

Geol 104 Geology of National Parks
List of Topics

Below is a list of topics we covered since the last exam. I have 'boiled' down much of the 'complex' geologic histories for you. These topics will not all be covered on the exam. The purpose of this list is to help you organize in preparation for the exam. A 'study guide' for the exam will follow soon...

I. History, Regulation and Geography of the Grand Canyon

- Located on the Colorado Plateau
- Powell's expedition
- The Canyon: 227 river miles, > 1 mile deep, 9-18 miles across
- Ecology of North vs. South Rim

II. Tectonics of the Colorado Plateau

- A. Early Cenozoic (Tertiary ~60 Ma): shallow subduction of Kula oceanic plate uplifts Colorado Plateau during Laramide Orogeny
- B. End of Paleocene ~55 Ma to Miocene (~20 Ma), Kula slab founders into Asthenosphere, causing upwelling and melting of Asthenosphere and Basin and Range extension forming the Rio Grand Rift and Basin and Range province. Colorado Plateau remains uplifted.

III. Formation of the Grand Canyon - 7-10 Ma

- A. Uplift of the plateau affects the flow of rivers.
- B. Headland erosion of Hualapai Drainage and Stream Piracy
- C. Form the canyon by river channel down-cutting and valley widening – controlled by bed thickness and joint spacing

IV. Geologic History of the Grand Canyon (and North America): Recall this history spans ~1.5 Ga and is recorded by the rocks exposed in the Canyon.

- A. Precambrian: The Nuna continent and Rodinia Supercontinent:
 - Formation of Nuna spans 2.5 to 1.6 Ga
 - Yavapai Orogen produces Mazatzal Mts, Vishnu Schist, Zoroaster Granite
 - Rodinia forms ~ 1 Ga with Greenville orogeny
 - Vishnu and Zoroaster uplifted
 - Grand Canyon Supergroup deposited in ocean offshore of Rodinia
 - Rodinia rifts in late Proterozoic (~750 Ma): this produces the faults in Grand Canyon
- B. Paleozoic: Repeated transgressions and regressions recorded in the rocks above The Great Unconformity
 - Cambrian Tonto Group = Transgressive sequence separated from overlying rocks by a disconformity
 - Overlying Limestones = marine setting
 - Ocean regresses: Supai Group, Hermit Shale, Coconino Sandstone (Pennsylvanian to Permian)
 - Recall the Supai Group has distinctive 'stair-step' pattern
 - Recall Coconino sandstone represents large coastal dunes (cross-bedding)
 - Permian Sea transgresses depositing Toroweap Formation and Kaibab Limestone
 - Recall Toroweap has evaporite (gypsum) deposits

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- V. Zion = canyon cut by Virgin River into Markagunt Plateau. This plateau bounded by two Basin and Range faults
- A: Stratigraphy of Zion: younger than Grand Canyon, Navajo Sandstone is the biggie, Kaibab Limestone is at the base, Much shorter time span recorded (~100 Ma: uppermost Permian, Triassic, Jurassic) compared to Grand Canyon's ~1.5 Ga.
- B. Geologic History of Zion: a continuation of the Grand Canyon geologic history. The rocks of Zion record regression of the Permian sea, followed by change to arid climate in Triassic, then transgression of the sea in later Jurassic.
- Regression: Kaibab limestone -> Moenkopi Fm – recall this one has gypsum deposits indicated fluctuating sea-level in arid climate.
- Triassic – Climate becomes more humid: Dinosaur tracks in river/lake deposits of the Moenave and Kayenta formations
- Jurassic
- Climate changes to arid and huge desert forms: NAVAJO Sandstone
 - Recall how sediment is transported by wind
 - Sea level rises again, and deposits limestones on top of the Navajo ss.
- C. Canyon and Arch formation at Zion: Mass wasting and river down-cutting.
- Mass Wasting = movement of large mass of material down-slope under the force of gravity.
- Frost wedging drives mass wasting in Zion (and much of the world) causing joint blocks to fall from the walls of the canyons. – forms Arches too.
- Hanging Valley- Down-cutting by the tributary stream cannot keep pace with the rapidly down-cutting main stream
- VI. Bryce Canyon: located on Paunsaugunt Plateau that is bounded by two Basin and Range faults. Rocks here are ~100 Ma younger than at Zion.
- A. Features of Bryce: 'open' amphitheaters (created by sheet wash over the plateau's rim) with joint controlled pillars left standing by differential erosion.
- B. Weathering: Mechanical vs. Chemical.
- Frost wedging & Clay expansion s surface area. Increased surface area increases rates of chemical reactions.
- Differential Weathering: Some rocks are more resistant to weathering processes. These remain while the less resistant rocks disintegrate. These different rates of weathering produce interesting features (e.g. Thor's Hammer in Bryce, Mesas in general)
- C. Geologic History of Bryce
- Cretaceous Seaway floods the continent (~150 Ma) (this ocean began to flood the continent after deposition of Navajo SS)
- The sediments from this transgression are not exposed in Bryce – but we do see them later in Mesa Verde and the Badlands
- Laramide Orogeny (late Cretaceous ~90 Ma) uplifts plateaus leaving basins between them. These basins fill with lakes – this is where the rocks at Bryce come from (Claron formation). They are layered limestones and mudstones that erode at different rates (differential weathering).

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- VII. Canyonlands & Arches – reflect same history as Zion and upper Grand Canyon
- A. Paradox Formation (new concept) = evaporite deposits: Seawater from regression of Permian sea (remember Supai and Hermit from Grand Canyon?) is trapped in basin and evaporates – causing salts to crystallize.
These evaporite deposits (1000s of feet thick) become buoyant and lift-up the overlying rocks (salt domes).
 - B. Incised meanders at Canyonlands – recall how they form
- VIII. Mesa Verde
- A. Rocks at Mesa Verde record the transgression of the Cretaceous Sea: Dakota sandstone -> Mancos Shale -> Mesa Verde Group
 - B. (Maybe) Why the Anasazi built cliff dwellings here: Recall Groundwater flow
Mancos shale is an aquiclude
Overlying Mesa Verde sandstones are permeable (aquifer):
Springs of groundwater on the cliff-side emerge at the contact between sands and the shales.
- IX. Continental Interior: Badlands, and Devils Tower
- A. What is badlands topography
 - B. Geologic History of Badlands National Park –
Records flooding of continental interior by Cretaceous sea (Pierre Shale – similar to Mancos shale at Mesa Verde). This sea retreats and Pierre Shale is exposed and oxidized (~rust).
Uplift of the Black Hills to the west sheds sediment onto the region (Chadron Formation). Many fossils preserved here – especially mammals.
 - C. Devil's Tower: towering mass of intrusive igneous rock displaying text-book columnar jointing. How did it form?
- X. Continental Interior: Mammoth Cave
- A. Geologic history of Illinois Basin – Different than everything above
Limestones deposited in tropical shallow sea (~350 Ma, Mississippian) when western Euroamerica was flooded (recall the Red Wall Limestone of Grand Canyon?).
Pennsylvanian time (~330 Ma) Gondwana collides with Euroamerica - Huge amounts of sediment are shed from the rising Appalachian Mountains into the IL basin and forcing regression of coast
Development of Mammoth Cave began ~10 Ma in the Limestones
1.6 Ma Pleistocene Glaciation accelerates down cutting of Green River and the vertical development of the cave system.
 - B. Development of Karst Terrain (uncommon groundwater system – remember the common system = Mesa Verde example)
CO₂ in groundwater makes acid that dissolves the limestone along bedding and joint surfaces (3-D network). As dissolution continues, the cavern system grows into an interconnected network of openings.
As rivers down-cut, the base-level drops (water table drops too) and the cave system develops vertically downward.
Carlsbad Caverns, NM = Very strange, huge cavern system. Much of which was developed by dissolution by sulfuric acid.

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XII. Appalachian Mountains

- A. Parts of the Appalachian Province: Coastal Plain, Fall Line, Piedmont, Blue Ridge, Valley and Ridge and App. Plateau. What are they?
- B. Tectonic History of Appalachian Mts
 - Grenville Orogeny ~1.1 Ga forms basement of Appalachians and builds Rodinia
 - Rifting of Rodinia (~600 Ma) = Break out (formation of) Laurentia
 - Taconic Orogeny (~490 Ma Ordovician) – Volcanic islands collide with Laurentia
 - Acadian Orogeny (~425 Ma Silurian to Mid-devonian) forms Euroamerica when Baltica and Avalonia collide with Laurentia
 - Alleghanian Orogeny (~320 Ma Pennsylvanian into Permian) forms Pangaea and Appalachian Mountains when Gondwana collides with Euroamerica
 - Pangaea Rifts apart (Begins in Triassic ~250 Ma) lifting the margin of North America and raising the modern Appalachian Mountains.
- C. Great Smoky National Park – Blue Ridge (Grenville) and Valley and Ridge Provinces (Alleghanian). Never Glaciated
- D. Acadia National Park – Accreted volcanic islands (Taconic) and Avalon microcontinent (Acadian). The topography today is from glacial erosion

XIII. Glaciers and Ice Ages

- A. Cause of Ice Ages - Current Ice Age began ~2 m.y. ago (Pleistocene)
Plate Tectonics and ‘Orbital Variations’
- B. Types of Glaciers: Valley Glaciers and Continental Ice Sheets
- C. How Glaciers Move: Plastic Flow vs. Basal Slip
- D. How glaciers erode, & transport: Plucking, Abrasion

XIV. Formation of Eastern Cordillera: Rocky Mountain NP and Glacier NP

- A. Formation of Nuna and Rodinia (above) produce Metamorphic and igneous rocks in rockies
- C. Subduction Zone on western continental margin during Paleozoic
 - Antler Orogeny (Mid-Devonian ~380 Ma) adds crust to western margin of continent and sediments derived from this event become the sedimentary rocks that are later uplifted in the ancestral Rockies.
- D. Pangaea forms and uplifts Ancestral Rockies (Alleghany & Ouachita orogenies)
- E. Uplift of the North American Cordillera (and Modern Rockies)
 - Sevier Orogeny (Jurassic to Cretaceous~165-80 Ma) forms the Sierra Nevada volcanic arc, and uplifts a fold-thrust belt = northern Rocky Mountains (preserved today in Glacier NP). The Sevier Orogeny not well preserved in central Rockies b/c it was ‘diced-up’ by later Basin and Range Extension.
 - Laramide Orogeny (Cretaceous to Cenozoic ~80 to 40 Ma) = change in angle of subduction from Sevier. This lifts the Colorado Plateau, and the eastern Rocky Mountains (preserved today in Rocky Mt NP) and shifts volcanic activity eastward (e.g. Devils Tower)