Continental Interior

- West of Cordillera and East of Appalachian Provinces
- Geologic History records the same transgressive-regressive events as the Grand Canyon/Colorado Plateau

- Rocks here are different from Colorado Plateau
- They record flooding of continent by ‘epicontinental seas’ and sediment fluxes from Rocky Mts and Appalachians
- The Pre-Cambrian Basement has the same origin and history as what underlies the Colorado Plateau (Yavapai)
Four parks of interest:

- Badlands,
- Devil’s Tower,
- Mammoth Cave
- and Carlsbad Caverns
  (not part of Cont. Interior, but interesting caves)

Badlands National Park

- What are badlands topography?
  - Dendritic drainage pattern
  - Deeply incised valleys
  - Sparse Vegetation
- Requires flat-lying, easily eroded rock
- Rocks at Badland NP have high clay content
  - Clay expansion (wetting-drying) causes physical weathering
  - Heavy rains wash away broken fragments
Geology of Badlands NP:

- Pierre Shale:
  - Late Cretaceous (80-65 Ma)
  - Laramide uplift of Rockies sheds sediment into Cretaceous Seaway
  - Shale = mud in marine setting
  - End Cretaceous to Oligocene (~30 Ma) Sea retreats and Pierre is exposed and weathers

- Chadron = Oligocene sands and gravels from erosion of Black Hills

- Brule = Oligocene muds (floods) and ashes (volcanoes)
  - Abundant mammal fossils
Fossils of the Oligocene

- Much of the evolution of NA mammals is preserved in the fossils of the Black Hills Brule Formation
- Camels, and Horses especially.

Devil’s Tower

- What is it?
  - Towering mass of syenite/phonolite (Feldspar-rich igneous rock)
  - Distinctive columnar jointing
- How did it form?
Enigmatic Origin

- Volcanic conduit or eroded sill-like body?
- Columnar Jointing indicates cooling from above and below
  - favors sill,
  - But, where is the rest of it (shape is more like volcanic conduit)

Or…
Mammoth Cave, KY

- Topics
  - Groundwater
  - Karst systems
  - Illinois Basin
  - Mammoth Cave
  - Carlsbad Cavern

Groundwater - how it normally exists

- Groundwater wets grains and fills pores (voids)
- Groundwater flows if pores are connected (rock is permeable = Aquifer)
Most Groundwater exists like this…

- Aquifer is recharged by precipitation falling on exposed aquifer.
- Gravity/pressure drives flow of groundwater
- Groundwater discharges (springs) where aquifer connects with surface

Karst (cavern) systems are uncommon groundwater systems

- In Karst systems, groundwater flows as underground streams through cavern system.
- Cavern system develops in soluble rocks (e.g. limestones)
- At Mammoth, the cave system is genetically linked to the Green River
Dissolution of Limestone

- Rain water and ground water are acidic
  - $\text{H}_2\text{O} + \text{CO}_2 \Leftrightarrow \text{H}_2\text{CO}_3$
  - $\text{H}_2\text{CO}_3 \Leftrightarrow \text{H}^+ + \text{HCO}_3^-$
- Acid water dissolves limestone
  - $\text{H}^+ + \text{HCO}_3^- + \text{CaCO}_3 \Leftrightarrow \text{Ca}^{2+} + 2\text{HCO}_3^-$
- Dissolution occurs along fluid pathways - joints and bedding planes. These widen into cave shafts and passages.

Rivers and Caves are linked

- Dissolution occurs at in the saturated zone beneath the water table
- As a river down-cut its channel,
  - the water table in the surrounding hills drops
  - And, the level of cave development drops too.

Green River, KY
Mammoth is in the Illinois Basin

- Mississippian Limestone overlain by Pennsylvanian sediments
  - Miss: ~350-330 Ma
    - Euroamerica near the equator and by warm shallow sea
  - Penn: ~330-290 Ma
    - Euroamerica collides with Gondwana (Pangaea forms)
    - Pulses of sediments shed from rising Appalachian mts force regressions of coast and deposit over Illinois basin

That way

Geologic History of Mammoth

- Begins ~10 Ma with the erosion of Pennsylvanian and upper Mississippian rocks
  - exposes limestones at the surface.
  - Karst development begins
- Pleistocene (<1.6 Ma) Glaciation diverted westward flow of rivers across IN to the Ohio River.
  - This causes increased flow in Ohio R.
  - Down-cutting of O.R. and tributary channels
  - This leave older caves ‘high and dry’ while forming younger caves deeper down
- Cave development continues today.
Look at Carlsbad Cavern…

- In Arid NM
- Begins with dissolution of Permian limestones
  - Captain Reef and Yeats Fm
  - Initially, dissolution by carbonic acid (same reaction as before).
  - But the main cavern system (huge was formed through the dissolution by sulfuric acid
  - $\text{H}_2\text{S} + 2\text{O}_2 \rightleftharpoons 2\text{H}^+ + \text{SO}_4^-$
  - $\text{H}^+ + \text{CaCO}_3 \rightleftharpoons \text{Ca} + \text{H}_2\text{O} + \text{CO}_2$