

Geol 104 Geology of National Parks  
Lecture 14 Parks of the Continental Interior

I. Introduction

A. We now move to the Continental Interior

1. Lies West of Cordillera and East of Appalachian
2. Geologic history records same transgressive-regressive events as the Grand Canyon through Zion through Bryce Canyon
  - a. The rocks here are different Formations – different names and different lithologies
  - b. They record
    - i. Flooding of the interior of the continent
    - ii. Sediment input from the Rockies to the west and Appalachians to the East
  - c. Precambrian Basement is the
    - i. Yavapai province
    - ii. Same province (age and origin) that underlies the Grand Canyon

B. We will focus on four parks and three processes

1. Parks: Badlands, Devil's Tower, Mammoth Cave and Carlsbad Caverns.
- 2: Processes:
  - a. Development of Karst Terrain (cave formation)
  - b. Development of Badland Topography
  - c. Formation of Columnar Jointing

II. Badlands and Devils Tower

A. What are badlands?

1. Type of topography
  - a. Dendritic drainage network of deeply incised valleys
    - Dendritic = branching pattern similar to the veins in a maple leaf
  - b. Sparse vegetation
2. Requires rocks that are
  - a. Flat lying
  - b. Soft and easily eroded
3. At Badlands National Park
  - a. Rocks have a high clay content (Montmorillonite from volcanic ash).
    - i. These clays absorb water and expand – opening cracks by clay expansion
    - ii. Desiccation/drying causes contraction and flaking, producing easily eroded rocks
  - b. Erosion of rocks here occurs during heavy rains on the arid High Plains

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B. Geology of Badlands National Park

1. Located in western South Dakota
2. Late Cretaceous 80-65 Ma
  - a. Laramide orogeny - uplifting of Rockies (sediment source to Continental Interior)
  - b. Cretaceous seaway flooded the continental interior
    - i. Pierre Shale = rock composed of very fine sediment from Rockies, deposited in marine environment
    - ii. Over 1000 feet thick, extends from Gulf of Mexico into Canada (not exposed everywhere).
3. End Cretaceous 65 Ma to Oligocene (~30 Ma)
  - a. Sea retreats and Continental Interior is exposed
  - b. Pierre Shale is erodes and weathered
4. Chadron Formation: Oligocene
  - a. Uplift of Black Hills to West of Badlands NP
  - b. Huge masses of sediment derived from Black Hills is deposited on rolling topography
  - c. Remaining, overlying stratigraphy is all non-marine (exposed continent)
5. Paleontological Note: Many fossil organisms are preserved in the Badlands strata e.g. Tortoises, reptiles, and especially mammals (Camels and Horses evolved in this region, both became extinct on NA. Horses reintroduced by Spanish).

C. Devil's Tower

1. Located in Eastern Wyoming
2. What is it?
  - a. Towering Mass of igneous rock
    - i. Phonolite/syenite porphyry: < 10% mafic minerals, Feldspar: > 90% alkali-potassium feldspar and < 10% plagioclase
    - ii. Columnar jointed – indicates cooling from above and below
  - b. Enigmatic origin
    - i. Not a lava flow
    - ii. Not a volcanic neck (no volcanic ash around of same age/origin)
    - iii. Possibly a laccolith (thick tabular intrusion into sedimentary rock. Problem – where is the rest of it.

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III. Mammoth Cave: Located – Kentucky, in much older rocks of the Continental Interior

A. Development of Karst Terrain

1. Common occurrence of Groundwater:
  - a. Groundwater exists in voids within rocks or sediment
  - b. Voids = pores between grains or open fractures in the rock
  - c. Permeability: Connected voids allow water to flow through the rock or sediment (aquifer). This is called permeability.
2. Recharge, Water table and Discharge
  - a. Recharge: Precipitation on the surface infiltrates the ground to supply the aquifer
  - b. Water table = boundary between saturated aquifer below and unsaturated (mostly air) zone above.
  - c. Discharge = Groundwater flowing onto surface (natural springs, and wells)
3. Karst development:
  - a. Relatively uncommon occurrence of groundwater – flowing in underground streams
  - b. These systems develop in highly soluble rocks like Limestone ( $\text{CaCO}_3$ )
    - i. Groundwater is acidic –  $\text{CO}_2$  from decaying organic mater
    - ii. This will dissolve the  $\text{CaCO}_3$  in limestone
$$\text{H}_2\text{O} + \text{CO}_2 \Leftrightarrow \text{H}_2\text{CO}_3$$
$$\text{H}_2\text{CO}_3 \Leftrightarrow \text{H}^+ + \text{HCO}_3^-$$
$$\text{H}^+ + \text{HCO}_3^- + \text{CaCO}_3 \Leftrightarrow \text{Ca}^{2+} + 2\text{HCO}_3^-$$
  - c. Dissolution of limestone progresses as surface water flows into fractures in limestone, -
  - d. As rivers down-cut their valleys,
    - i. Water table drops with the stream base level,
    - ii. The cave systems develop deeper into the ground, leaving the older overlying caverns above.

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B. Geology of Mammoth area

1. Illinois Basin:

- a. Mississippian limestones overlain by Pennsylvanian sediments
- b. Mississippian (~350-330 Ma) Period:
  - i. Western Euroamerica was flooded and near the equator = shallow warm sea
  - ii. Reefs and carbonate platform (like Caribbean today)
- c. Pennsylvanian time Period (~330 – 290 Ma)
  - i. Gondwana collides with Euroamerica forming Pangaea
  - ii. Huge amounts of sediment are shed off the rising Appalachian Mountains
  - iii. Pulses of these sediments force regressions of the coast and deposition in Illinois Basin.

2. Development of Mammoth Cave

- a. Begins ~ 10 Ma after erosion of Penn. and upper Miss. Rocks
  - Continues slowly until Pleistocene ~1.6 Ma
- b. Pleistocene Glaciation accelerates down cutting of river systems and cave development
  - i. River system: Green River tributary to Ohio River
  - ii. Glaciers advance over IL and IN, diverting west flowing rivers to Ohio R. drainage
    - This greatly increases flow and down cutting of Ohio and it's tributaries
    - Green River down cuts valley, leaving older caves high and dry while forming younger caves deeper down.
  - iii. Repeated periods of down cutting produce different levels to the caves – well developed levels = times when river base level was stable
- c. Cavern development continues at Mammoth today.

IV. Carlsbad Caverns, New Mexico

A. Permian Captain Reef limestone

B. Development of Karst system

- 1. Begins in Permian with dissolution by carbonic acid.
- 2. Main cavern systems (huge) formed by dissolution by sulfuric acid (H<sub>2</sub>S)!
  - a. Acid from petroleum source rocks migrating into Permian rocks
  - b.  $\text{H}_2\text{S} + 2\text{O}_2 \Leftrightarrow 2\text{H}^+ + \text{SO}_4^-$ , H<sup>+</sup> dissolves CaCO<sub>3</sub>