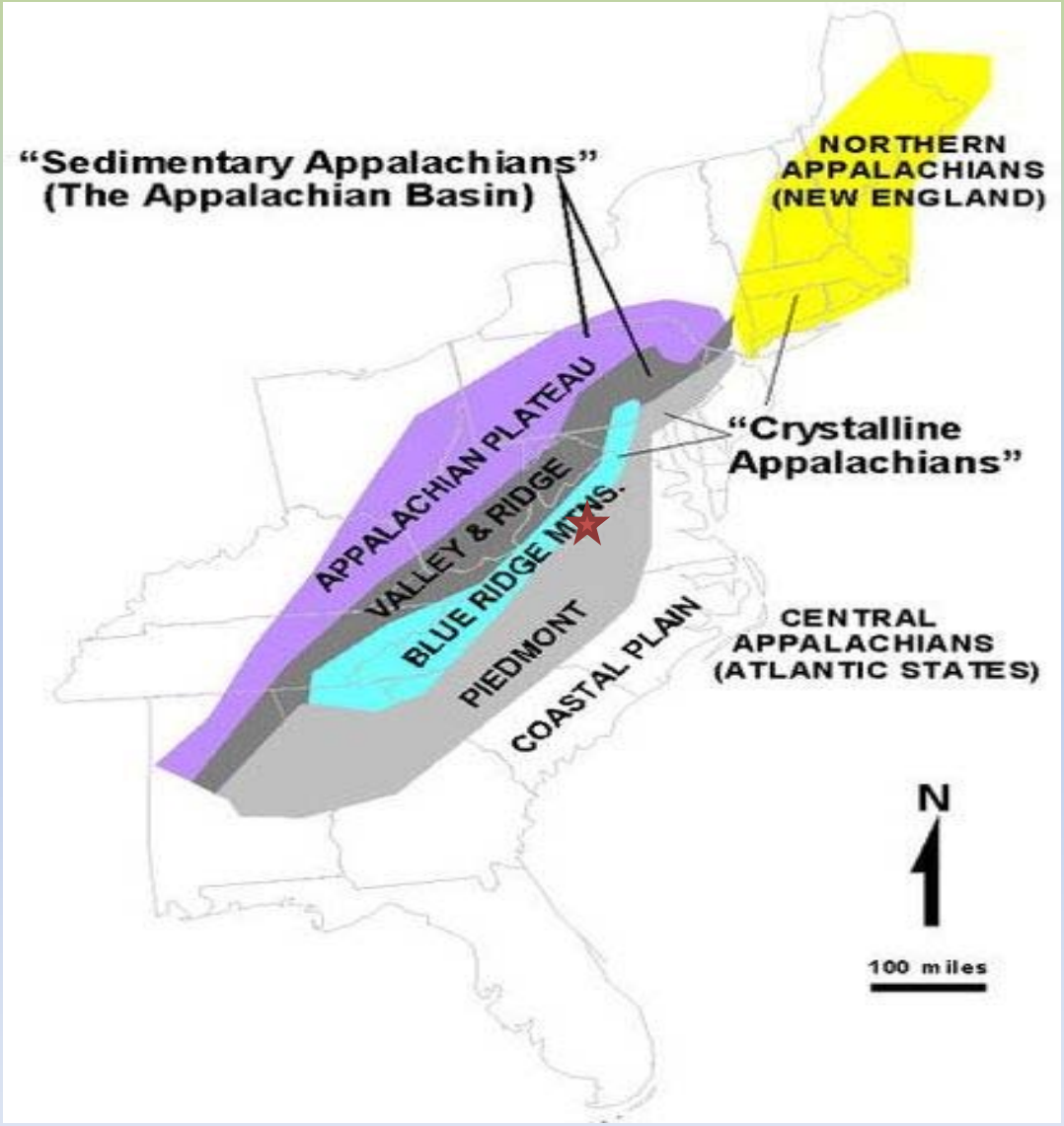
Lovingston Gneiss of Nelson County VA

By: Ashley Steffen and Josh Swanson

Rock Location

- Found in Nelson County, Virginia, on the Nelson County Wayside, off of I-29




"Sedimentary Appalachians"
(The Appalachian Basin)
NORTHERN
APPALACHIANS
(NEW ENGLAND)
"Crystalline
Appalachians"
APPALACHIAN PLATEAU
VALLEY & RIDGE
BLUE RIDGE MTNS.
PIEDMONT
COASTAL PLAIN
CENTRAL
APPALACHIANS
(ATLANTIC STATES)
N
100 miles

Appalachian Mountains

- The range is mostly located in the United States but extends into southeastern Canada, forming a zone from 100 to 300 miles wide, running from the island of Newfoundland 1,500 miles south-westward to central Alabama in the United States.

- The system is divided into a series of ranges, with the individual mountains averaging around 3,000 ft (900 m).

Categories of Metamorphic Rocks

- Contact
  - Occurs at or near contacts of igneous intrusions
- Dynamic
  - Found in narrow zones such as thrusts and faults
- Regional
  - Occur in large tracts of Earth's surface, not associated with igneous intrusions, faults or thrust belts, although often present

Regional Metamorphism

- Agents of Regional Metamorphism
  - Heat, lithostatic and directed pressures
- How are they applied?
  - Lithosphere plates collide. Subduction or continent-continent collision creates intense directed pressure; heat comes from friction and position within the Earth

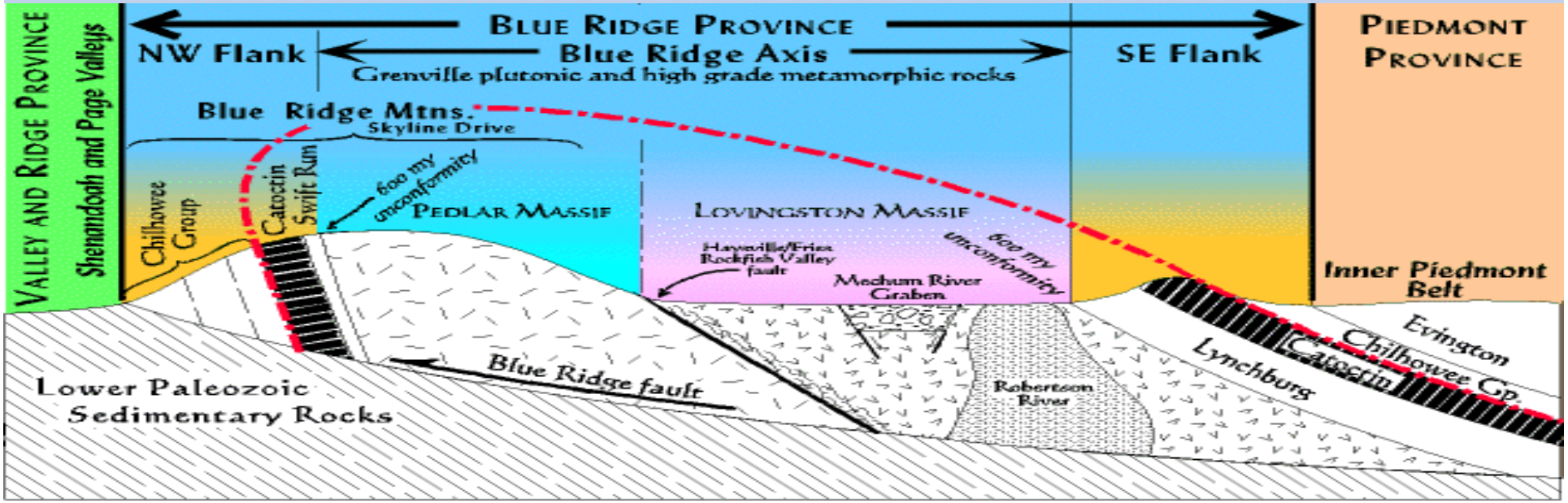
Metamorphism Cont.

- Retrograde metamorphism
  - The recrystallization of pre-existing rocks in response to a lowering of metamorphic grade in the presence of a fluid phase.

History of Area

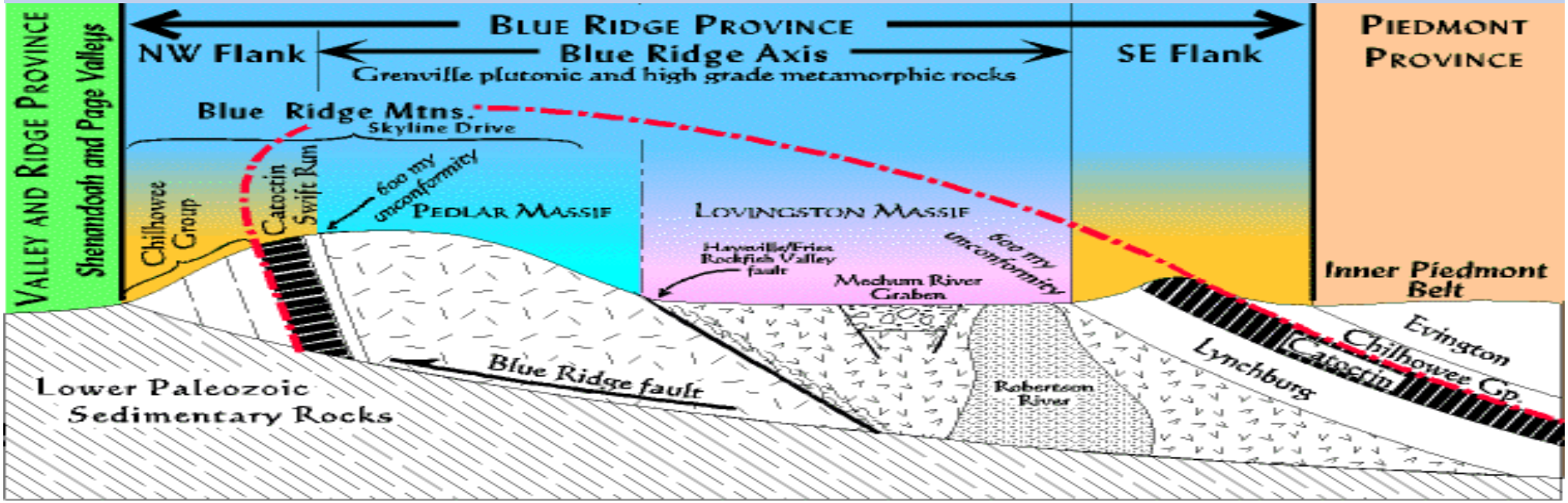
- The Blue Ridge is an overturned anticline, the rocks have been arched up into a fold

- Notice the Blue Ridge thrust fault at the base



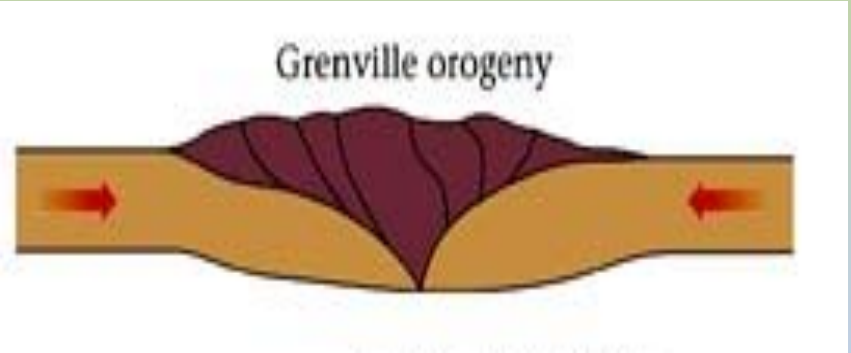
•**Grenville Metamorphic Rocks-** The oldest rocks in Virginia running in a NE-SW trend down The Blue Ridge. They are dominantly deep forming igneous rocks (granite and granodiorites) having undergone various degrees of metamorphism to produce gneisses.

• A large fault system (the Haysville-Fries-Rockfish Valley fault; HFRV) cuts down the middle dividing the Grenville rocks into the Pedlar massif to the northwest, and the Lovingston massif to the southeast.



Grenville Orogeny

•The generally-accepted view is that the eastern and southern margins of Laurentia were convergent margins.

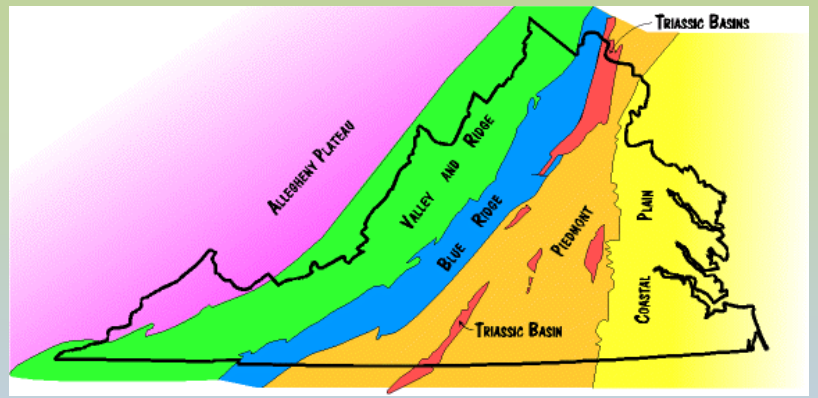


•These periods of thrusting and metamorphism were not continuous, but rather interrupted by comparatively quiet periods, during which AMCG (anorthosite/ mangerite/ charnockite/ granite) plutons were intruded into the country rock.

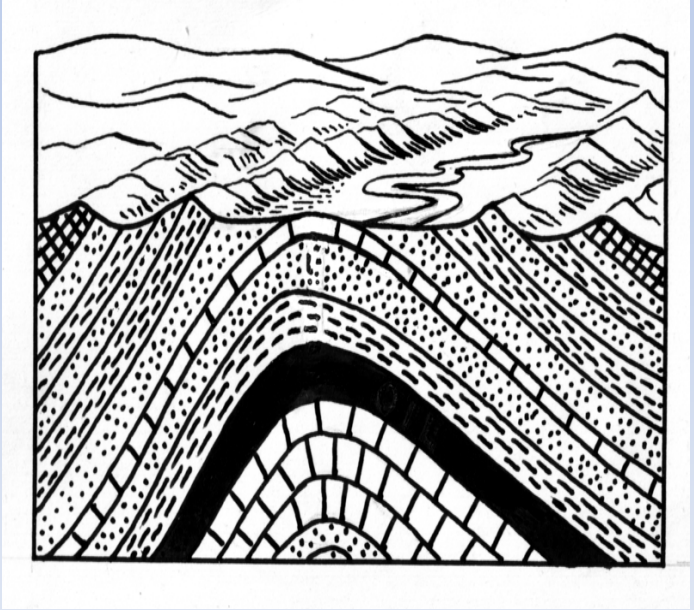
•The Grenville orogen is marked by northwest verging fold-and-thrust belts and high pressure metamorphic regimes. Metamorphism is commonly granulite facies, that is, medium to high temperature and pressure alteration

•Around 1.2 billion years ago, the oldest rocks in Virginia, the granites and gneisses, were formed in an event called the Grenville Orogeny. This is when the North American continent collided with another land mass, quite possibly what we now know as Africa. There is evidence though that there may have been other land masses involved in this orogeny such as South America. Another event that was occuring in the Proterozoic was the formation of the supercontinent called Rodinia. Virginia was located in the middle of this supercontinents.

•The rocks of the Grenville can be found up and down the east coast of North America from Newfoundland to North Carolina.



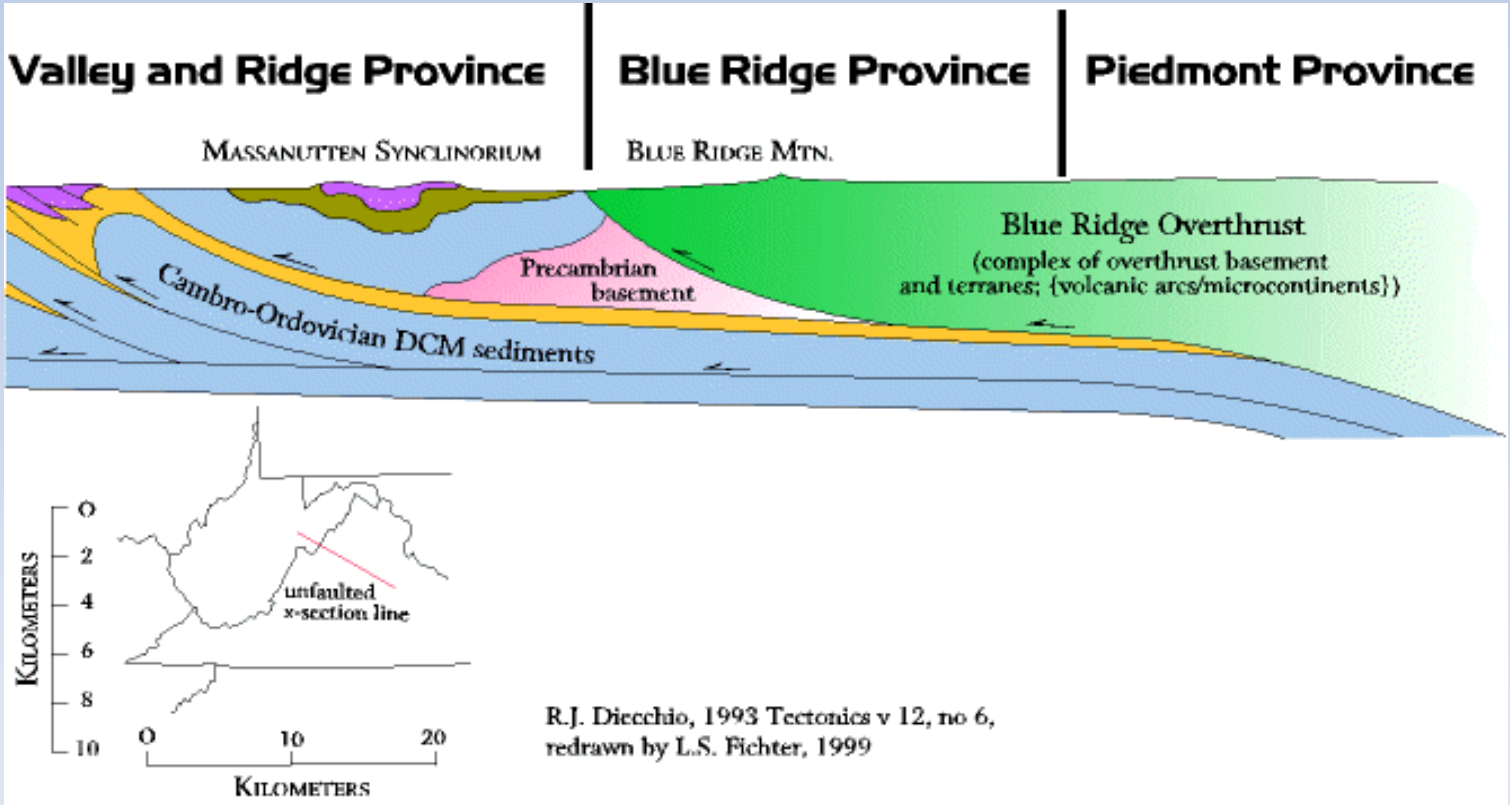
•This event is what formed the core of our Blue Ridge Mountains.



•On both sides of this anticline you will find the Grenville rocks covered with younger strata including lava flows and sedimentary layers.

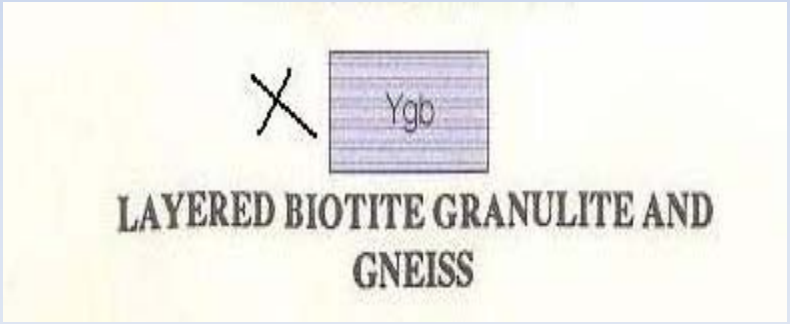
•Note that the piedmont and Blue Ridge "basement" rocks have been transported westward along a thrust fault.

•Also, the block labeled "Blue Ridge Overthrust" is not a uniform block



•**Gneiss -** Any rock possessing a gneissic foliation, in which individual grains are visible to the naked eye or easily seen at 10X magnification. The name can be prefixed by the dominant and/or porphyroblastic minerals present, Such as Muscovite-biotite gneiss, and/or by the word augen when appropriate.

•**Granulite** - At the highest grades of metamorphism most of the hydrous minerals and sheet silicates become unstable and thus there are few minerals present that would show a preferred orientation. The resulting rock will have a granulitic texture.



Rock Sample One: Layered Biotite Granulite and Gneiss

Rock Description:

•Medium grained 0.75-1 mm

•Segregation layering is defined by alternating quartzofeldspathic and biotite-rich domains on the order of a few millimeters to centimeters thick.

•Quartz and feldspar are granoblastic

•Biotite defines a penetrative schistosity that crosscuts segregation layering.

• Migmatitic leucosomes composed of alkali feldspar and Blue quartz cut segregation layering

Rock Sample Two: Layered Biotite Granulite and Gneiss

Rock Description:

- Medium grained 0.75-1 mm

- Segregation layering is defined by alternating quartzofeldspathic and biotite-rich domains on the order of a few millimeters to centimeters thick.

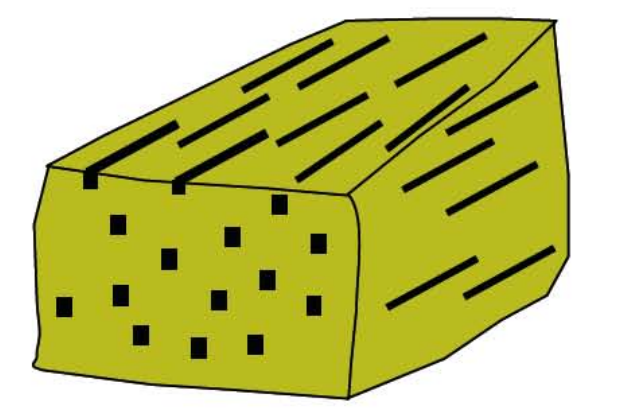
- Feldspar and Quartz are granoblastic

- Biotite defines a penetrative schistosity that crosscuts segregation layering.

- Migmatitic leucosomes composed of alkali feldspar and Blue quartz cut segregation layering

Texture

- Lineation:
  - Rod-shaped minerals are aligned parallel to one another, producing a streaky appearance on some surfaces and a dotted pattern on others



Texture Hypothesis

From the information it appears that our sample rocks were metamorphosed by the Grenville Orogeny and the Haysville-Fries-Rockfish Valley fault. Our sample rocks appear to be a metamorphosed granite that was hydrated. Through Regional metamorphism it appears to have a Granoblastic texture, lineation, and slight foliation.

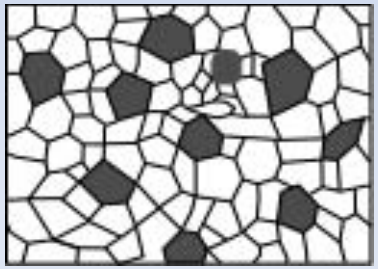
Foliation

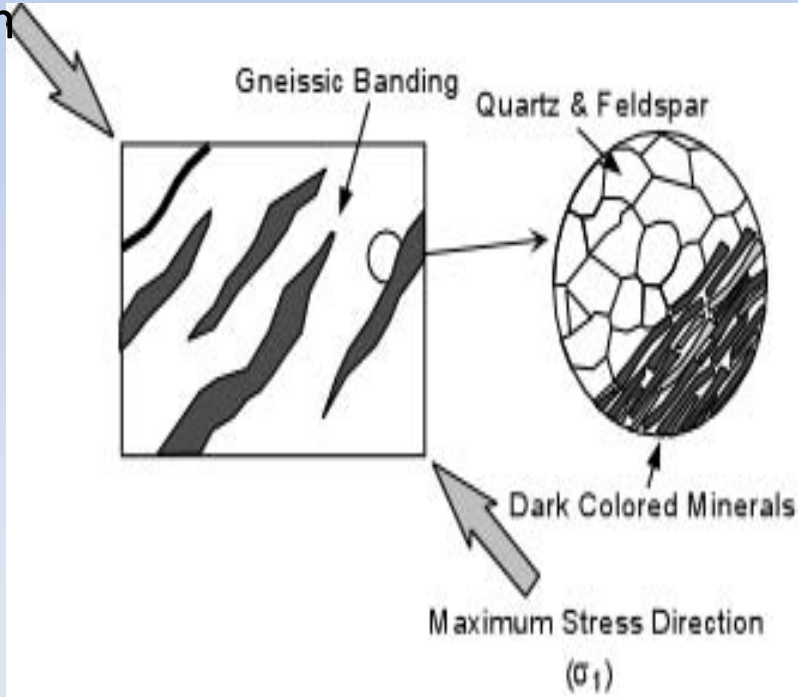
- The layering within metamorphic rocks
- occurs when a rock is being shortened along one axis during recrystallization. This causes the platy or elongated crystals of minerals, such as mica and chlorite, to become rotated such that their long axes are perpendicular to the orientation of shortening. This results in a banded, or foliated, rock, with the bands showing the colors of the minerals that formed them

•Gneissic Banding

- •Dark colored minerals tend to become segregated into distinct bands through the rock (metamorphic differentiation). Because the dark colored minerals tend to form elongated crystals, rather than sheet- like crystals, they still have a preferred orientation with their long directions perpendicular to the maximum differential stress.

- **•Granulitic Texture**





Gneissose Structure

- Either a poorly-developed schistosity or segregated into layers by metamorphic processes
- Gneissose rock usually have medium to coarse grains
- Layered generally with alternating felsic and darker mineral layers

Granoblastic

- Typical of non-foliated metamorphic rocks
- Grains have sutured boundaries, are approximately equidimensional, and meet at ~120° triple junctions. Characteristic of recrystallization.

Porphyroblast

- Porphyroblast are large mineral crystals in a metamorphic rock which has grown within the finer grained groundmass.
- As porphyroblasts grow, the foliation may be preserved as oriented inclusions trapped by the porphyroblast as it overgrows them
- The most common porphyroblasts in metapelites (metamorphosed mudstones and siltstones) are garnets and staurolites

Conclusion of Texture

Our rock samples have been highly metamorphosed making the texture difficult to pin point. It has a Gneissose structure, with Granoblastic texture.

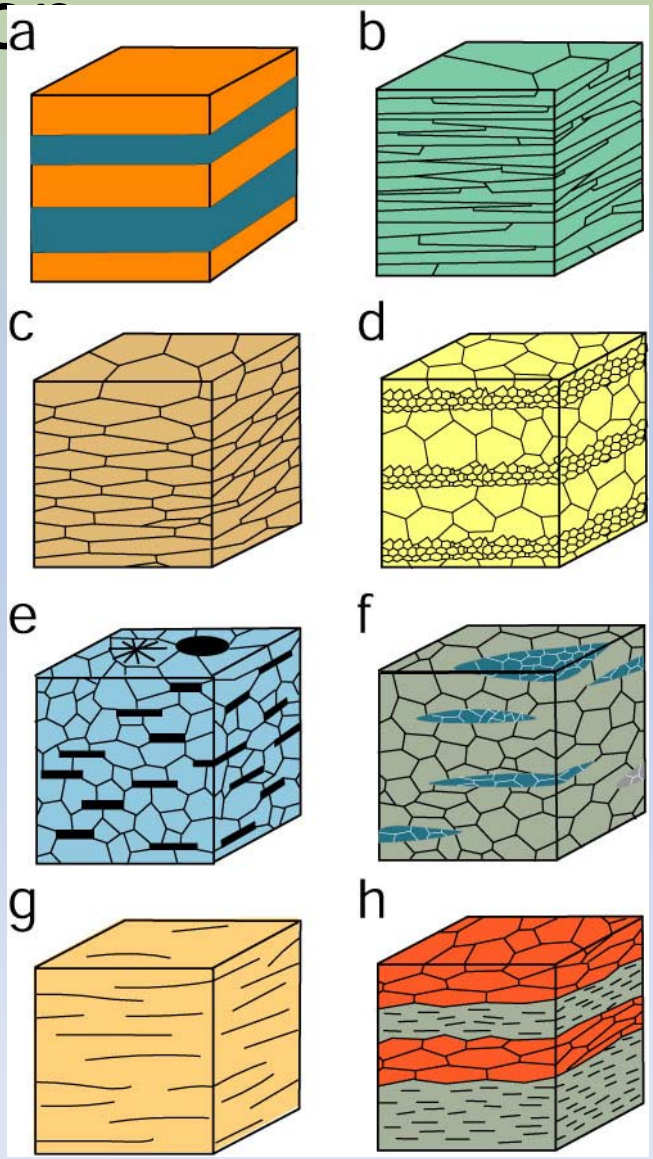
There is evidence of Foliation and lineation as stated in the hypothesis. Also Gneissic Banding. It also has Porphyroblast though it contradicts with the Granoblastic texture while Porphyroblast are seen in our thin sections. The matrix or groundmass of our rocks has a Granulitic texture.

The assumption that it was a granite was incorrect when in our research it states that is most likely a Charnockite. A charnockite is a Proterozoic anothosite that are associated with anhydrous pyroxene-bearing granitoid rocks, also Fe-rich and K-rich diorites, monzonites and other K-rich granitoids. It is most likely that are rock sample was hydrated at one point before metamorphism and became dehydrated after being introdused to such high temperature and pressure.

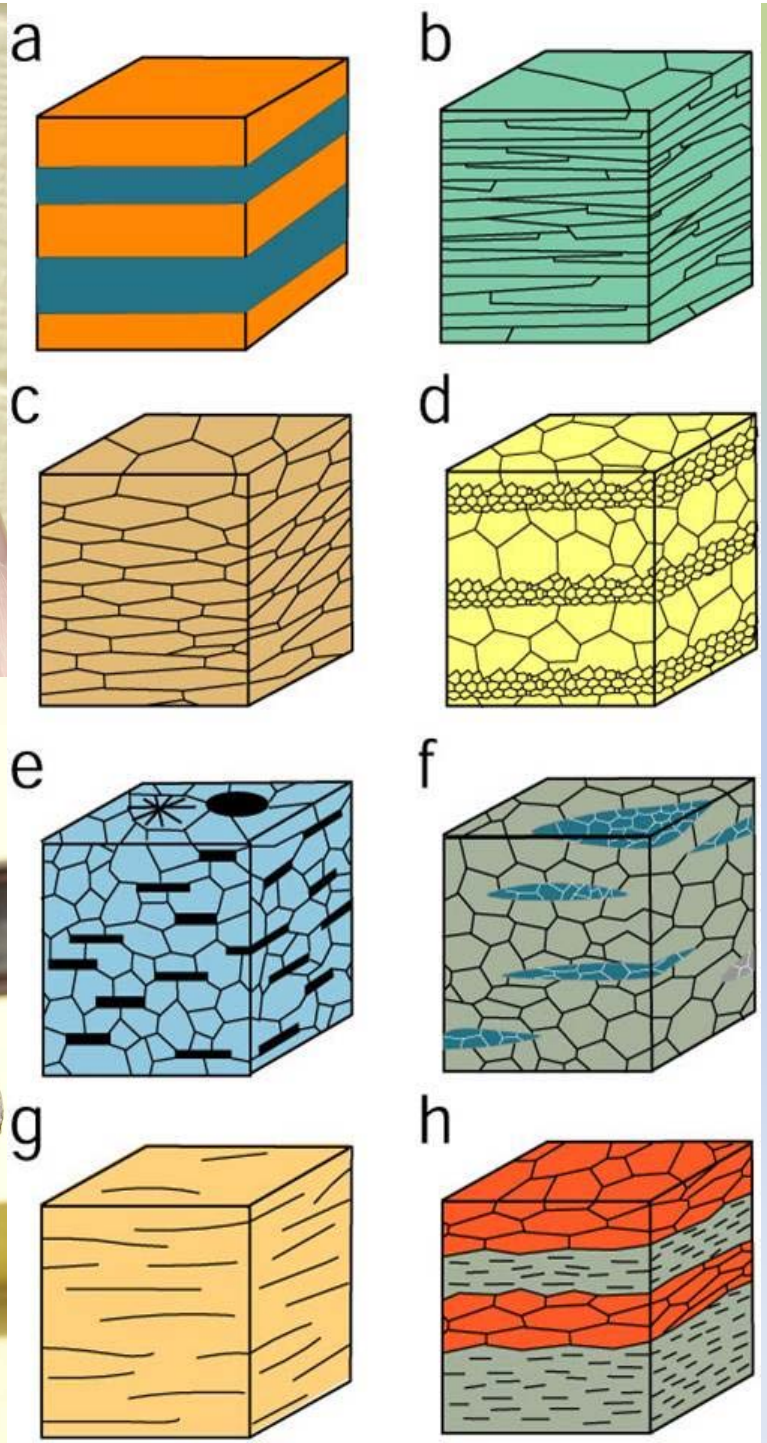
Our samples are heavily metamorphosed since our samples are roughly 1.2 GA, and have taken place in an Orogeny and near a fault. It makes it difficult to get an exact texture.

Types of Texture Elements That May Define a Foliation

- **a.** Compositional layering
- **b.** Preferred orientation of platy minerals
- **c.** Shape of deformed grains
- **d.** Grain size variation
- **e.** Preferred orientation of platy minerals in a matrix without preferred orientation
- **f.** Preferred orientation of lenticular mineral aggregates
- **g.** Preferred orientation of fractures
- **h.** Combinations of the above



From Turner and Weiss (1963) and Passchier and Trouw (1996).



Layered Biotite Granulite and Gneiss

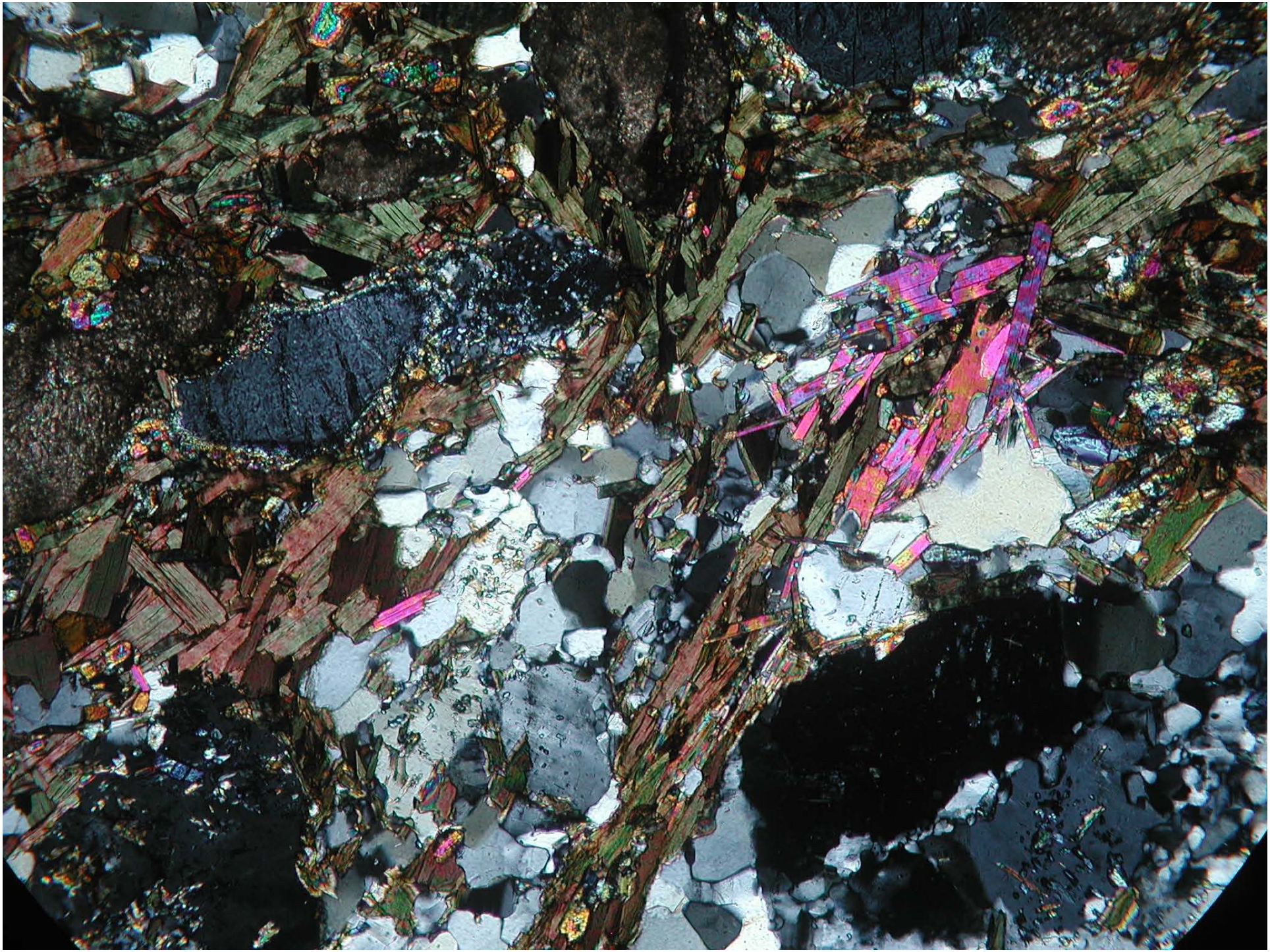
- Preferred orientation of platy minerals in a matrix without preferred orientation

Thin Sections

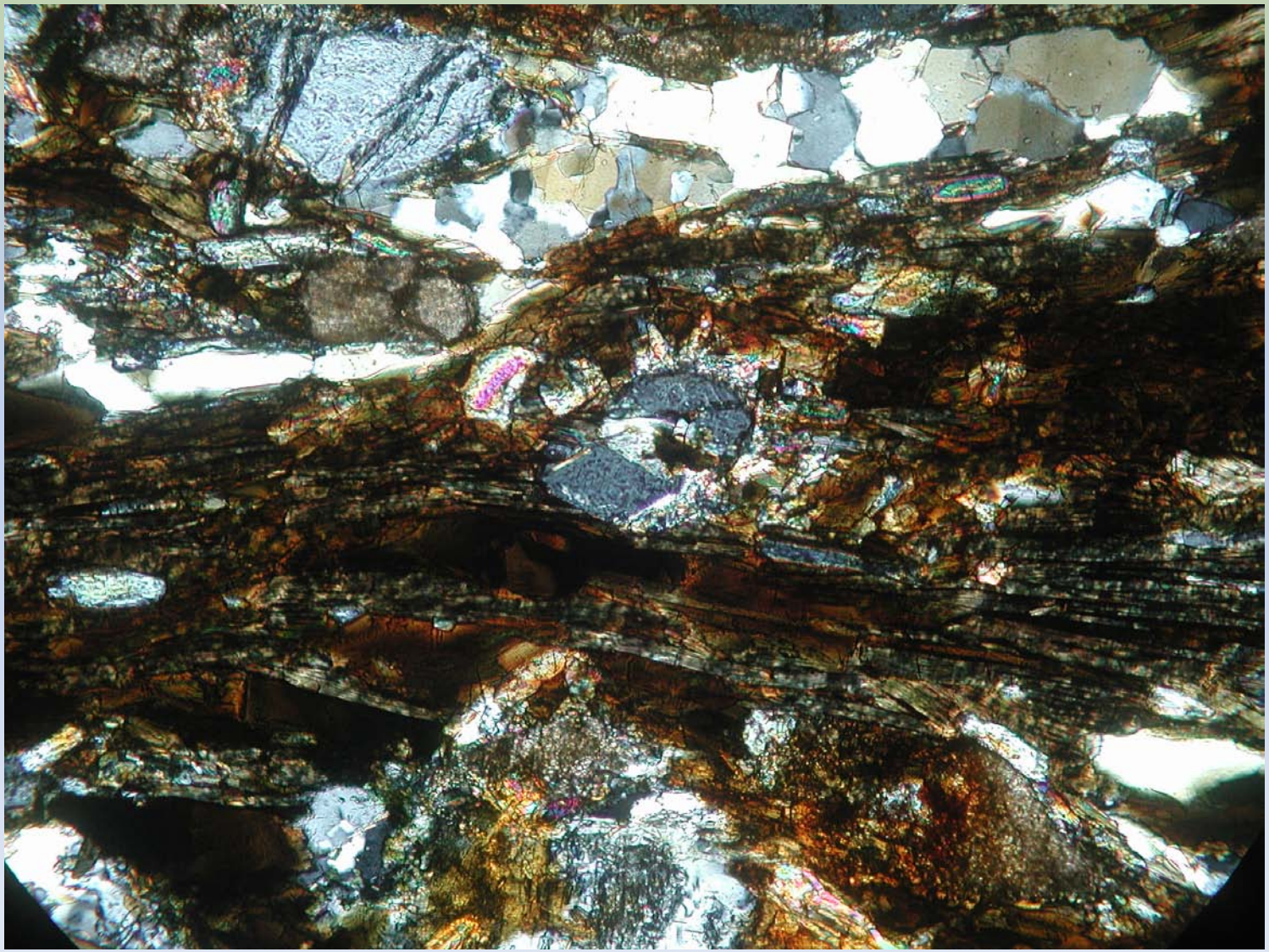
- Minerals found
  - Biotite
  - Plagioclase
  - K-spar
  - Quartz
  - Garnet
  - Sillimanite
  - Epidote

  - No amphiboles or pyroxenes *

- Microscopic textures
  - Biotite foliation
  - Extensive alterations
    - quartz
    - feldspars
    - possibly biotite

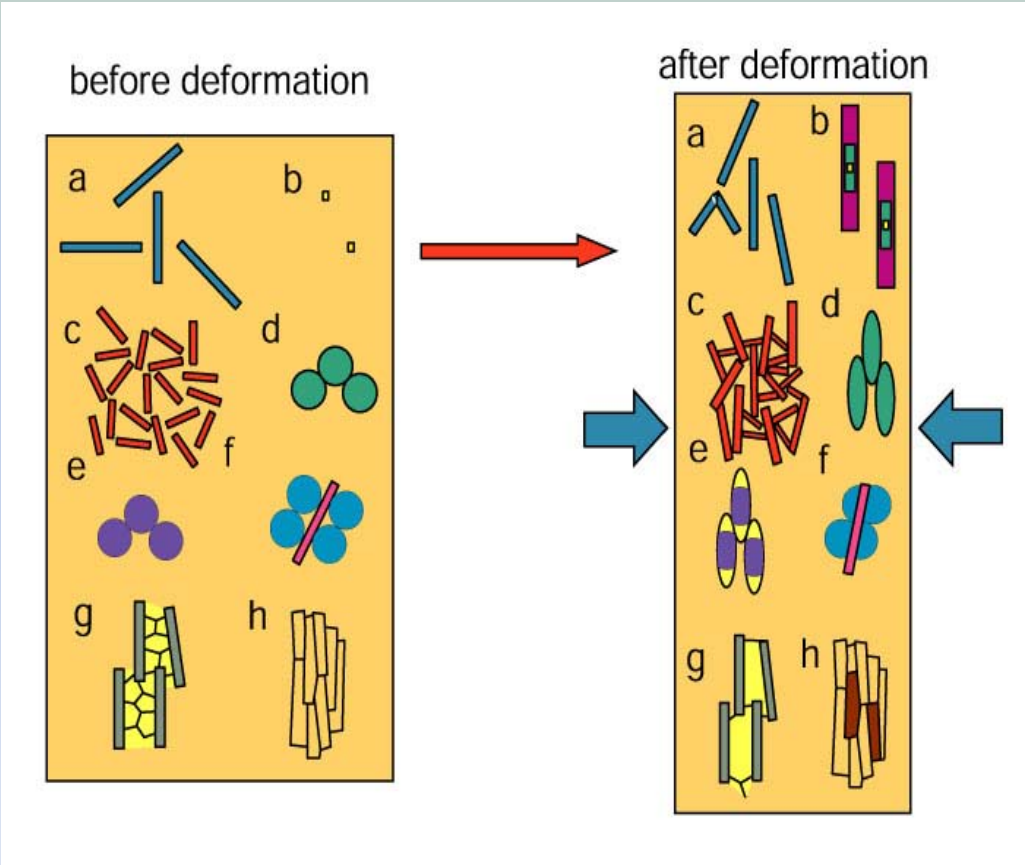


Biotite



Steffen and Swanson, 2010

Texture of Minerals

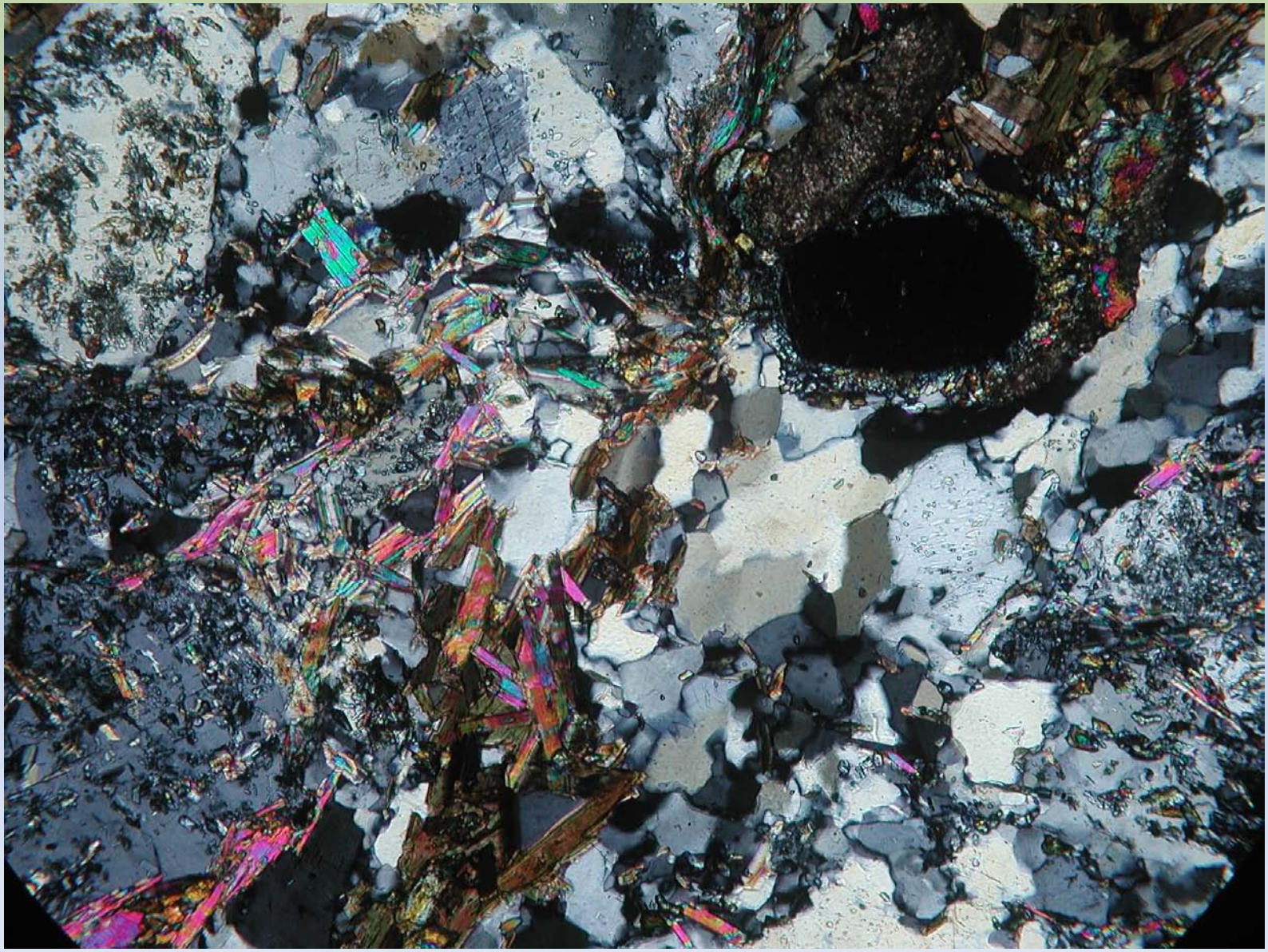


(Winter, 2010)

Grains with advantageous orientation grow whereas those with poor orientation do not (or dissolve)

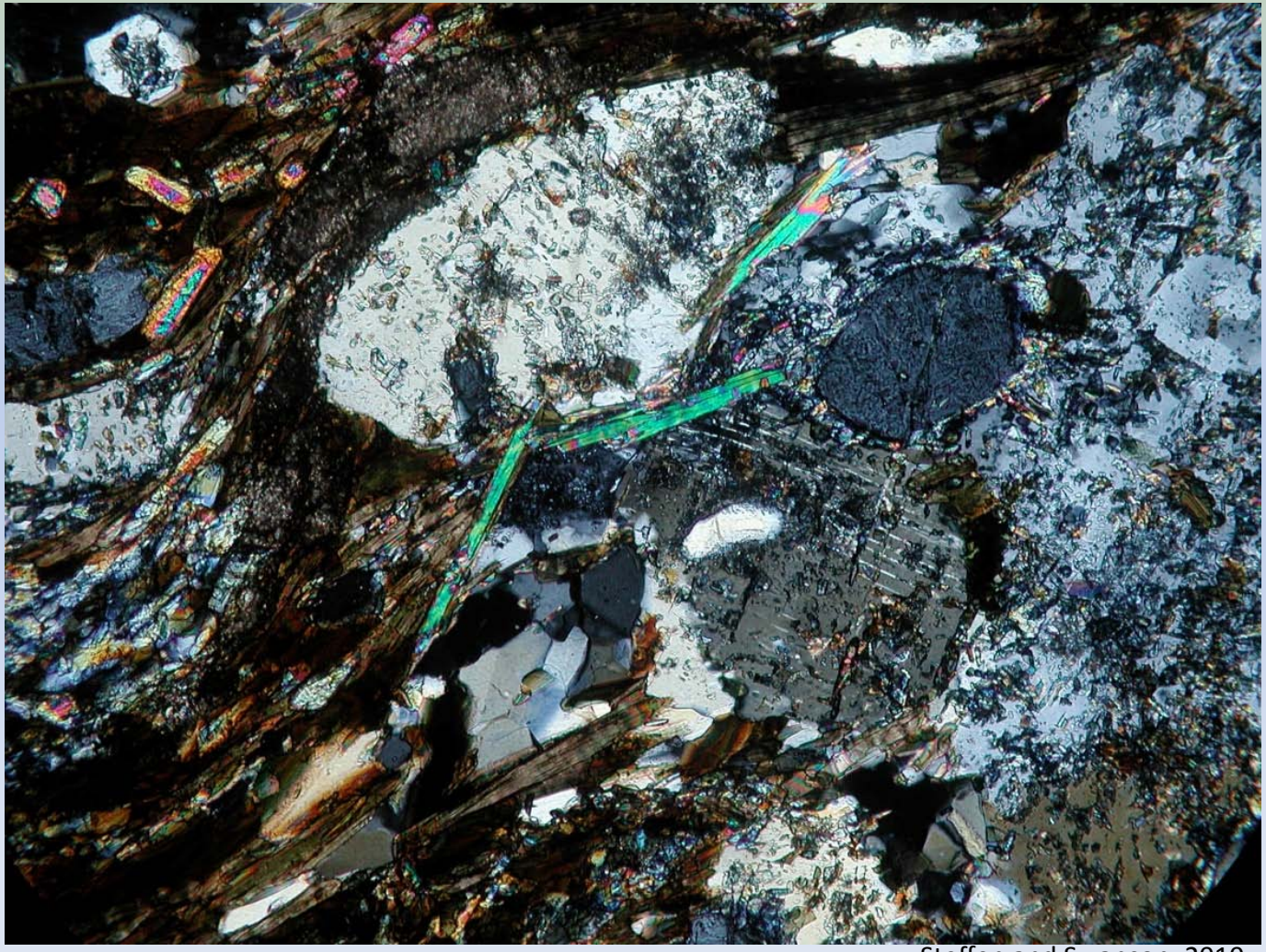
A combination of a and e, Constrained growth between platy minerals

Alterations of Feldspars



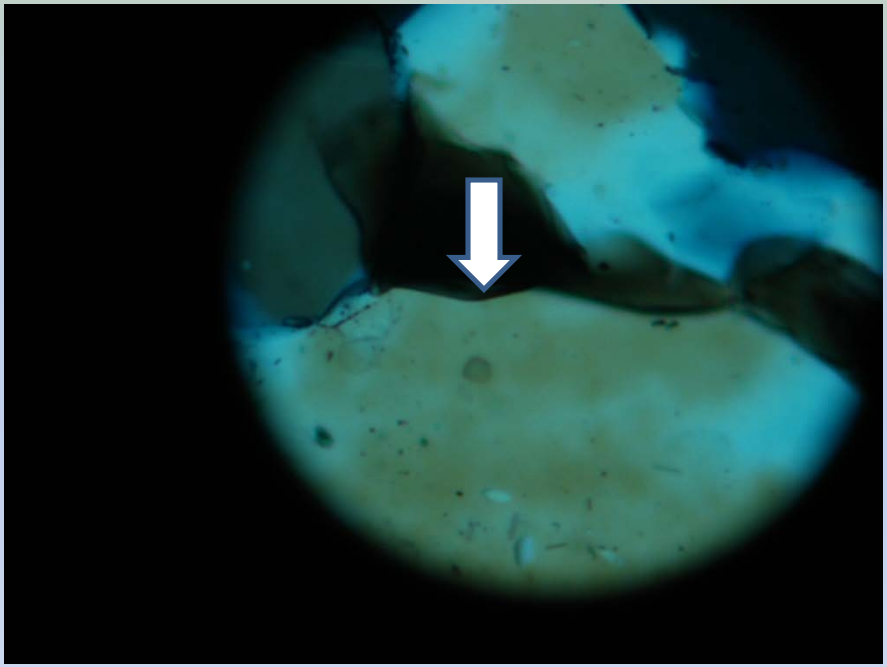
Steffen and Swanson, 2010

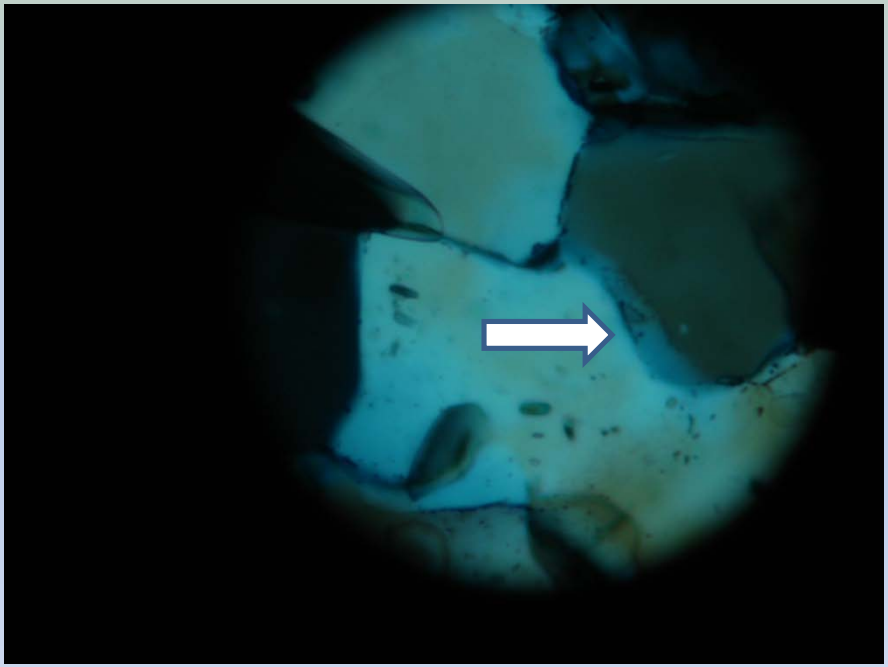
Sillimanite



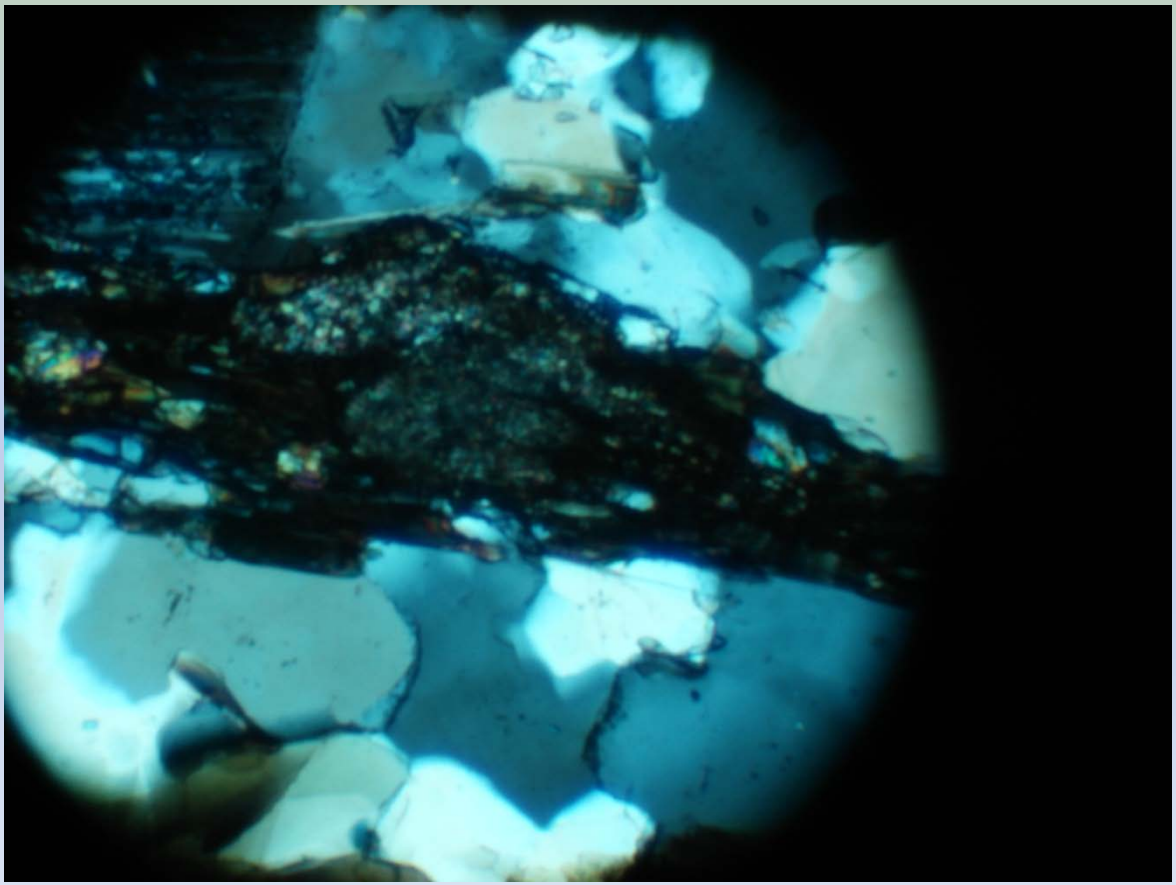
Steffen and Swanson, 2010

Pressure Solution in Quartz





Steffen and Swanson, 2010

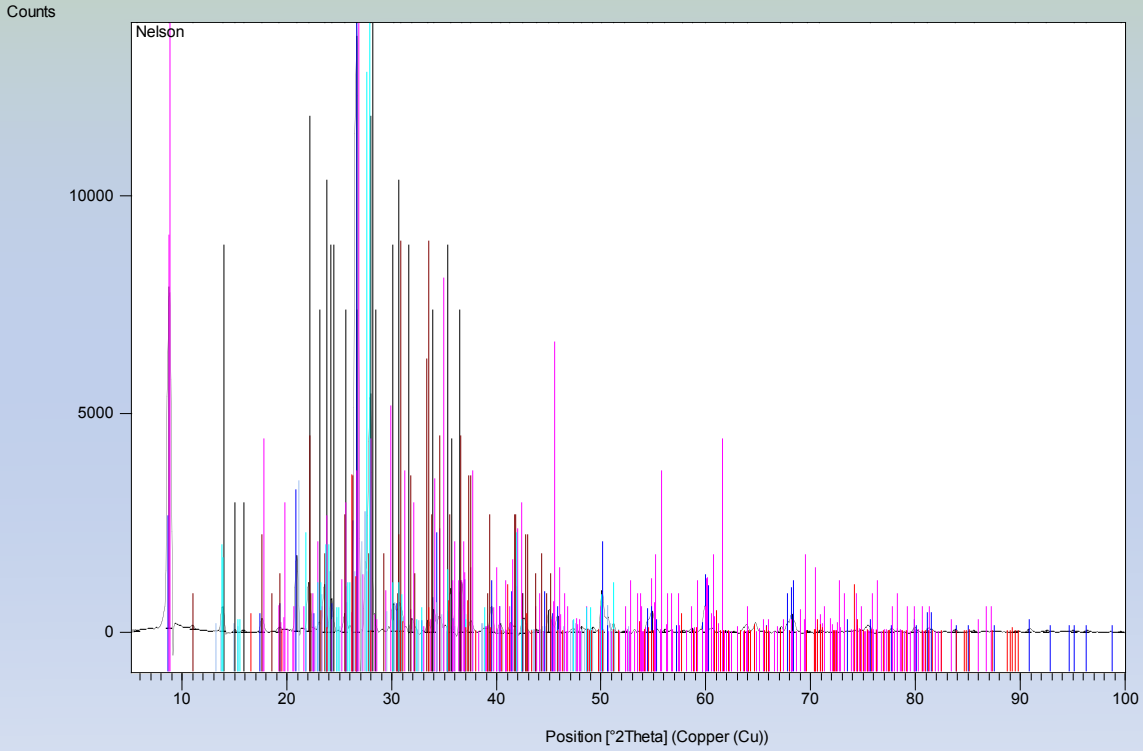


Steffen and Swanson, 2010

XRD Data

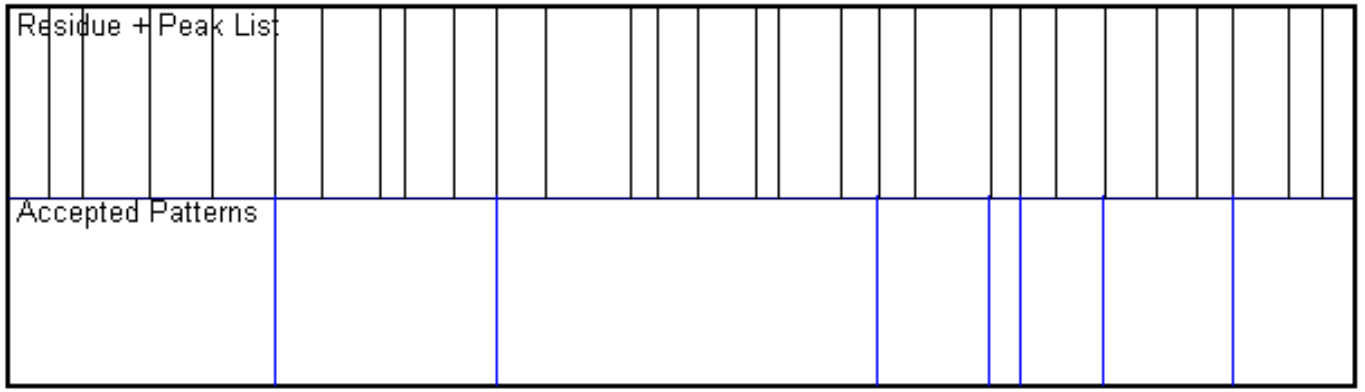
X'Pert Highscore
- Subtract Background
- Smoothed Peaks
- Search & Match
- Peak Search
- Corrected peaks to Quartz

Minerals Matched
- Biotite
- Microcline
- Anorthoclase
- Albite
- Silica (Quartz)
- Muscovite
- Epidote
- Sillimanite



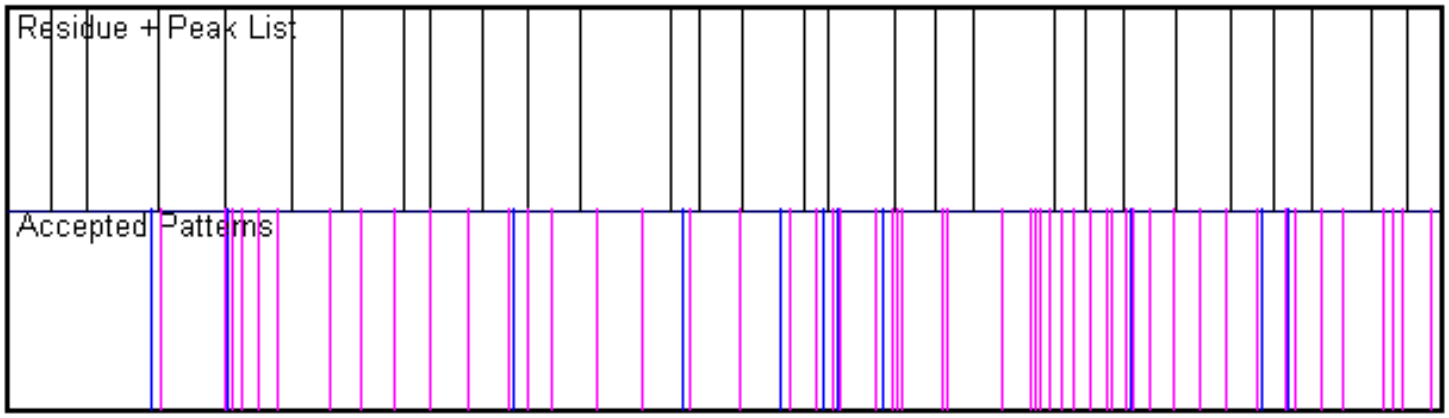
XRD Data

Quartz



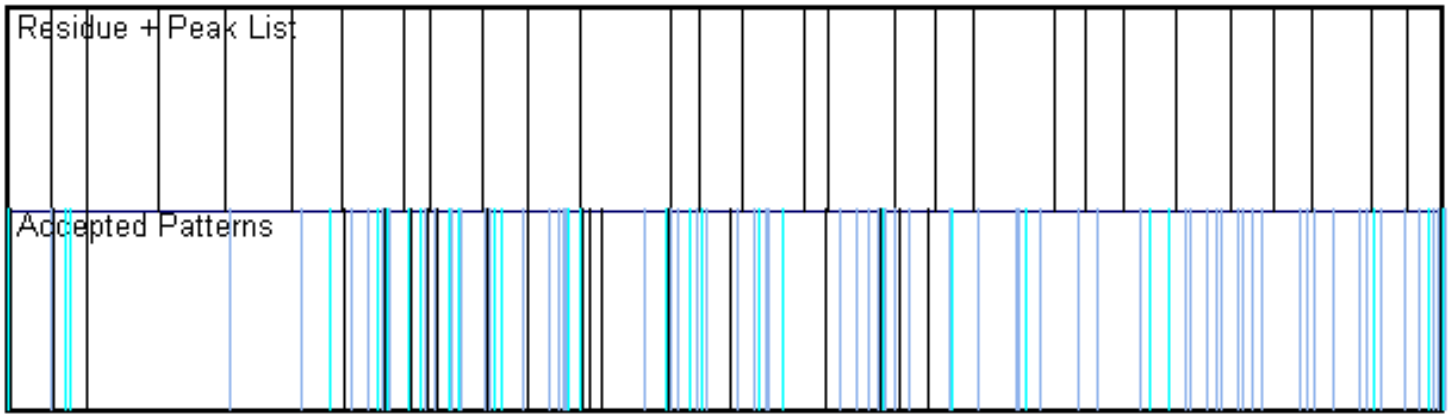
XRD Data

Biotite



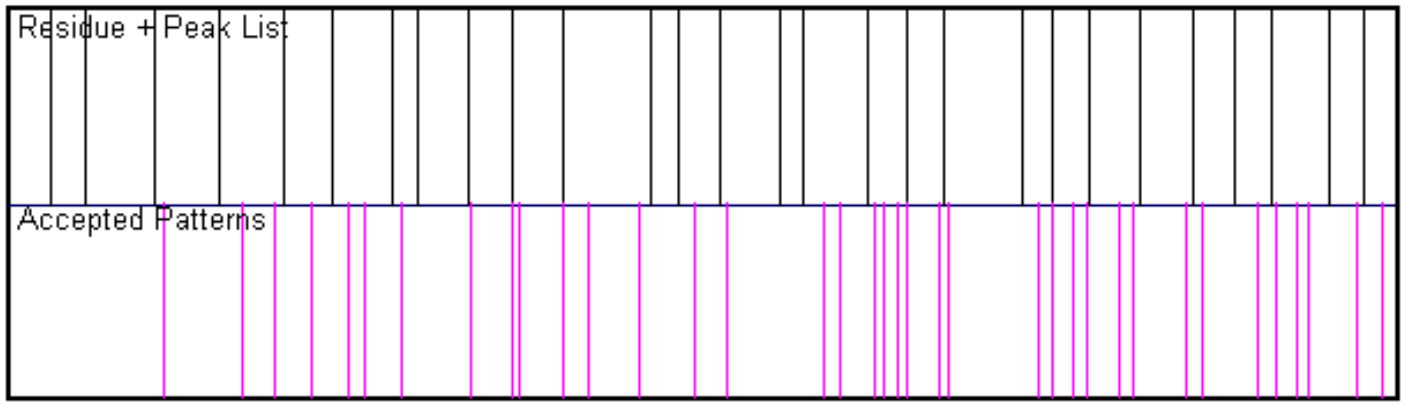
XRD Data

Feldspar



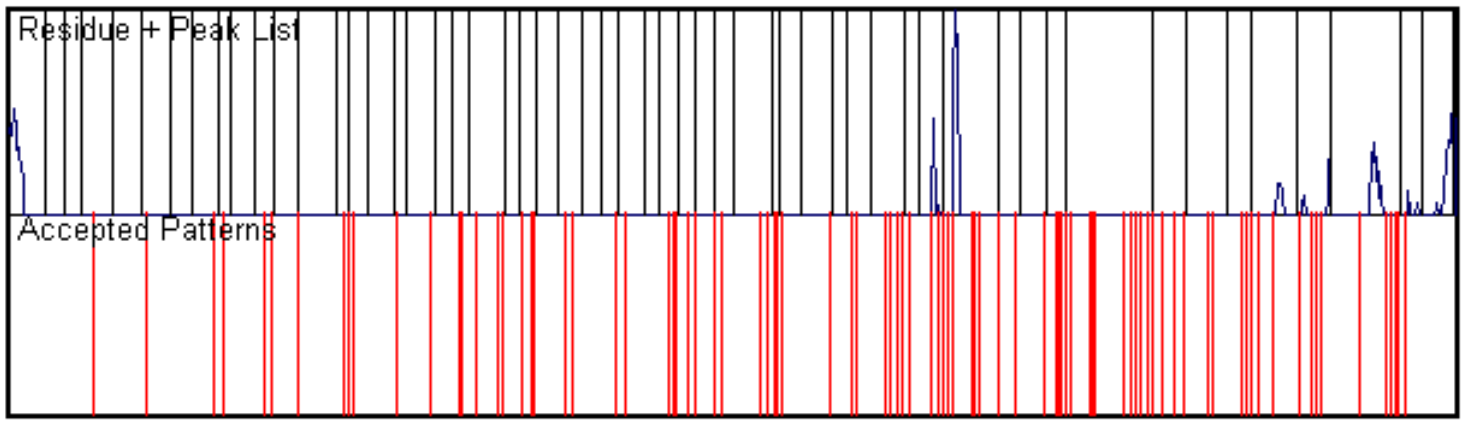
XRD Data

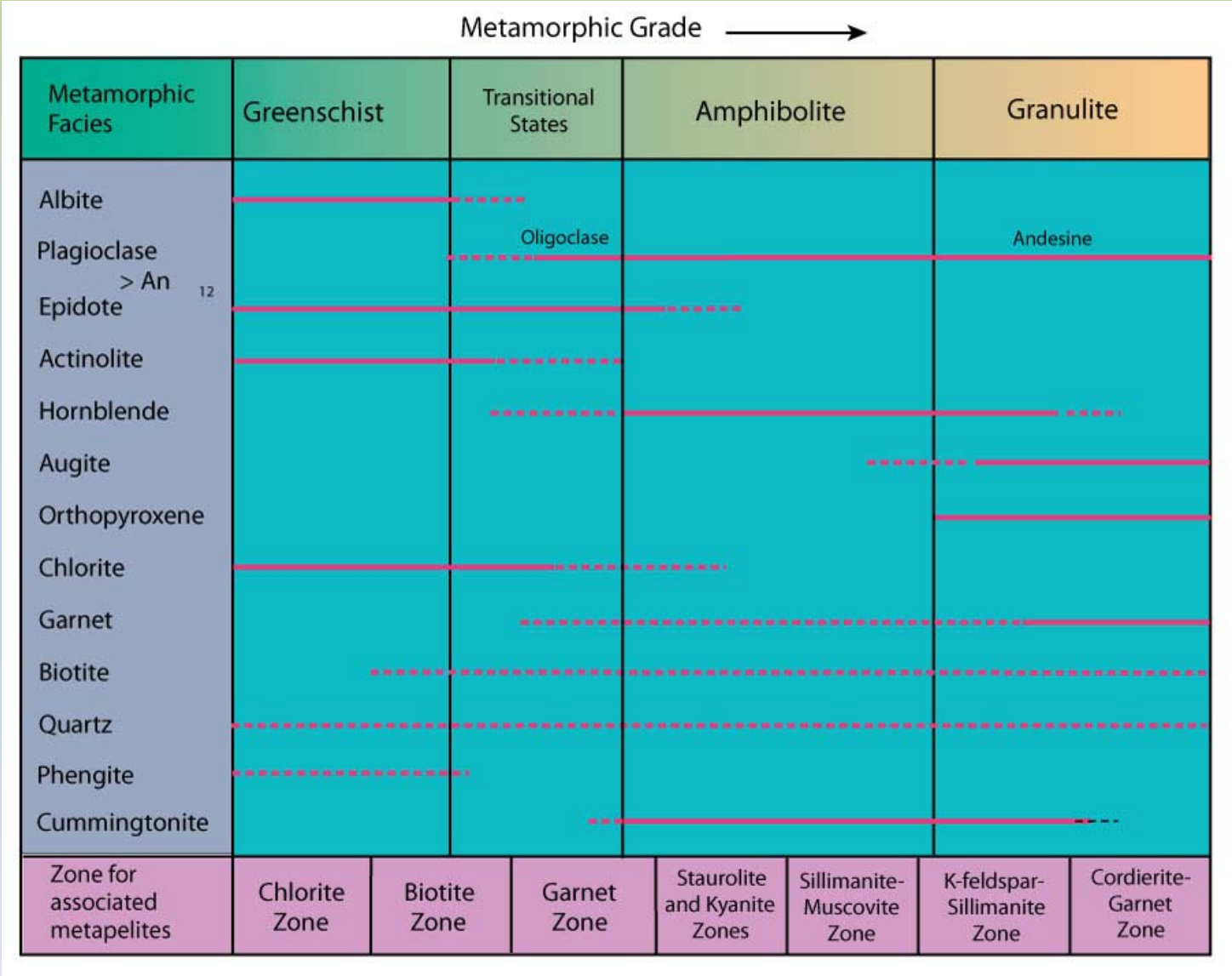
Muscovite



XRD Data

Sillimanite




Metamorphic Grade
Metamorphic Facies
Greenschist
Transitional States
Amphibolite
Granulite
Albite
Plagioclase > An 12
Epidote
Actinolite
Hornblende
Augite
Orthopyroxene
Chlorite
Garnet
Biotite
Quartz
Phengite
Cummingtonite
Oligoclase
Andesine
Zone for associated metapelites
Chlorite Zone
Biotite Zone
Garnet Zone
Staurolite and Kyanite Zones
Sillimanite-Muscovite Zone
K-feldspar-Sillimanite Zone
Cordierite-Garnet Zone

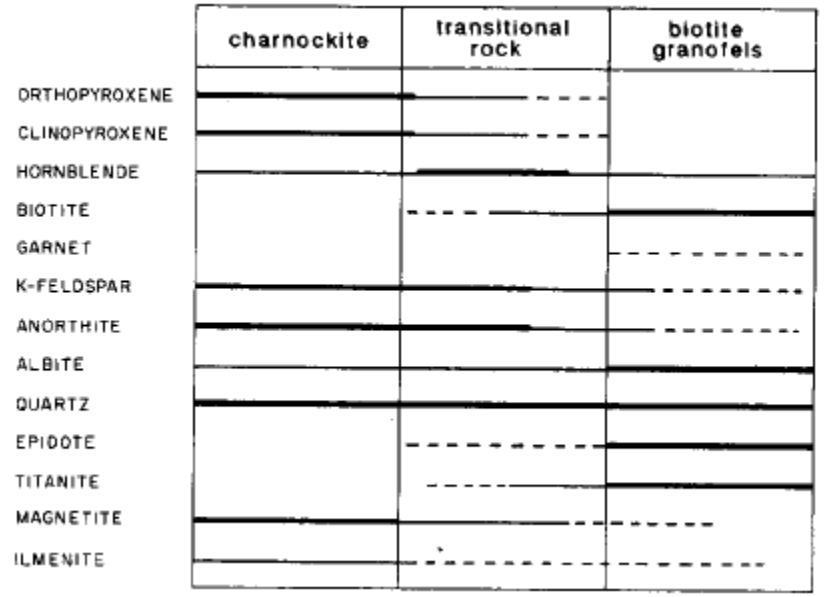
Winter, 2010

Origin of Biotite

- Evans, N.H., 1991
  - Difference between Lovingston and Pedlar basement terranes
  - Amphibole- and granulute-facies

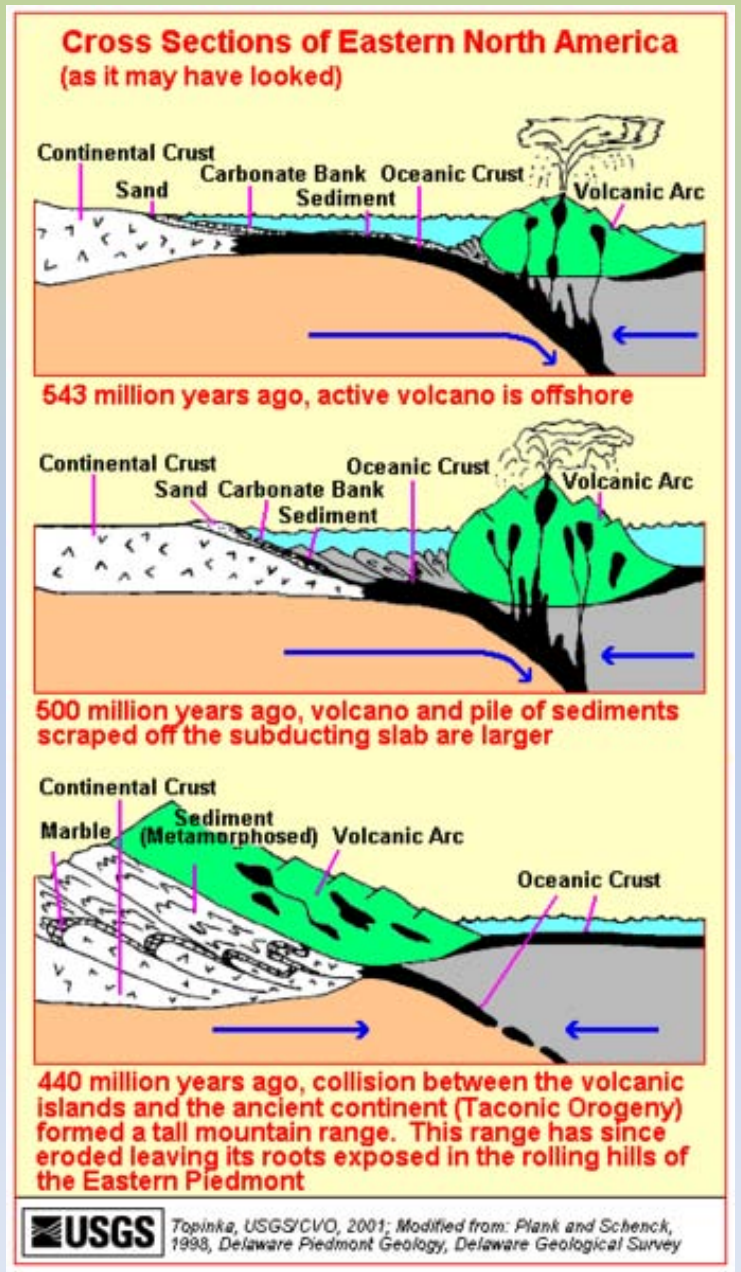
- Alteration of biotite under mesothermal conditions
  - George M. Schwartz, 1958

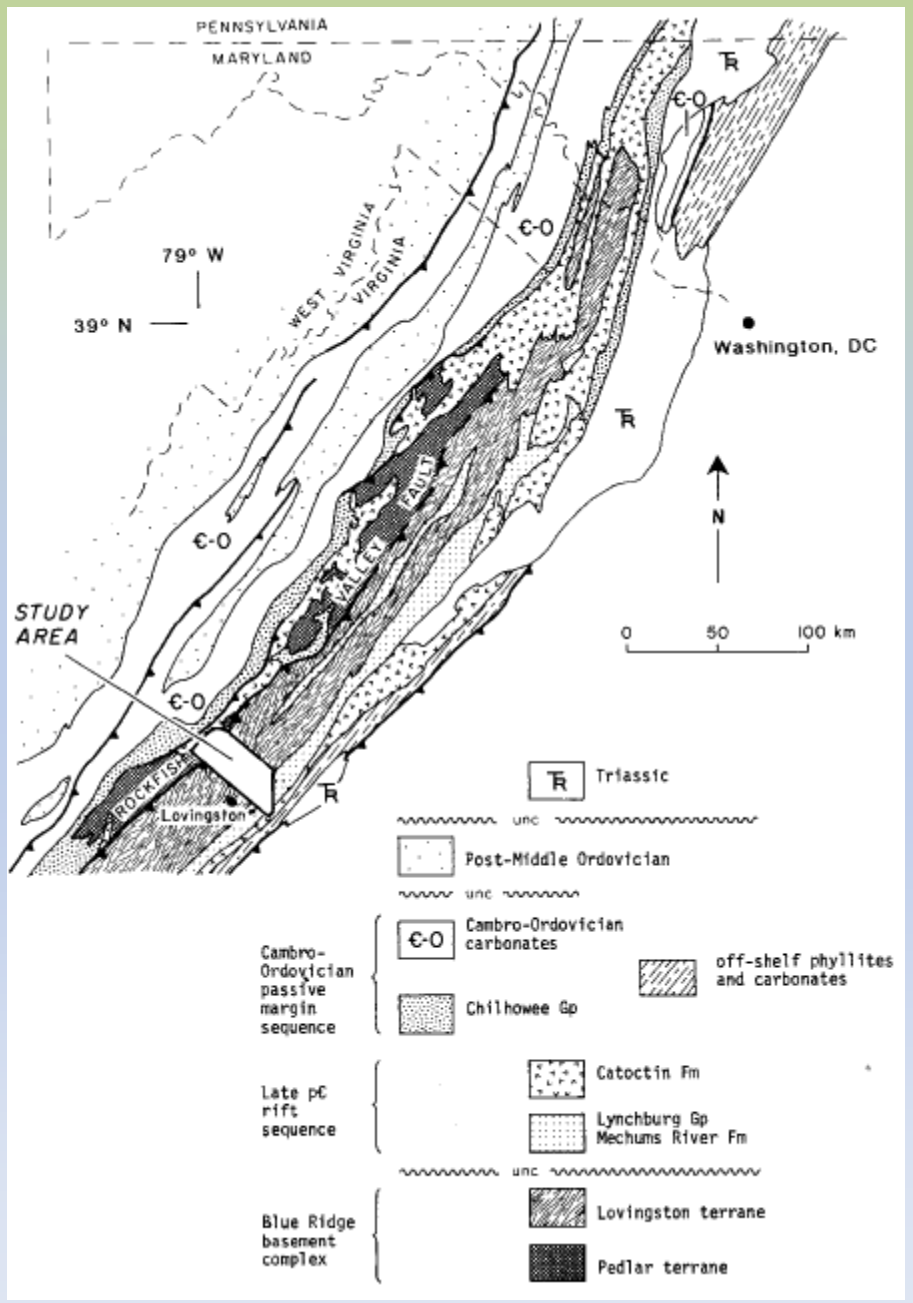
- Between amphibole and granulite facies
  - No amphiboles or pyroxenes



(Evans, 1991)

- Grenville Orogeny
  - (1.2 - .8 Bya)
- Hydration of basement complex
  - Iapetus Ocean
- Taconic Orogeny




PENNSYLVANIA
MARYLAND
79° W
39° N
WEST VIRGINIA
VIRGINIA
Washington, DC
STUDY AREA
VALLEY FAULT
ROCKFISH
Lovingston
N
0 50 100 km
Triassic
unc
Post-Middle Ordovician
unc
Cambro-Ordovician carbonates
Chilhowee Gp
off-shelf phyllites and carbonates
Cambro-Ordovician passive margin sequence
Late pC rift sequence
Catoctin Fm
Lynchburg Gp
Mechums River Fm
unc
Lovingston terrane
Pedlar terrane
Blue Ridge basement complex

Metamorphic Hydration

308 **qz** + 220 **pc** + 160 **ksp** + 60 **opx** + 60 **cpx** + 30 **mgt** +21 **ilm** + 39 $\mathbf{O_2}$ + 86 $\mathbf{H_2O}$

= 453 **qz** + 132 **ab** + 100 **ksp** + 25 **bt** + 26 **amph** + 10 **mu** + 39 **ep** + 1 **mgt** + 21 **ilm** + 14 $\mathbf{O_2}$ + 50 $\mathbf{H_2O}$

= 539 **qz** + 142 **ab** + 50 **ksp** + 50 **bt** + 10 **mu** + 53 **ep** + 21 **ti**

Conclusion

If indeed there is sillimanite in this sample, higher grade metamorphism would need to have taken place

Rifting system

Seaward side of Rockfish Valley Fault

Hydration

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