Geol 104: Geology of National Parks
Lecture 11: Zion National Park

I. Stratigraphy of Zion

Point: 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.

A. Kaibab Limestone (Permian > 250 Ma)

1. At base of the Zion Section
2. This is the same limestone that forms the cliffs that cap the Grand Canyon
   - So, the sequence here at Zion is YOUNGER than that preserved in the GC.
3. Outcrops to the north of Zion on the Hurricane Cliffs (a fault scarp)

B. Moenkopi Formation (Lower Triassic ~250 Ma)

1. Varied rock types: Limestone, Shales, siltstones, and gypsum
   - Form slopes (not cliffs)
2. Indicate deposition on a coastal plain with fluctuating sea level

C. Chinle Formation (Middle Triassic ~230 Ma)

1. Mudstones and limestones over a basal conglomerate
2. These are channel (conglomerate) and coastal swamp deposits.

D. Moenave and Kayenta Formations (Late Triassic ~220 to Early Jurassic ~206 Ma)

1. Silt, sand and mudstones
2. Lake and stream deposits
3. Fossil fish (BIG) and fossil dinosaur foot prints (in silts on the banks of lakes etc.)

E. Navajo Sandstone (Early Jurassic ~200 Ma)

1. Sandstone: cross-bedded, fine, well sorted, frosted sand grains
   - Very thick (~2000 feet), major cliff forming unit,
2. These are Dune deposits from a huge, near-shore desert
3. Wind Transport:
   a. How does sand move over a desert surface? Saltation
   b. How does cross bedding form?

F. Temple Cap: mid-Jurassic (~170 Ma)

- Stream deposits (channels and floor plain deposits)

G. Carmel Limestone: Late Jurassic (~150)

- Marine deposits again.

II. Geologic History of Zion

Big Point: this is a continuation of the Grand Canyon geologic history. The rocks of Zion record regression of the Permian sea, followed by change to arid climate, then transgression of the sea in later Jurassic.

A. Permian Sea regresses (no more Kaibab Limestone)

1. Lower Triassic (~250 Ma)
   - Coastal plain in an arid (gypsum) environment. Sea level is fluctuating (interbedding of rock types)
2. Middle Triassic (~230 Ma)
   a. Sea level continues to fall or continent rises
   b. River systems and swamps advance onto the coastal plain (Chinle formation)
   c. Climate changes to Tropical – amphibian fossils and swamps
3. Late Triassic (~220 Ma)
   a. Climate changes to Northern Tropics (dry winter)
   b. Dinosaurs move in
4. Jurassic (~200 Ma)
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B. Changes in the Jurassic

1. Change to arid environment and a huge desert forms lasting till end of Triassic
2. Lots of erosion (unconformity) lasts until mid-Jurassic
3. Climate begins to become more humid (Temple Cap ~ 170 Ma)
4. Sea level rises again ~150 Ma (Carmel L.S.)

C. Extension of North America ~ 20 Ma

1. This 'stretches' he N.A. lithosphere
2. Creates the Basin and Range province
3. Results in high-standing Markagunt Plateau that Zion sits on (and Colorado Plateau)
   a. Bounded to West by Hurricane Fault and the east by Sevier Fault
   b. Virgin River cuts into plateau much the same way as before

III. Canyon and Arch formation at Zion: Mass wasting and river down-cutting.

A. Valley cutting

1. The Narrows = slot canyon cut into Moenave and Navajo sandstones.
   a. Virgin River cuts into resistant bedrock
   b. Rocks form a competent wall
   c. Over time, continued down cutting results in a deep, narrow canyon with steep walls.
2. Wide – steep sided canyon further down stream (Navajo Sandstone)
   a. Caused by undercutting of the wall
      i. Here, portions of the wall are underlain by less resistant to erosion.
      ii. The river cuts under the overlying sandstone.
      iii. Eventually the overhanging sandstone breaks away from the wall and widens the valley.
      iv. These blocks break along vertical fractures in the rock (joints). These joints are vertical, so the walls of the canyon are vertical.
   b. When only a portion of the wall breaks away, forms an "inset arch".
3. V-shaped valleys
   a. If the bedrock were less resistant to weathering, the walls fail in landslides and slumps.
   b. Ultimately, this produces valley walls composed of slide material resting at the angle of repose (~30º)

B. Mass Wasting = movement of large mass of material down-slope under the force of gravity.

1. Many types of mass wasting:
   a. Some fast and devastating others slow (e.g. Landslides, avalanches, mudflows, creep)
   b. They all lead to landscape evolution
   c. Driven by many forces: Shaking from Earthquakes, lubrication from wetting clays, clay expansion.
2. Frost wedging drives mass wasting in Zion (and much of the world) causing blocks to fall from the walls of the canyons.
   a. Water infiltrates fractures (joints)
   b. Freezes and expands – this forces the joints to open further
   c. Eventually, after repeated freeze-thaw events joint bounded blocks will break free of the wall.

C. Hanging Valley

1. This is a small tributary valley that is perched on a cliff above the main valley.
2. These form when
   a. Down-cutting by the tributary stream cannot keep pace with the rapidly down-cutting main stream, and
   b. The main stream is cutting a canyon (not a v-shaped valley).