

# Geologic Evaluation of North America

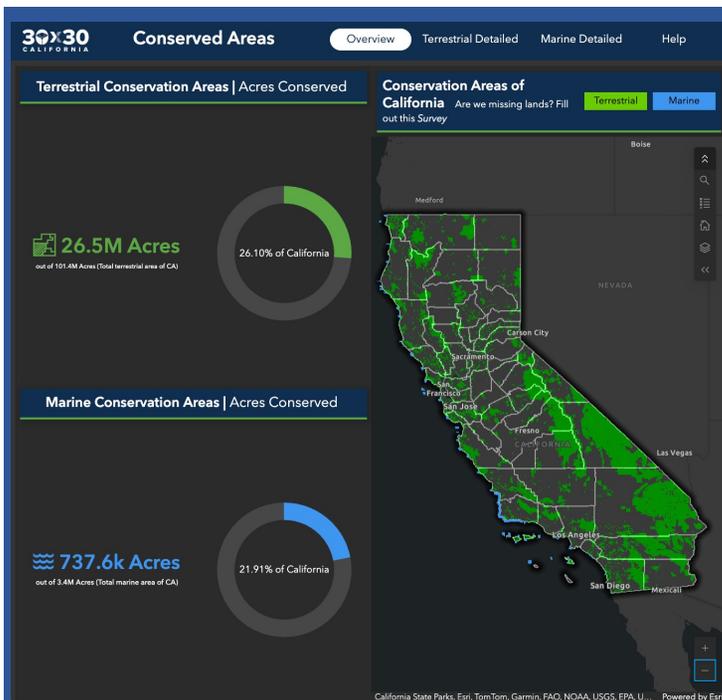
## With a Focus on the US National Parks with Nicole Myers

*Week 5: The Only Supercontinent with Life*

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



Video link: [https://www.youtube.com/watch?v=xaj\\_J\\_3YJMc](https://www.youtube.com/watch?v=xaj_J_3YJMc)



# 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]*

## Select nearby conserved & protected areas:

- NP: Pinnacles, Yosemite, Lassen Volcanic, Redwood
- National Seashore: Point Reyes
- National Monument: Muir Woods
- State Parks: Trione-Annadel, Sugarloaf, Sonoma Coast, Mount Tamalpais
- Armstrong Redwoods State Natural Reserve (↑protection)

## Conservation Goals

- California Now: 26.1% of lands, 21.9% of coastal waters
- Sonoma County: 22% of lands conserved

<https://experience.arcgis.com/experience/83b5c08cae8b47d3b7c623f2de1f0dcc>

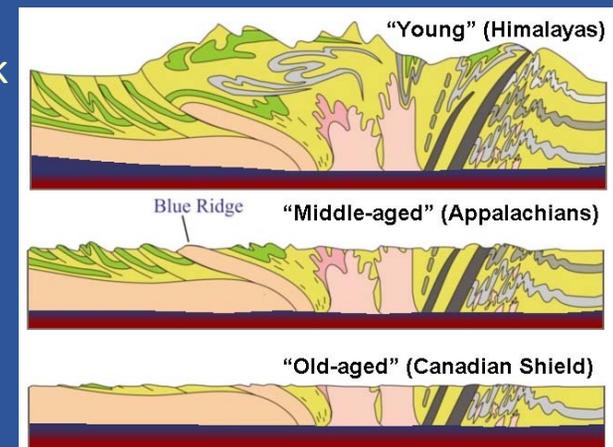
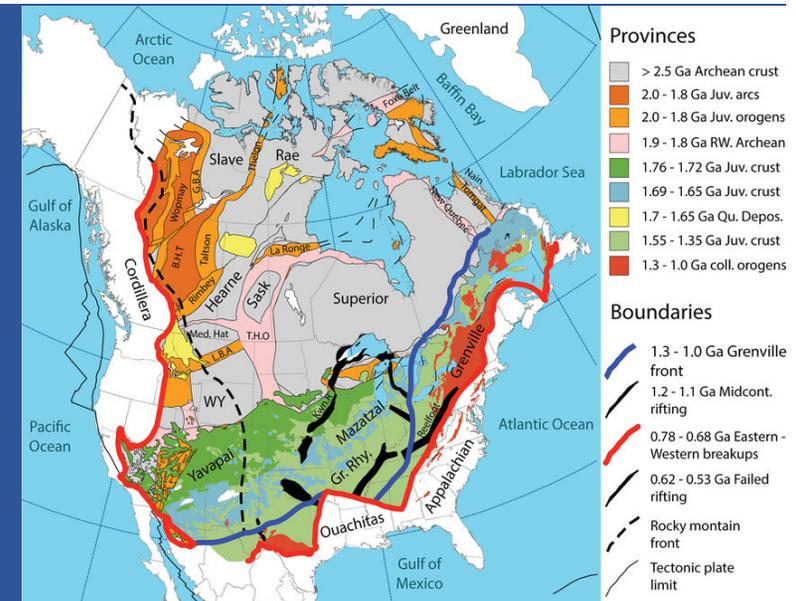
# Recap

## Precambrian craton

- 2800-2500Ma Kenorland Supercontinent
- 2400-2200Ma Snowball Earth
- 1650-1630Ma Penokean Orogeny
- 2000-1400Ma Trans-Hudson Orogeny/Columbia “SC”
- 1800-1600Ma Yavapai , Mazatzal, Mojave Orogenies
- 1300 - 700Ma Grenvillian Orogenies = Rodinia “SC”
- 720 - 635Ma Final Snowball Earth
- 541 - 530Ma Cambrian Explosion
- 480 - 260Ma Assembly of Pangaea & evolution of life on land

Only ~57% of National Parks have rock outcrops older than 360Mya:

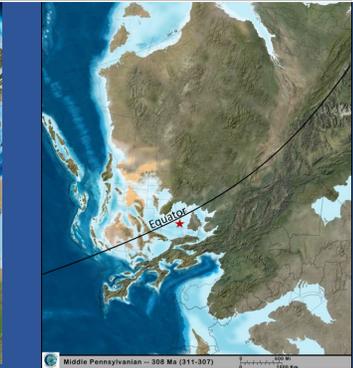
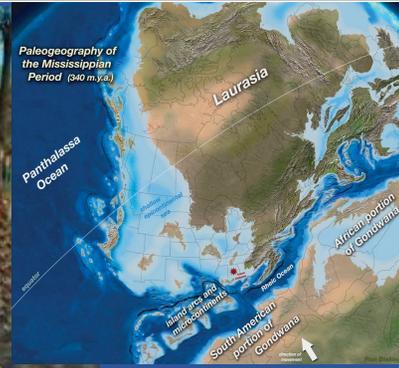
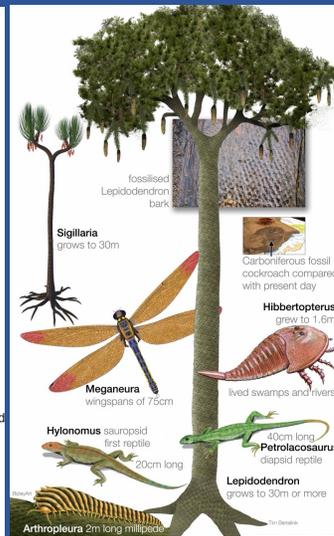
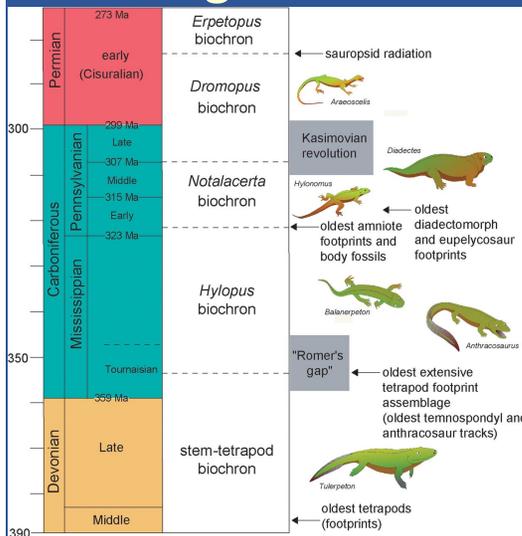
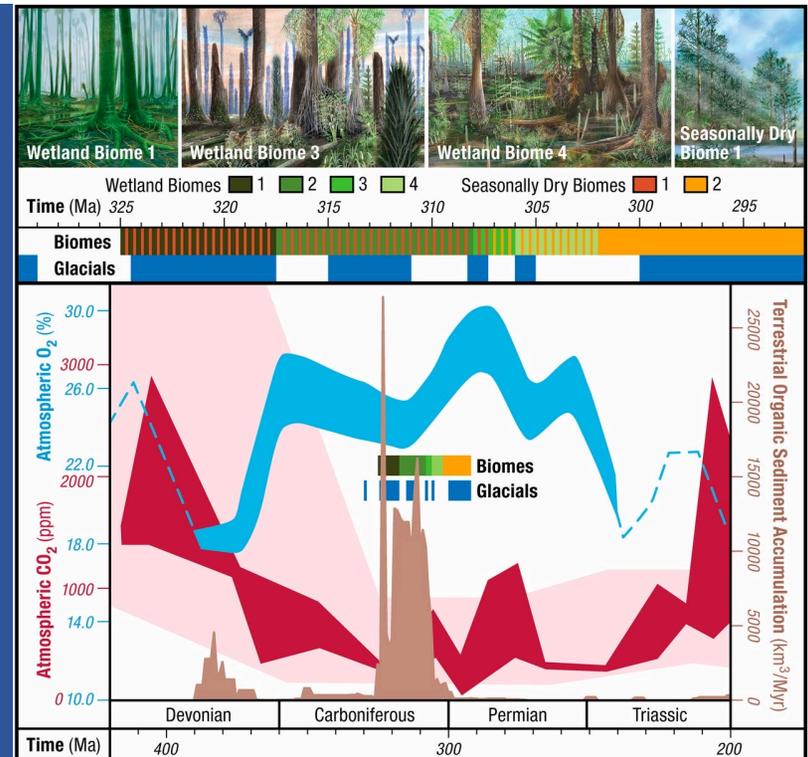
Voyageurs, Pipestone, Grand Teton, Yellowstone, Wind Cave, Glacier, Black Canyon of the Gunnison, Rocky Mountains, Joshua Tree, Grand Canyon, Death Valley, Saguaro, Isle Royale, Great Smoky Mountains, Shenandoah, Great Basin, Denali, Gates of the Arctic, Kobuk Valley, Wrangell-St. Elias, Sequoia, Kings Canyon, Yosemite, New River Gorge, Hot Springs, Acadia, Congaree, Pinnacles, Katmai, Lake Clark, Glacier Bay, Channel Islands, North Cascades, Indiana Dunes, Mammoth Caves, Cuyahoga Valley



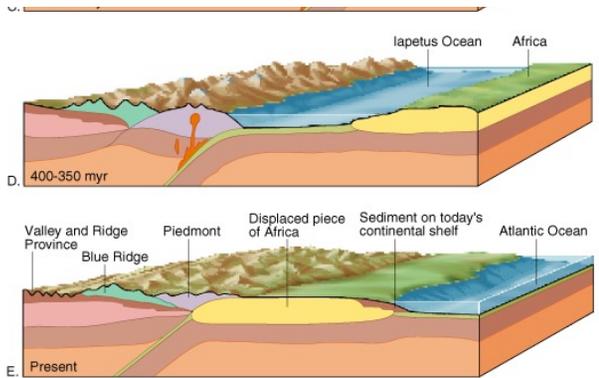
# Carboniferous Active Margins

## 359 - 299Ma Equatorial North America

- Mississippian & Pennsylvanian subperiods
- Pangaea Supercontinent formation
- Coal Formation & swampy forests
- Huge O<sub>2</sub> rise & CO<sub>2</sub> drop
- First basal amniota → sauropsids & synapsids
- Ice Age & Carboniferous Rainforest Collapse



Global temperatures		Phanerozoic: times of origin of plants and animals	
CENOZOIC	Quaternary		<b>Holocene</b> Pleistocene with alternating periods of glaciation and warm periods <i>Homo sapiens</i>
	Neogene		Early humans <i>Sahelanthropus</i> Apes Monkeys Primates
CENOZOIC	Paleogene		<b>Pliocene</b> <b>Miocene</b> <b>Oligocene</b> <b>Eocene</b> <b>Paleocene</b>
	Mesozoic		<b>Late Cretaceous</b> <b>Early Cretaceous</b>
MESOZOIC	Jurassic		<b>Late Jurassic (Malm)</b> <b>Middle (Dogger)</b> <b>Early (Lias)</b>
	Triassic		<b>Keuper</b> <b>Muschelkalk</b> <b>Buntsandstein</b>
	Permian		<b>Zechstein</b> <b>Rotliegend</b>
	Carboniferous		<b>Pennsylvanian</b> Vegetation that became coal <b>Mississippian</b>
PALEOZOIC	Devonian		Cycads Lycophytes Ferns Horsetails (Equisetidae) first terrestrial vertebrates
	Silurian		first bony fish (Osteichthyes) Placodermi
PALEOZOIC	Ordovician		Cephalopods
	Cambrian		all life forms are still aquatic new developments: Arthropods e.g. Trilobites Brachiopods, snails first vertebrates Chordates Annelids, Mussels Echinoderms, Tunicates Jellyfish, first corals
Precambrian		<b>Archaea</b> <b>Bacteria</b> <b>Algae</b> <b>Parazoa</b> <b>Ediacara Fauna</b>	Ediacara fauna



# Carboniferous: Pangaea Forms

Video link:

[https://www.youtube.com/watch?v=g\\_iEWvtKcuQ](https://www.youtube.com/watch?v=g_iEWvtKcuQ)

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

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# Rheic Coast & Appalachia Carboniferous Rocks

- 325-260Ma Alleghenian Orogeny: accretion of Europe, North America, Africa
- 318-217Ma Ouachita Orogeny: Accretion of South America

Equatorial: Coastal swamps to shallow continental shelf to deep basin with approaching continents

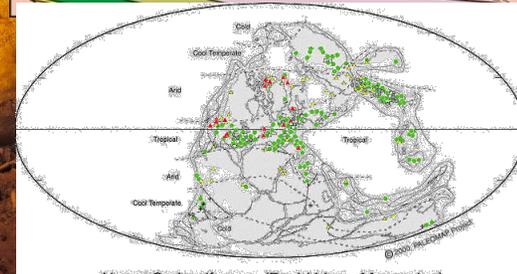
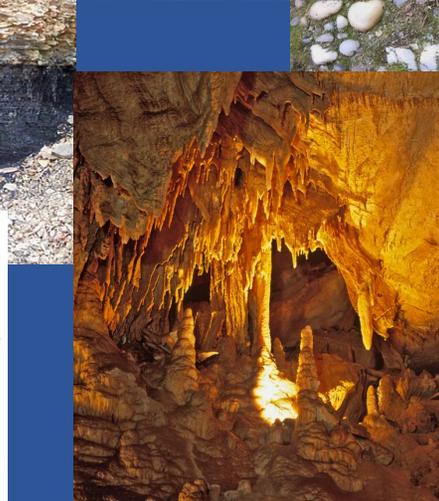
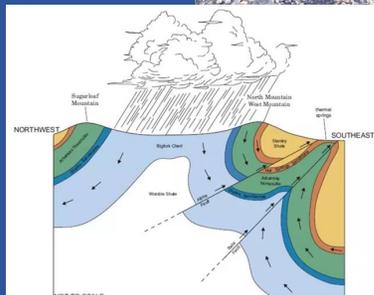
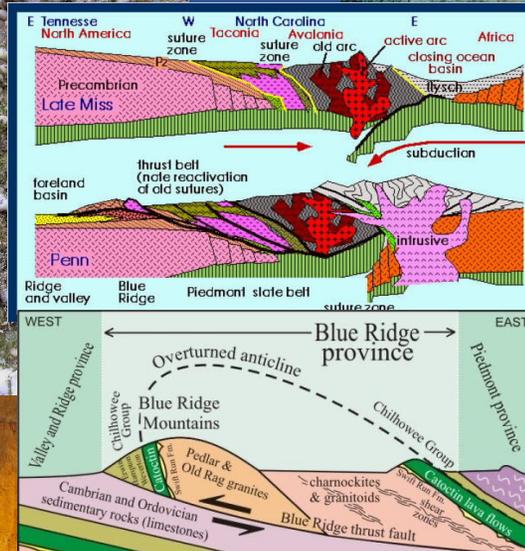
## Regression to Coastal Deltas + Coal Swamps

- Virginia: Shenandoah (faulting)
- West Virginia: New River Gorge
- Ohio: Cuyahoga Valley

## Offshore Shallow to Deep Marine

- Tennessee: Great Smoky Mountains
- Arkansas: Hot Springs
- Kentucky: Mammoth Cave
- Arkansas: Hot Springs

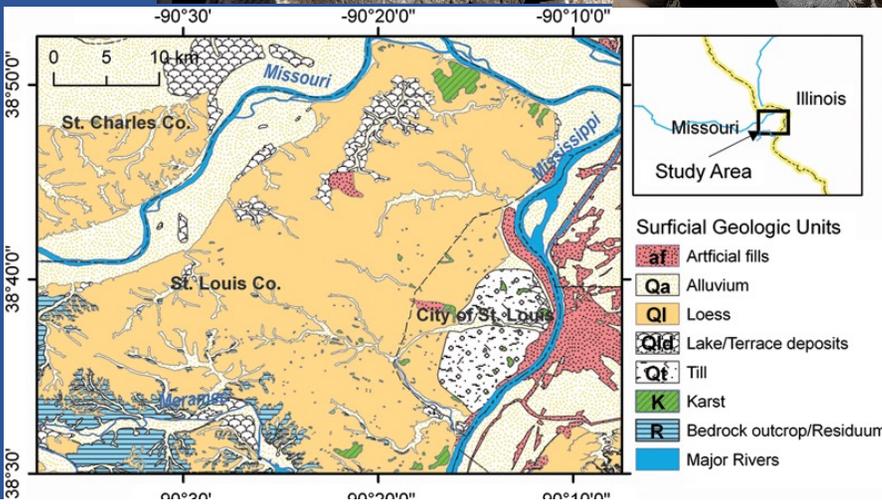
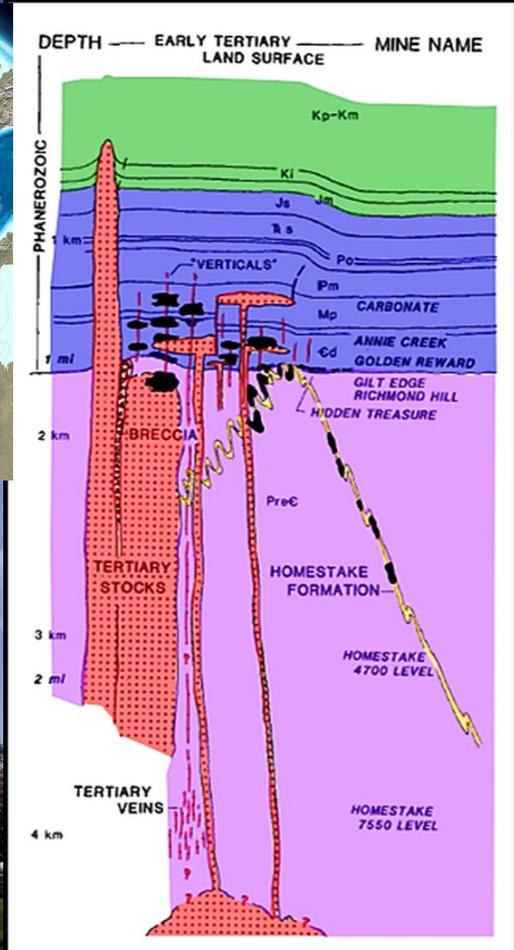
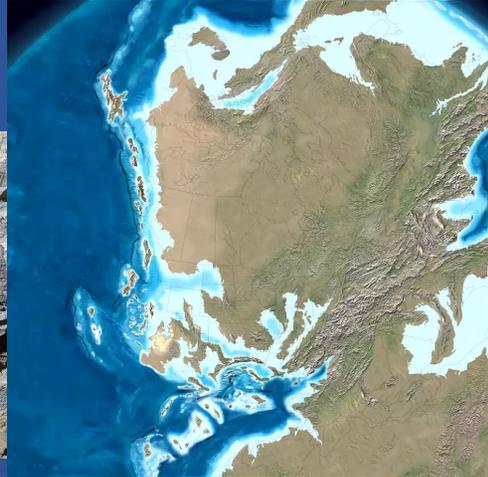
a Mississippian seafloor "crinoid garden"



# Midcontinent Carboniferous Rocks

Equatorial: continental sea & carbonate shelf

- South Dakota: Wind Cave
- Missouri: Gateway Arch



# Panthalassa Coast Carboniferous Rocks

- 375-320Ma Antler Orogeny: accretion of volcanic arcs
  - 280-250Ma Sonoma Orogeny: accretion of volcanic arcs
- Equatorial: submerged continental shelf & subduction trench

## Volcanic Island Arc, Deep & Shallow Marine Basins

- California: Channel Islands, Sequoia, Kings Canyon, Yosemite
- Washington: North Cascades

## Continental Carbonate Shelf → Mountain Uplift

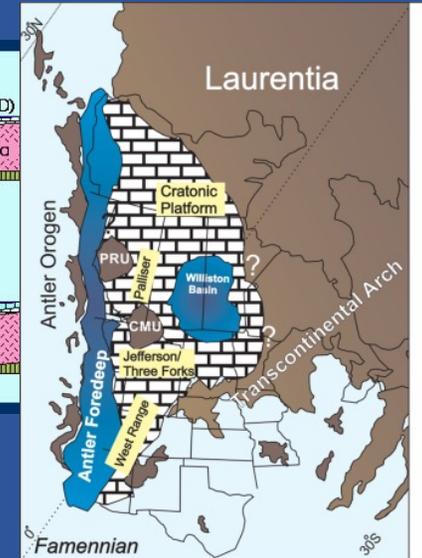
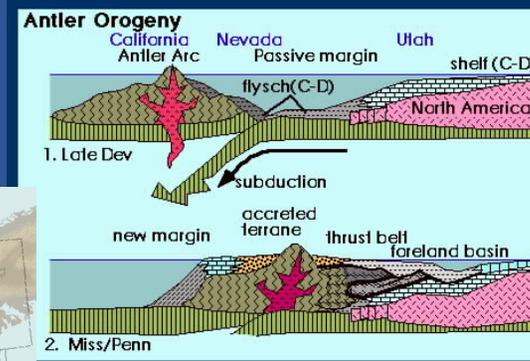
- Colorado: Rocky Mountains

## Continental Carbonate Shelf

- MT/WY/ID: Yellowstone, Grand Teton
- Nevada: Great Basin
- Arizona: Grand Canyon
- California: Death Valley

## Evaporate Basin

- Utah: Canyonlands



# Alaskan Carboniferous Tropical Islands

- 380-320Ma Ellesmerian/Innuitian Orogeny: continental margin volcanism
  - 340-250Ma Yukon-Tanana & Alexander accretion of volcanic arcs
- Equatorial, submerged passive margin continental shelf & deep basins

## Volcanic Arc & Marine Basin

- Denali
- Wrangell-St. Elias
- Katmai
- Lake Clark

## Carbonate Shelf

- Gates of the Arctic
- Kobuk Valley
- Noatak
- Wrangell-St. Elias
- Glacier Bay

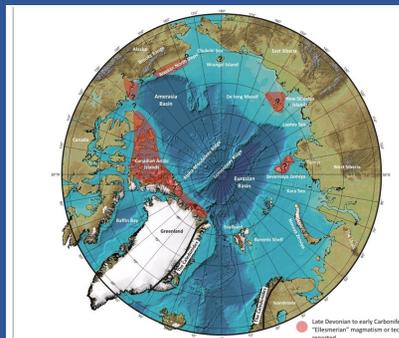
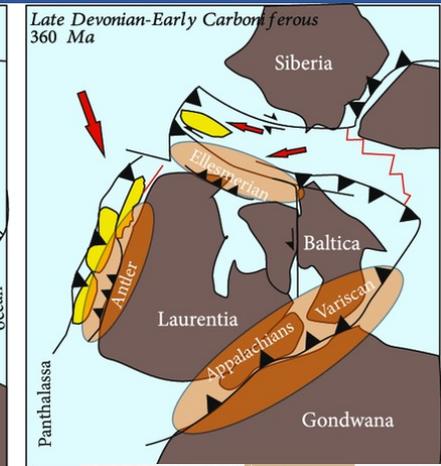
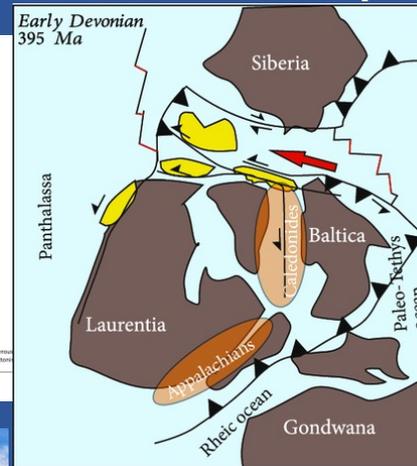


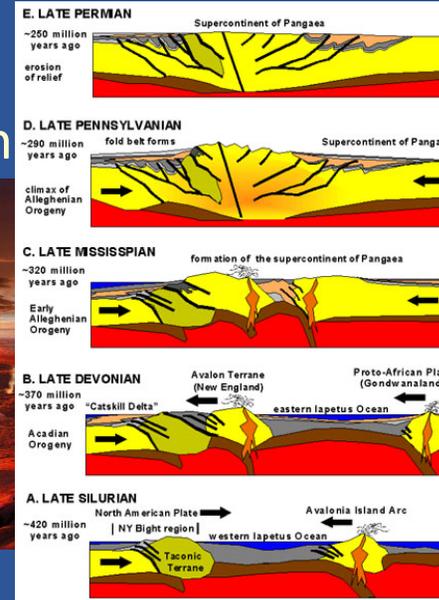
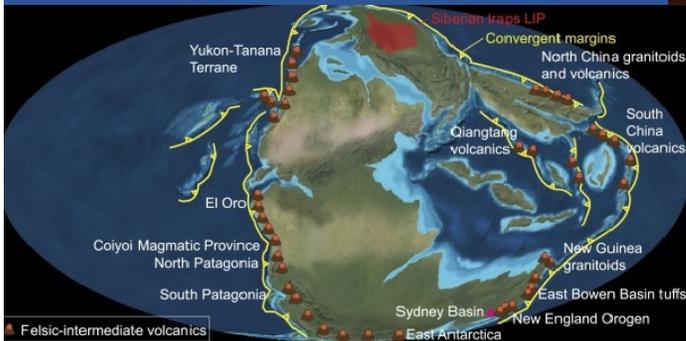
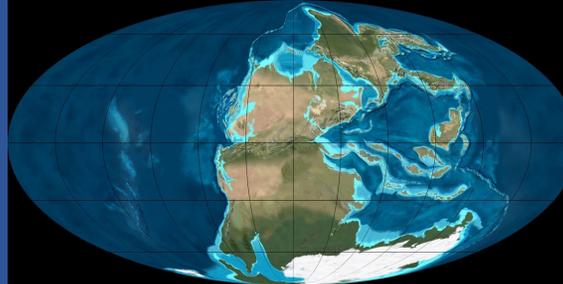
Figure 1. Map of the Arctic showing locations where evidence for Late Devonian to early Carboniferous tectonism has been cited in literature. Base map from IBCAO 2008.



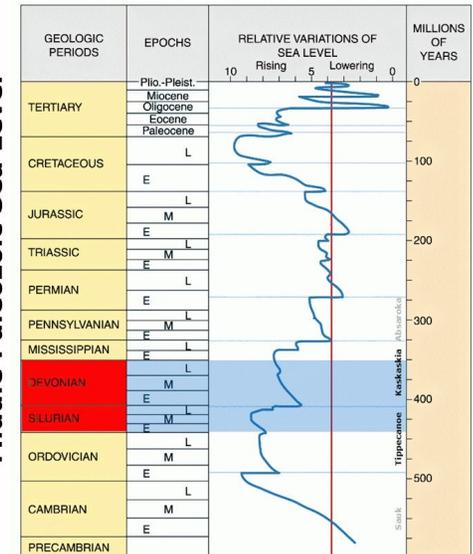
# Permian Supercontinent

## 299-252Ma Equatorial North America

- Ice Age (299-270Ma)
- Pangaea final assembly
- Sea level dropped
- Climate warmed & dried
- Evolution of ferns & seed plants
- Massive LIP (252Ma) & ocean anoxia
- Largest Phanerozoic Eon 96% extinction
- Desertification



Middle Paleozoic Sea Level

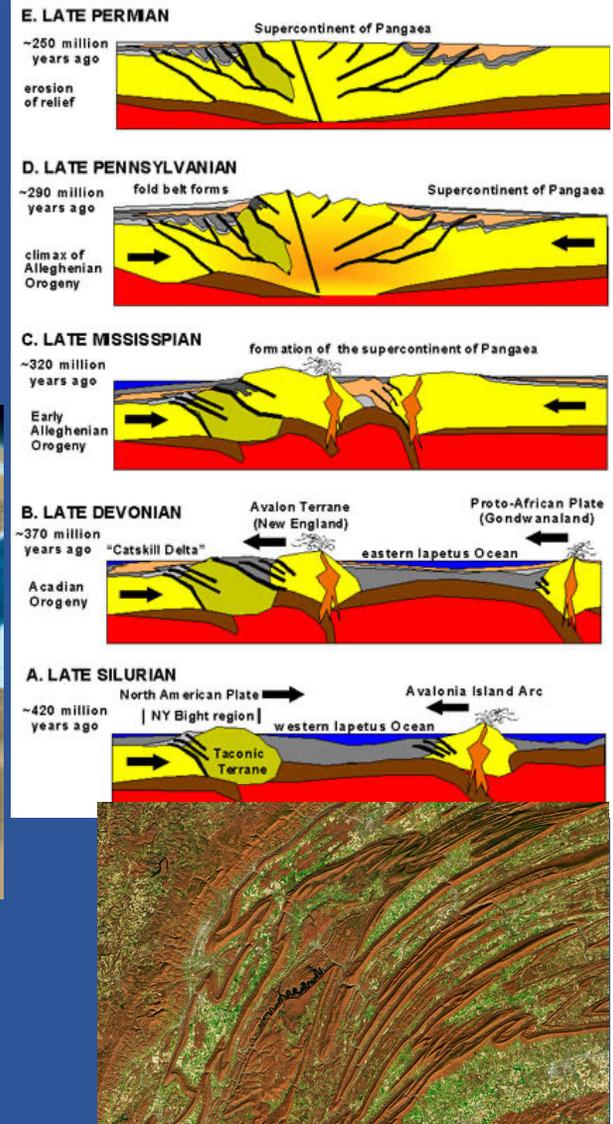
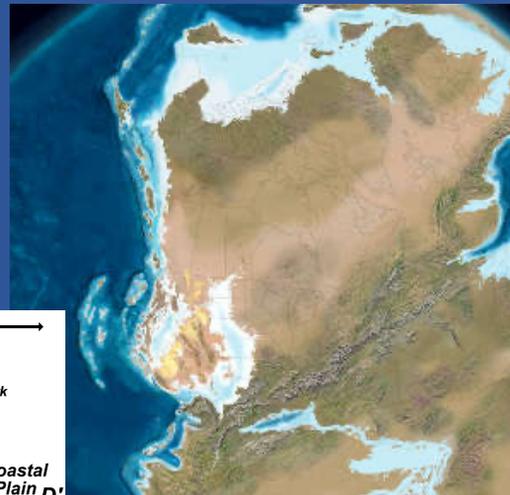
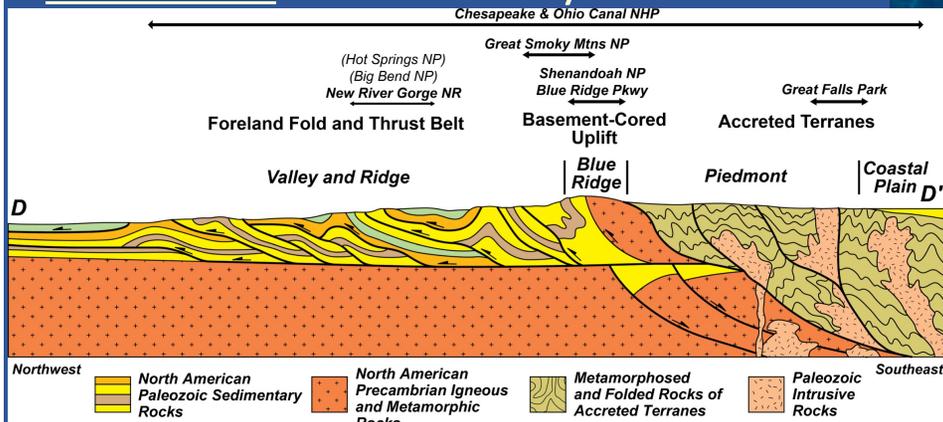


# Appalachian Permian Rocks

- 325-260Ma Alleghenian Orogeny: Pangaea
  - 318-217Ma Ouachita Orogeny: Accretion of S. America
- Equatorial: Coastal swamps to shallow continental shelf to deep basin with approaching continents

## Continent-Continent Collision Zone

- Virginia: Shenandoah
- Maine: Acadia
- Tennessee: Great Smoky Mtns



Global temperatures		Phanerozoic: times of origin of plants and animals	
CENOZOIC	Quaternary		<b>Holocene</b> Pleistocene with alternating periods of glaciation and warm periods
	Paleo- gene	16° C 18° C 15° C 26° C 20° C	<b>Pliocene</b> <b>Miocene</b> <b>Oligocene</b> <b>Eocene</b> <b>Paleocene</b>
CENOZOIC	Cretaceous	30° C 17° C	<b>Late Cretaceous</b> <b>Early Cretaceous</b>
	Jurassic	25° C 19° C	<b>Late Jurassic (Malm)</b> <b>Middle (Dogger)</b> <b>Early (Lias)</b>
MESOZOIC	Triassic	22° C 36° C 26° C	<b>Keuper</b> <b>Muschelkalk</b> <b>Buntsandstein</b>
	Permian	11° C	<b>Zechstein</b> <b>Rotliegend</b>
MESOZOIC	Carboniferous	21° C 16° C	<b>Pennsylvanian</b> Vegetation that became coal <b>Mississippian</b>
	Devonian	32° C 17° C 28° C	Cycads Lycophytes Ferns Horsetails (Equisetidae)
PALAEZOIC	Silurian	24° C 16° C	early land plants in riparian zones
	Ordovician	27° C 28° C	all life forms are still aquatic new developments:
PALAEZOIC	Cambrian	27° C 26° C	brain eyes with lenses segmentation Bilateria Radiata
	Precambrian		Archaea Bacteria Algae Parazoa Ediacara Fauna

# 10 Minute Break!

Video link:  
[https://www.youtube.com/watch?v=g\\_iEWvtKcuQ](https://www.youtube.com/watch?v=g_iEWvtKcuQ)

Video link:  
<https://www.youtube.com/watch?v=lva1m8cl9-Q>



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

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# Midcontinent Permian Rocks

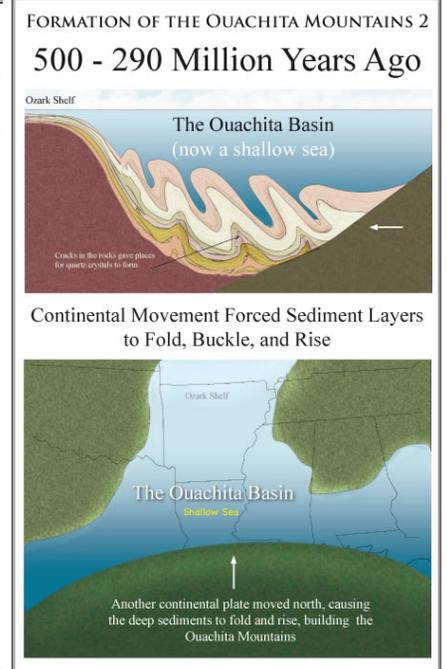
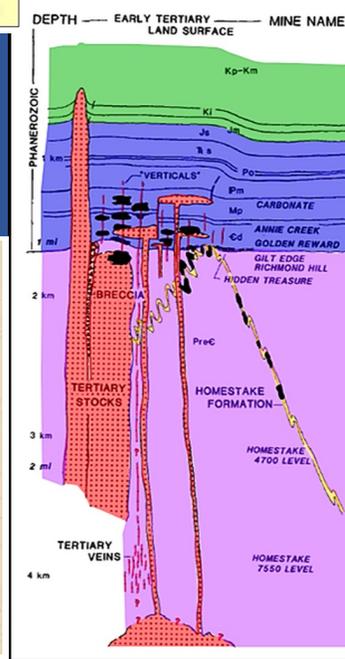
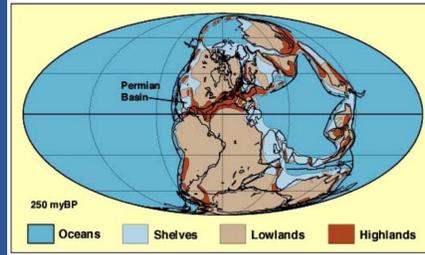
- 318-271Ma Ouachita Orogeny: S. Amer. collides Equatorial: drying supercontinent with inland seas Shallow Marine

- South Dakota: Wind Cave Permian Sea & Delaware Basin

- Texas: Guadalupe Mountains
- New Mexico: Carlsbad Caverns, White Sands

## Coastal Delta

- Ohio: Cuyahoga Valley
- Ouachita Collision Zone
- Arkansas: Hot Springs
- Texas: Big Bend



# Panthalassa Coast Permian Rocks

- 280-200Ma Sonoma Orogeny microcontinent & volcanic island arc accretion

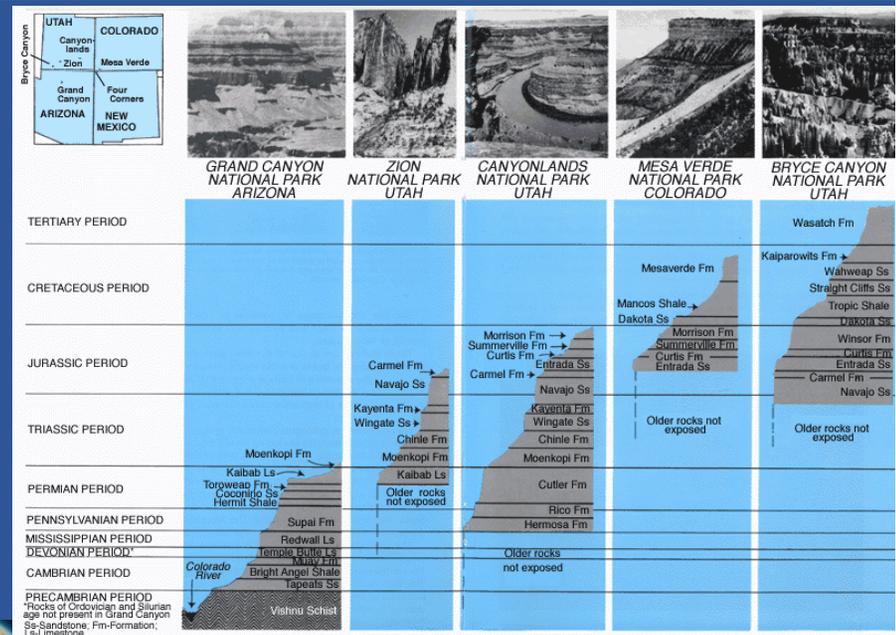
Low latitude: submerged continental shelf & deserts

## Volcanic Island Arc, & Marine Basins

- California: Channel Islands, Sequoia, Kings Canyon, Yosemite, Joshua Tree

## Eolian & Coastal

- Utah: Canyonlands, Capitol Reef
- Utah: Zion, Arches (Kaibab Lm)
- Arizona: Grand Canyon
- California/Nevada: Death Valley, Great Basin
- MT/WY/ID: Yellowstone, Grand Teton



# Alaskan Permian Tropical Islands

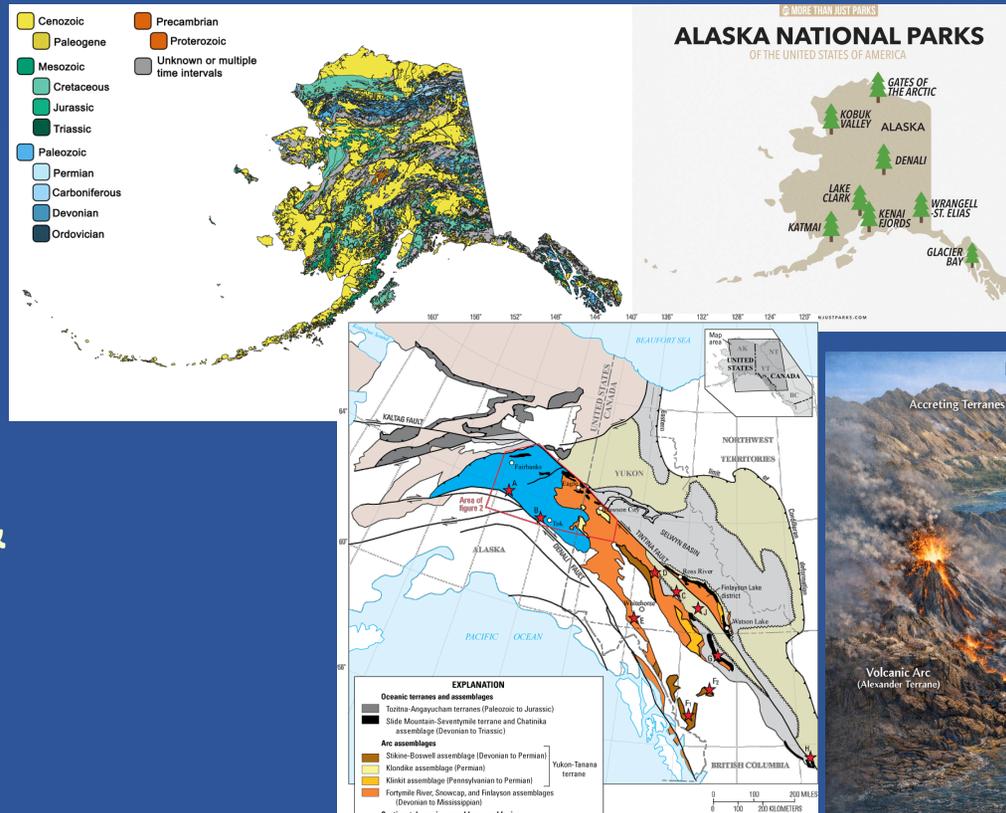
- 340-250Ma Yukon-Tanana & Alexander accretion of volcanic arcs
  - 260-252Ma Klondike Orogeny (concurrent with Sonoma Orogeny)
- Mid-Latitudes: tropical to subtropical marine basins + volcanism

## Continental Shelf

- Gates of the Arctic
- Kobuk Valley
- Lake Clark
- Denali
- Glacier Bay

## Foreign Terrane, Volcanic Island Arc & Marine

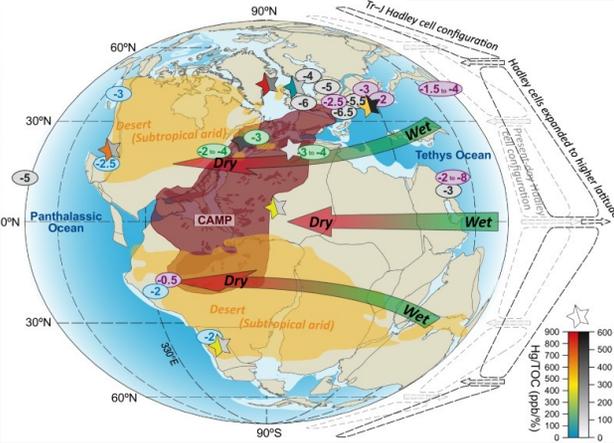
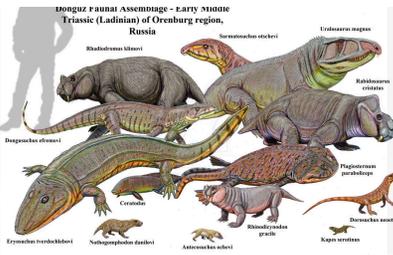
- Wrangell-St. Elias
- Kenai Fjord



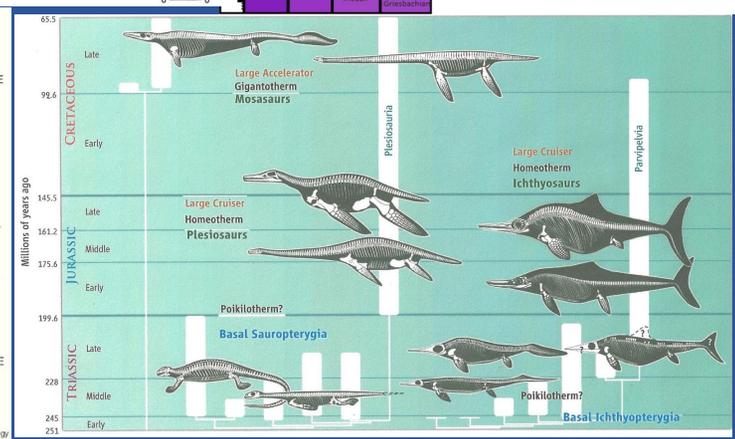
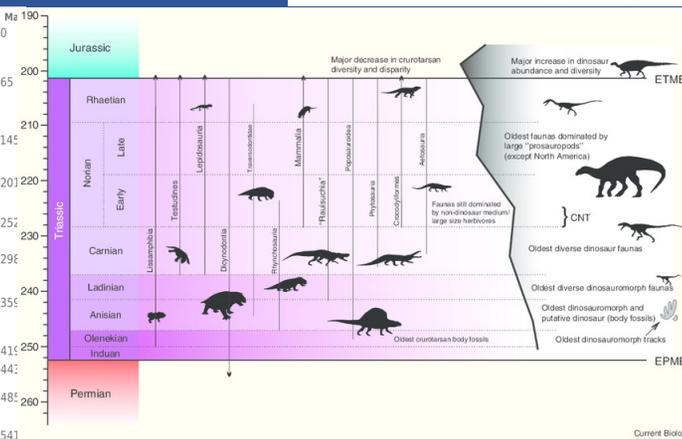
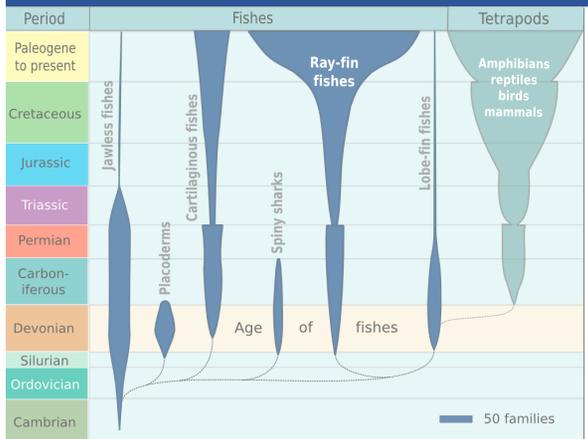
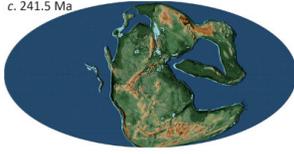
# Triassic Deserts

## 252-201Ma Subtropical N. America

- Low sea level
- Climate hot & dry → desertification
- First marine reptiles, dinosaurs, pterosaurs, mammals
- End with 80% mass extinction



Ma	Period	Epoch	Age/Stage	Substage
202	Late Triassic	Rhaetian		
201				
200				
200	Middle Triassic	Anisian	c. 241.5 Ma	
211				
213				
213	Early Triassic	Induan and Olenekian	248.5 Ma	
214				
217				



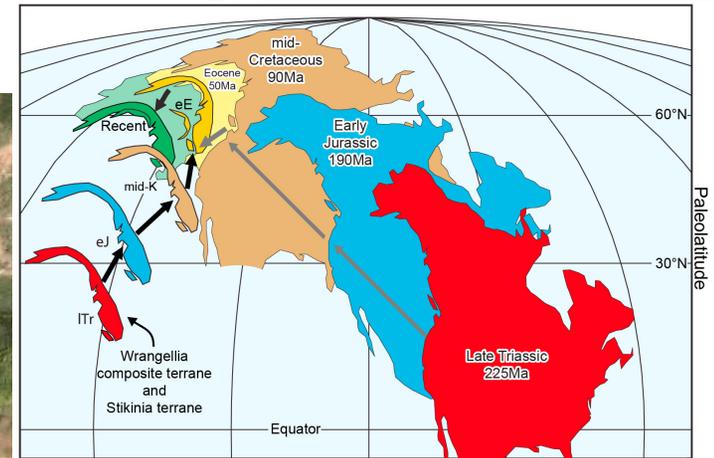
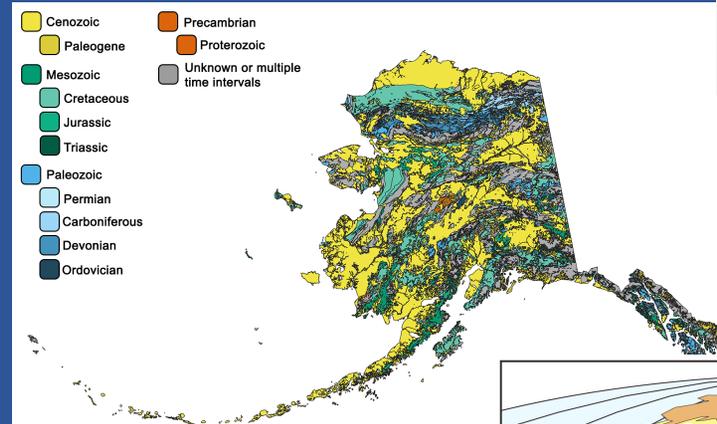
# Alaskan Triassic Tropical Islands

- 230-220Ma Wrangellia LIP oceanic plateau
- 200-170Ma Peninsular Terrane Volcanic Arc

Mid-Latitudes: tropical to subtropical marine basins + volcanism

## Volcanic arc & marine shelf

- Wrangell-St. Elias (Wrangellia & Alexander terranes)
- Glacier Bay (Alexander & Stikine terranes)
- Katmai (Peninsular terrane)
- Denali
- Kenai Fjords
- Lake Clark



# Panthalassa Coast Triassic Rocks

- 280-200Ma Sonoma Orogeny microcontinent & volcanic island arc accretion

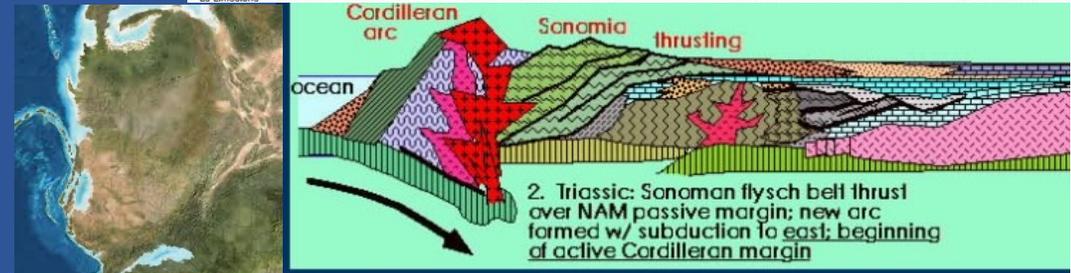
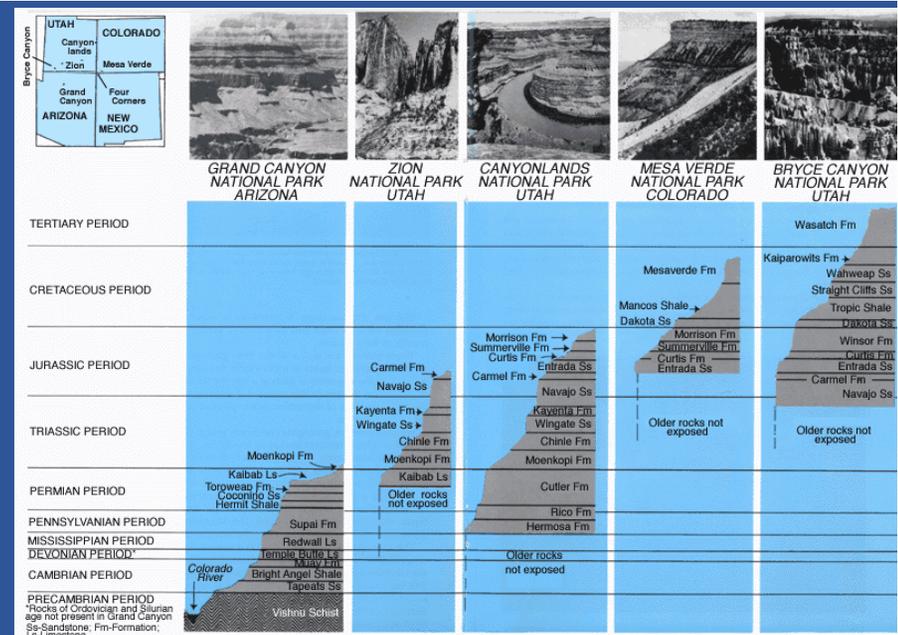
Subtropical: continental shelf, ↑ arid coastline

## Volcanic Island Arc & Marine Basins

- Washington: North Cascades
- California: Yosemite, Channel Islands, Sequoia, Kings Canyon

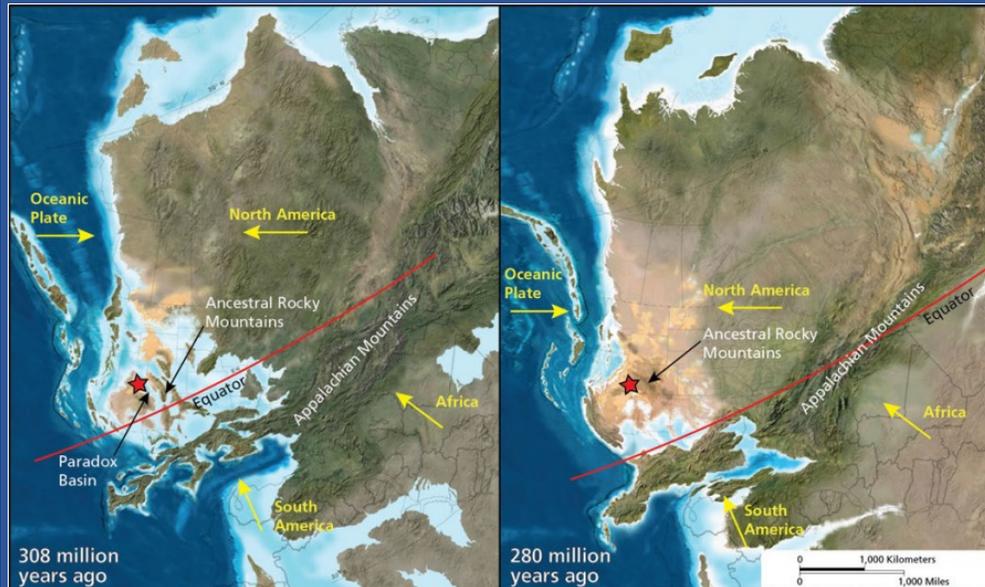
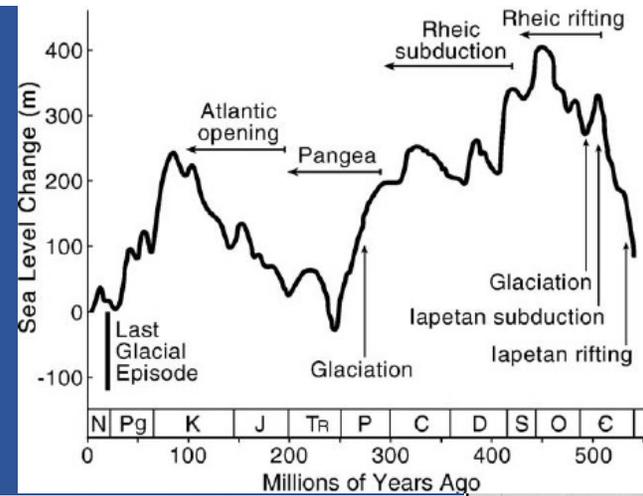
## Shallow Marine, Coastal + Some River Systems & Volcanic Ash → more arid

- MT/WY/ID: Yellowstone, Grand Teton
- Colorado: Rocky Mountain
- UT/AZ: Capitol Reef\*, Arches, Zion\*, Petrified Forest\*, Canyonlands\*, Grand Canyon, Bryce Canyon
- CA/NV: Death Valley, Great Basin

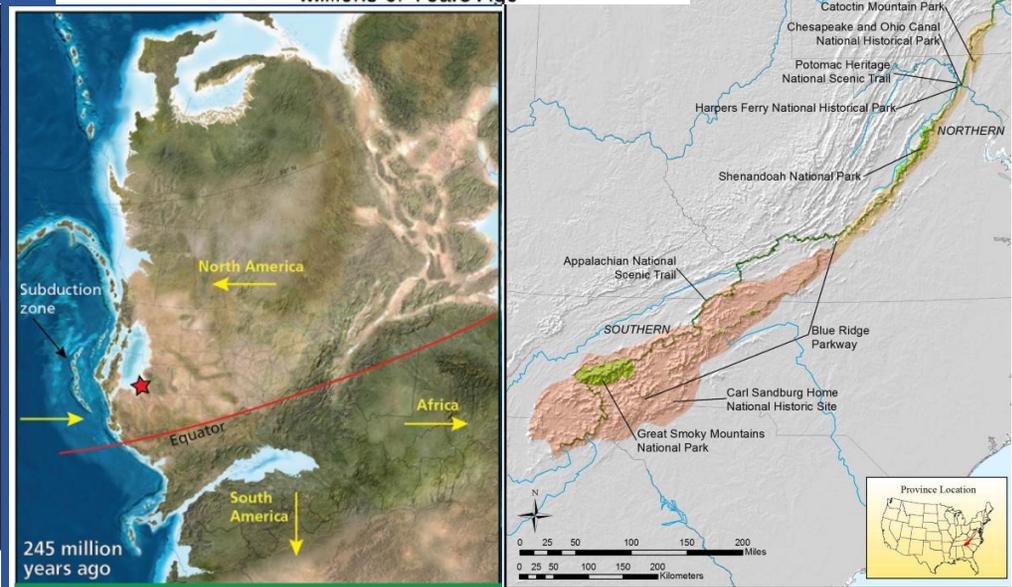


# Appalachian Triassic Rocks

- 318-217Ma Ouachita Orogeny: S. America
  - 201-0Ma Atlantic Rifting & erosion
- Subtropical: drying supercontinent with linear sea developing and significant erosion (no Triassic rocks)



During the Middle Pennsylvanian, North America, Africa, and South America were colliding to form Pangea. By the Early Permian, the Paradox Basin closed and the Ancestral Rockies and Appalachian mountains formed.



In the Triassic Period, Pangea began to split apart; the Gulf of Mexico and Atlantic Ocean opened. In the Jurassic, coastal mountains rose along the western coast of North America. Shallow seas began to encroach from the north. By the Late Cretaceous, the entire continent was bisected by the Western Interior Seaway.