GEOLOGY 25 - LECTURE 2A

COLORADO PLATEAU: Zion NP

(Textbook: Ch 4, p. 52-60)

Be sure to study these notes together with the images. These words really don't make a lot of sense on their own but are much more easily understood when combined with the graphics.

Zion National Park

The main Zion Canyon within the park (where most visitors go) is about 2500' deep and less than a mile wide

- canyon created relatively recently (past few million years) by the Virgin River cutting down into thick Mesozoic redrock.
- Zion noted for its near-vertical, extremely high, red-stained cliffs.
- National Monument status in 1909, National Park in 1919. Visited by >4 million/year.

Virgin River watershed is part of the larger Colorado River watershed. It begins in southwestern Utah, flowing through Zion NP, then merging into the Colorado River in what is today Lake Mead, the reservoir behind Hoover Dam. So over geologic time spans (pre-dam), the rock eroded to create Zion Canyon was transported as loose sediment by the Virgin River into the Colorado River, then to the Gulf of California.

In the Google Earth view, Zion Canyon is incised into a high plateau (part of the larger Colorado Plateau) by the Virgin River; erosion has also accentuated the system of near-parallel vertical fractures (called **joints** – more on this later).

As in the Grand Canyon, the redrock composing the canyon walls is much older than the canyon itself. The Virgin River carved into the underlying rocks much more recently in geologic time.

Rocks composing the Zion landscape

The age of rocks in Zion begins where the age of rocks in the Grand Canyon ends . . .

Zion dominated by reddish, horizontally bedded **Mesozoic** sedimentary rock spanning about 150 m.y. of time (between ~250 to ~100 m.y.a.) (so younger than the Paleozoic rocks of the upper Grand Canyon)

- horizontally bedded sedimentary rocks record deposition in environments ranging from shallow seas (represented by limestones and shales containing fossils of marine creatures), to coastal plain sluggish river systems and tropical swamps (shales and siltstones containing fossils of amphibians, other freshwater fauna, and dinosaur tracks), to vast coastal deserts (sandstones showing wind-driven dune-like features)
- these rocks were originally deposited near or just above sea level, but are now exposed at several thousand feet in elevation on the Colorado Plateau. So they must have been lifted upward by geologic forces at some time long *after* they were deposited and buried.
- remember from our discussion of Grand Canyon that these rocks were once extensive horizontal layers that are now modified into their current landscape by recent river incision and erosion

Dominant cliff-forming formation in Zion is the **Navajo Sandstone** that forms massive, towering cliffs and monoliths.
- the steep Navajo cliffs rise above the thinly vegetated slopes of the underlying **Kayenta Formation**, a shale and siltstone layer
- remember that these were once laterally continuous layers, but stream incision, weathering and erosion occurred over millions of years to create the canyon we see today

The Kayenta shales and siltstones were deposited in streams flanked by broad floodplains. The sluggish streams meandered back and forth across the region. When they would flood, they would overtop their banks and spread out across the floodplain, leaving behind a layer of mud and silt. Dinosaurs evidently ran across the muddy surface, leaving three-toed imprints of their presence. Combined with fossils of bones, it's thought that the footprints represent a human-sized meat-eater. This is to remind us that the Mesozoic was the age of reptiles, including dinosaurs.
- with time, uplift, and the constant effects of erosion, the tracks were exposed to view, providing greater insight into the environmental conditions of the Mesozoic world when the Kayenta sediments were deposited.
- we can use the principle of faunal succession to determine a relative age of the rocks in Zion. Because we find fossils and footprints of dinosaurs, the rocks have to be Mesozoic in age.

The Navajo Sandstone forms steep, imposing cliffs. It's noted for its steeply inclined **cross-bedding** (thin parallel beds tilted downward, marking the front of migrating sand dunes)
Navajo cross-bedding represents deposition of sand within a vast coastal desert system of sand dunes that extended north-south from southern Nevada to northern Wyoming about 200 m.y.a. (Mesozoic). Strong, northwesterly coastal winds pushed piles of loose sand around, forming steep-walled sand dunes.

How do crossbeds form within sand dunes?

Sand grains will self-organize into dunes under the influence of strong prevailing winds, as are common in desert environments.
The orientation of the dunes reveals the direction of prevailing winds. Dunes are steeper on their downwind side (the lee face) and have gentler slopes on their upwind side.

As the wind blows, sand grains bounce up the gently inclined windward face to a crest. They then avalanche down the steep-walled lee face, building inclined layers of sand into crossbeds. ("windward" means the upwind side, while the "lee face" means the downwind side)
- so the windward side is erosional, whereas the lee side is depositional. Sand grains are constantly being picked up by wind on the upwind side, then transported by the wind to the steep leeward face of the dune. The accumulation of sand grains on the advancing lee side produces cross-bedding within the body of the dune.
- as the sand grains avalanche down the steep front of the sand dune, they separate according to size and density, creating individual thin layers of cross-beds. Heavier, larger grains settle to the bottom of the bed, while the lighter, smaller grains rest on top of the coarser layer.

The orientation of the cross-beds (i.e., the physical front of advancing sand dunes) indicates the direction of winds at the time of deposition. In the Navajo, thousands of cross-bed orientations have been measured that indicate that Mesozoic winds blew mostly from the northwest across the American West, although there is considerable variability, likely due to seasonal changes.

The ancient dunes preserved in the Navajo Sandstone may have had crests approaching tens to hundreds of feet in height. (this interpretation of the Navajo Fm is based on *actualistic* examples from desert dunefields around today's world, such as the coastal Namib Desert in the country of Namibia in southwest Africa.)

What is the shape and dimensions of the Navajo Sst across the American West?

The Navajo is 600-800 meters thick near Zion, thinning to 0 m near eastern Colorado.
- extends northward all the way into Wyoming (where it is known as the Nugget Sandstone). (wedge-shaped, thickest in west, feather edge in east). This is an area larger than modern California.
- sedimentary layers may be laterally extensive, but they're not necessarily tabular (equal thickness in all directions); they more typically are wedge-shaped, tapering to a thinner edge in a landward direction (like the Navajo)

By piecing together exposures of the Navajo Sst from numerous places around the American West and following the principle of lateral continuity, we can create paleographic maps that show the areal extent of the desert at the time of its deposition.
The paleogeographic setting of the Navajo, created by mapping the thickness and extent of the formation across the American West, shows the Navajo Desert extending from southern Nevada, northeast across Utah, and deep into Wyoming.
- coastline ran through central Nevada into Idaho

It's important to remember that during Paleozoic and Mesozoic time, the region that would become the Colorado Plateau was either just below or just above sea level near the western coastline. Most of California didn't exist, sea levels were high, and the shoreline migrated across the future Colorado Plateau region.
- the Colorado Plateau would be uplifted twice, once near the beginning of the Cenozoic and again toward more recent time (more on this later)

The depositional setting of the Navajo Desert is thought to be similar to the modern Namib Desert along the west coast of Africa where huge sand dunes are driven by strong coastal winds. The Atlantic Ocean lies adjacent to the Namib Desert.

Zion Landscape: How does Zion Canyon deepen and widen?

Erosional downcutting by the Virgin River during countless floods is partly responsible for *deepening* the canyon, primarily acting on the softer Kayenta along the base of the canyon.
The main process that *widens* the canyon occurs as slabs of Navajo sandstone break away from the cliff faces and crash downward as **rockfalls**.

The massive layer of Navajo Sandstone is cut by numerous vertical fractures called **joints**. Rainwater and snowmelt filters downward through the fractures where it dissolves the natural cement holding the sandstone together, weakening the rock.

- the weathered rock along the vertical joints eventually weakens to the point where great slabs of rock separate and plummet to the floor of the canyon as rockfalls
- triggers for rockfalls might be heavy rains, spring snowmelt, small earthquakes, or just time
- rockfalls may happen every few years, but given the long spans of geologic time, many many rockfalls have maintained the vertical cliffs of Navajo that mark the canyon walls.

All of the scenery at places like the Colorado Plateau is erosional in nature. The original layers of sedimentary rock formed long ago. Subsequent uplift acted to raise the rocks to high elevations when the rocks were eroded to create the landscape we see today. It doesn't matter if you're at the Grand Canyon, Zion, or Bryce, the vistas you enjoy are the product of weathering and erosion acting on the original slabs of rock.

There are many wonderful hikes in Zion, but two of the most popular are Angel's Landing and The Narrows. Plan carefully before you do either of them.

These websites may be useful to those of you who have chosen not to use the textbook.

National Park Service – Geology of Zion NP
https://www.nps.gov/zion/learn/nature/geology.htm

Wikipedia – Geology of Colorado Plateau
https://en.wikipedia.org/wiki/Colorado_Plateau

Wikipedia – Geology of Zion
http://en.wikipedia.org/wiki/Zion_National_Park

_____