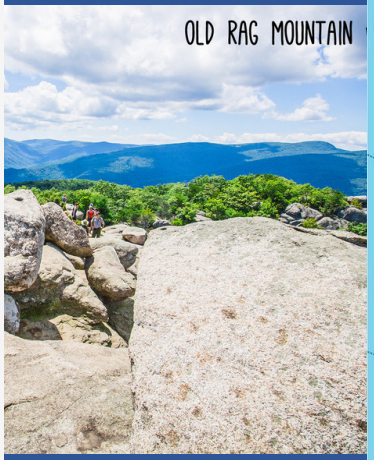
Geologic Evaluation of North America

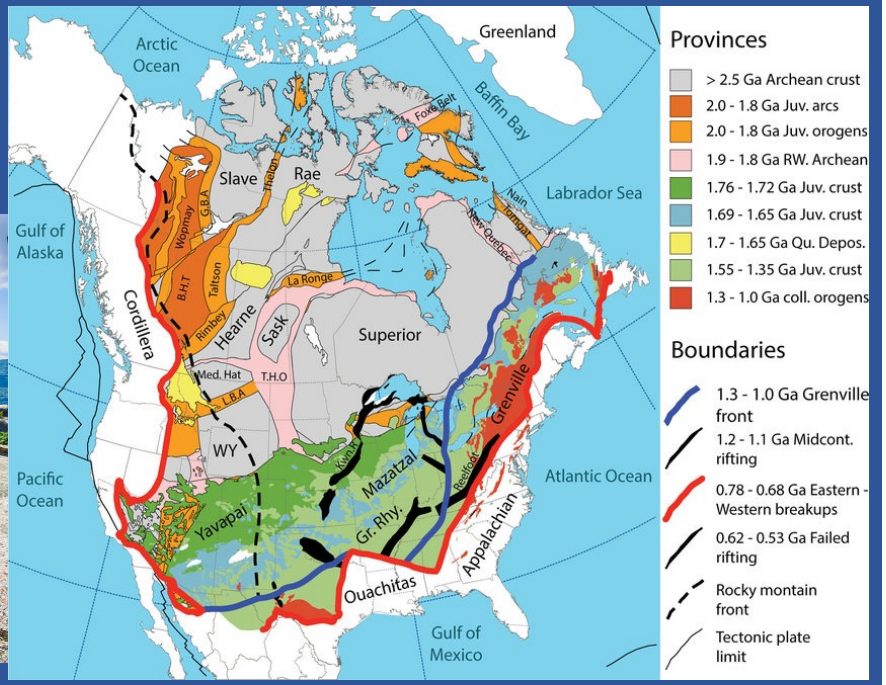
With a Focus on the US National Parks

with Nicole Myers

Week 2: Final Assembly of the North America Craton

https://www.appreciatingearth.com/olli





National Park Service

*"conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them **unimpaired for the enjoyment of future generations**." [National Park Service Organic Act of 1916]*

"Non-impairment" standard applies to every NPS designations:

- Total Federal Public lands (all agencies) = ~640 million acres
- National Park System (NPS): >85 million acres in 433 NSP sites/units
- 63 National Parks = ~50 million acres with "Very High-Protection"
  - Resource extraction prohibited: no mining, logging, drilling
  - Development minimal: tightly constrained
  - Motorized access limited: regulated tourism infrastructure
  - Conservation Priority very high: landscape-scale protection, ecosystem integrity & strong wildlife protections, emphasis on natural conditions/processes (fire, hydrology), active management when necessary
  - **National Wilderness = Overlay Designation = strictest conservation standard in U.S. law** = No motorized vehicles, permanent structures, commercial enterprises, mechanized equipment (rare exceptions)

Week 1 Recap

Conserved land provides opportunities for unimpaired land & ecosystems to be studied

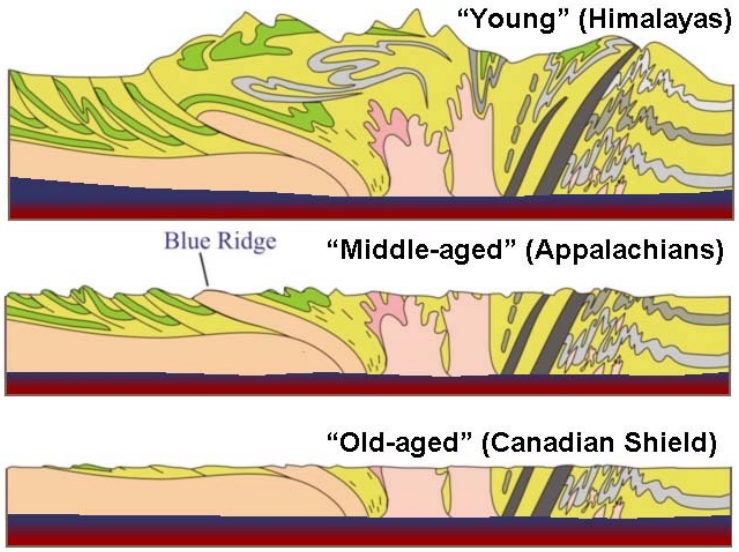
3 rock types & 3 tectonic boundary types

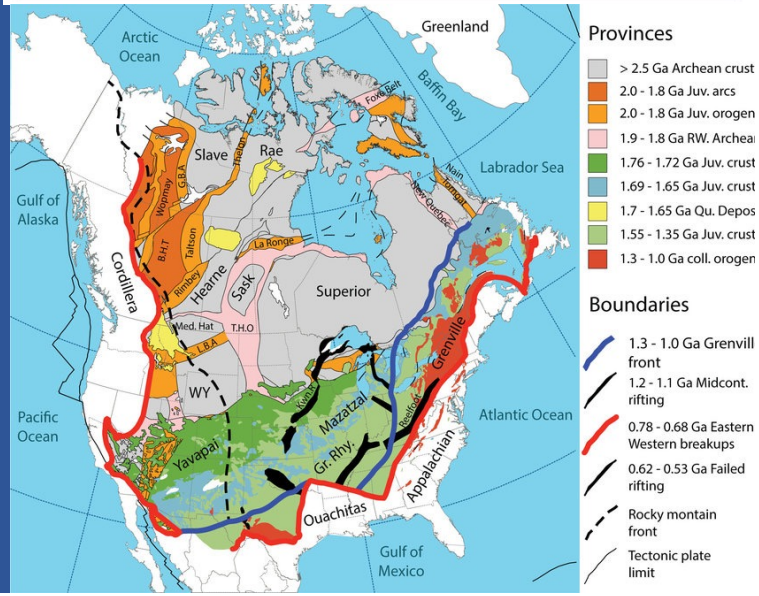
- Basement rocks = metamorphic + intrusive ign.
- Cover rocks = sedimentary + extrusive igneous
- Cratons = Precambrian continent assembly

Orogenies = convergent continental grow

- 2.8-2.5Ga Kenorland Supercontinent
- 2.4-2.2Ga Snowball Earth
- 1.65-1.63Ga Penokean Orogeny
- 2.0-1.4Ga Trans-Hudson Orogeny = Columbia "SC"

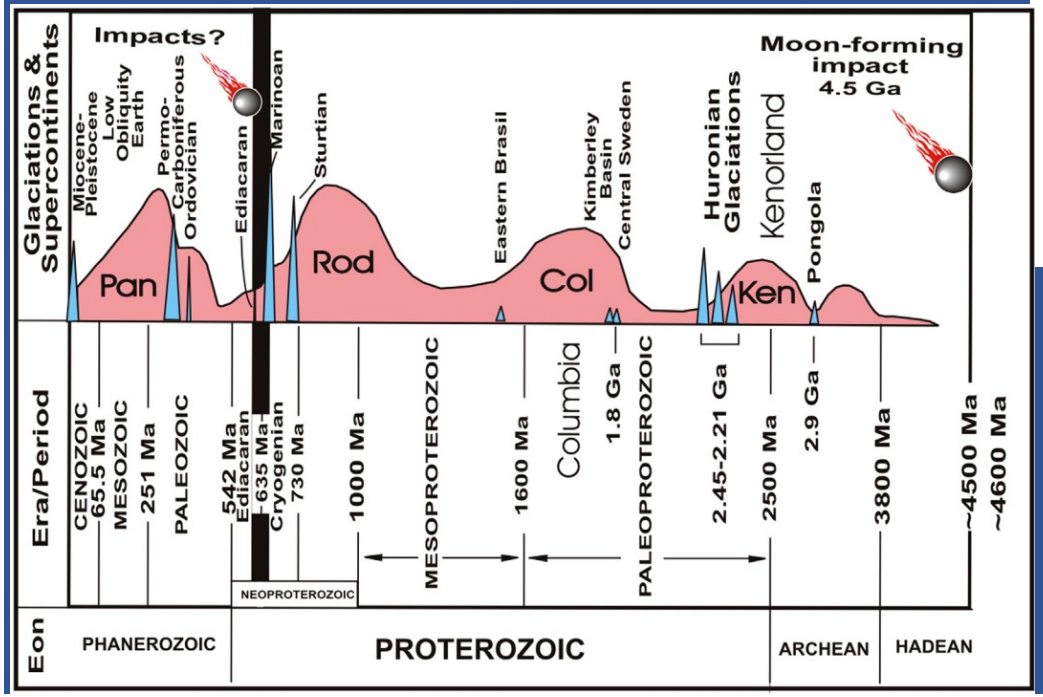
National Parks So Far: Voyageurs, Pipestone, Grand Teton, Yellowstone, Wind Cave, Glacier

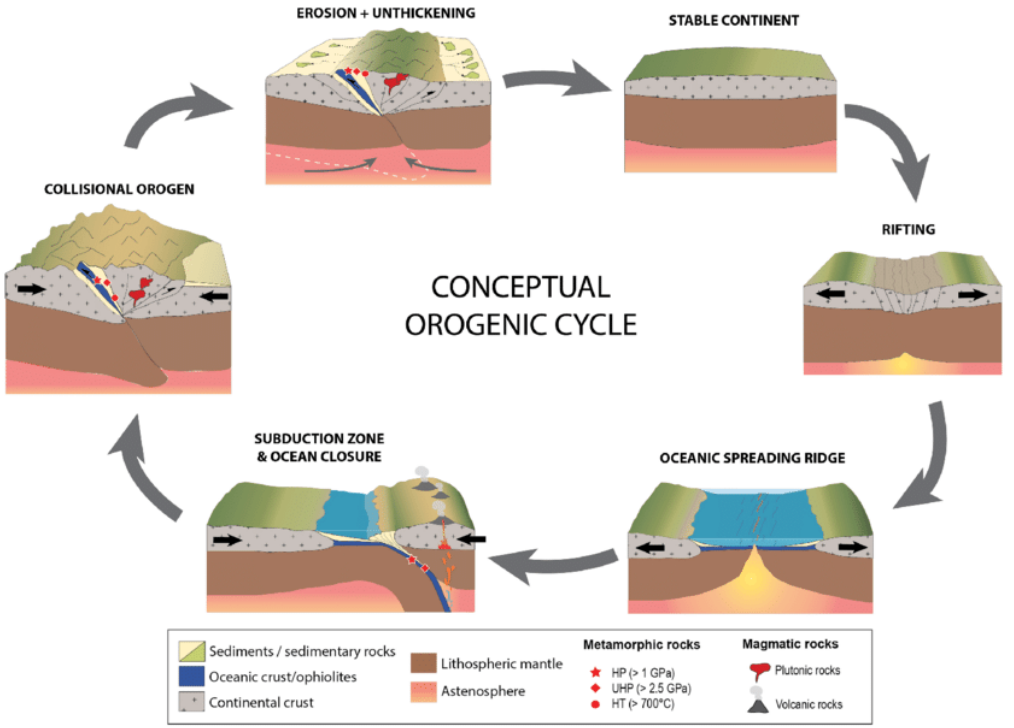


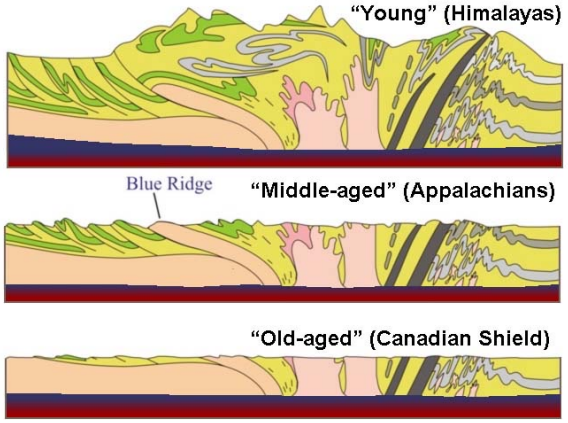


Orogenies & Supercontinents

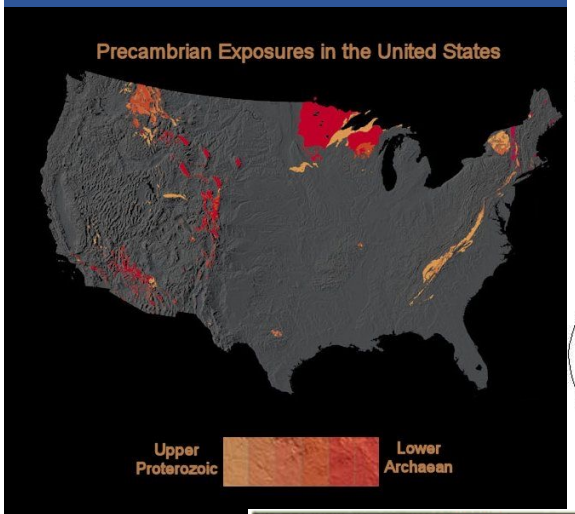
- The Wilson Cycle: the cyclical opening & closing of ocean basin
- The Supercontinent Cycle: the consolidation of continental crust into a single landmass that then breaks up

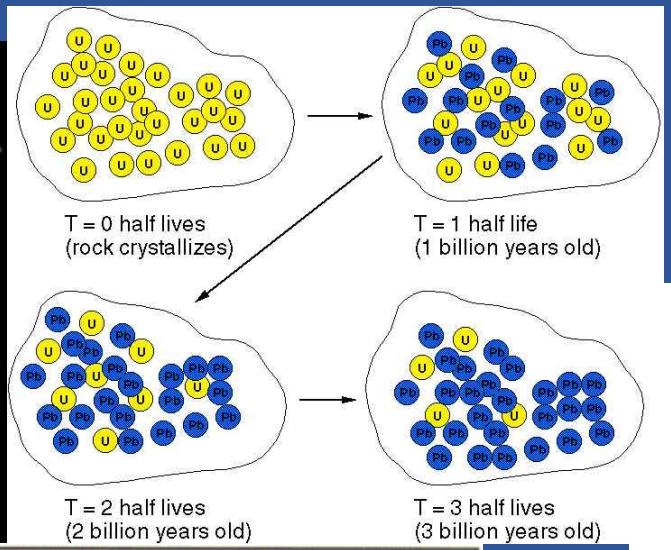




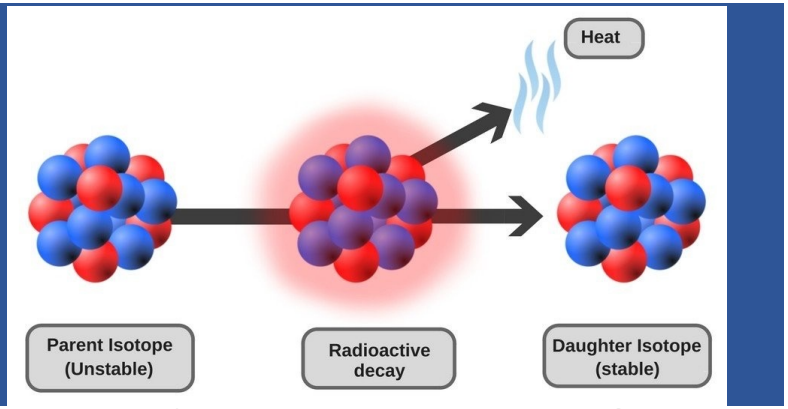


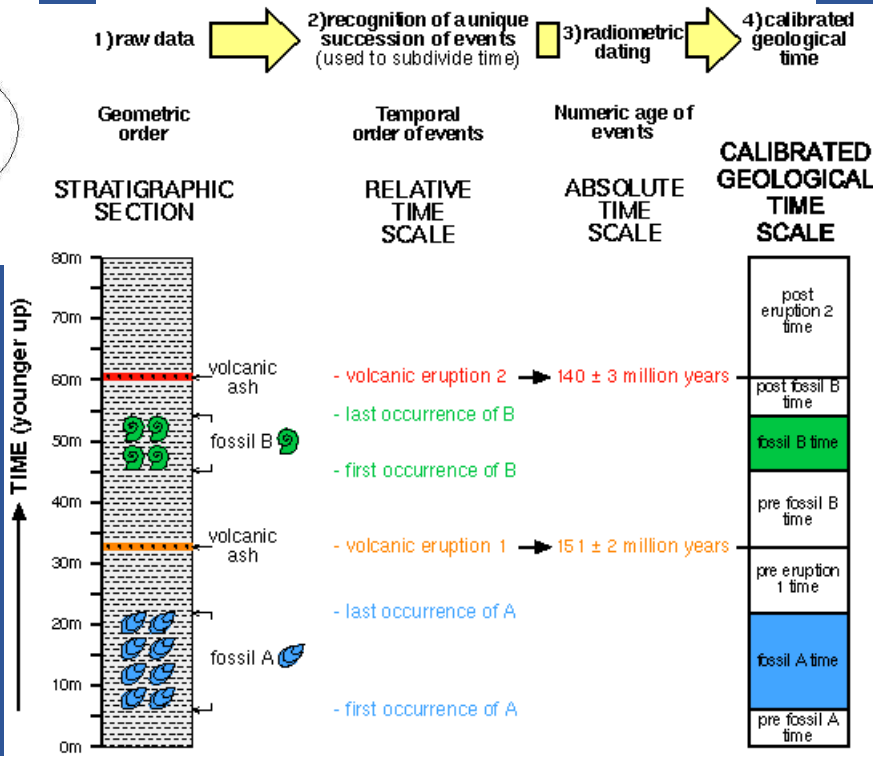
Developing a Timeline

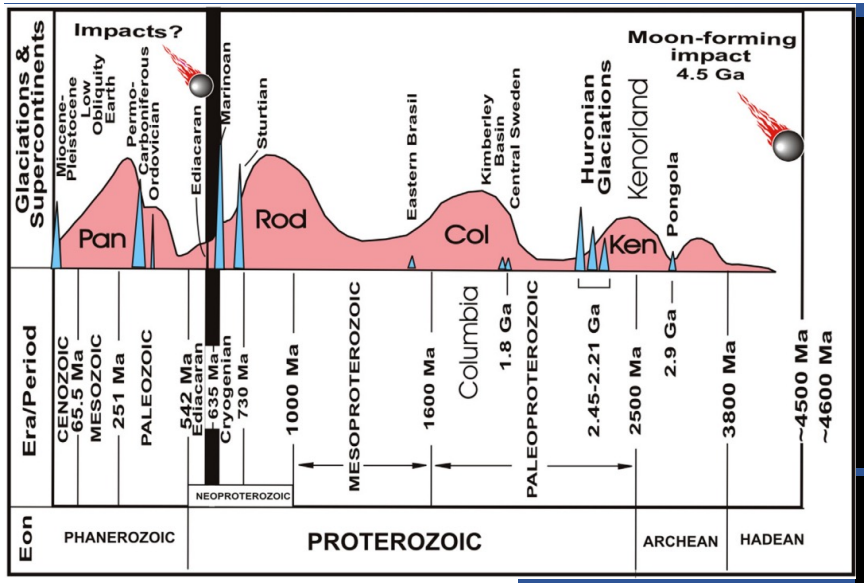


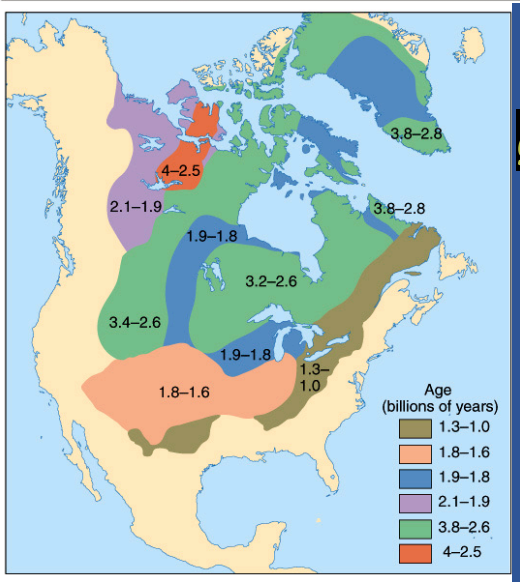


Isotope		Half-life of parent (years)	Useful range (years)
Parent	Daughter		
Carbon 14	Nitrogen 14	5,730	100 - 30,000
Potassium 40	Argon 40	1.3 billion	100,000 - 4.5 billion
Rubidium 87	Strontium 87	47 billion	10 million - 4.5 billion
Uranium 238 Uranium 235	Lead 206 Lead 207	4.5 billion 710 million	10 million - 4.6 billion









Focus on the green shapes & watch North America slowly form

Link: https://www.youtube.com/watch?v=UwWWuttntio&t=32s

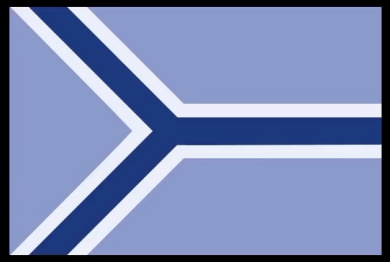
This map will show the continents colored by current location.

Africa
Antarctica
Australia & Oceania
Eurasia
North America
South America
Does not belong to any

Continent Formation

Supercontinents provide opportunities for increased accretion and continental growth

3.3 Billion Years of Continental Drift



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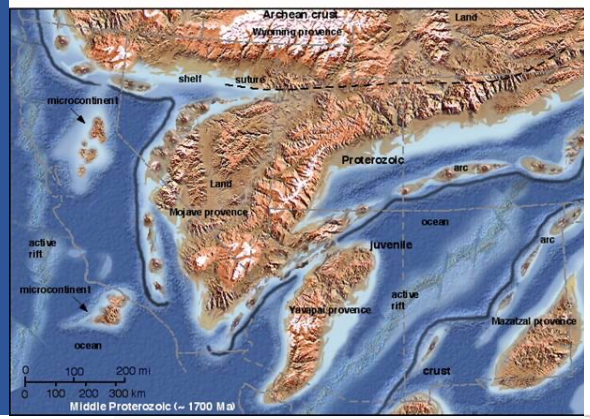
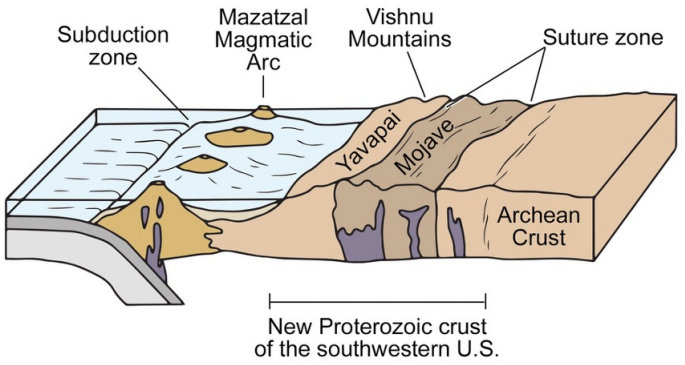
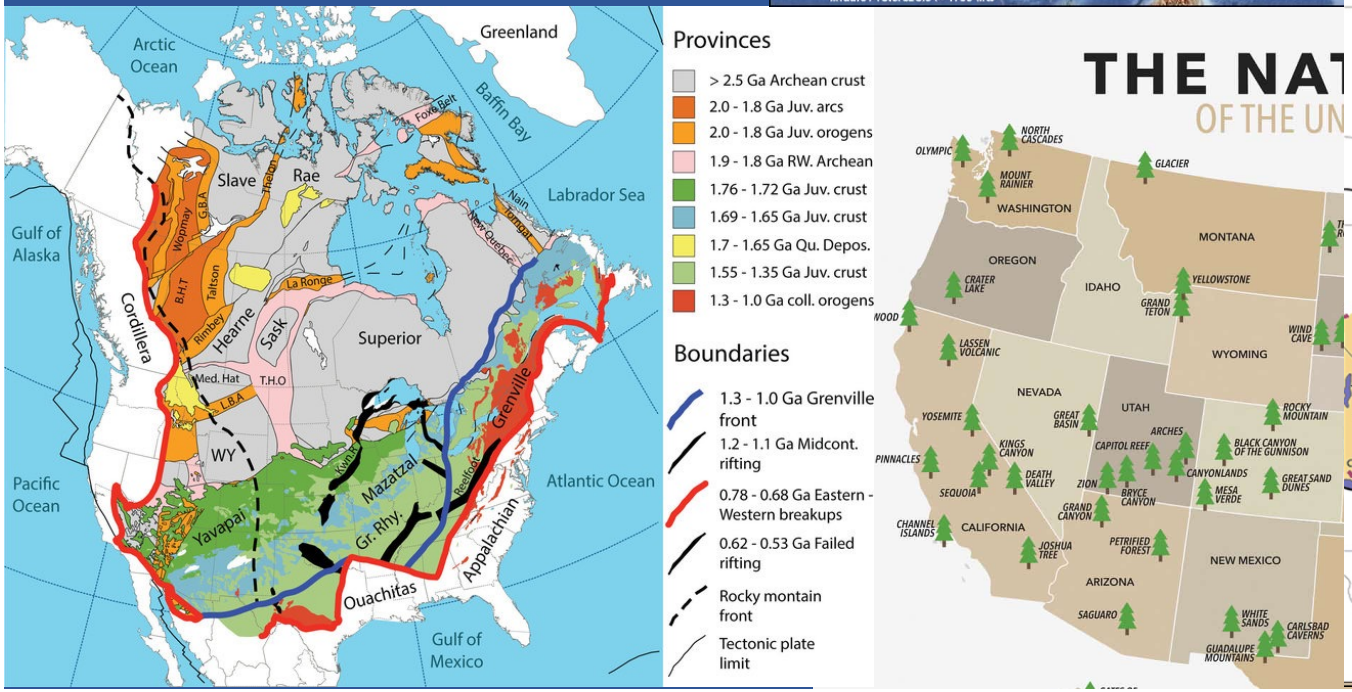
Proterozoic Eon: Yavapai & Mazatzal (Colorado) + Mojave Orogenies

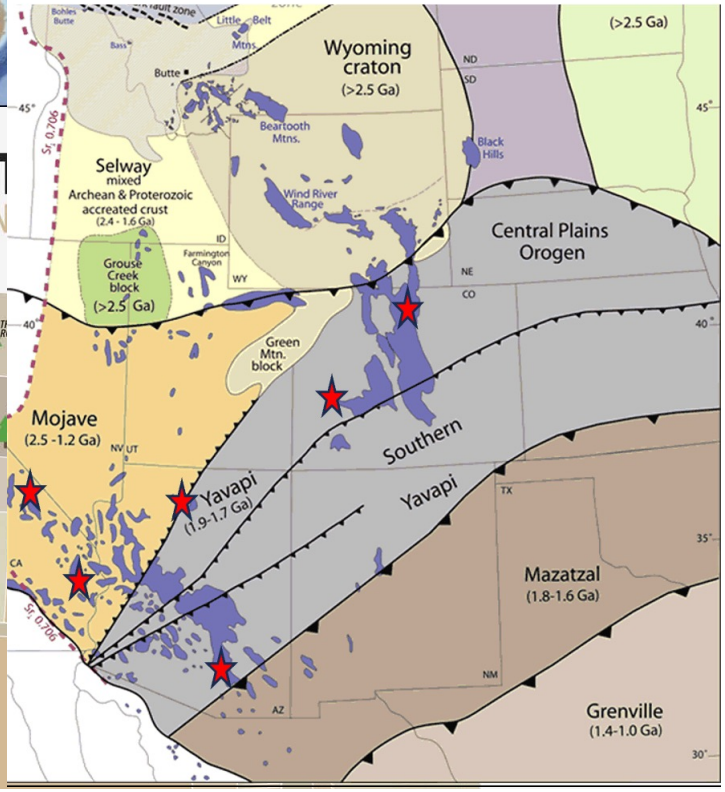
Proterozoic Eon ~1.8-1.6Ga:

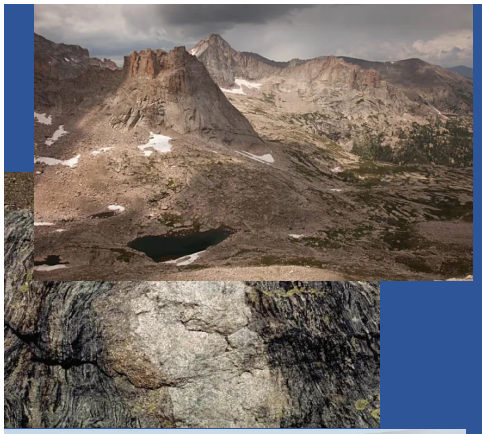
Successive oceanic island arcs accreted on to NA

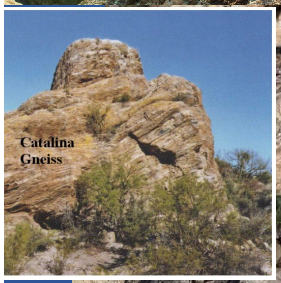


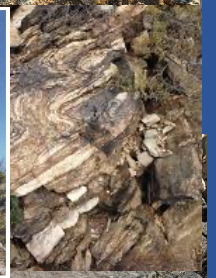












Accreted Terranes

Rocky Mountains National Park, CO:

- 1.8Ga sedimentary deposited
- 1.9-1.4Ga YM Orogenies: gneiss & schist
- ~1.4Ga Granite Intrusions

Black Canyon of the Gunnison NP, CO:

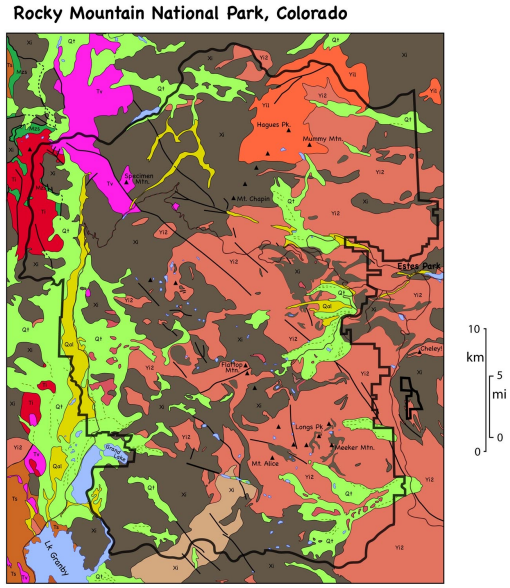
- 1.7Ga YM Orogenies: gneiss
- 1.4Ga pegmatite & granitoids

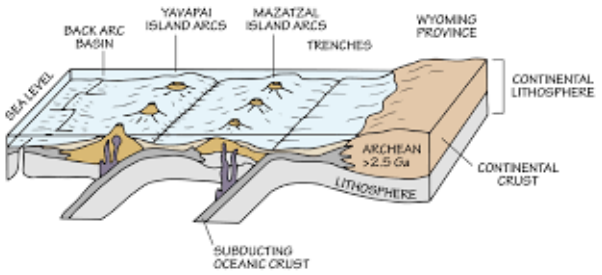
Saguaro National Park, AZ:

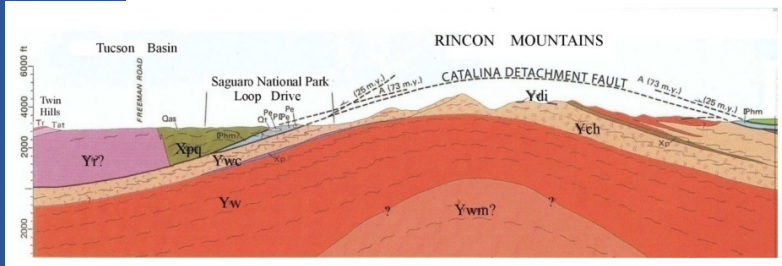
- 1.7-1.4Ga Mojave orogeny
- Deep marine sed. → gneiss & schist

Joshua Tree NP, CA:

- Mojave O. 1.7-1.4Ga gneiss, quartzite, schist, dolostone + intrusions







The Grand Canyon

Protoliths:

- ~2Ga sedimentary & volcanic rocks

Yavapai Orogeny:

- 1.8-1.7Ga metamorphism = Vishnu Mountains
- ~1.75-1.4Ga intrusions

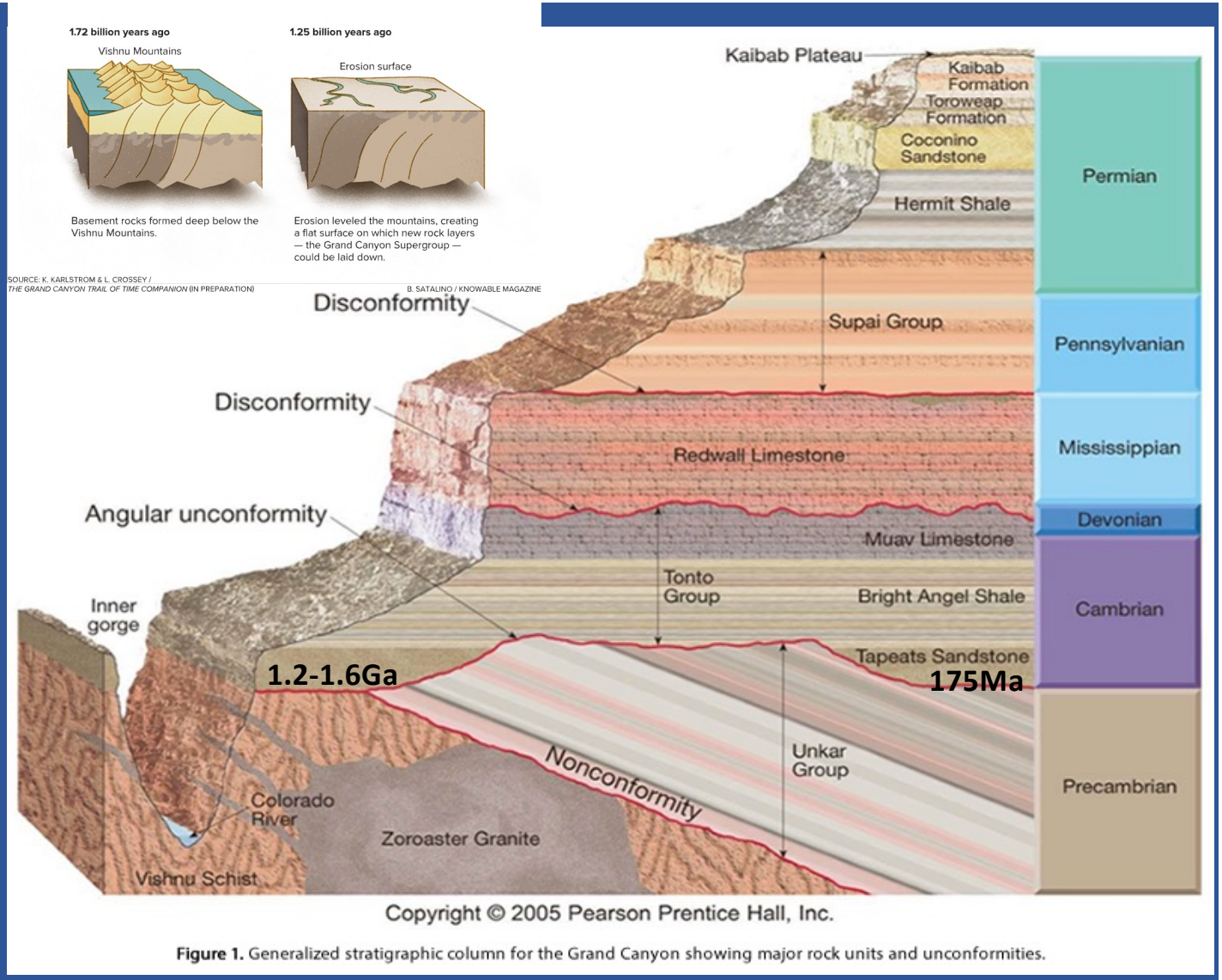
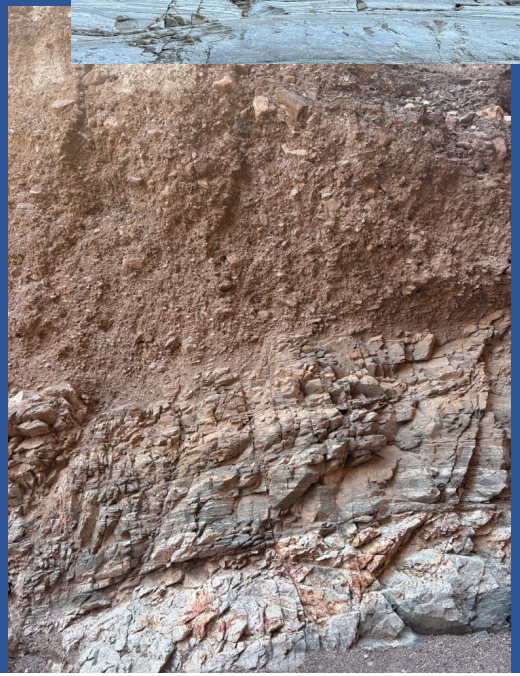
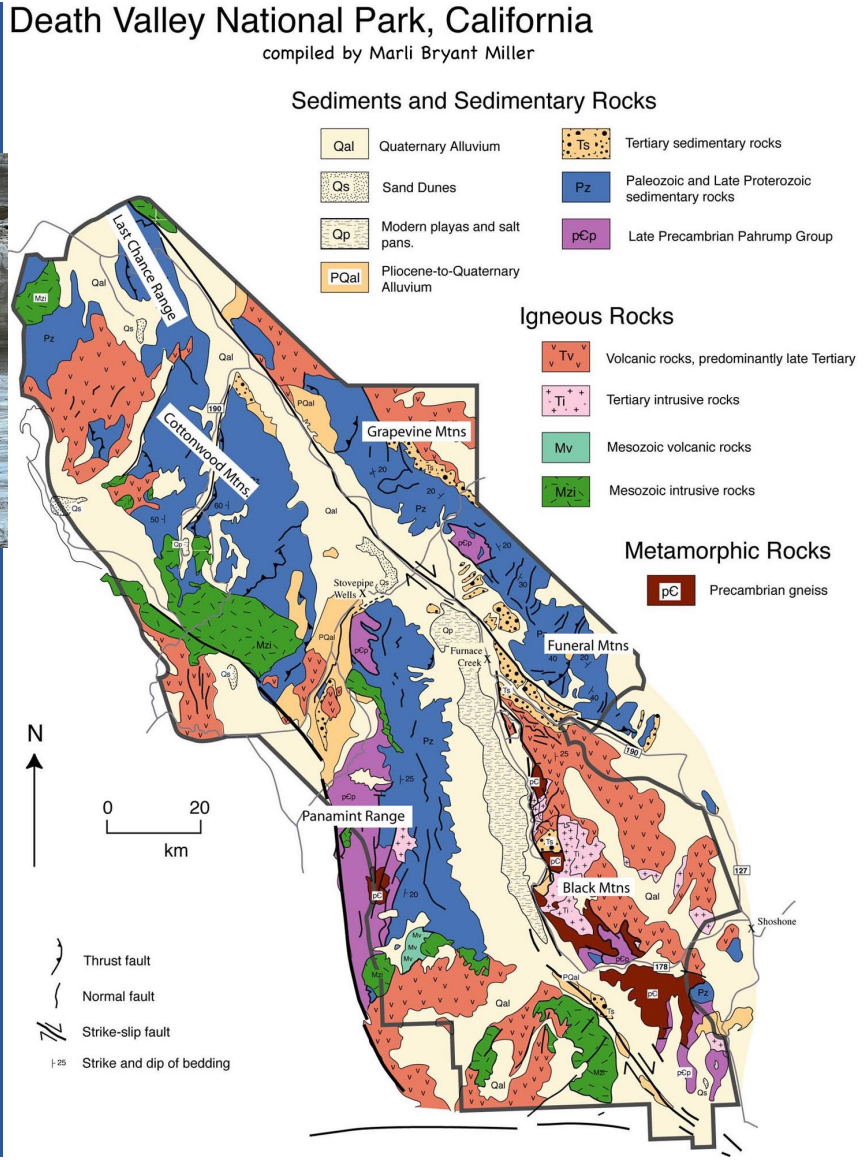


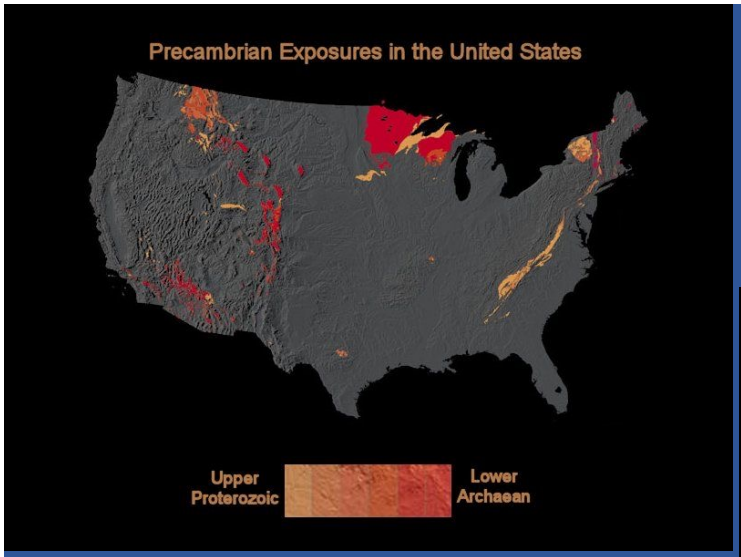
Figure 1. Generalized stratigraphic column for the Grand Canyon showing major rock units and unconformities.

Death Valley National Park, CA

- 1.7-1.4Ga Mojave basement: gneiss, schist, marble







This map will show the continents colored by current location.

Africa

Antarctica

Australia & Oceania

Eurasia

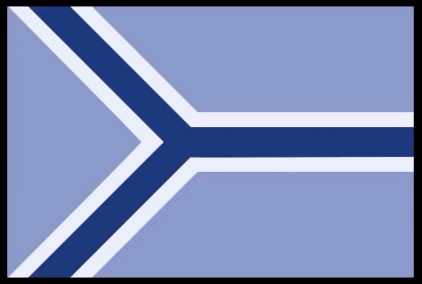
North America

South America

Does not belong to any

10 Minute Break!

3.3 Billion Years of Continental Drift



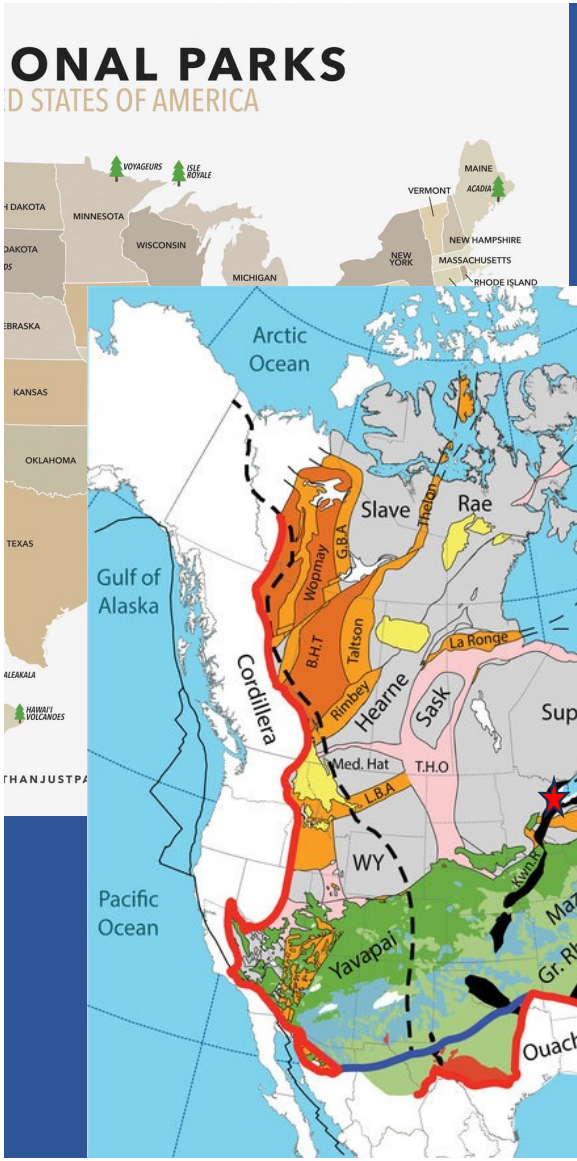
Created by: revrunnertech2772 (Algol)

Link: https://www.youtube.com/watch?v=UwWWuttntio&t=32s

Proterozoic Eon: Midcontinental Rifting

Proterozoic Eon ~1.1Ga:

- Divergence arrested

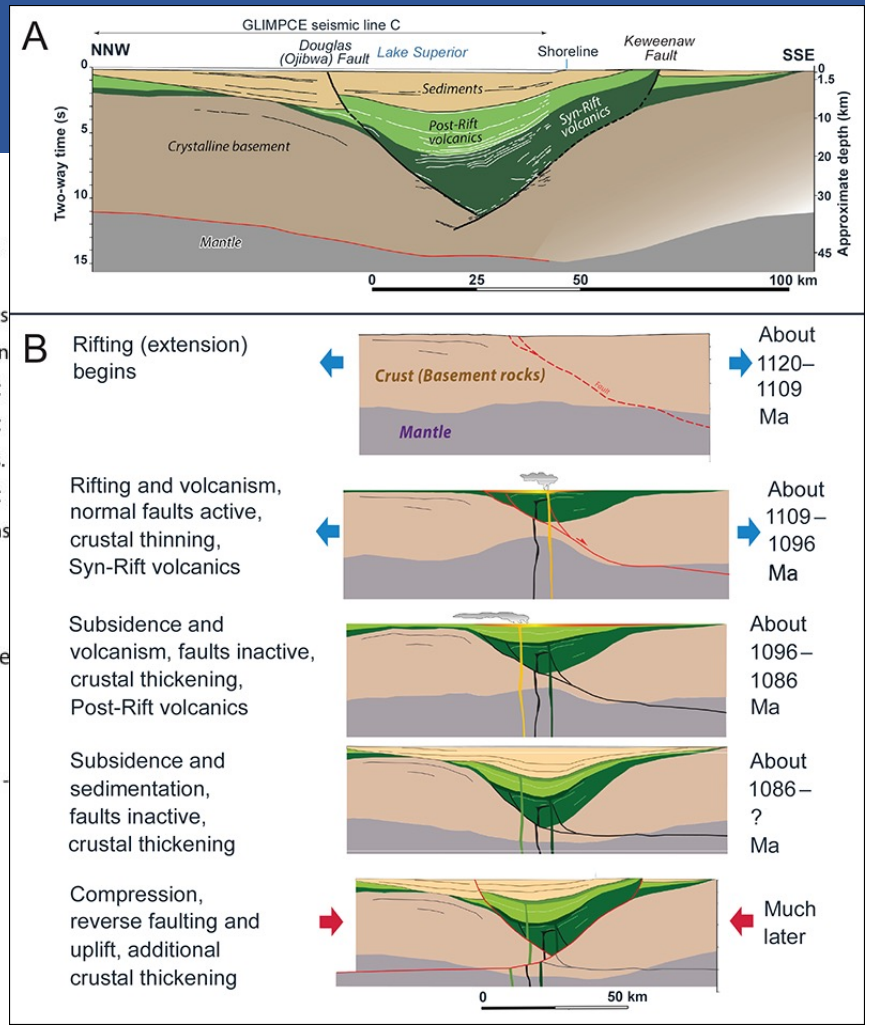


Provinces

- > 2.5 Ga Archean crust
- 2.0 - 1.8 Ga Juv. arcs
- 2.0 - 1.8 Ga Juv. orogens
- 1.9 - 1.8 Ga RW. Archean
- 1.76 - 1.72 Ga Juv. crust
- 1.69 - 1.65 Ga Juv. crust
- 1.7 - 1.65 Ga Qu. Depos.
- 1.55 - 1.35 Ga Juv. crust
- 1.3 - 1.0 Ga coll. orogens

Boundaries

- 1.3 - 1.0 Ga Grenville front
- 1.2 - 1.1 Ga Midcont. rifting
- 0.78 - 0.68 Ga Eastern - Western breakups
- 0.62 - 0.53 Ga Failed rifting
- Rocky montain front
- Tectonic plate limit

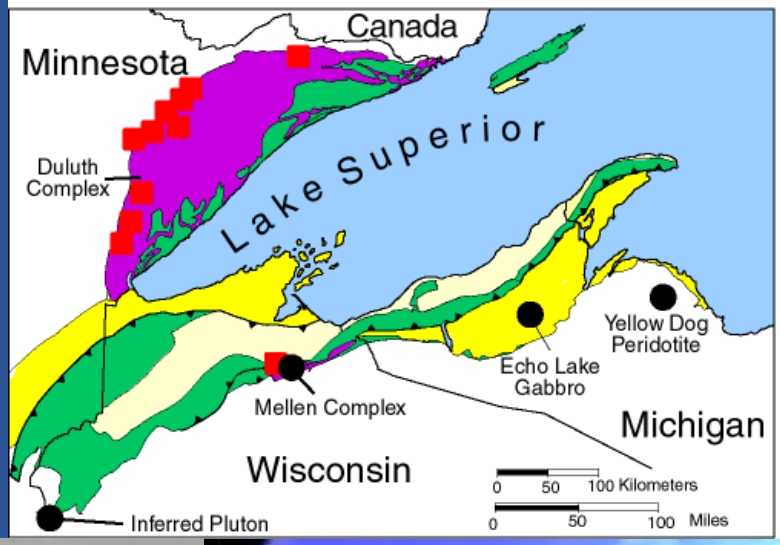


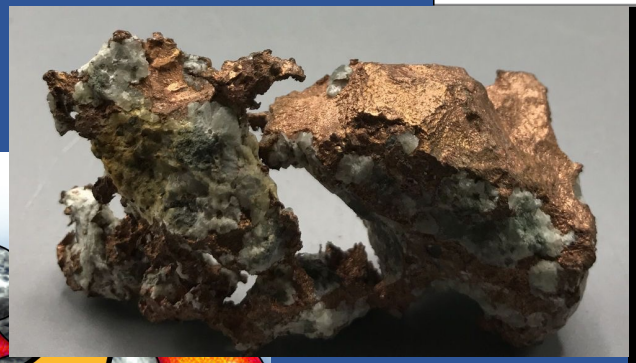
North America Tearing Apart

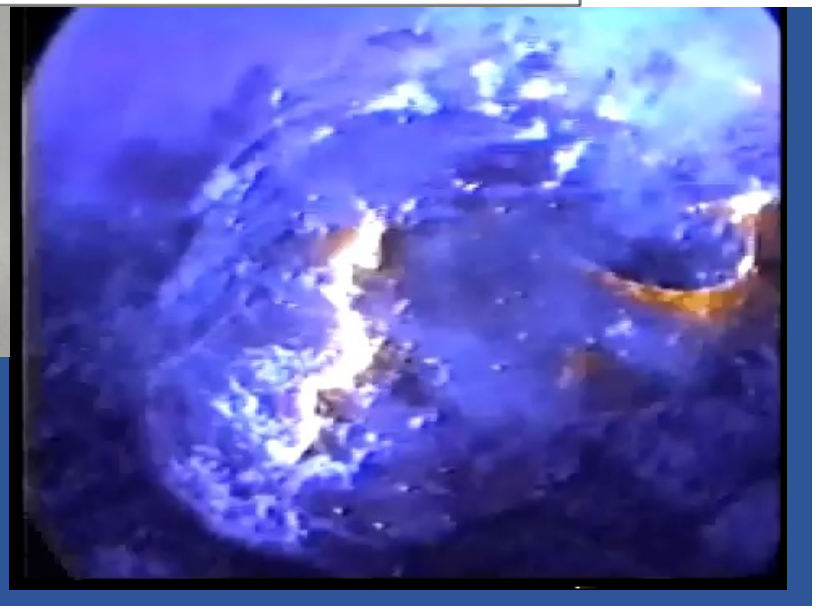
Isle Royale National Park, MI:

1.1Ga volcanism for 24 million years =

- basalt flows
- pyroclastic eruptions
- hydrothermal metamorphism

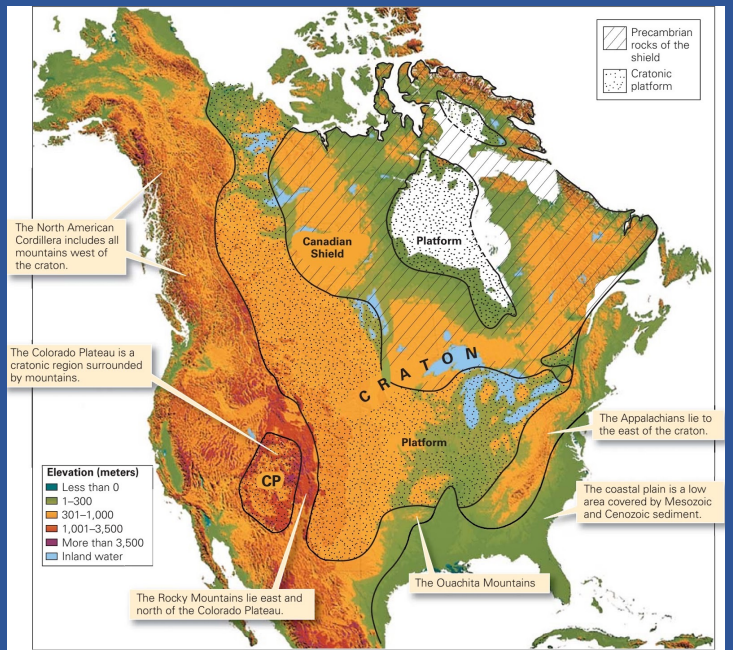


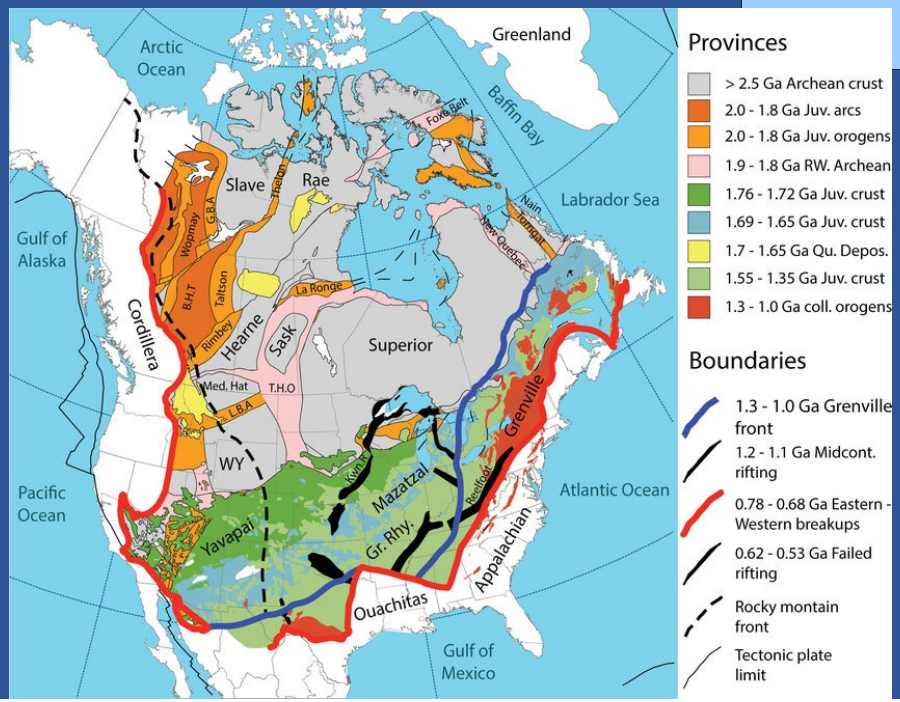




Final Global Accretion Event of the Precambrian

- **Almost all continental converge = multiple orogenies = Rodinia Supercontinent formation**
- Great Smoky Mountains, Shenandoah, Death Valley, Acadia, New River Gorge, Congaree, Cuyahoga Valley, Mammoth Cave, Everglades, Biscayne, Dry Tortugas

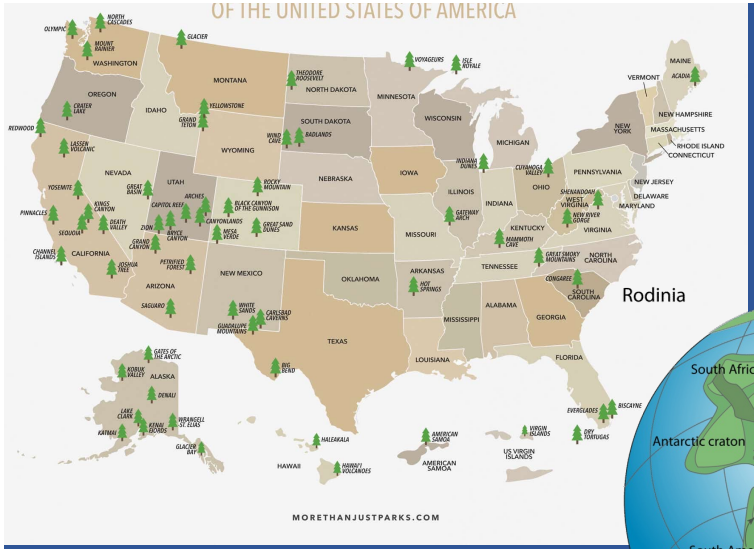


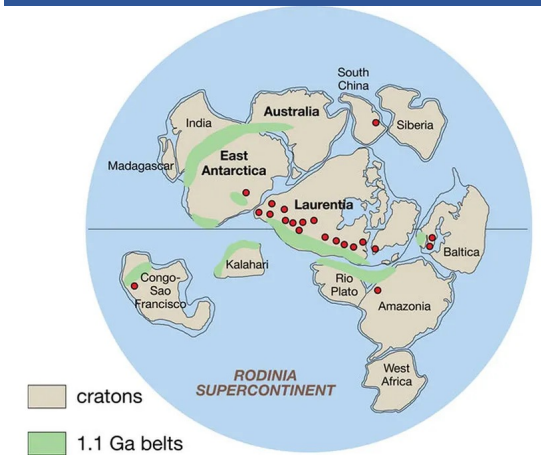


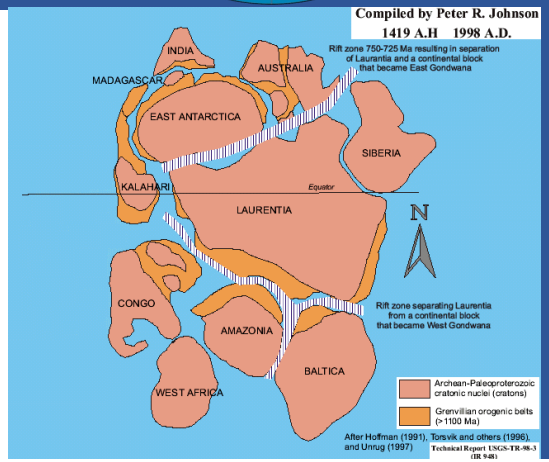
Late Proterozoic Eon: Rodinia Supercontinent

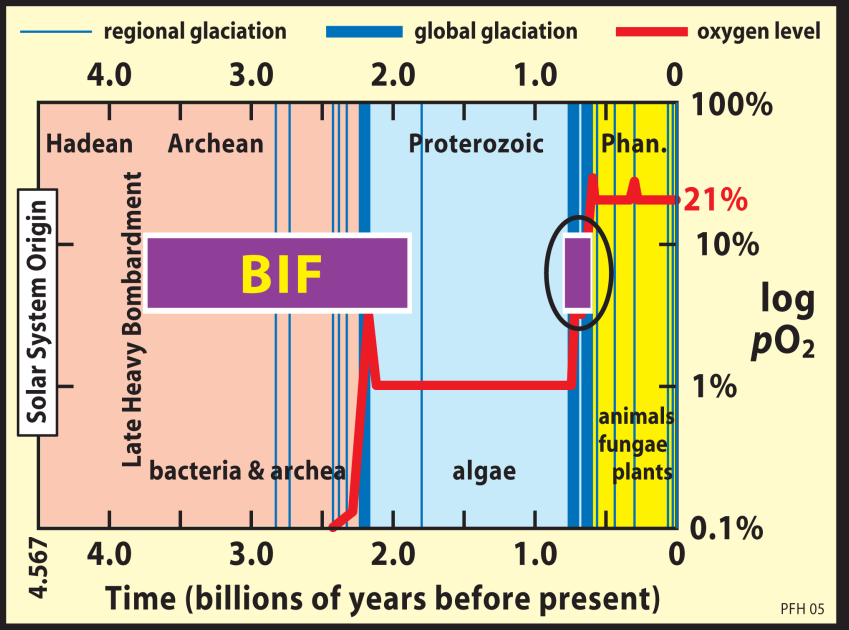
~1.3-0.7Ga at the end of the Precambrian

- Laurentia in the center
- Grenville Orogeny = ”east coast”
- Orogenies at modern west coast





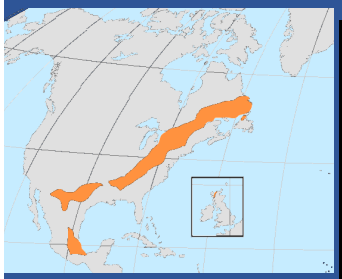


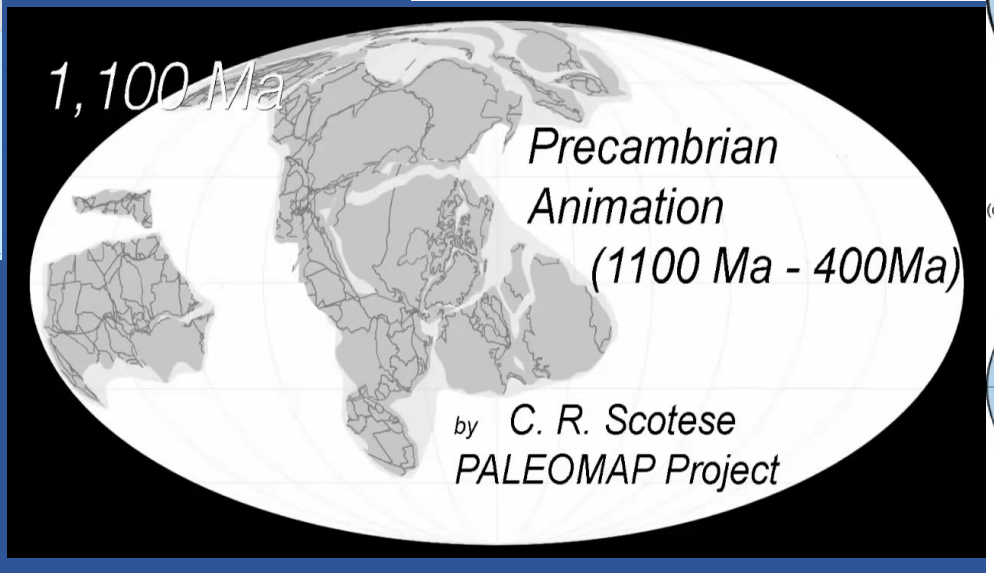


Grenville Orogeny

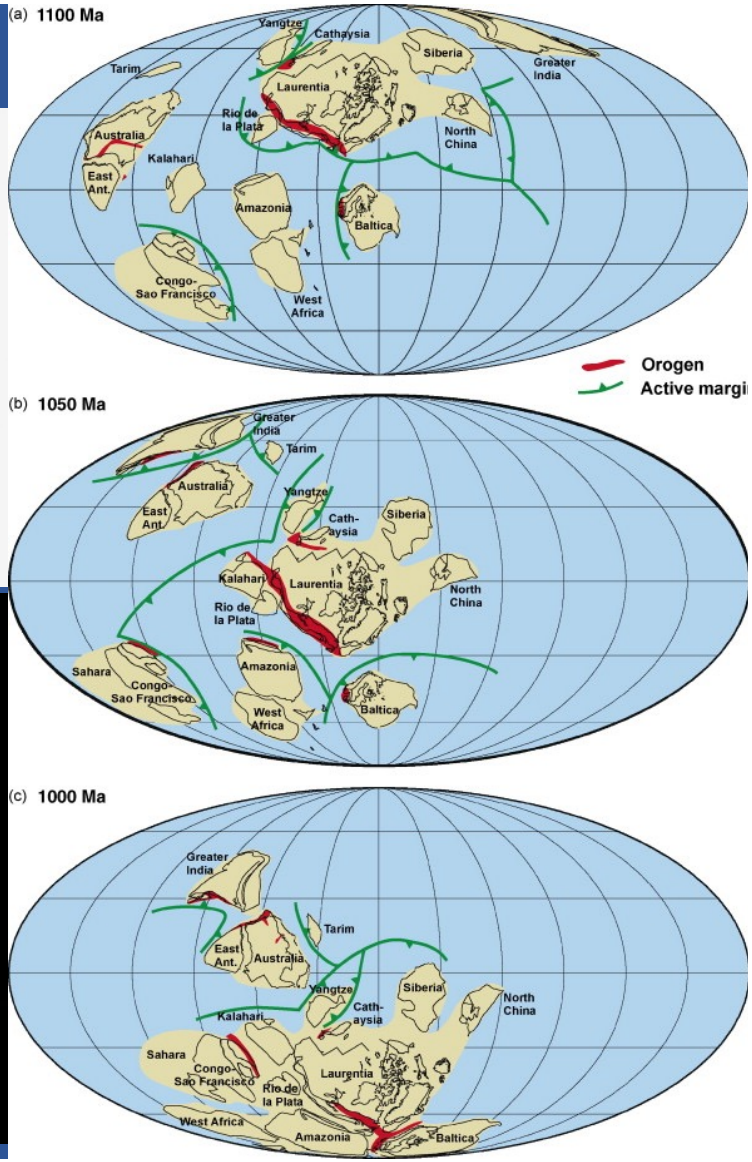
Rodinia formed 1.3-0.9Ga

- 1.1Ga Great Smoky Mountains
- 1.1Ga Shenandoah
- The Basement of the Appalachians





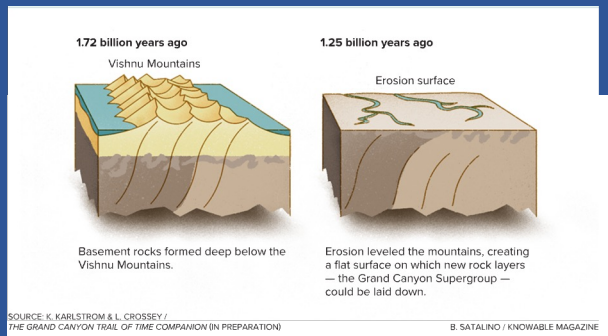
Video: https://www.youtube.com/watch?v=XJf5_p_H-V8



Mountain Chains, Rivers & Shallow Seas of Rodinia

The Grand Canyon NP

- 1.7-1.25Ga erosion & 16miles of uplift
- 1.25-1.1Ga Lower Grand Canyon Supergroup = Rodinia assembly marine & non-marine deposition + eruptions



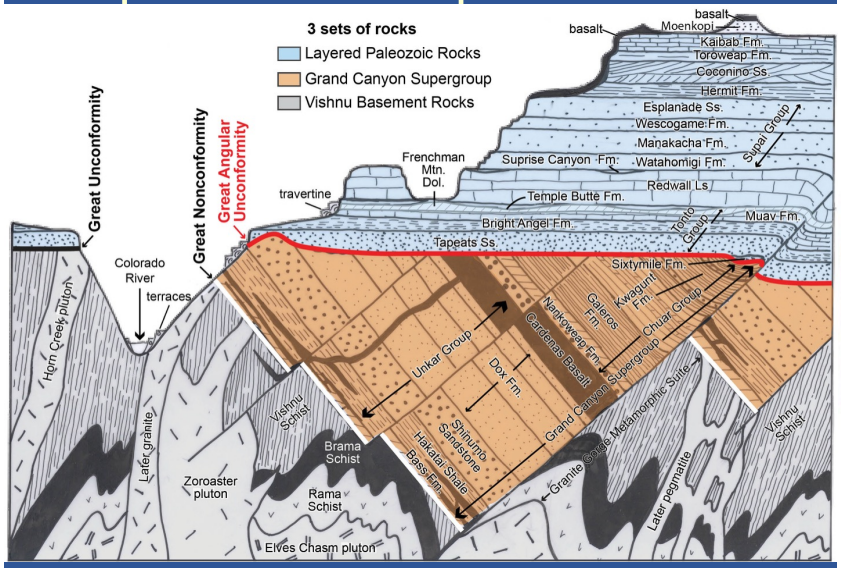


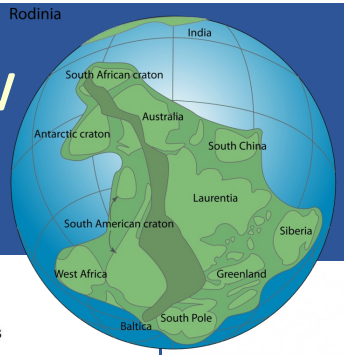
Figure 1. Generalized stratigraphic column for the Grand Canyon showing major rock units and unconformities.

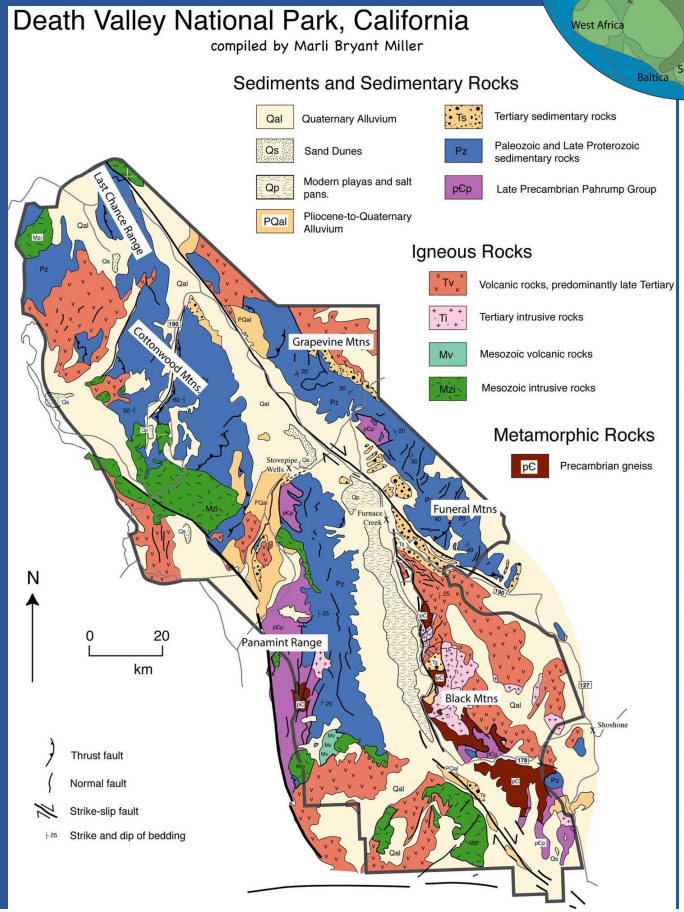
Rodinian Shallow Sea

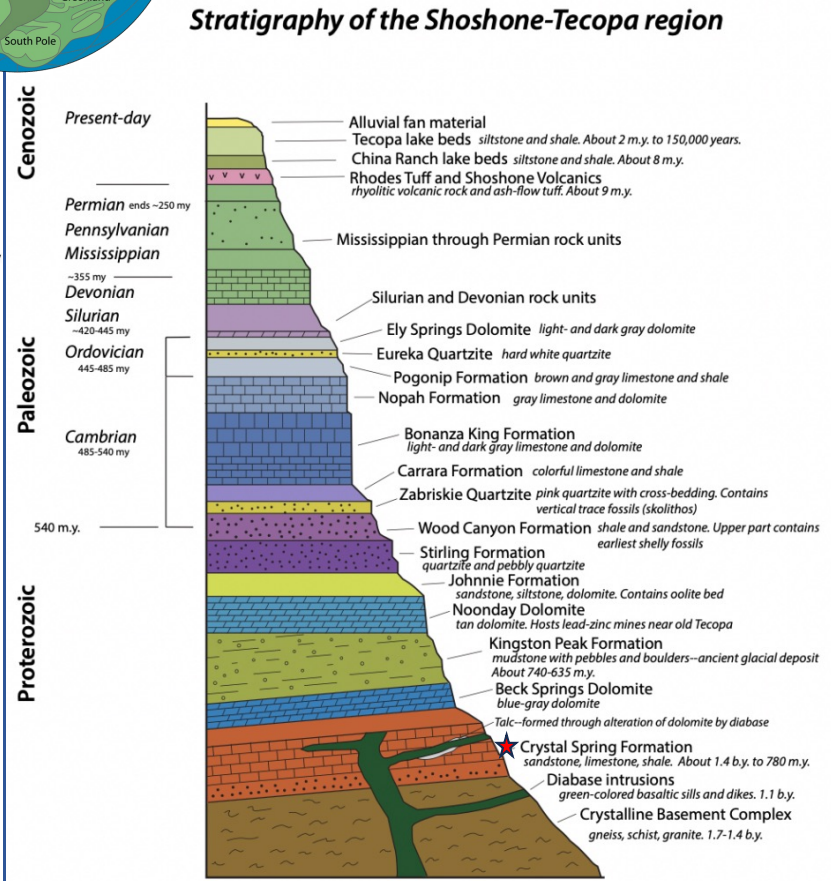
<u>Death Valley NP</u>

1.2-0.7Ga Pahrump Group

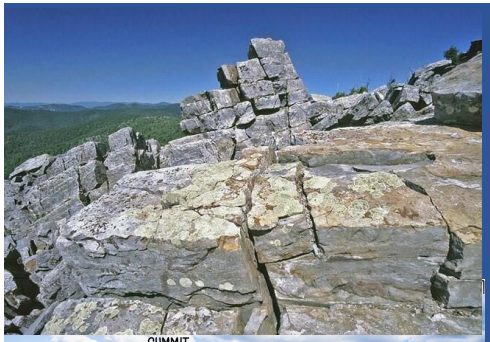
- Nonconformity atop granite & gneiss
- Assembly = Crystal Springs Formation quartzite, shale, dolomite
- "intracratonic trough" → shallow sea with stromatolites
- 1.1Ga diabase sills = = "Grenvillian" Orogeny

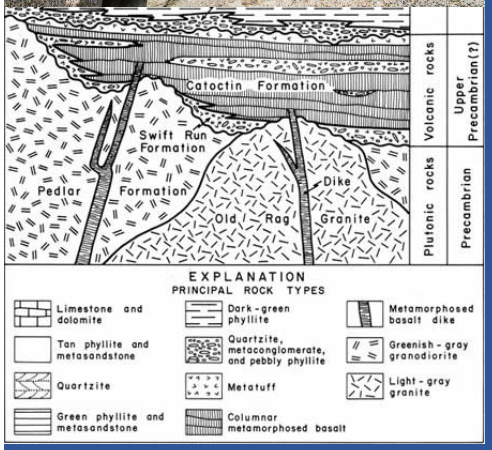


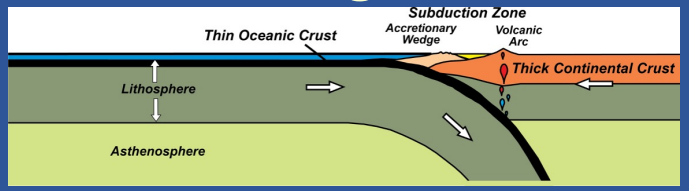




Grenville Orogeny Basement:
The Blue Ridge Mountains





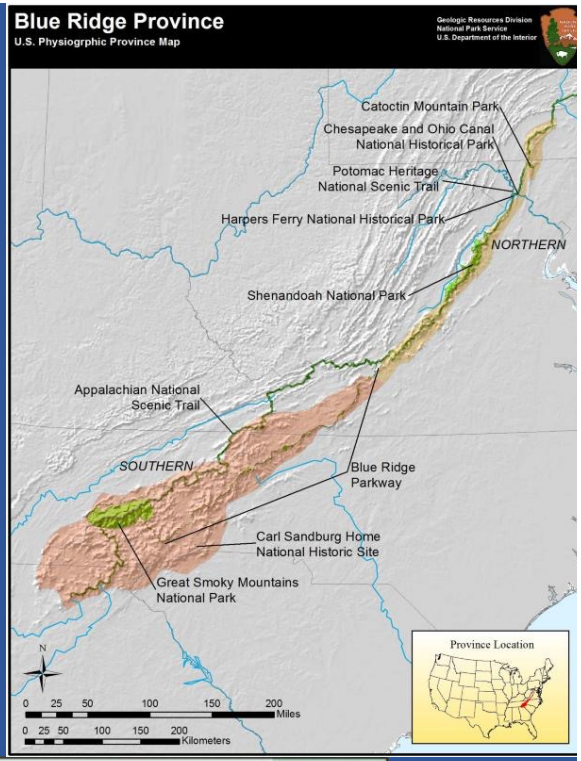


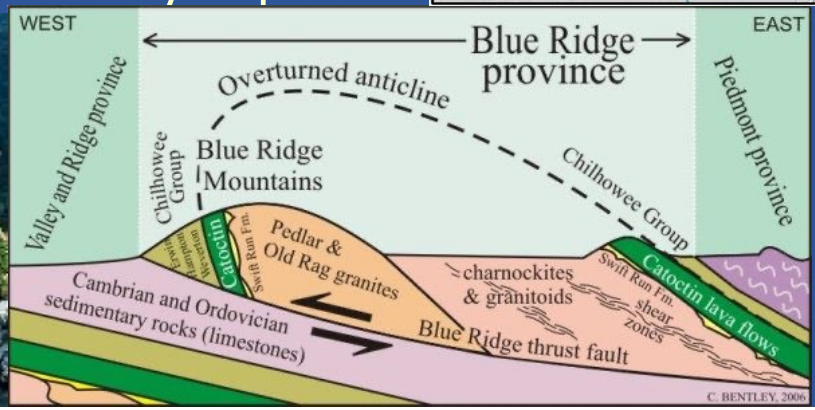
<u>Shenandoah NP, VA</u>:

- 1.1Ga Old Rag Granite + Pedlar Formation Gneiss

<u>Smoky Mountains NP, TN:</u>

- 1.1Ga gneiss + schist + granitic gneiss
- Marine <u>trench</u> sedimentary deposits

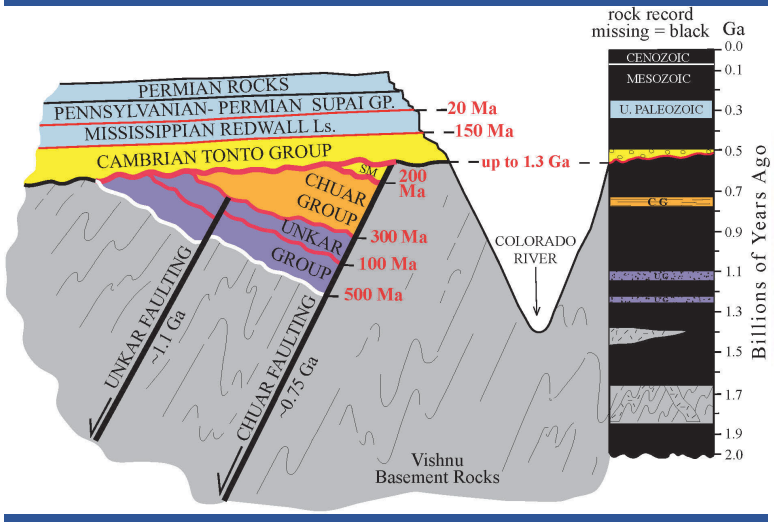




The Great Unconformity

The Grand Canyon NP

- 800-700Ma Chuar Group = Rodinia break-up
- Basement + Grand Canyon Supergroup = Unkar + Chuar Groups tilted when Rodinia rifted apart



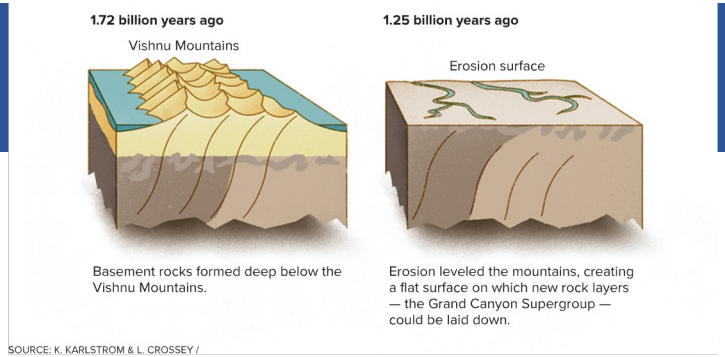


Figure 1. Generalized stratigraphic column for the Grand Canyon showing major rock units and unconformities.