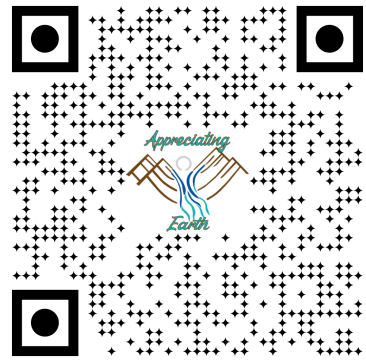


Announcements!

Walking Buddies Program!

Community Planting Day in the SSU Native Plant Garden

- Join us on Saturday, February 28th 10am-2pm
- More info at <https://cei.sonoma.edu/calendar-events>



Geologic Evaluation of North America

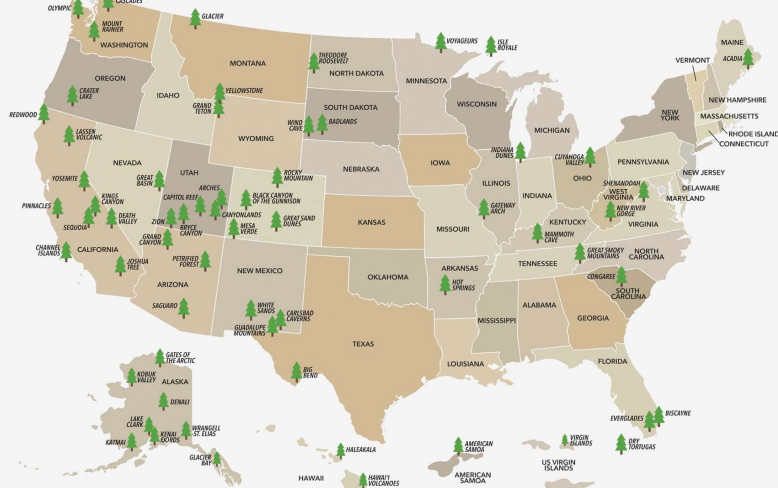
With a Focus on the US National Parks with Nicole Myers

Week 3: North America & the Dawn of Animal & Plant Life

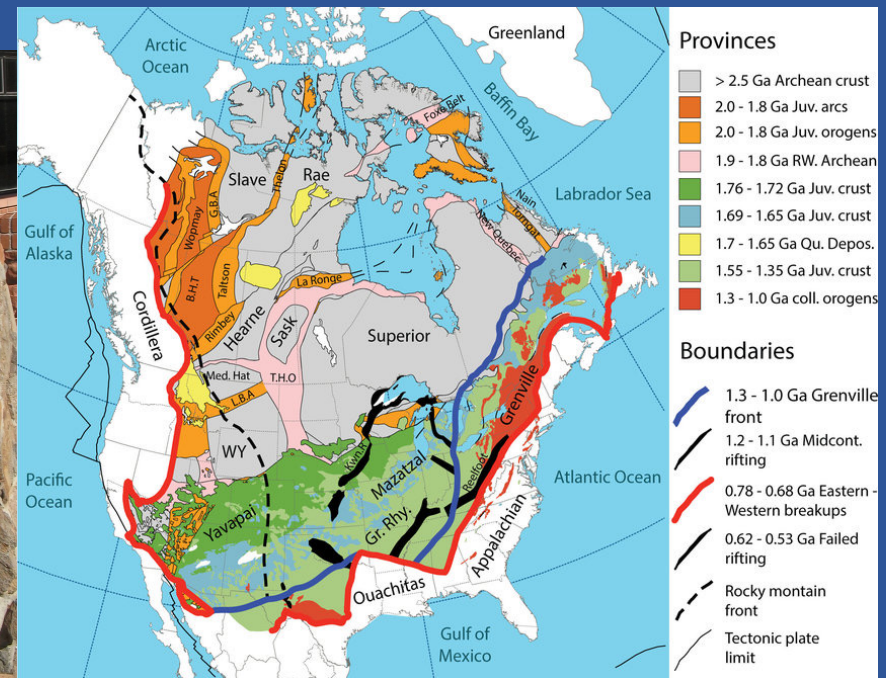
<https://www.appreciatingearth.com/olli>

MORE THAN JUST PARKS

THE NATIONAL PARKS OF THE UNITED STATES OF AMERICA



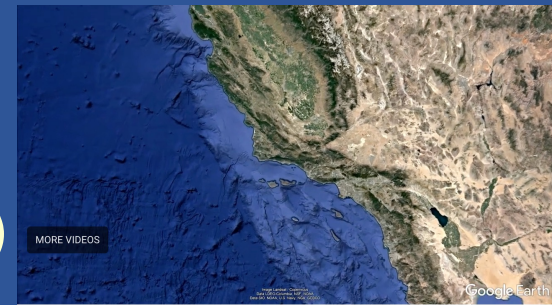
MORETHANJUSTPARKS.COM



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]

- **National Parks**: prioritize public benefit & environmental protection providing protected landscapes (public engagement)
- **Field Stations**: prioritize research & knowledge generation to improve conservation (scientific communities = not open to the general public)
 - **“Living laboratories”** for outdoor-based research & education to support conservation and research endeavors and develop expertise to address environmental challenges
 - **Provide** scientific research, ecological monitoring, study human impact, develop restoration techniques, train future scientists & conservationists
- **Some field stations are located within National Parks**: Channel Islands, Yosemite, Sequoia & Kings Canyon, Capitol Reef, Grand Teton, Lassen Volcanic, Virgin Islands



The Virtual Field:
<https://thevirtualfield.org/video/santa-rosa-island-torrey-pines/>



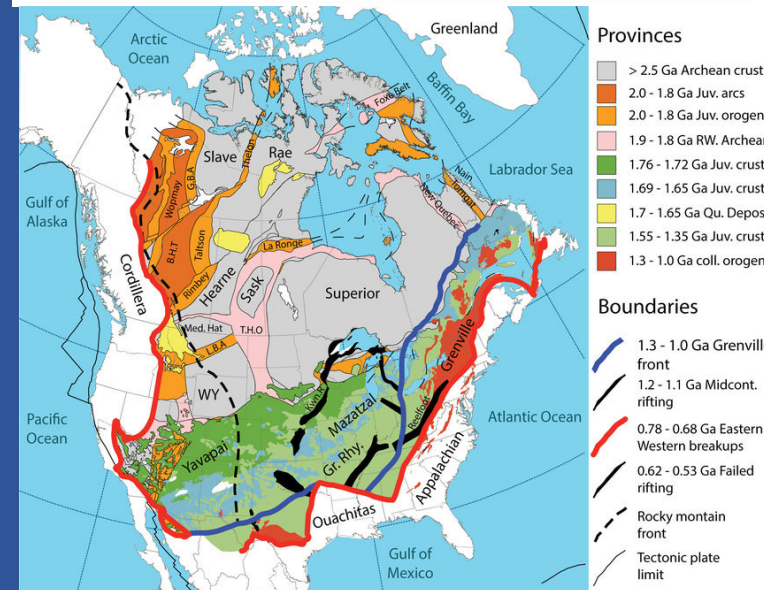
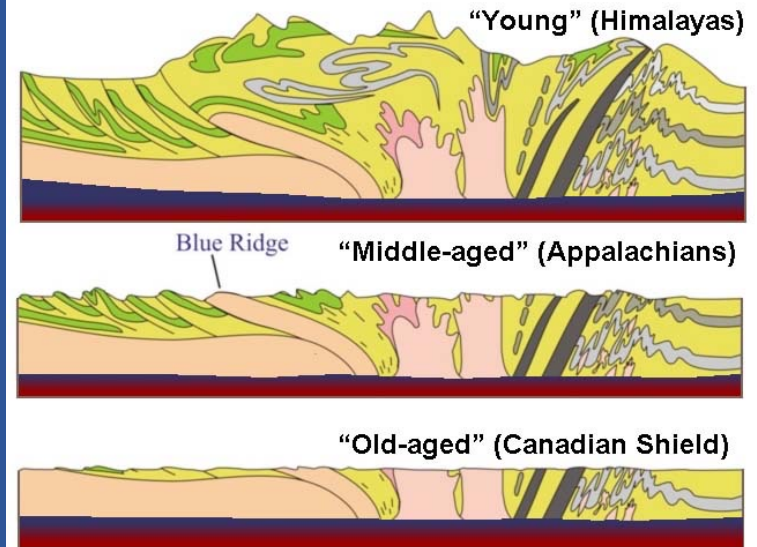
Recap

National Parks provide very high conservation protection & public access

Cratons grew through successive orogenies = Precambrian convergent continental growth

- 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”
- 1.8-1.6Ga Yavapai , Mazatzal & Mojave Orogenies
- 1.3-0.7Ga Grenvillian Orogenies = Rodinia “SC”

National Parks So Far: Voyageurs, Pipestone, Grand Teton, Yellowstone, Wind Cave, Glacier, Rocky Mountains, Black Canyon of the Gunnison, Saguaro, Joshua Tree, The Grand Canyon, Death Valley, Isle Royale, Great Smoky Mountains, Shenandoah



End Precambrian Unconformities

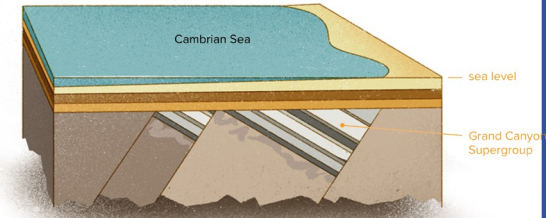
- Rodinia break-up → intense erosion & sea level rise
- Early Cambrian shallow marine deposition

Evidence of:

- rapid transgression
- rising oxygen
- rising calcium (& other seawater elements)
- invertebrate fossils

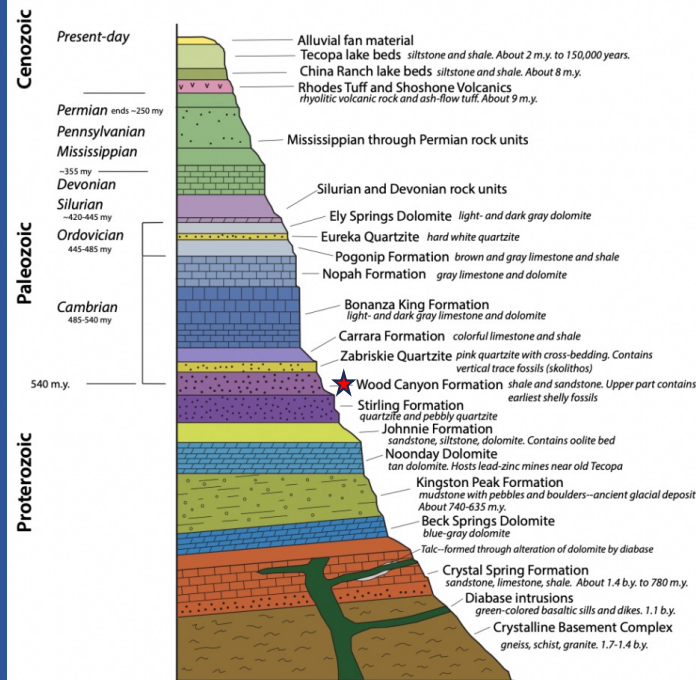


500 million years ago

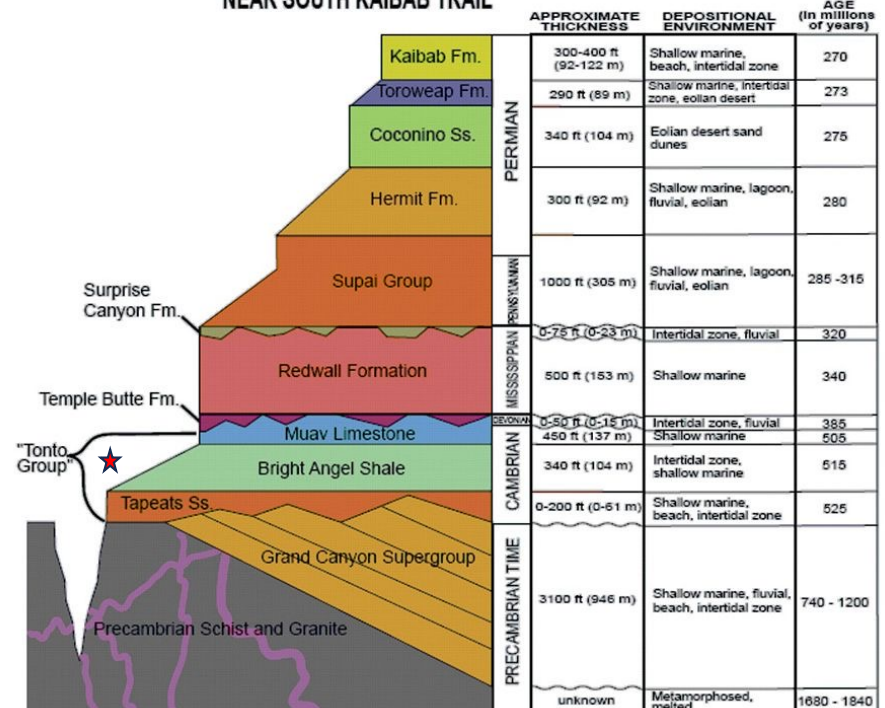


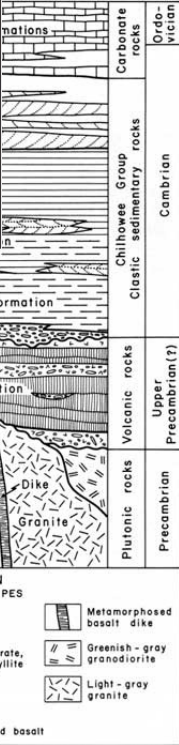
Geological forces broke apart and tilted the Grand Canyon Supergroup layers. Erosion then scoured a flat surface and allowed even more rock layers to be deposited.

Stratigraphy of the Shoshone-Tecopa region



STRATIGRAPHIC COLUMN NEAR SOUTH KAIBAB TRAIL





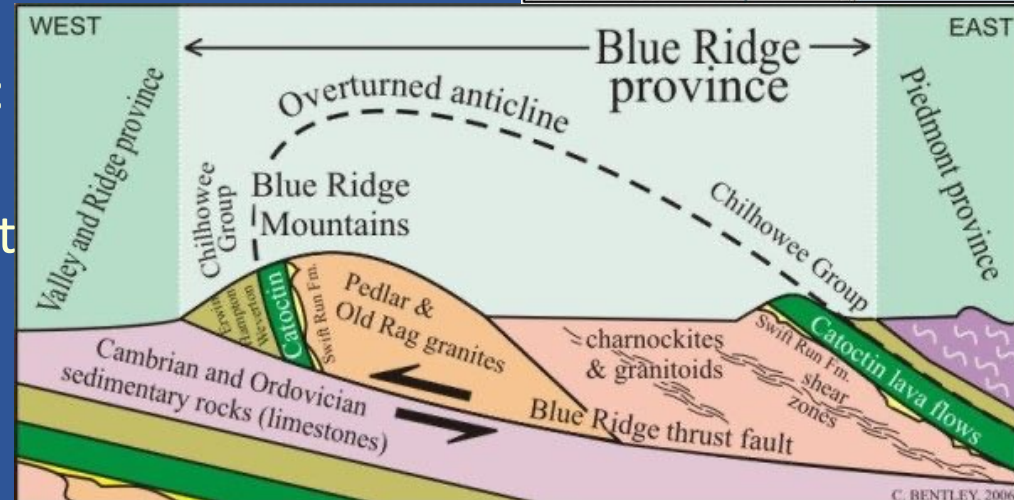
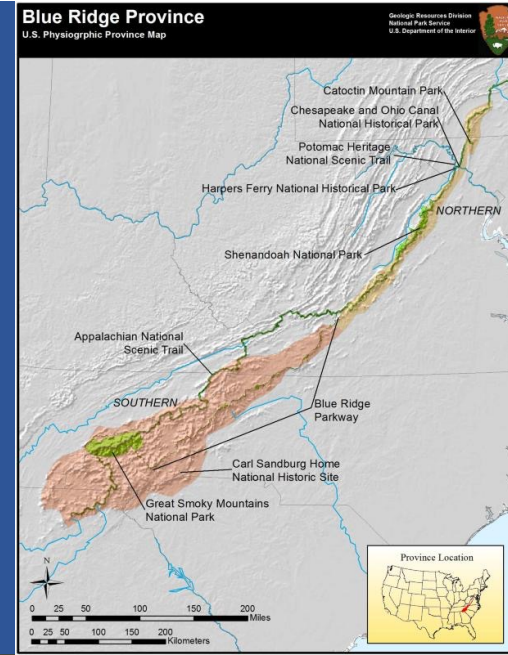
Rodinia Break-up: Iapetus Ocean

Smoky Mountains NP, TN:

- 750-600Ma Ocoee Supergroup = sediments deposited in rift fault basins

Shenandoah NP, VA:

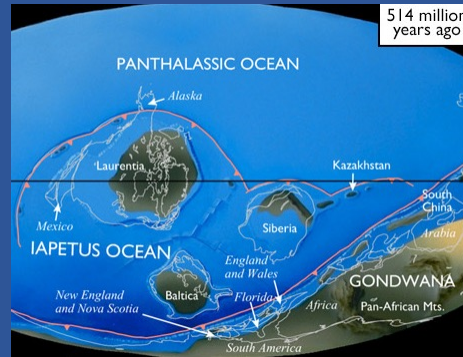
- 570Ma Catoclin Formation = rift flood basalts during supercontinent break-up
- Cambrian Sediments: 541-520Ma
Chilhowee Group = rift → shoreline → passive margin sediments



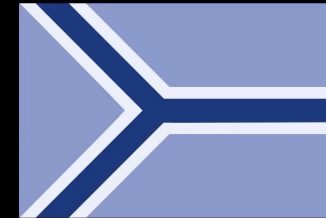
The Cryogenian: Marinoan & Sturtian Snowball Earth Glaciations

“SC” break-up → global glaciation 720-635Ma

- ↑ volcanism, shallow seas, coastlines → chemical weathering & erosion → carbon↓

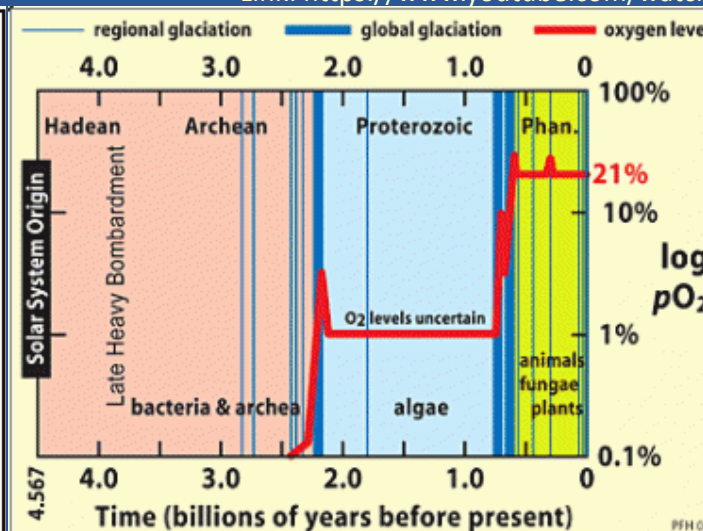
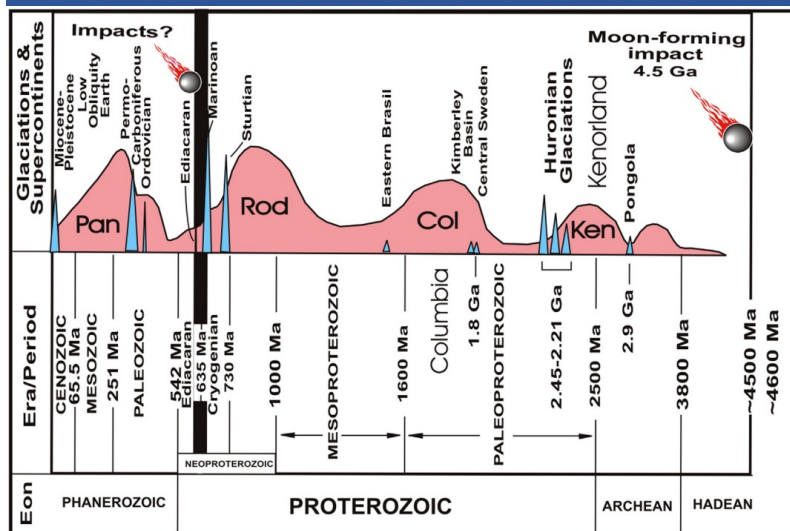


3.3 Billion Years of Continental Drift

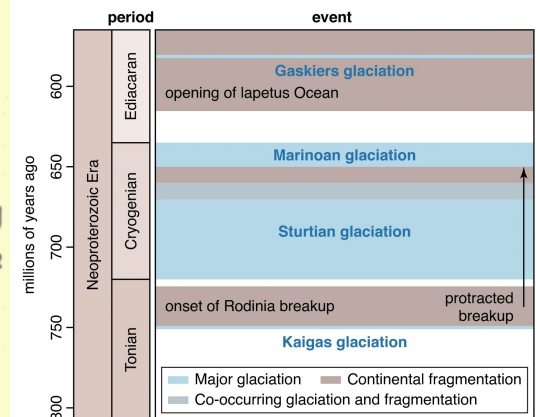


Created by: revrunnertech2772
(Algol)

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



Major events of the Neoproterozoic Era



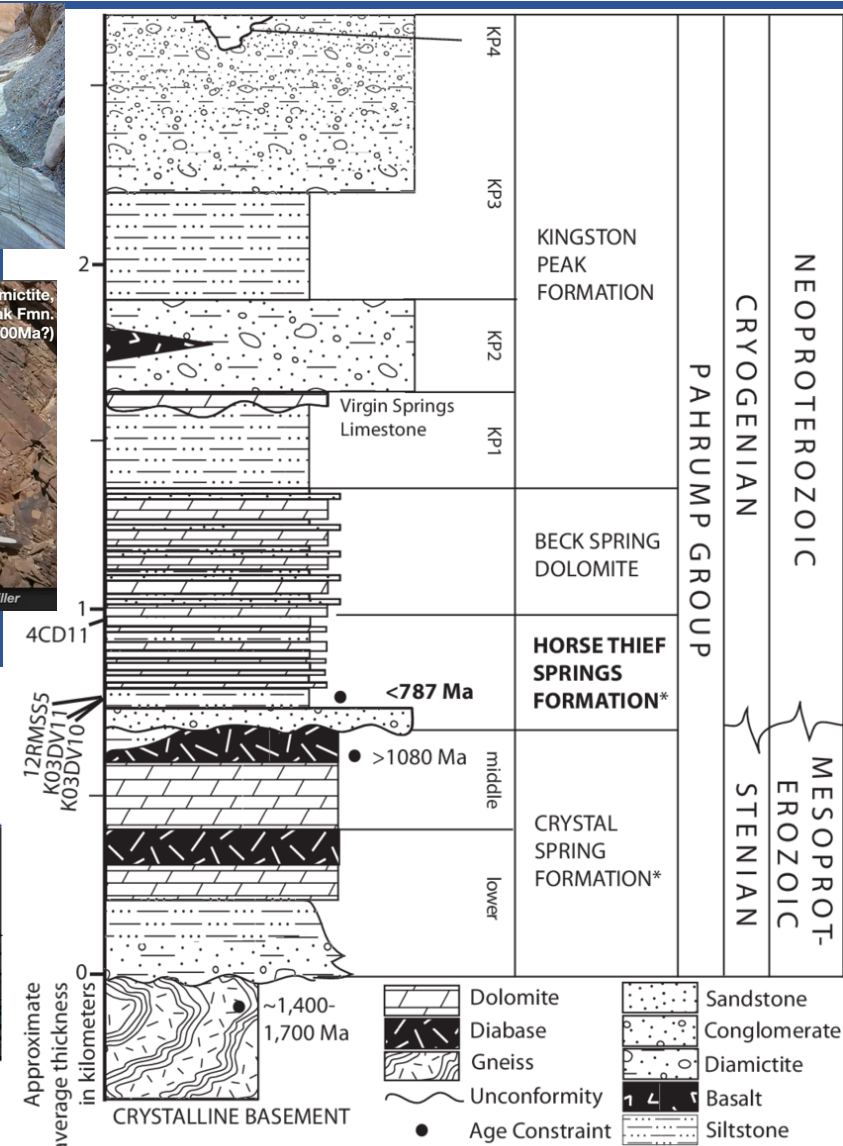
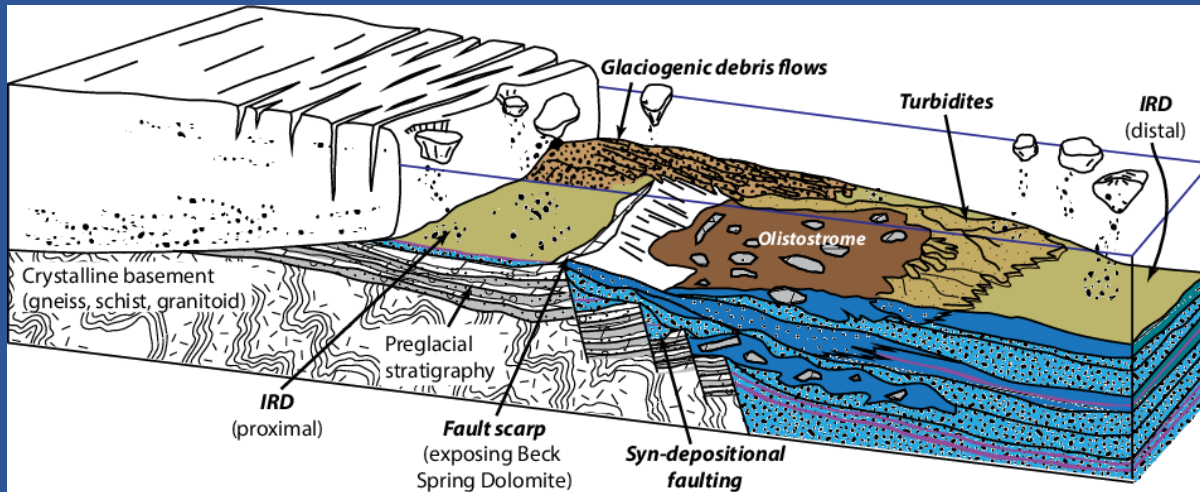
Source: T.M. Gernon et al., “Snowball Earth Ocean Chemistry Driven by Extensive Ridge Volcanism During Rodinia Breakup,” *Nature Geoscience*, 9(3):242–248 (March 2016).

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Equatorial Glaciations

Death Valley National Park

- Pahrump Group = Rodinia rifting
 - ~800Ma Kingston Peak Formation = diamictite from Snowball Earth
 - faulting & tilting
- ~635Ma Noonday Dolomite “cap carbonate” = global warming after Snowball Earth



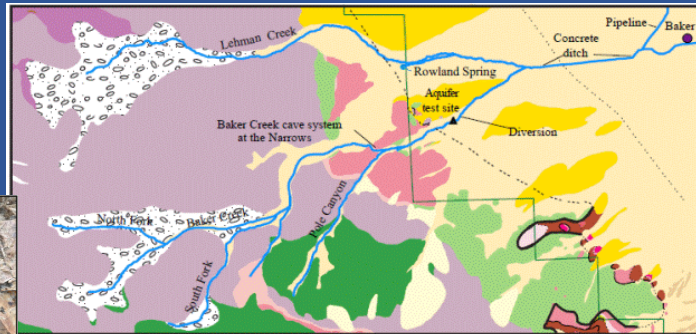
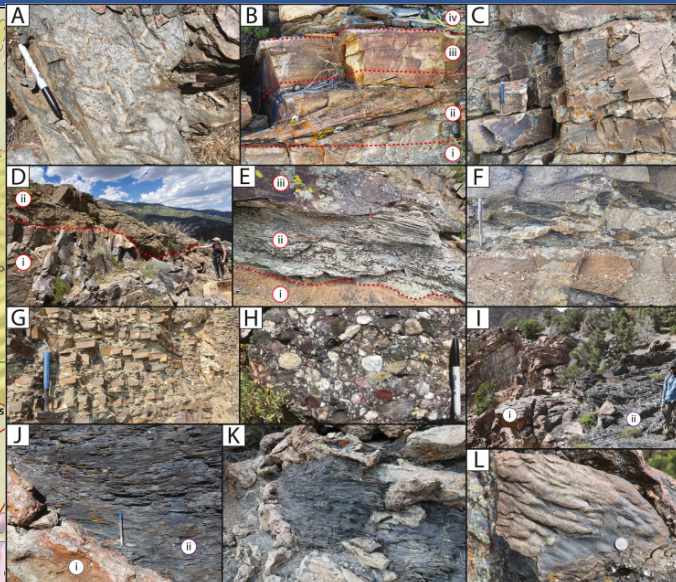
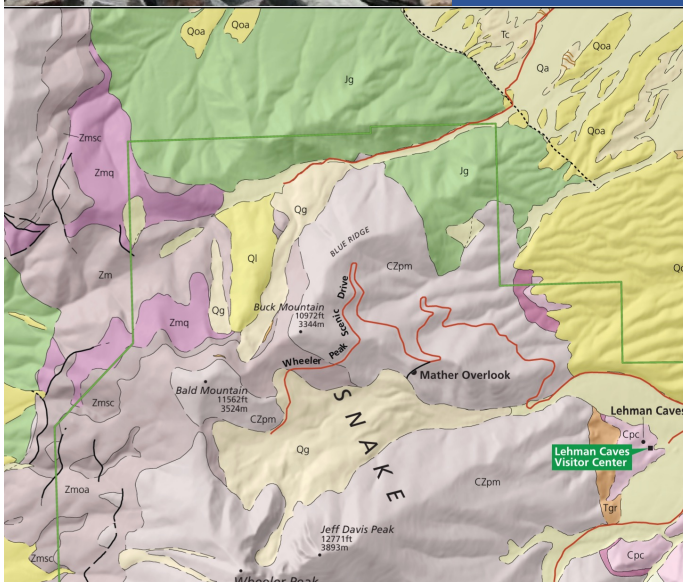
Rodinia Break-up: Panthalassic Ocean

Great Basin NP, NV (*unconformity vs. comformable*)

- Continental margin deposition
- **Above:** ~575-550Ma Prospect Mountain Quartzite - marine transgressive sandstone (cratonic source)
- **Basement:** ~650-575Ma McCoy Creek shallow marine + diamictite

Hyper detailed geologic map:












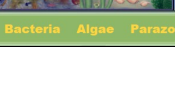
<https://npshistory.com/publications/grba/nrr-2014-762.pdf>



Base from U.S. Geological Survey digital data 1:100,000, 1979-1988. Universal Transverse Mercator projection, North American Datum of 1983, Zone 11

Geology modified from digital data (National Park Service, 2009). Additional faults from D.S. Sweedind, written commun., 2010

EXPLANATION	
Geology	
Qtd - Talus and Landslide deposits	Os - Eureka Quartzite
Qa - Alluvium	Op - Pogoip Group, undifferentiated
Qg - Glacial deposits	OCa - Notch Peak Limestone
Qoa - Older alluvium	Cjw - Johns Wash Limestone
Tc - Conglomerate	Cip - Lincoln Peak Formation
Tmp - Rhyolite porphyry dikes and sills	Cpc - Pole Canyon Limestone
Tgr - Biotite granite	Cpi - Fische Shale
MZg - Granite	CZpm - Prospect Mountain Quartzite
OSB - Fish Haven and Laketown Dolomites	Zm - McCoy Creek Group, undifferentiated
Detachment/Décollement	
— Known	Faults
- - - Approximate, concealed or inferred	— Known
- - - - - Approximate, Miller et al., 1995; Asch and Sweedind, 2009	- - - - - Approximate, concealed or inferred
— Great Basin National Park Boundary	
▲ Location of multi-well aquifer test	

Phanerozoic: times of origin of plants and animals				
Global temperatures				
CENOZOIC	Quaternary		Holocene Pleistocene with alternating periods of glaciation and warm periods	<i>Homo sapiens</i>
	Neogene		Pliocene Miocene Oligocene Eocene Paleocene	Early humans <i>Sahelanthropus</i> Apes Monkeys Primates
	Paleogene		Late Cretaceous Early Cretaceous	Mammals Angiosperms
	Cretaceous		Late Jurassic (Malm) Middle (Dogger) Early (Lias)	bird <i>Archaeopteryx</i> earliest Mammals (i. e. <i>Hadrocodium wui</i>) Pterosaurs
MESOZOIC	Jurassic		Keuper Muschelkalk Buntsandstein	Fish dinosaurs Dinosaurs
	Triassic		Zechstein Rotliegend	Reptiles Therapsids Sauropsids Synapsids first Amniotes Giant dragonflies
	Permian		Pennsylvanian Vegetation that became coal Mississippian	Cycads Lycophytes Ferns Horsetails (Equisetidae)
	Carboniferous		Devonian	early land plants in riparian zones Placodermi
PALAEOZOIC	Silurian		all life forms are still aquatic new developments: brain eyes with lenses segmentation Bilateria Radiata	Cephalopods Arthropods e.g. Trilobites Brachiopods, snails first vertebrates Chordates Annelids, Mussels Echinoderms, Tunicates Jellyfish, first corals Ediacara fauna
	Ordovician		Cambrian	
	Ordovician			
	Cambrian			
Precambrian				

	Eon	Era	Period	Epoch	
Phanerozoic		Cenozoic	Quaternary	Holocene	← Today
				Pleistocene	← 11.8 Ka
			Neogene	Pliocene	1.8 Ma
				Miocene	5.3 Ma
			Paleogene	Oligocene	23 Ma
				Eocene	34 Ma
				Paleocene	56 Ma
		Mesozoic	Cretaceous	~	← 66 Ma
			Jurassic	~	100 Ma
			Triassic	~	201 Ma
		Paleozoic	Permian	~	← 252 Ma
			Carboniferous	~	299 Ma
			Pennsylvanian	~	323 Ma
			Mississippian	~	359 Ma
			Devonian	~	419 Ma
			Silurian	~	443 Ma
			Ordovician	~	485 Ma
			Cambrian	~	541 Ma
Proterozoic					← 2.5 Ga
					← 4.0 Ga
					← 4.56 Ga
Precambrian					

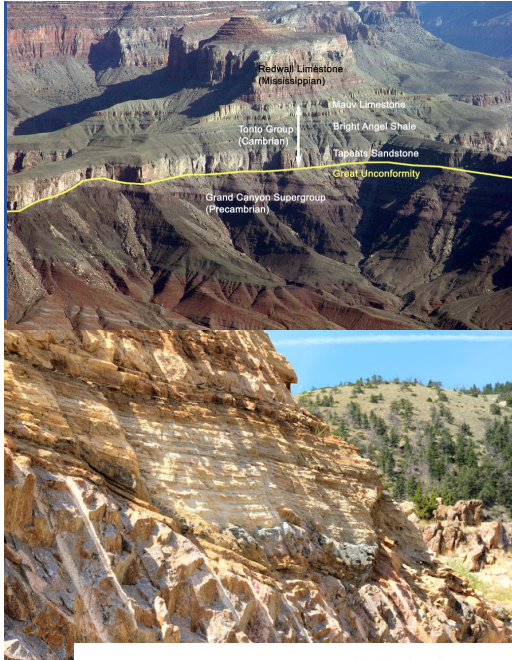
10 Minute Break!

Video link:

https://www.youtube.com/watch?v=g_iEWvtKcuQ

PLATE TECTONICS, PALEOGEOGRAPHY, and ICE AGES (Modern World - 540 Ma)

© 2016, C. R. Scotese



The Great Unconformity

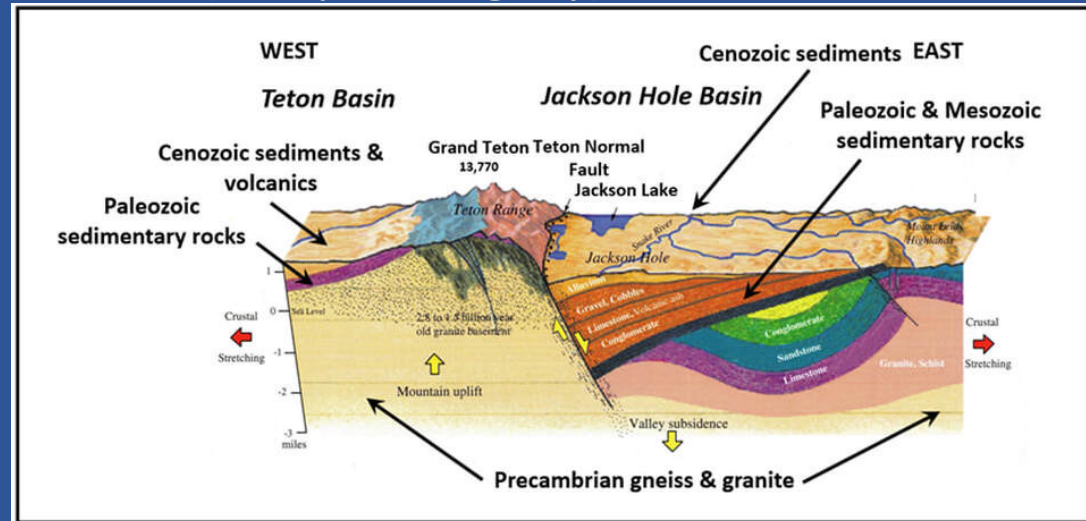
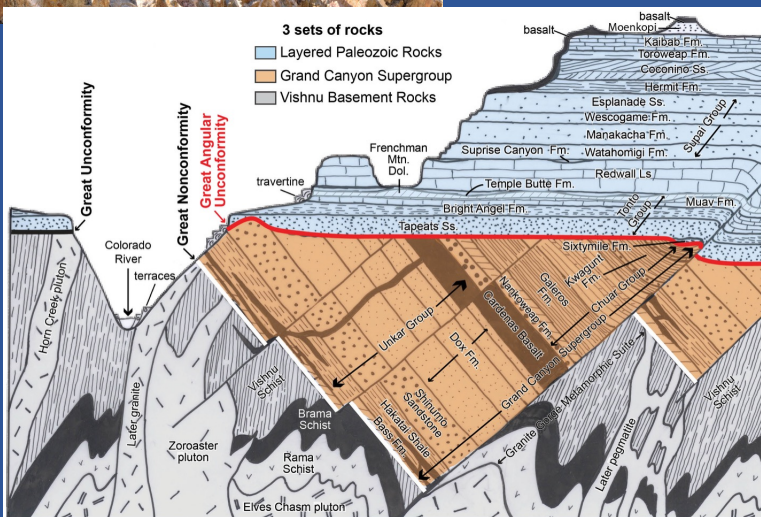
A Continent-Scale Surface of Cambrian Cover Rocks

Grand Teton & Yellowstone NP, WY

- **Cover** = 530-520Ma Flathead Sandstone: marine transgression
- **Basement** = Archean gneiss & granite (Wyoming Craton)

Grand Canyon NP, AZ

- **Cover** = 508-497Ma Tonto Group: marine transgression
- **Basement** = Vishnu Schist (Yavapai Orogeny)



End of Rodinia & the Precambrian

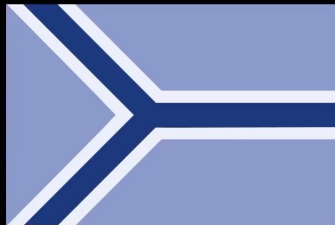
Precambrian Rocks of Alaska

- Rare outcrops & dates largely undetermined
- Scant evidence of Rodinia formation and break-up in Gates of the Arctic NP

Laurentia “west” coast becomes a passive margin

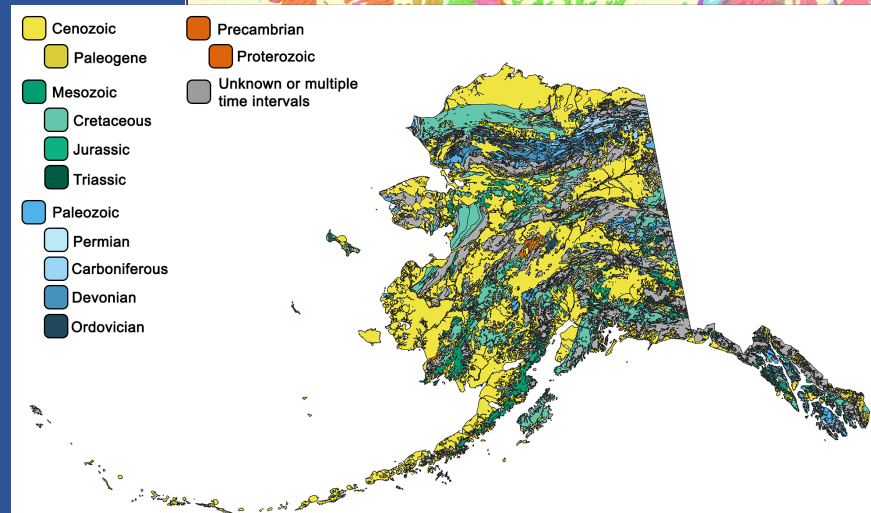
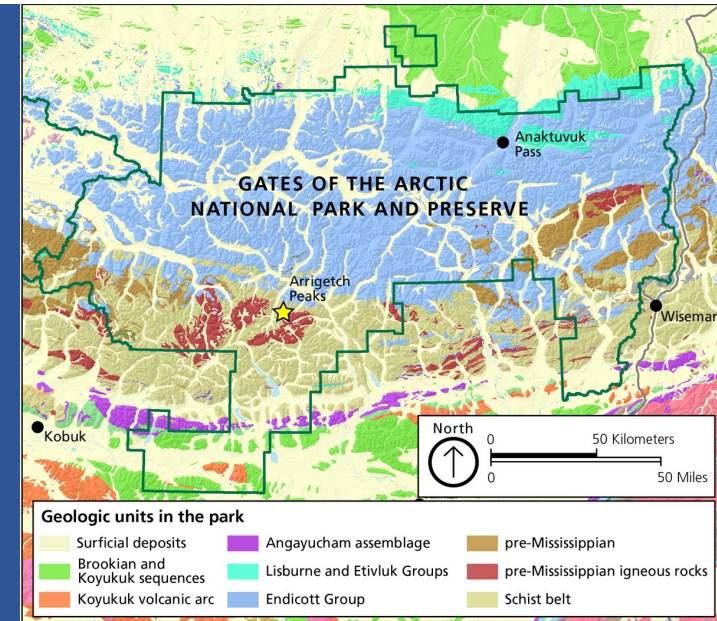
Focus on the green shapes & watch North America slowly form

3.3 Billion Years of Continental Drift



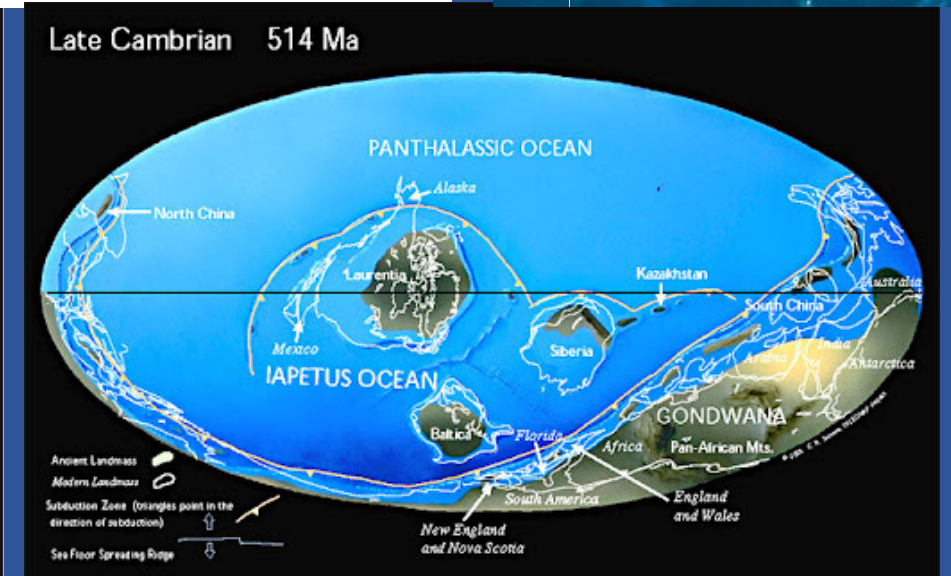
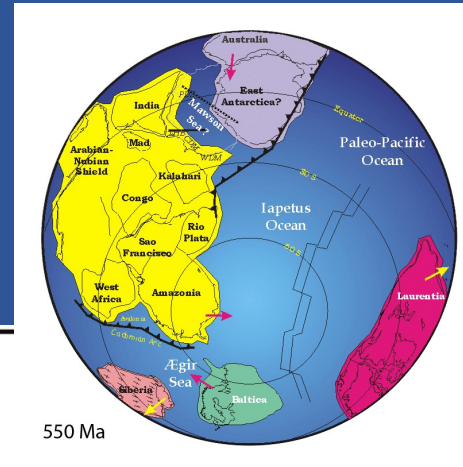
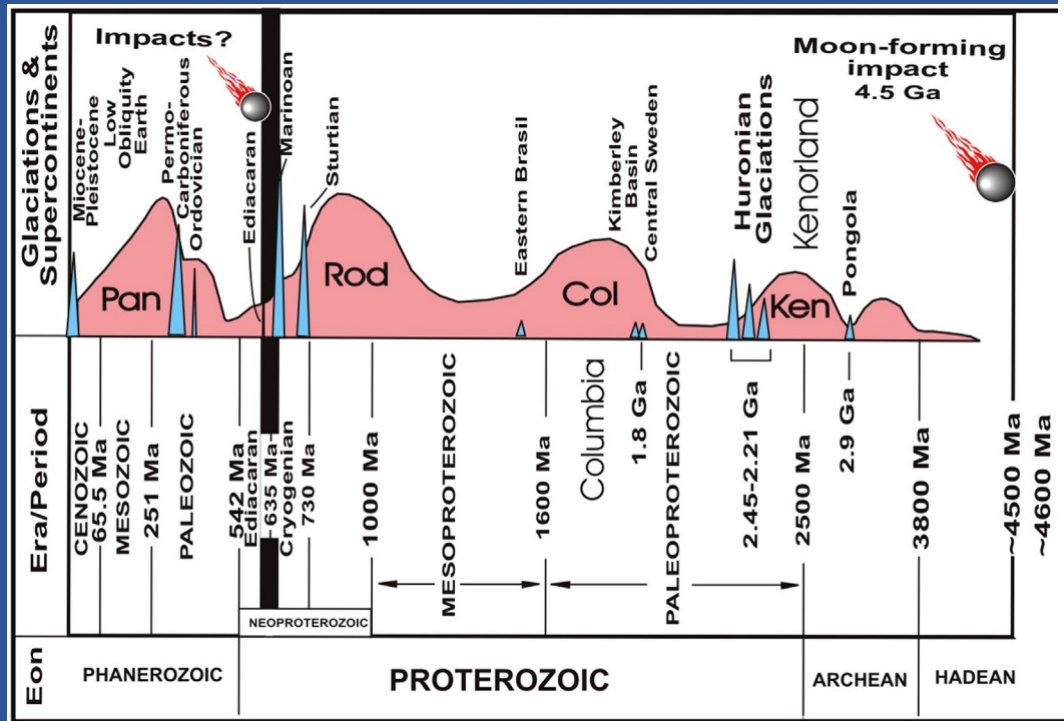
Created by: revrunnertech2772
(Algol)

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



Phanerozoic Eon: Laurentia & Gondwana

- Cambrian Explosion: end of Snowball Earth → first animals with hard parts



The Cambrian Explosion Diversification

~541-530Ma

Grand Canyon NP

- Tonto Group: trilobites & brachiopods

Death Valley NP

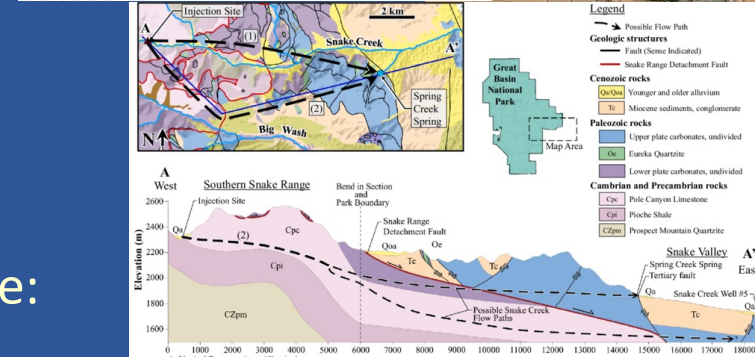
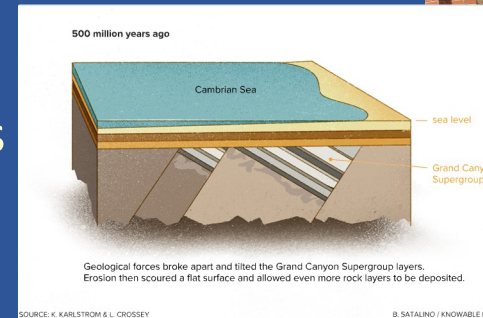
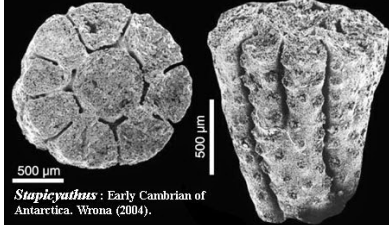
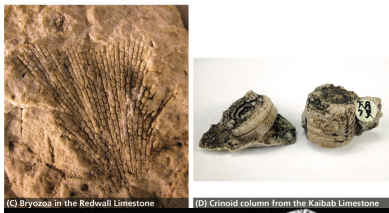
- Wood Canyon Formation: trilobites, archaeocyathid sponges

Great Basin NP

- Pioche Shale & Pole Canyon Limestone: trilobites, archaeocyathid sponges

Yellowstone & Grand Teton NP

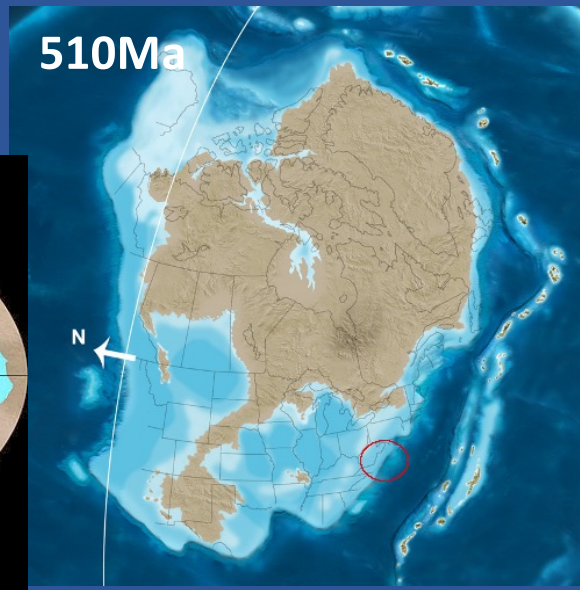
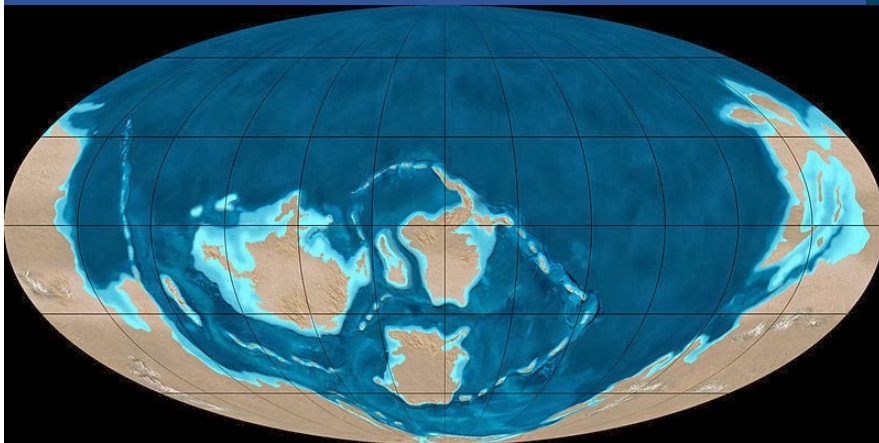
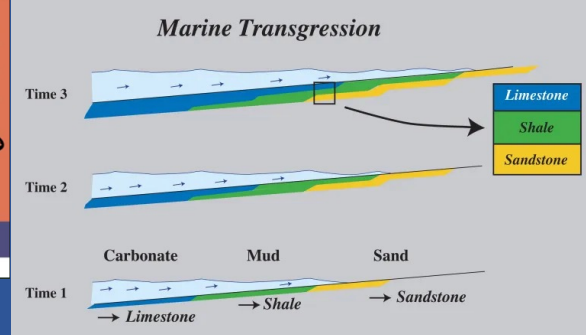
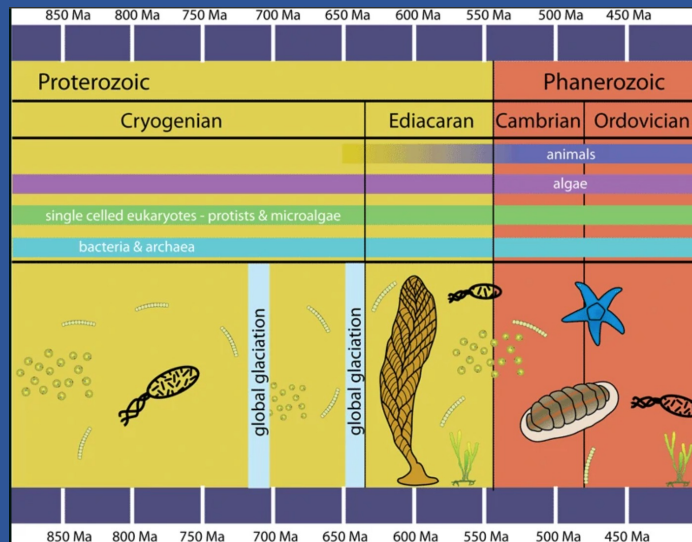
- Flathead Sandstone & Pilgrim Limestone: trilobites, brachiopods, stromatolites



Cambrian Shallow Seas

541-485Ma Equatorial NA

- Oldest shells & skeletons
- First apex predator
- First aquatic plants
- First chordates
- Global warming
- Rising sea levels = transgression
- Oxygenated seas



Ordovician Drowned Continent

485-443Ma Equatorial North America

- GOBE = The Great Ordovician Biodiversity Event
- First animals with jaws
- First terrestrial plants
- Ice Age
- Taconic Orogeny
- LIP
- 85% extinction

